The Geography of Traffic Accidents and Risk Reduction

An Assessment of the Ottawa-Carleton Region

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Abstract

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Accident research traditionally concentrates on the identification of factors that influence events preceding a traffic accident. The factors are associated with a variety of disciplines including behaviourial, mechanical and environmental studies. Geography contributes to the understanding of the phenomena of accidents as a result of considerable attention given to the explanation of patterns of land use and traffic movement in regional settings. The circumstances are studied to develop and implement countermeasures in effort to reduce the risk associated with vehicle operation.

This research project evaluates the effectiveness of safety countermeasures at locations up-graded from stop sign to traffic signals in the Regional Municipality of Ottawa-Carleton. The study begins with an overview of the Region and countermeasure policies implemented by RMOC. The emphasis of the evaluation is based on the application of the "Traditional" approach and the "Probabilistic" approach to 54 locations that received traffic signals in 1986. The accident frequencies at these locations are studied using a "before-and-after" comparison and the data is standardized for risk by using traffic volume. The results indicate a substantial drop in accident rates, however, the evaluation does not indicate the level of contribution by traffic signals or by other factors.

The allocation of traffic signals is evaluated in a supplementary analysis of components associated with traffic accidents. This complementary evaluation is of a "with-and-without" nature and includes a land use matrix of socio-geographic factors associated with the 54 countermeasure locations. The results indicate the presence of land use combinations common to particular locations. However, the results are inconclusive in the absence of representative multi-variate analysis. The study concludes that more standardized evaluation techniques are required to ensure the cost effective allocation of safety resources in the Region.

Key Words:

Traffic accident analysis, traffic management, safety improvement, evaluation, countermeasure, traffic signal, traffic signal warrant, risk exposure, accident frequencies, traditional approach, probabilistic approach, "regression to the mean", before-and-after, with-and-without, spatial factors, socio-geographic factors.

Résumé

Géographie des accidents de la circulation et de la réduction du risque

Une évaluation sur la région d'Ottawa-Carleton

Les recherches sur les accidents ont traditionnellement été effectuées sur l'identification des facteurs qui influencent les évenements précédant les accidents de circulation. Ces facteurs sont associés avec une variété de disciplines incluant des études sur le comportement, de mécanique et de l'environement. La géographie contribue à comprendre le phénomène des accidents en donnant beaucoup d'attention à l'explication des patrons de terrains et du mouvement de la circulation dans certains environnements. Les faits sont étudiés pour développer et mettre en mesure des contre-mesures pour réduire les risques associés avec l'opération d'un véhicule.

Ce projet de recherche évalue l'efficacité des contre-mesures de sécurité à des emplacements où les signaux d'arrêt ont été remplacés par des feux de circulation dans la Région Municipale d'Ottawa-Carleton. Cette recherche commence avec une vue générale sur la région et sur les politiques de contre-mesures appliquées par R.M.O.C.. L'emphase de l'évaluation est basée sur l'application de l'approche traditionnelle et de l'approche de probabilité sur 54 emplacements ayant reçus des signaux en 1986. La fréquence des accidents à ces emplacements est étudiée utilisant une comparaison de "avant-après" et l'information est ensuite unifiée pour les risques utilisant le volume de circulation. Les résultats indiquent une baisse substentielle du taux d'accidents, par contre, l'évaluation n'indique pas le niveau de contribution apportée par les feux de circulation ou autres facteurs.

La répartition des feux de circulation est évaluée dans une analyse supplémentaire des constituants associés aux accidents de circulation. Cette évaluation complémentaire est de nature "avec our sans" et inclue une matrice des facteurs socio-géographiques d'utilisation de terrains associés avec les 54 emplacements de contre-mesures. Les résultats indiquent la présence de combinaisons d'utilisation de terrain communes avec certains emplacements. Par contre, les résultats sont peu concluant en l'absence d'analyses représentant des multi-variantes. L'étude conclue que des évaluations techniques plus uniformes sont requises pour assurer la rentabilité des allocations de ressources de sécurité dans la région.

Mots clés:

Analyse d'accidents de circulation, administration de circulation, amélioration de la sécurité, évaluation, contre-mesures, feux de circulation, justification des feux de circulation, exposition au risque, fréquence d'accidents, approche traditionnelle, approche de probabilité, régression à la moyenne, avant-après, avec ou sans, facteurs spaciaux, facteurs socio-géographiques.

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Chapter 1

The Geography of Traffic Accidents and Risk Reductions An Assessment of the Ottawa-Carleton Region

1.10 Background

The common perception of a traffic accident is that of a rare or unique event that occurs by chance. However, Cantilli and Horodeniceau (1979) suggest only 5 to 10 percent of traffic accidents fall under this category. Traffic accidents are more often attributed to a combination of human, mechanical and environmental factors which, to some extent, make these events predictable (Langlois & Olsthoorn, 1990). Traditionally, traffic accident research attempts to disaggregate factors such as driver and pedestrian demography, quantity and quality of exposure and vehicle composition in order to identify a manageable set of factors that influence the sequence of events that result in a traffic accident (Hauer, Sept. 1981). The multiple components drawn from these factors are studied in greater detail in order to develop and implement remedial countermeasures, in a cost effective manner.

A geographical approach, without claiming precedence over other approaches, offers an additional perspective to the understanding of the phenomena of accidents (Whitelegg, 1987). Geography has contributed to the subject area as a result of considerable attention given to the explanation of patterns of location and movement in regional and intraurban settings. For example, the movement of vehicles is determined by a multitude of Land Use System components: residential patterns, street geometries, population densities, traffic densities, location of workplace, shopping areas and other generators of traffic. Many of these components, familiar to the geographer, are involved with the circumstances preceding road traffic accidents by varying degrees. When applicable, they may be used to estimate the accident probabilities associated with particular locations.

The operation of a vehicle involves a certain amount of danger that is associated with a particular activity whether it is the journey to work, a shopping expedition or simply a sightseeing event. The risk associated with these activities is often reduced significantly through the application of risk management techniques. However, the danger is never eliminated as a result of cost/benefit trade-offs between reducing risk, or the accident rate, and the expenditure of resources (Roberge, 1984).

The implied acceptance of risk, whether in industrial applications, railway and highway crossings or at roadway intersections, denotes the recognition of the concepts of risk assessment and risk management. Vehicular traffic at roadway intersections is controlled by various signalling devices such as traffic signals, stop signs or yield signs. The controlling features have been placed in effort to reduce risk, hence, the accident rate. In some cases, the control elements have been placed to increase the level of convenience to the driver, regardless of accident rates associated with the location. In either instance, the traffic management technique is expected to enhance the flow of traffic without jeopardizing the safety of the user.

What motivates the application of traffic management techniques throughout a particular region and why are certain control devices found at specific locations? To what extent do major Land Use System components determine the application of particular types of traffic management and how are these related to volumes or traffic flow? How is Land Use System information to be used to identify the role played by individual land use components in the allocation of traffic control devices. These are questions and issues that are addressed in the study of traffic accidents and risk management, from a geographers perspective.

1.20 Objectives

The main objective of this research project is to review the spatial distribution of traffic accidents in the Ottawa-Carleton Region that occur at intersections with traffic signals and stop signs. More specifically, the intent of this study is to identify and evaluate the effectiveness of current policy directives towards up-grading traffic management techniques within the Region. The scope of the study is directed at the evaluation of the effect of safety countermeasures at locations that have undergone a transition from stop sign to traffic signal control techniques. These objectives are viewed from a "policy evaluation" perspective using the traditional form of evaluation and a probabilistic method of analysis.

1.21 Policy Evaluation

Administrators of traffic safety research and improvement programs are continually faced with the task of making decisions concerning the most effective method of allocating the limited number of safety dollars set aside for accident reduction (Council et al, 1980). The decision making process involves a variety of inputs that range from political considerations to budget limitations. The decision process has become more critical as the transportation system expands at a greater rate than the resources put aside to insure traffic safety. Thus, it is no surprise that the continuing need for a well designed system to evaluate the effectiveness of safety improvement programs is a major issue of concern today.

Safety countermeasure programs are evaluated to ensure that resources are spent on projects that actually improve the accident picture for a particular area. However, safety administrators may be sincerely persuaded, by rigorous policy directives for countermeasure implementation, that efforts to evaluate the program are unnecessary. Nonetheless, it is poor policy to finance marginal or ineffective safety initiatives while other accident locations are inadequately addressed. Likewise, it is important to evaluate how effectively a safety countermeasure has brought about the desired result for a particular situation. The success or failure of the countermeasure, in terms of the desired result, will remain unknown unless the effectiveness is evaluated.

The allocation of traffic accident countermeasures in the Regional Municipality of Ottawa-Carleton is based on strict policy requirements that are outlined by traffic control signal warrants. The warrants have been developed by traffic safety administrators at a Provincial level and have been adopted as policy by Regional Council for a variety of reasons. Perhaps the most important reason is that Provincial funding for the countermeasure implementation will not be given unless the warrants are satisfied. Secondly, the traffic warrant requirements have been developed based on historical traffic volume and accident trends throughout the Province of Ontario.

The Region does not conduct a formal countermeasure effectiveness evaluation program for traffic signal control installations. The safety administration staff will conduct a traditional evaluation of the countermeasure upon request of senior management or Council members. This traditional approach involves the comparison of the accident frequencies for three years prior to installation and three years following installation of the traffic control signals. However, these studies are not conducted on a regular and consistent basis. The evaluation procedure, when conducted, is simplistic in nature and fails to give timely results. Therefore, it is very difficult to determine whether the Regional policy directives for individual countermeasure implementations are successful.

It is also very difficult to determine if Regional implementation policies have improved the allocation of countermeasures to those locations in most need throughout the Region. There are no formal comparisons of locations that have undergone countermeasure treatments to untreated locations with similar or higher accident rates. In fact, certain high risk locations may have been overlooked because they did not meet the particular requirements outlined in the traffic control signal warrants. Unfortunately, it is difficult to distinguish these inadequacies without a formal method of evaluation.

This study is intended to address the inadequacies of the current Regional policy directives with respect to traffic safety countermeasure implementation and evaluation. The study will describe the allocation procedure in place at the Region followed by a detailed account of traffic signal control warrants. In order to address the current policy needs more succinctly, this study will attempt to evaluate the effectiveness of countermeasure implementations in the Region using a variety of traditional and more sophisticated methods found in accident research annals. The results will be summarized and compared to current policy objectives in order to identify key variables that may be currently overlooked. An attempt will be made to introduce a valid evaluation procedure that will address the policy areas that are not currently emphasized at the Region.

1.22 Evaluation Techniques

The evaluation of the effectiveness of safety countermeasures is generally of a "before-and-after" nature and seldom includes a control group for "with-and-without" comparisons. This is not unusual because of the practical difficulty of identifying a set of countermeasure "with" locations and a set of "without" locations that are similar in terms of street geometry, accident frequencies, traffic volume and other specific casual factors (Hauer, 1985).

The traditional "before-and-after" approach is relatively simple to apply. It involves the evaluation of the variance between the most current accident rates and the reported accident histories of years past, much in a similar pattern to that currently used at the Regional Municipality of Ottawa-Carleton. The countermeasure is said to be successful if the variance is positive and unsuccessful if the variance is negative. It is difficult to determine the roles played by various land use components in the accident process from this sort of analysis.

The traditional approach is relatively easy to apply, however, the conclusions drawn may be misleading because they do not account for accident fluctuations that occur in response to specific components other than the safety countermeasure treatment (Council et al, 1980). An example given by F.M. Council highlights that many evaluation studies of the reduction of the speed limit to 55 mph in the United States in the mid 1970's concluded the countermeasure caused a significant decline in fatalities. However, Council notes that there were other causes at work such as a decrease in mileage driven due to the energy shortage (Council, 1980). Similarly, the aging of the accident data used in particular areas may highlight a maturation effect where the accident trends decrease naturally over time (Council, 1980). If the accident researcher did not account for this, it may be incorrectly concluded that the decrease in the accident rate was directly attributable to the countermeasure implementation.

The most significant cause of erroneous conclusions in traffic safety evaluations is found in the phenomena of "regression to the mean" (Council, 1980). Traditional evaluation methods are based upon the common assumption that "what happened in the past will happen again" if no countermeasures are put in place. More often than not, this approach provides a positive evaluation in terms of a drop in accident rates. This conclusion is obscure and misleading. The analysis does not consider the phenomena of "regression to the mean". This phenomena refers to individual data points "regressing to the overall trend mean" without any countermeasure treatment having been applied (Council et al, 1980). That is to say, the highest deviant points in any empirical study will tend down to the mean number of the points while the lowest deviant points will tend up towards the mean number (Blalock, 1979).

In other words, the number of accidents occurring in the past will not happen again because each location will tend towards the mean number of accidents in the particular study area if no countermeasure is implemented (Hauer, 1985). For example, the mean number of accidents for a particular city may be 1. The locations with 2 or more accidents in the current year would have predicted accidents in subsequent periods that are closer to 1 because of the regression to the mean effect (Hauer, 1984). Therefore, it is difficult to state that the number of accidents "before" is a good indication of what will take place if countermeasure is implemented.

1.23 Objectives Summary

In attempt to improve upon traditional methods, more sophisticated prediction techniques have been developed to provide accident estimates for evaluative comparisons, for "before-and-after" studies particularly. Instead of using past histories as the benchmark measure, estimated accident frequencies are calculated with adjustments to reflect the "regression to the mean". These "average mean" estimates are used for the comparative analysis to provide a more realistic appraisal of the safety countermeasure performance over time.

The approach taken in this study is of an investigative nature in attempt to test both the "traditional" and the "average mean" or probabilistic approaches of evaluating safety countermeasures at traffic accident locations. The study attempts to make "before-and-after" and "with-and-without" countermeasure location comparisons in both the "traditional" manner and in the "average mean" manner in order to evaluate the effectiveness of countermeasure Policy implemented in the Regional Municipality of Ottawa-Carleton.

Chapter 2

The Regional Municipality of Ottawa-Carleton

The Regional Municipality of Ottawa-Carleton (RMOC) is located at the junction of the Ottawa and Rideau rivers. The Region spans an approximate area of 2,767 square kilometres including area municipalities and a rural region which comprises approximately 90 percent of the entire area (RMOC, 1989). The Region was established by the Ontario Legislature in 1969 and comprises the upper tier of the two tier system of local government. The lower tier is comprised of 11 area municipalities.

2.10 Socio-Economic Characteristics

The demand for travel and transportation in the Region, as in any place, is governed by land use, or, specifically, the demographic and socioeconomic profile of the area. Therefore, it is appropriate to briefly examine the key characteristics of population, dwelling units, and employment in the Region, particularly for those readers that are unfamiliar with the area. The changing dimensions of the Socio-Economic fabric and the subsequent impact on traffic accidents may deserve more detailed study but that must rest in another research paper at this time.

The population of the Region, in 1986, was approximately 606,639 which is a 10 percent increase from 1981. According to a demographic profile from the RMOC Planning Department (Table 1), the major population changes occurred in the eastern (30%) and western (19%) suburban areas while the central core (1.7%) within the greenbelt remained relatively constant. The same trend exists in terms of the number of dwelling units in each municipality, however, the central core maintains a relatively constant 60 percent distribution of total dwelling units.

Table 1

Socio-Economic Characteristics - RMOC

Population	1981	1986	Growth	1981 Distribution	1986 Distribution
Cumberland	16,177	26,999	66.9%	3.0%	4.5%
Gloucester	72,859	89,810	23.3%	13.3%	14.8%
Goulbourn	9,559	12,303	28.7%	1.7%	2.0%
Kanata	19,728	27,519	39.5%	3.6%	4.5%
Nepean	84,361	95,490	13.2%	15.4%	15.7%
Osgoode	9,360	11,197	19.6%	1.7%	1.8%
Ottawa	295,163	300,763	1.9%	54.0%	49.6%
Rideau	9,052	10,271	13.5%	1.7%	1.7%
Rockcliffe	1,869	2,033	8.8%	0.3%	0.3%
Vanier	18,792	18,426	-1.9%	3.4%	3.0%
West Carleton	9,929	11,828	19.1%	1.8%	1.9%
Total	546,849	606,639	10.9%		
Core	315824	321222	1.7%	57.8%	53.0%
East	98396	128006	30.1%	18.0%	21.1%
West	123577	147140	19.1%	22.6%	24.3%
South	9052	10271	13.5%	1.7%	1.7%

Dwelling Units	1981	1986	Growth	1981 Distribution	1986 Distribution
Cumberland	4,636	7,890	70.2%	2.3%	3.5%
Gloucester	21,475	28,020	30.5%	10.7%	12.3%
Goulbourn	2,940	3,935	33.8%	1.5%	1.7%
Kanata	5,675	8,360	47.3%	2.8%	3.7%
Nepean	26,670	31,830	19.3%	13.3%	14.0%
Osgoode	2,830	3,490	23.3%	1.4%	1.5%
Ottawa	121,705	128,615	5.7%	60.7%	56.4%
Rideau	2,790	3,230	15.8%	1.4%	1.4%
Rockcliffe	570	635	11.4%	0.3%	0.3%
Vanier	8,065	8,325	3.0%	4.0%	3.6%
West Carleton	3,125	3,800	21.6%	1.6%	1.7%
Total	200,501	228,130	13.8%		
Core	130360	137575	5.5%	65.0%	60.3%
East	28941	39400	36.1%	14.4%	17.3%
West	38410	47925	24.8%	19.2%	21.0%
South	2790	3230	15.8%	1.4%	1.4%

Employment	1981	1986	Growth	1981 Distribution	1986 Distribution
Cumberland	1,162	2,449	110.6%	0.4%	0.7%
Gloucester	18,275	25,108	37.4%	6.3%	7.4%
Goulbourn	1,618	2,122	31.1%	0.6%	0.6%
Kanata	7,194	8,258	14.8%	2.5%	2.4%
Nepean	25,722	37,118	44.3%	8.9%	10.9%
Osgoode	948	1,823	92.3%	0.3%	0.5%
Ottawa	226,999	253,806	11.8%	78.1%	74.5%
Rideau	1,263	1,725	36.6%	0.4%	0.5%
Rockcliffe	296	200	-32.4%	0.1%	0.1%
Vanier	5,864	6,211	5.9%	2.0%	1.8%
West Carleton	1,186	1,957	65.0%	0.4%	0.6%
Total	290,547	340,817	17.3%		
Core	233159	260217	11.6%	80.2%	76.4%
East	20405	29420	44.2%	7.0%	8.6%
West	35720	49455	38.5%	12.3%	14.5%
South	1263	1725	36.6%	0.4%	0.5%

Employment growth and the proportional distribution of jobs throughout the Region differs from these trends significantly. The growth of employment in the Region between 1981 and 1986 was approximately 17 percent. However, the geographic distribution of this growth was concentrated in the eastern (44.1%) and western (37.5%) suburban areas while the central core (11.6%) grew less rapidly. More interestingly, the proportional distribution of the jobs changed significantly. The central core dropped from 80.2% concentration level to 76.3% between 1981 and 1986. The eastern suburban area proportion of jobs rose from 7% to 8.6% and the western suburban job inventory rose from 11.8% to 13.9%. The core area decline in job concentration was partially explained by the relocation of some federal government employment to the Quebec side of the Census Metropolitan Area. In 1986, the central core remained the focal point for the proportion of jobs in the Region, however, the level was declining. Hence, it may be expected that travel patterns adjusted accordingly.

2.20 The Regional Road System

The Regional road system is overseen by four different governing bodies: the National Capital Commission acting for the Federal Government; the Province; Local Area Municipalities; and the Regional Municipality of Ottawa-Carleton (RMOC, 1989). The total road kilometres found within the Region are approximately 4,500 kilometres of roads and highways (RMOC, 1989). The Region is responsible for approximately 1,110 kilometres of streets and highways, of which 350 kilometres are located in the urban and semi-urban areas, and 760 kilometres which are rural (RMOC, 1989). This is illustrated by Figure 1 and Table 2.

The NCC is responsible for the 80 kilometre system of scenic driveways and parkways that span the urban and suburban areas of the Region (RMOC, 1989). The Provincial Government presides over the King's highway network that links the Region to other population centres in Ontario. This includes approximately 220 kilometres of highways that include the 417, Highway 15, 16, 17, 29, 31 and 44 (RMOC, 1989). The province also provides guidelines and funding for special transportation management and improvement programs. The local area municipalities are responsible for approximately 3,150 kilometres of local streets that provide access to residences, businesses and other properties (RMOC, 1989).

Within this framework, the NCC, Provincial and Regional roads are considered as part of the upper tier road system. The upper tier is typified by roads providing an arterial function, or, providing the shortest practical route between major traffic generation centres (RMOC, 1989). The service provided by the Regional road system is modified on a perpetual basis to meet travel needs as land use and roadway functions change. In addition, the Region works regularly with the area municipalities to systematically review the current situation of changes in road jurisdiction. Improvements made to the Regional road system include signage, road widening, road construction, intersection improvements, as well as transportation system management such as traffic signal controls, highway ramp metering and bus priority measures.

Roadways in the Region are broken down into a rural and urban designation which is further classified as Freeway, Arterial, Collector and Local. The factors that are considered in this process include the following: type of service, traffic volume, flow characteristics, speed, vehicle mix and connections to other classes (RMOC, 1989). The Freeway classification is typified as a divided highway with full access control and grade separations at intersections. The speeds are relatively high and traffic volume is generally greater than 20,000 vehicles (Average Daily Trips; ADT) (RMOC, 1989). The Arterial Road is designed to collect and distribute traffic along a continuous route. The Arterial carries volumes between 5,000 and 30,000 (ADT) and are typified by streets such as Bank, or, Carling Avenue (RMOC,

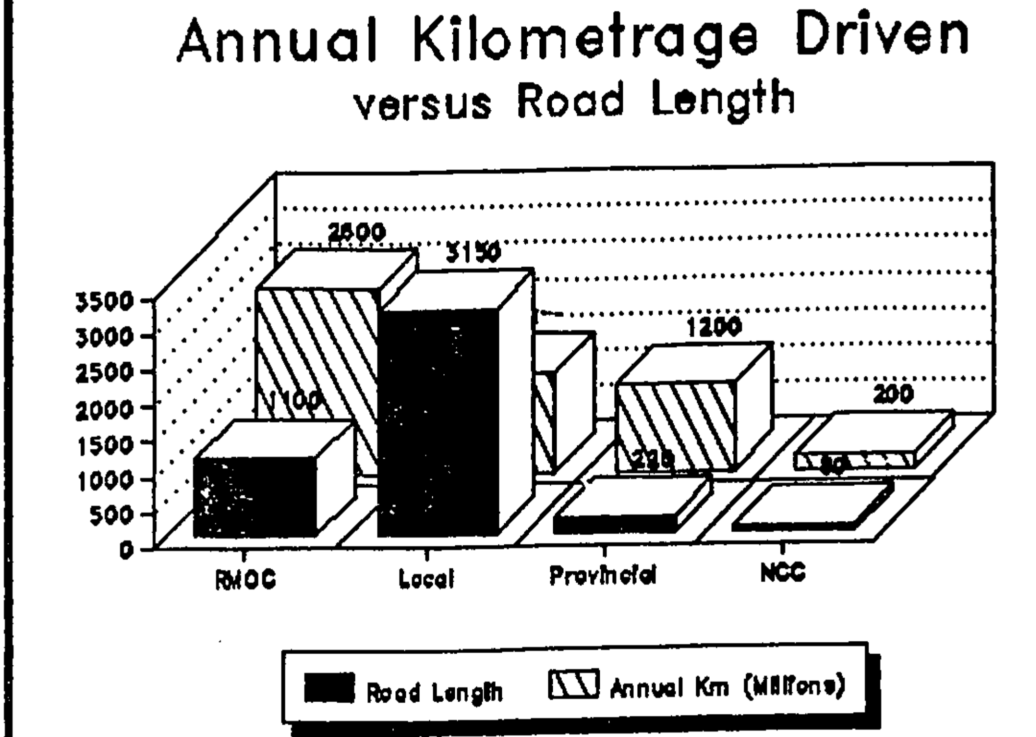


Figure 1

Table 2
Pattern of Vehicle Movements - RMOC 1986

Road Juridiction	Annual Kilometrage	% Distribution		Road Length Kilometres	% Distribution
RMOC	2,600,000,000	48.1%		1,100	24.2%
LOCAL	1,400,000,000	25.9%		3,150	69.2%
PROVINCIAL	1,200,000,000	22.2%		220	4.8%
NCC	200,000,000	3.7%		80	1.8%
Total	5,400,000,000			4,550	

1989). The Collector roadway contains traffic signals at major intersections and carries volumes between 1,000 and 12,000 vehicles (ADT) (RMOC, 1989). The purpose of a collector is to collect and distribute traffic from major arterial roads to secondary traffic generators, such an example is Kilborn Avenue. The Local street designation simply provides full and direct access to residences and businesses throughout the Region.

The general pattern of vehicle movements over the entire network for 1986 is illustrated by Table 2 (RMOC, 1989). On an annual basis, over 5.4 billion vehicle miles occur within the Region. Almost 505 of this takes place on the Regional road system which only accounts for 24% of the total road network. Only 26% of the vehicle miles are incurred upon the local network which accounts for almost 70% of the total network kilometres.

2.30 Transportation System Management - Regional Policy

The Regional transportation system has evolved into a very complex state and requires attentive management in terms of the development, implementation and monitoring of programs and projects designed to improve the functioning of the system. The management activities undertaken by the Region are delineated by several categories from financial management to environmental assessment, project management and transportation planning management, to name a few. For the purposes of this study, the areas of interest lie within the sectors of priority planning management, traffic management, traffic signal control warrants and development control agreements.

2.31 Priority Planning Management

The objective underlying priority planning management is to rank the various Regional transportation projects based on certain guidelines to ensure an appropriate allocation of resources based on the available funding. The primary function of this sector is to compile and perform the analysis for project justification, selecting and scheduling a program of projects and activities, and monitoring the subsequent status and cash flow. The Regional Transportation Department currently uses a "programme type" method of grouping projects into priority levels. This involves the classification of approximately 100 programs and activities into categories relating to common services, transportation planning, design-construction and operations.

Projects for the forthcoming year are chosen based on project priorities, estimates of project cost and cash flow needs, and, finally, on subsidy considerations. The project priorities are defined within the following categories in order of importance (RMOC, 1989);

1. Committed works,
2. Maintenance of existing system,
3. Salvaging assets and extending useful life,
4. Improve level of service and safety,
5. Extend service.

Each proposed project must undergo further priority ranking within one of the above categories. This is accomplished through what is called a "needs" study. This study is comprised of an inventory of conditions and adequacy ratings, including the costs of the improvements to eliminate the deficiencies. Each "Needs" study is applied to the appropriate category from which comparisons and rates are compiled with all other projects. In the cases of intersection and traffic signal improvement programs, the rates and rankings are based on the number of accidents, traffic volume and traffic signal warrants and would fall sixth in line to Road Construction, Road Reconstruction, Transitway Construction, Structure Construction and Street Lighting priority categories (RMOC, 1989).

2.32 Traffic Management

The Traffic Management sector is comprised of several components dedicated to the control, improvement and monitoring of the Regional transportation system. The primary components are traffic surveys, traffic signal systems, intersection improvement programs, traffic accident analysis systems and safety improvement programs. Each of these divisions represent the primary data sources that are used to compile the various traffic management "Needs" studies.

2.33 Traffic Volume Surveys

Traffic volume surveys represent the average annual vehicular traffic flow through an intersection on a daily basis. Traffic volume surveys are the source documents used to standardize accident frequency data analyzed in this research paper.

Traffic volume surveys have been collected at the Region for several years, primarily by two methods. First, by means of automatic traffic recorders at 42 locations and, second, from data collected in the field by approximately 40 temporary summer staff (RMOC, 1989). Approximately 1,000 manual and 2,000 automatic counts are taken each year on turning movements and classification counts (RMOC, 1989). This data is used as significant inputs to other studies such as traffic signal timing determination, safety and intersection improvements and other transportation planning activities.

2.34 Traffic Signal Control Systems

The traffic signal control system at Region is comprised of approximately 605 signals which are controlled by a central computer system (RMOC, 1989). This is an increase of 125 locations or 26% since 1986. Out of the 125 locations, 80 locations (64%) represented a transition from a stop sign or pedestrian cross walk traffic management device. The remaining 45 locations represent brand new installations and over half of these were made at rural locations. The purpose of the traffic signal control program is to provide pedestrian and vehicle traffic with adequate safety and clearance time when crossing or turning at a street intersection. The traffic signals are also used in a system of highway "ramp metering" in order to control traffic flows during peak hour tidal flows.

2.35 <u>Intersection Improvement Program</u>

The intersection improvement program is comprised of low cost geometric improvements that are a highly effective measure for enhancing capacity and safety. These locations were not considered in this research paper because of the "low cost" nature of the countermeasure implementation. This paper was more concerned with the high cost allocation of traffic signal devices.

The locations, under the Intersection Improvement Program, are often identified by the public, Regional council members and the Transportation Department. Each project is priority ranked based on a benefit/cost ratio in which the numerator takes into consideration, with equal weight, the traffic volume and number of accidents affected by the improvement (RMOC, 1989). Apparently, there are an average of 20 such projects with highest priority with only 3-5 projects implemented each year (RMOC, 1989).

2.36 <u>Traffic Accident Analysis System</u>

The traffic accident analysis system at the Region is based on the Motor Vehicle Accident Reports that originate from the various police forces in the Region. The information contains all traffic accidents that occur on public roadways within the Region, excluding non-reportable accidents (those with estimated damage under $700). The average annual accident frequencies are approximately 15,000 and occur at approximately 2,300 locations (RMOC, 1989). In 1988, approximately 40% of the accidents took place at intersections with traffic signal controls, 30% at non-controlled locations, 20% at stop sign locations and 10% at locations having yield signs, pedestrian cross walks, police school guards and school bus stops (RMOC, 1989).

The traffic accident analysis group produce three reports on a quarterly basis. The first report is a Detail Report of Traffic Collision Location and lists each accident alphabetically by road location. This information is summarized in the Frequency Ranking Report of Traffic Collision Locations which categorizes the locations by the specific control type: traffic signal, stop sign, yield sign, no control, pedestrian cross walk, police school guard and school buses. The report ranks the locations by accident frequencies for each category. The Frequency Report has been provided by the Region, by special permission, in database format for the period of 1986 to 1989 and will comprise the basic information for this study. An example of the report is illustrated in Table 3. The third report is the Statistical Summary Report that aggregates and cross tabulates related items such as time of day, weather conditions, directionality and injury occurrences. These reports are of high quality and have been rigorously scrutinized.

2.37 Safety Improvement Program

The safety improvement program conducts an annual study based on the aforementioned accident and traffic volume reports when the year end reports have been completed. The program selects approximately 15-20 new locations each year for site specific analysis (RMOC, 1989). The locations are selected by a priority ranking scheme in which the accident frequency is adjusted by exposure, or, traffic volume. Upon identification, a cause-effect relationship is identified between a hazard and the accidents and attempts are made to eliminate the problem. Contributing factors identified by the safety improvement group include roadway geometries, traffic control device design or location, traffic operating characteristics, environmental conditions and roadway surface conditions.

Table 3

- FREQUENCY RANKING REPORT OF TRAFFIC COLLISION LOCATIONS -

ALL PUBLIC ROADWAYS IN THE REGIONAL MUNICIPALITY OF OTTAWA-CARLETON

TRAFFIC SIGNALS — REPORTING PERIOD: 1 JAN 88 TO 31 DEC 88

RANK	LOCATION			TOTAL COLLISIONS	NON REP COL	IN DARKNESS	7-9:30 AND 3:30-6	WET/ ICY ROAD	VEHICLE RIGHT ANGLE N-E	S-E	S-W	N-W	DIRECTIONAL OPPOSING N-S	E-W	MOVEMENTS SAME N-N	E-E	S-S	W-W	NOT SPEC	ONE VEH COL	INJURY COL. PED/ALL
1	BANK	&	WALKLEY	50	1	17	11	24	0	1	1	0	25	12	3	1	3	3	0	1	0/ 17
2	HERON	&	RIVERSID	40	0	12	16	12	1	2	1	0	12	1	7	3	8	2	0	3	1/ 19
3	BASELINE	&	MERIVALE	37	3	15	9	15	0	0	0	1	6	11	5	4	3	6	0	1	0/ 16
4	MONTREAL	&	VAN-PKW	36	0	9	10	12	3	1	1	2	10	6	6	2	3	2	0	0	0/ 7
5	BEECHWOO	&	VAN-PKW	34	3	10	10	23	1	0	0	3	6	1	6	9	1	3	0	4	0/ 8
6	CARLING	&	PRESTON	30	0	6	13	12	2	1	2	0	4	13	0	4	1	1	0	2	2/ 11
6	COVENTRY	&	VAN-PKW	30	0	4	11	14	0	1	0	2	8	1	1	0	11	3	0	3	1/ 10
8	CARLING	&	CHURCHIL	28	2	10	10	14	0	0	1	0	0	10	0	2	1	9	0	5	5/ 9
9	ELGIN	&	SLATER	27	2	10	8	8	10	3	1	0	0	0	3	7	3	0	0	0	0/ 10
9	FISHER	&	MEADOWLA	27	0	7	6	10	2	1	0	1	16	1	3	0	2	1	0	0	0/ 11
11	COVENTRY	&	S.LAUREN	26	1	8	7	13	1	0	1	1	7	0	7	0	3	3	0	3	0/ 8
11	MACKENZI	&	RIDEAU	26	0	4	6	6	0	6	14	0	0	0	0	2	3	1	0	0	0/ 8
11	MCARTHUR	&	VAN-PKW	26	1	8	4	9	0	0	0	0	9	6	3	1	2	1	0	4	2/ 13
11	RR- 34	&	RR- 50	26	0	11	7	13	2	3	1	1	2	7	2	3	2	1	0	2	1/ 4
15	BASELINE	&	CLYDE	25	0	13	5	9	1	1	2	2	6	5	1	1	0	4	0	2	1/ 7
15	BASELINE	&	GREENBAN	25	1	9	6	13	0	0	2	0	8	7	4	0	1	1	0	2	0/ 9
15	BASELINE	&	WOODROFF	25	2	4	9	14	2	0	1	1	0	0	5	2	5	4	0	5	0/ 9
15	CATHERIN	&	KENT	25	1	8	2	11	0	0	0	3	0	0	20	0	0	2	0	0	0/ 6
15	DONALD	&	S.LAUREN	25	1	12	10	12	0	0	0	1	9	5	3	1	1	1	0	4	2/ 10
20	ALTAVIST	&	SMYTH	24	2	4	6	9	4	0	0	3	3	7	3	0	1	3	0	0	0/ 12
21	CARLING	&	MERIVALE	23	0	6	7	8	1	0	3	2	6	7	0	1	1	2	0	0	0/ 9
21	KINGEDWA	&	S.PATRIC	23	0	5	7	9	0	0	8	2	1	0	0	0	5	5	0	2	1/ 8
21	RR- 17	&	RR- 51	23	0	10	4	13	0	1	0	0	5	4	3	1	6	1	0	2	0/ 13
24	LAURIER	&	NICHOLAS	22	1	8	5	10	1	2	1	2	5	0	2	5	3	0	0	1	1/ 8
24	MONTREAL	&	S.LAUREN	22	3	8	3	5	2	0	1	2	2	5	1	4	1	0	0	4	0/ 8
24	RR- 12	&	RR- 13	22	0	5	14	12	0	1	0	0	2	12	3	1	2	0	0	1	0/ 8
24	RR- 36	&	RR- 49	22	0	6	7	7	1	1	0	0	11	0	2	0	3	3	0	1	0/ 4
28	BRONSON	&	SOMERSET	21	2	3	4	10	3	1	1	2	3	2	4	1	1	2	0	1	1/ 5

The safety improvement studies normally lead to the provision of an effective traffic accident countermeasure through the intersection improvement program or the annual traffic control signal priority program. During the last 6 years, the group has studied approximately 120 locations and countermeasures have been implemented at 65 of the locations (RMOC, 1989). The safety improvement group evaluate the success or failure of implemented projects in order to reduce the potential or continuing projects that are ineffective. The method of evaluation consists of comparing the accident experience at the location for a certain time period, usually three years, "before-and-after" the implementation of the countermeasure. In addition, the group conducts an analysis using cost data and minimum economic benefit data from Transport Canada in order to determine the accumulated savings as a result of countermeasures implemented. The group estimates that approximately $3 million have been saved annually as a result of the introduction of safety countermeasures (RMOC, 1989).

2.38 <u>Traffic Signal Control Warrants</u>

Traffic signal control warrants have been developed by the Provincial Ministry of Transportation as an outline governing cost contributions by the Province. In addition, the guidelines offer a method of comparing potential locations for safety improvement on a consistent basis.

In conjunction with the priority review program, an application for implementation of traffic signal controls is based on the following four requirements.

1. The accident history for the location must be provided for the current and previous three years.

2. In order to avoid the proliferation of traffic signals, the Region requires that no two traffic signalling device locations be closer that 300 feet.

3. The report must be accompanied by a detailed traffic study analysis. This report should include the following:

a. Vehicle counts entering the intersection in each hour, from each approach in a representative 8 hour day; with the 8 hours representing the greatest percentage of the 24 hour traffic.
b. Peak hour period studies should include 2 hours in the morning and evening and disaggregated into 15 minute intervals with classification by vehicle type (ie) autos, light trucks, trucks.
c. Indication of Speed.
d. Potential collision diagram based on past experience.
e. Seasonal Variations.
f. Details of Physical Layout:
   i. Intersection Geometrics
   ii. Channelization
   iii. Grades
   iv. Site/Distance Restriction
   v. Bus Stops/Routings
   vi. Parking Conditions
   vii. Pavement Markings
   vii. Street Lighting
   ix. Driveways
   x. Rail Crossings
   xi. Nearest Signals
   xii. Utility Poles.

4. The traffic signal warrant analysis must be complete in order to secure Provincial funding of the project. Regional Council may waive the need for the warrants, however, Provincial funding will not be provided.

The following analysis is required to meet the regulations outlined as traffic signal warrants. In addition an example warrant is illustrated in Appendix 1 (RMOC, 1989).

The Restricted Flow Conditions refer to urban areas where speed limits are less than 70 kilometres per hour. The Free Flow Conditions refer to rural areas where speeds are posted in excess of 70 kilometres per hour. In addition, right turns are not considered traffic crossing the artery, and channelized flows should not be included. Finally, volume requirements must be increased by 25 percent if road capacity is greater than 4 multilanes.

i. Minimum Vehicle Volume Warrant:
Restricted Flow: Vehicles entering from all approaches each hour for the heaviest 8 hours must exceed 720. Volume from the minor street must be 170 vehicles per hour for each of the heaviest 8 hours.

Free flow: Vehicles entering from all approaches each hour for the heaviest 8 hours must exceed 480. Volume from the minor street must be 120 vehicles per hour for each or the heaviest 8 hours.

ii. Delay To Cross Traffic Warrant:
Restricted Flow: The major street approach volume must exceed 720 vehicles per hour for each of the heaviest 8 hours. Volume crossing major street must exceed 75 for each hour of the 8 hours.
Free Flow: The major street approach volume must exceed 480 vehicles per hour for each of the heaviest 8 hours. Volume crossing major street must exceed 50 for each hours of the 8 hours.

iii. Accident Hazard:
A minimum of 5 accidents must have occurred in the last 12 months, averaged over 36 consecutive months, involving damage serious enough to be reported to police.
An adequate trial of less restrictive remedies with satisfactory observance and enforcement have failed to reduce accidents.
Volume is not less than 80% of requirements specified in Minimum Vehicular Volume or the Delay to Cross Traffic Warrant.

iv. Combination Warrant: If the other conditions are only met to extent of 80% and: There happens to be a sudden rural to urban change such as a business district development.
Extreme width of road for pedestrians to cross.
Predominance of small children or handicapped persons.

v. Minimum Pedestrian Volume Warrant:
Restricted Flow: Pedestrians crossing major street must be 240 per hour for the heaviest 8 hours of the day.
Vehicular traffic from the major street approaches must be 575 for the 8 hours.
Free Flow: Pedestrians crossing major street must be 120 per hour for the heaviest 8 hours of the day.
Vehicular traffic from the major street approaches must be 290 for the 8 hours.

2.39 <u>Development Control Agreements</u>

The situation often arises that the aforementioned warrants cannot be met because of the absence of historical traffic flow data for new developments or because of expected changes in traffic patterns as a result of the redevelopment of traffic generating entities. In this event, the Region enters into a development control agreement contract with the developer. The contract outlines the responsibilities of the developer and is normally accompanied by a letter of credit for the amount of the installation or, a security bond to ensure that all commitments are completed.

The installation of traffic signals, in the absence of historical data is calculated using trip generation rates for particular types of developments and the aforementioned a traffic signal control warrants. This ensures that developers provide the appropriate traffic management device at key locations in order to control the flows anticipated by the particular development. In the majority of the new development cases, there will be no subsidy from the Provincial Ministry of Transportation. Therefore, the Region requires the developer to agree to "front-end" the entire cost, assuming the device will be warranted within two years. The Region will assume all maintenance and operating costs at that time, unless Council directs otherwise.

The Development Services Branch of the Region is responsible for the compilation and coordination of the conditions to be outlined in the development control contract, on behalf of the Transportation Department. The conditions may vary in complexity based on the scope of the development proposal and may require different device installations at various stages throughout the project. The requirements are based upon the projected traffic flows expected to be generated by the project. These flows are projected using a Trip Generation Manual that was recently developed for the Region. The manual is a summary document containing trip generation rates and relationships for a wide range of land uses specific to the National Capital Area. The manual outlines both vehicle and pedestrian trips that may be generated from various densities of land use development such as office, retail, residential, educational, health care, lodging, transport terminal and industrial areas and residential areas.

These categories are subject to further disaggregation to indicate flows generated by specific land uses, government offices versus business parks, for example.

Chapter 3

Risk Management-Transportation System Countermeasure Evaluation

3.10 Background

The concepts of transportation management, safety effectiveness and risk reduction are all closely linked and have been studied through a variety of disciplines. Road safety scientists have been working on the development of a theoretical approach to analyze accident occurrences and reduce traffic hazards for several years. However, no one method seems to be applied on a consistent basis. Perhaps the various approaches simply answer questions at different stages in the risk management process. The concepts or risk management are in no way peculiar to transportation management; applications have been made with regards to technological hazard, scientific exploration and social policy implementation (Kates, 1977).

Risk management is summarized by two distinct but overlapping categories: risk determination and evaluation. The determination of risk is typified by identification and estimation while the evaluation of risk is typified by acceptance or aversion (Kates, 1977). The identification of risk infers the statistical screening of events considered to be hazardous. Case clusters are often identified to uncover areas of adverse consequences (Shrader-Frechette, 1985) in a fashion similar to research by the Safety Improvement Group at the Regional Municipality of Ottawa-Carleton. Upon identification, the estimation of risk addresses the direct measurement of threat potential based on the concentration of exposure (Kates, 1977). Risk estimation is an attempt to measure the magnitude of risk based on various forms of scientific extrapolation from experience. Estimations may be calculated using simple averages of historical data or they may incorporate a more sophisticated approach through linear regression. The evaluation phase considers the risk estimates or, magnitude of the threat potential and levels of risk acceptance or aversion are identified.

The threat potential accepted for particular situations implies societal preference that is revealed by behaviourial attitudes or expressed by specific rules and regulations (Kates, 1987). The implementation or risk reducing techniques depend on costs and benefits associated with providing safety levels that are acceptable to society (Roberge, 1986).

The traditional approach to traffic accident research is closely linked to the fundamental components outlined in risk management. The risk identification phase is comprised of calculating levels of hazard associated with various locations throughout the traffic system. These levels are normally measured in terms of historical accident and exposure rates that are illustrated by "accidents per million miles or kilometres" (Pigman, 1980). In the case of studies conducted by the Region, these rates are expressed by "million entering vehicles" (Mev). The accident database is generally ranked by the accident rates to identify those locations with the highest risk measure. These locations are generally chosen for more detailed studies.

Additional studies may include the calculation of revised risk estimates based on historical accident performance and projected traffic volumes associated with the particular locations. The locations are ranked by severity and, depending upon budgeted guidelines, a specific number of sites are chosen for risk reduction, or countermeasure implementation. The risk evaluation stage is comprised of highlighting a manageable set of factors that are considered to influence the sequence of events resulting in a traffic accident. The elimination of the causal factors is believed to reduce the number of accidents. The causal component assessment process identifies a taxonomy of human, environmental and vehicle deficiencies that are ranked in a hierarchic system of definitely, probably or possibly a causal or severity increasing factor (Treat, 1980). These measures are normally identified and tested for significance using the classical statistical hypothesis testing method. The contributing factors are evaluated in terms of a cost-benefit analysis of alternate countermeasures that may be implemented to reduce risk. In order to allocate resources most efficiently, the most effective and least costly safety measure is chosen for implementation.

In effort to evaluate the steps taken to reduce risk, specific "before-and-after" and "with-and-without" analysis are applied to compare the current accident rates to the rates that would be expected to occur if the countermeasure was not introduced. There are two popular evaluation approaches: the "traditional" and the "average mean" approach. The techniques are relatively simply to understand. However, the assumptions and calculations vary in terms of sophistication and the results may be difficult to interpret. The following section will appraise the methods in more detail to identify the advantages and shortcomings or each approach.

3.20 Traditional and Probabilistic Approaches

3.30 Traditional Approach

The traditional approach taken to evaluate the effect of safety countermeasure is comprised of a series of comparative studies of accident rates in a "with-and-without" and a "before-and-after" approach (Hauer, July 1978). These types of studies are relatively simple to apply and involve the evaluation of the variance between the most current accident rates and the reported accident histories of past years. As a rule, the countermeasure is deemed successful if the accident rate has dropped in comparison to previous years. When the accident rate remains the same, the countermeasure is again deemed successful because it stopped the situation from becoming worse. In the case where the accident rate has increased, the countermeasure is deemed ineffective and further studies are conducted to determine additional causal factors.

3.31 Standardization for Traffic Exposure

The traditional approach is used in several types of traffic safety evaluations. The applications range from testing traffic signal installations to stop and yield sign replacement. For example, during the 1970's the city of Seattle began installing traffic circle controls in residential neighbourhoods in order to increase traffic flow and decrease energy consumption and pollution emissions (Rutherford et al, 1985). The rules at such intersections were the same as at other non-signalized locations. The right of way is given to the driver on the right. The accident rate comparisons for evaluation were comprised of "before-and-after" comparisons for a 3 years period prior and a 3 year period following the countermeasure implementation and were conducted for intersections with yield signs versus the locations with traffic circles. The results were based on the raw accident frequencies and no estimates were used. The outcome indicated a 30% drop in accidents at the traffic circle locations whereas the yield sign locations exhibited a 10% drop.

The traditional approach is seemingly straight forward at the outset but there are certain practical difficulties to be identified. First, an important difficulty encountered in traditional countermeasure evaluation studies is the standardization of accident location records in terms of exposure levels, or traffic volume. Particular locations with high volumes of traffic flow, such as arterial or collector streets, have a greater risk-exposure factor that those locations with lower volumes of traffic flow, such as local street configurations. Therefore, it is inappropriate to draw comparisons between of accident frequencies without standardizing for traffic volume. The comparisons are more meaningful if the data is standardized in terms of exposure levels. The results of standardization make the "before-and-after" type studies easier to evaluate. For example, the actual accident rate drops when traffic volumes rise from one period to the next but the number of accidents remain the same. This indicates that the countermeasure arrested the expected growth in the number of accidents.

The standardization process requires that exposure levels are known for all the locations in question. The accident rates are adjusted by using a common exposure index such as accidents per million kilometres or, in the case of Regional Municipality, in terms of accidents per million entering vehicles. The results of standardization are less misleading than the raw accident frequencies. For example, a local accident location may have experienced 1 accident in the past year with exposure levels in the range of 100 traffic volume movements during a 24 hour period. An arterial location may experience 50 accidents over the same period with exposure levels in the range of 45,000 traffic volume movements during a similar 24 hour period. Initially, the arterial location is perceived as the location with the highest number of accidents. However, the standardization of data in terms of accidents per million entering vehicles indicates that the local street locations would have 18 accidents per million vehicles versus 2 accidents for the arterial location. The accident rate is calculated as follows:

AR = (A * (10)^6) / (B * C)

Where: AR = Accident Rate
A = Number of Accidents per Intersection
B = Number of Days in the Year
C = 24 Hour Annual Average Daily Trips

and is provided by the traffic safety section at the Region's transportation department.

3.32 Cross Sectional Studies

The standardization of the data improves the accuracy of the comparative evaluations but it becomes difficult to differentiate between locations that are similar in nature. That is to say that the results of the evaluation become obscure when comparing local accident locations to those of a collective, arterial and freeway type nature. The standardized data should be disaggregated into categories of location type to facilitate cross sectional comparisons between similar types of locations in the "with-and-without" perspective.

The need for cross sectional studies, as part of the resource allocation evaluation, identifies a second practical difficulty with the traditional approach to countermeasure evaluations. The cross sectional, or, "with-and-without" approach requires a significantly large database to ensure there are locations that are indeed comparable. The task of identifying "with-and-without" locations that are identical in terms of all factors that influence the occurrence of a traffic accident is practically impossible in a non-controlled experimental environment (Hauer, 1985). This problem is partially alleviated through a step-wise process of data disaggregation into location groups of similar traffic volumes and accident histories; for example, comparing arterial to arterial locations, collector to collector locations, and so on. Distinct differences may still exist in terms of street geometry, road gradients, visibility barriers, weather conditions and other geographic factors. These special conditions should be considered when site specific comparisons are made. Nonetheless, the disaggregation process permits the evaluation of standardized accident rates for locations that are similar in nature. This approach is particularly useful in cross sectional studies in order to identify "without" locations that may have warranted countermeasures more than locations that recently received such safety devices.

3.33 Database Size

The size of the accident base also leads to an alternate perspective on the practical difficulty of traditional countermeasure evaluations. There are a host of small and extensive research studies conducted to evaluate the effect of safety countermeasures. However, in many instances the small size of the data samples have led to insignificant results in terms of levels of significance testing (Langlois & Olsthoorn, 1990). Even when the results are statistically significant, a single study by itself is often too small to offer any final authoritative knowledge that settles a problem (Hauer, 1981). Consequently, the information resulting from the outcome of these studies lose value as they are shelved. In light of evaluative research as an on-going process, it is logical that the decision making process regarding countermeasure implementation is improved if studies are designed to tabulate results in a cumulative manner over time.

3.34 Comparative Estimates

The final and probably most important difficulty concerning the traditional approach to countermeasure evaluations refers to the method of estimating the comparative number of accidents if there were no countermeasure implementation. This topic was briefly described in the overview of Chapter 1 but warrants more detailed description at this point.

The traditional method of estimating the safety effect of a countermeasure in the typical "before-and-after" study is based on the following premise:

> At some time a measure is implemented on a few entities. The entities may be intersections, drivers, cities or vehicles. The record of accidents for these entities "before" treatment is compared to the record of accident occurrence "after" treatment. On the basis of such comparison, conclusions are drawn about the effect of the treatment (Hauer, 1985).

The premise on its own is not uncommon and seems straight forward. However, the comparative evaluation inherent in the premise make one major assumption:

> What has happened during the period "before" treatment implementation is a good indication of what "would have happened" during the "after" period had the treatment not been implemented. (Hauer, 1985)

More often than not, this approach confirms a positive evaluation of countermeasure implementation in terms of a reduction in the accident rate. However, it is not strikingly evident from this analysis that the reduced rate is a direct reflection of the countermeasure implementation. The drop in the rate may be a result of inherent differences in the location such as volume, street configuration, or other extraneous features.

Moreover, the accident rate is expected to fluctuate even if the countermeasure had not been implemented. As indicated in Chapter 1, the fluctuation in accidents may be a result of historical influences from other events such as economic swings or fuel shortages or simply a result of a transportation maturation effect during which accident rates fall naturally (Council et al, 1980). Fluctuations caused by the aforementioned variables are sometimes difficult to identify and it is even more difficult to determine the degree of impact on the accident rate.

Once again, the "regression to the mean" problem identified in Chapter 1 must be re-emphasized with respect to the fact that very few traditional accident research studies consider the natural movement of the accident statistics to the "mean". The regression problem has been considered by several safety researchers in more recent years. In fact, attempts have been made to create more sophisticated evaluation models that consider the implications of the regression to the mean tendency. These models are designed to replace the historical accident bench marks used as the "before" comparison figures with more realistic accident estimates. These estimates represent what would have been expected to happen if no countermeasure was implemented. One such approach, proposed by Hauer, is comprised of a combination of 1. Least Squares Fit, and, 2. Linear Function fit and has been applied to metropolitan areas such as San Francisco, Philadelphia and Toronto (Hauer, 1985). This method is meant to provide a more realistic evaluation of the effect of the countermeasure by using the regression to the mean, or, average mean approach for estimating accidents in a "what if" scenario. This, in turn, is expected to offer a more effective evaluation of the allocation of resources by traffic safety administrators.

The average mean, or regression to the mean approach is very similar to the traditional approach. The same sort of problems are encountered by both approaches. They share the same problem of accident rate standardization for exposure. They also require large, or at least, growing databases from which to draw significant comparisons and calculations. Both approaches share the common inability to identify whether the accident rate change is a direct result of the countermeasure implementation, or a result of factors independent of the traffic control devices. The primary difference between the two approaches is in the manner of estimating the expected number of accidents to occur if no countermeasure is implemented. This estimate represents the revised bench mark comparison to be juxtaposed with the more recent accidents occurring after a countermeasure has been implemented. The traditional accident histories are deemed to re-occur from one year to the next, whereas, the probabilistic approach provides more accurate estimates on a year to date basis.

3.40 Probabilistic Approach: Regression to the Mean

The probabilistic approach is very similar to the traditional approach of evaluating safety countermeasure implementation. As stated earlier, the major difference between the two methods is based on what type of components are used as comparative bench mark measures. The traditional approach simply uses a one-to-one comparison of historic accident frequencies to current performance. Meanwhile, the probabilistic approach is based on regression to the mean type estimates that consider the impact of the average accident rate for a particular region.

The development of several equations that address the bias resulting from the regression to the mean are the result of extensive historical research. The problem was first identified by Sir Francis Galton, a meteorologist and statistician in 1877, that the offspring of tall parents are, on average, shorter than their progenitors (Hauer, Accident Anals & Prev., 1986). Galton attributed the term regression with the meaning tendency to "return toward" the mean. In his case, as in the case with accident estimations, "what happened before, stature of parent, turned out to be a biased inddication of what happened after, the height of offspring" (Hauer, Accident Anals & Prev., 1986).

A more quantitative account of this phenomenon has been provided by works by H. Robbins. This work pertaining to the Bayseian approach to statistics and estimation problems encountered with compound Poisson distributions is summarized by E. Hauer in "On the Estimation of Expected Accidents" (Acc. Anals & Prev., 1986). In this publication, Hauer explains the development of the Least Squares and Linear Function Estimates by Robbins.

The estimates were developed to resolve a problem encountered with Poisson probability estimates. In particular, the problem dealt with an inability for the Poisson model to be applied when te expected number of accidents for entity was unknown. The new estimate provided by Robbin's calculation; the Least Squares Estimate, not only estimated the number of accidents for a particular entity but it also included a correction factor for the mean of the accident population. Subsequently, the concept was built upon an a more sophisticated Linear Function Estimate was developed to improve the precision, or smoothness, of the estimation further (Hauer, Acc. Anals & Prev., 1987).

The regression to the mean problem is more evident by using a specific example from past research on countermeasure evaluations. The information in Table 4 is taken from a study by Hauer on evaluation techniques and illustrates the accident performance at approximately 1,100 stop sign locations in the San Francisco Bay area between 1974 and 1975 (Hauer, 1985). The accident locations, [n(x)], are highlighted in the first column and are disaggregated according to the frequencies of accidents. The accident frequency categories, (x), are ranked in ascending order. For example, in 1974 there are 553 locations with zero accidents, 296 locations with one accident, 144 locations with two accidents, and so on.

In this approach, the number of locations remains fixed over the period of the study such that changes in the accident rates from year to year are more easily identified. As a result, the accident frequencies in subsequent periods, as indicated by M(x) in column 3, are averages, or, non-integer values. That is to say that the accident values in subsequent years are the average mean number of accidents that occurred at the same fixed number of locations in the following year.

The comparison of the average number of accidents in 1975 to the results of 1974 indicate a drop in the number of accidents for virtually all locations except those with zero accidents. For example, the 296 locations with 1 accident in the first year dropped slightly to .97 average accidents in the second year. More significantly, the 144 locations with 2 accidents in the first year dropped to 1.5 average accidents in the second year and the 65 locations with 3 accidents in the first year dropped to 1.9 average accidents in the second year.

The comparison of the variances between the two years of accident data indicates that the mean number of accidents is slightly below 1. The effect of the regression to the mean becomes evident as the number of locations with zero accidents in 1974 move towards the mean in 1975 with an average of .54 average accidents. Similarly, the cases of locations with accident frequencies greater than 1 tend to move down towards the mean number of accidents in 1975.

The San Francisco study is but one example of natural fluctuations in traffic accidents from one year to the next. However, similar trends exist in the Regional Municipality of Ottawa-Carleton as well. For example, the total number of police accident reports processed in the Region in 1982 was approximately 18,000. This figure dropped to 17,000 by 1985 and during 1988, the number of accidents reported in the Region fell to 15,500 (RMOC, 1989). Of course, the regional data is somewhat deceiving because several locations have been improved by countermeasure implementations but it is expected that a fixed set of locations studied in isolation would illustrate the same results as the San Francisco example.

Table 4
Accident Frequencies - Stop Sign Intersections
San Fransico Bay Area

1974 Accidents 1 [n(x)]	 2 (x)	1975 Accidents 3 M(x)	Least Squares Estimate (Hauer) 4 E1(x)	Least Squares Estimate (Calculated) 5 E1(x)	Linear Function Estimate 6 E2(x)
553	0	0.54	0.53	0.54	0.44
296	1	0.97	0.98	0.97	1.04
144	2	1.53	1.43	1.35	1.64
65	3	1.97	1.88	1.91	2.24
31	4	2.10	2.32	3.39	2.84
21	5	3.24	2.77	2.57	3.44
9	6	5.67	3.22	10.11	4.04
13	7	4.69	3.67	3.08	4.64
5	8	3.80	4.11	3.60	5.25
2	9	6.50	4.56	13.00	5.85
2	13	N/A	N/A	8.00	8.25
1	16	N/A	N/A	0.00	10.05

[n(x)] = Initial set of fixed locations 1974.
(x) = Accident frequencies per location.
M(x) = Average number of accidents 1975 for same locations.
E1(x) = Least squares estimate of 1975 accidents.
E2(x) = Linear function estimate of 1975 accidents.

3.41 Least Squares Estimate

In an attempt to improve the comparison between what happens after countermeasure implementation and what would have happened without the safety device, a least squares and linear function model are expected to provide an improved estimate of the number of accidents that would occur if no countermeasure is implemented. The first estimate is based on the least squares fit of function epsilon (x), or E1(x) to "points based" data which is illustrated as follows (Hauer, 1985):

$$E1(x) = (x+1) * n(x+1)/n(x)$$

Where: (x+1) = accident frequencies + 1
n(x) = current category of fixed intersections
n(x+1) = next category of fixed intersection

The calculated estimates are illustrated by column 4 in Table 4 indicating that the value of the estimated number of "after" accidents (if countermeasure was not implemented) are more closely in line with those accidents that actually occurred in the third column, 1975. However, it should be noted that the values found in column 4 of Table 4 are not a direct result of the application of the E1 formula. Following the application of the E1 formula, Hauer smooth's the data further with the application of inversely weighted standard deviations in the following format (Hauer, 1985):

$$E1^2(x) \times [1/n(x+1) + 1/n(x)])$$

In addition, Hauer contends that for reasons of mathematical consistency, this function may only be applied when E1(x)/(x+1) is less than unity when x approaches infinity. Finally, Hauer adds one more stipulation; for reasons of logical consistency, it would seem desirable to ensure that E1(x) x n(x) is summed over all of x and that it adds to the sum of all n(x) (Hauer, 1985). Unfortunately, the application of these calculations are not indicated in the published literature and the subsequent results remain unverified. Nonetheless, the E1 results using the initial formula have been calculated and added to Table 4 in column 5 in effort to illustrate that, in the absence of calculating Hauer's smoothed results, the raw estimated calculations are, at least, better than simply using the previous periods figures for evaluative comparisons.

A closer examination of columns 4 and 5 indicates that the intersections with the frequency of 2 accidents was comprised of 144 locations in 1974 and was estimated to have 1.43 and 1.35 average accidents, respectively, in 1975 using the least squares approach. The estimates are very close to the 1.5 average accidents that occurred in 1975. The majority of the estimates (both Hauer and the initial E1 calculation) are more conservative than the previous years' performance. However, the initial E1 estimate is actually higher than the previous year in two cases; for the accident frequency categories of 6 and 9 accidents per location. The E1 estimate calculations were actually 10.1 and 13 accidents, respectively. The smoothed Hauer estimates for these categories were 3.2 and 4.6, respectively. Meanwhile, the actual 1975 figures resulted in 5.7 and 6.5, respectively. It is difficult to say which is more accurate; the more conservative "smoothed" approach or the raw E1 estimate. However, either choice is a more accurate representation of "what would have happened with no countermeasure" than simply using the previous year activity as the bench mark evaluative measure.

3.42 Linear Function Estimate

The second accident estimate is based on the linear function fit to the "points based" data and is calculated using the sample mean and the sample variance (Hauer, 1985). The purpose of using the linear function approach is to consider the standard deviations of the different data points (represented by the sample variance) and to ensure that all categories are summed for accident location categories and the accident frequencies. The linear function is calculated using the following formulas:

The sample mean: $\bar{x} = \Sigma x * n(x) / n(x)$
The sample variance: $s^2 = \Sigma(\bar{x}-x)^2 * n(x)/\Sigma n(x)$
The estimate: $E2(x) = x + (\bar{x}/s^2)*(\bar{x}-x)$

Where: Σx = the sum of accident frequencies
$n(x)$ = current category of fixed intersections
$\Sigma n(x)$ = the sum of the fixed intersection categories

The results are listed in column 6 of Table 4 and, once again, represent a closer fit to the 1975 data than the 1974 occurrences. That is to say that the E2 estimates are more conservative than the previous years performance and are also a closer prediction of what was to happen in the following year. The epsilon two (E2) approach is simple to apply and is less ambiguous than the E1 approach. In addition it involves fewer steps in obtaining the smoothed effect of the estimates between the various categories.

Interestingly, both approaches have an exception where the 1974 data is a closer fit to the actual 1975 results than the estimates themselves. This instance is found with the 9 locations that experienced 6 accident frequencies in 1974. In 1975 these locations experienced 5.7 average accidents. Meanwhile, the estimate "smoothed E1" predicted 3.2; the raw E1 predicted 10.1 and the E2 estimate predicted 4.0. The E2 approach seems to exhibit the most accurate predictive qualities of the three, in the case of the given data. In conclusion, the results of this study indicate that the average mean approach represents a more accurate presentation of accident estimates than using historical data.

The success of this approach in a "before-and-after" study becomes more apparent through an evaluative study of locations that have undergone the implementation of countermeasure techniques. An example of such a study is provided in Table 5 which illustrates a number of locations in the San Francisco that have undergone the transition from 2-way stop signs to 4-way stop sign controls (Hauer, 1985). The first row indicates the accident frequencies per intersection in the "before" period and are ranked 0 through 10 in ascending order. The second row illustrates the distribution

Table 5

San Fransico - Accident Frequencies "Before-and-After"

Estimate Application Table

Conversions from 2-way to 4-way Stop Sign Controls

# of "Before" Accidents per Intersection	0	1	2	3	4	5	6	7	8	9	10	Total
# of Intersections in the 1974 sample	7	6	8	7	4	6	4	3	0	2	2	49
Frequency of "Before" Accidents 1974 (row 1*2)	0	6	16	21	16	30	24	21	0	18	20	172
Frequency of "After" Accidents 1975	2	3	7	5	4	12	6	5	0	2	4	50
Estimate "E2" From Table 4	0.44	1.04	1.64	2.24	2.84	3.44	4.04	4.64	0.00	5.85	6.45	
# of Expected Accidents without Countermeasures (row 2*6)	3.1	6.2	13.1	15.7	11.4	20.6	16.2	13.9	0.0	11.7	12.9	124.8

of the intersections, ranked by the number of actual accidents incurred. The third row is the product of rows one and two, thereby indicating the total number of accidents occurring throughout the various accident frequency rankings. The data illustrates that during the "before" period there were 172 accidents distributed among 49 intersections. The fourth row represents the actual number of accidents that occurred at the fixed set of intersections during the period "after" the countermeasure was implemented. The results indicate that there were 50 accidents distributed among the 49 locations during the "after" period of countermeasure implementation. Traditionally, the evaluative analysis compares the 50 accidents to the 172 accidents.

Linear function fit estimates are calculated for the data set of two-way stop signs denoted by E2(x) and are illustrated in row 5, Table 5. This calculation represents the estimate of the average number of accidents that would be expected for particular frequency categories if no countermeasures had been implemented. Changes in exposure and secular trends are not considered, however, exposure may be taken into account by increasing the estimated accidents proportionately with the increase in traffic volume (Hauer, 1985). For example, if the traffic volume at intersections with 4 accidents in the "before" period increased by 10% then it is to be expected that there would be 2.84 x 1.10 accidents during the "after" period.

The estimates from row 5 are multiplied against row 2 in order to estimate the average number of accidents for the particular intersections in the sample. The results are indicated in row 6 to Table 5. The 7 intersections indicating 3 accidents each during the before period is estimated to have 2 x 2.24 = 15.7 average accidents during the "after" period. The sum of the results indicate that a total of 124.8 average accidents were expected for the particular locations if no countermeasure had been implemented using the regression to the mean approach. This is substantially less than the 172 "before" accidents that would be used as bench mark comparisons in the traditional approach. This example indicates a reduction in the expected number of accidents by 60% as a result of the conversion from two-way to four-way stop sign controls.

The results of the probabilistic approach are somewhat more conservative than the results given by the traditional approach. The traditional approach would have indicated a drop of 70% in the number of accidents. The probabilistic approach actually weakens the performance of the countermeasure implementation, hence, reducing the success level of the countermeasure according to the evaluative process. However, the probabilistic approach provides a smoother fit of estimated traffic estimates to the actual "after" accidents than those occurring in the previous year. This would indicate a more realistic level of comparison for evaluative analysis. The probabilistic method attempts to incorporate the nature of the overall traffic accident relationship over time, as opposed to 2 individual years. However, the results still depend on the year that the estimate was taken.

Chapter 4

Evaluation Design

4.10 Introduction

The primary purpose of this study is to review the geographic distribution of traffic accidents occurring at stop sign and traffic signal controlled intersections in the Regional Municipality of Ottawa-Carleton. The current policy directives by the Region have been reviewed and now stand to be scrutinized with respect to effectiveness. The traditional and probabilistic methods of traffic safety evaluation have been outlined and appraised in theory. Therefore, the remaining chapters in this study are concentrated on the application of these techniques in order to evaluate the effectiveness of traffic management safety techniques implemented within the Region.

4.20 Evaluation Design - Outline

The Evaluation Design chapter is comprised of several sections dealing with the evaluation of traffic safety countermeasures. The sequence of the sectional flow is designed to introduce the data through a Composition and Quality section followed by Data Preparation section. These sections basically outline the structure of the data received from RMOC and outline some of the initial problems encountered in preparing the data for further analysis. The final section deals with the Evaluation Design and describes the 2 primary databases resulting from the data composition and preparation stages. The 2 databases are the "before-and-after" table and the "without countermeasures" table.

4.30 Composition and Quality of the RMOC Accident Data

The basic information for this study is provided by the various accident reports produced by the accident analysis group of RMOC. The specific databases are provided individually in annual sets as follows: the Frequency Ranking Report of Traffic Collision Locations, RMOC Accident Rates, and, RMOC Traffic Signal

Installations. The data is available for four years: 1986 through 1989. Each annual data set contains approximately 15,000 annual accident frequencies for all traffic control types and involve approximately 2,300 locations throughout the Region.

The Frequency Ranking Report summarizes the reportable collision locations according to following traffic control types: traffic signals, stop signs, yield signs, no control, pedestrian crossovers, police school guards, and school buses. The accident frequencies are ranked in descending order by location within the respective traffic control category. The data used for this particular study consists of accident frequencies for intersections with traffic signals and stop signs. This comprises approximately 60% of the total accident locations and 70% of the total reported accident frequencies occurring within the Region.

An example of the Frequency Ranking Report of Traffic Collision Locations was introduced in Chapter 2, Section 2.36, as Table 3. The data is nominal in nature and is categorized by the following 10 divisions:

1. Rank based on frequency.
2. Location based on alpha street names.
3. Total number of reportable accidents.
4. Frequency of non-reportable accidents.
5. Collisions occurring in darkness.
6. Frequency of collisions occurring at peak hours (07:00-09:00 and 15:30-18:00).
7. Collisions occurring on wet/icy roads.
8. Vehicle direction: Right angle/Opposing/Same, based on compass points.
9. Frequency of single vehicle collisions.
10. Hazard index indicating pedestrian injury as the numerator and total number of injuries as the denominator.

The RMOC Accident Rates Report is comprised of a ranked set of accident rates derived from accident frequencies and traffic flows for specific locations throughout the Region. The traffic volumes by the Region do not cover all the records in the stop sign and traffic signal database, however, the majority of key stop sign intersections in the Region have traffic volume records. This

Table 6
RMOC ACCIDENT RATES: 1988

LOCATION		NUMBER OF ACCIDENTS	12 HOUR TRAFFIC VOLUME (7:00 a.m. - 7:00 p.m.)	ACC. RATE ACC./MEV	NO. OF INJURY ACC.	YEAR OF VOLUME
DON	GREENVIE	1	108	18.79	0	87
HAMILTON	INGLEWOO	6	1026	11.86	0	85
RR- 14	HAWTHORN	10	2433	8.34	2	82
MERIVALE	THAMES	3	857	7.1	1	82
RR- 25	RR-114	5	1466	6.92	4	87
EVELYN	ROSEMERE	1	394	5.15	0	83
FRANCES	QUEENMAR	3	1645	3.7	0	84
RR- 34	RR- 57	7	4014	3.54	0	87
RR- 34	RR- 35W	2	1200	3.38	0	82
MARTHA	SUSAN	1	607	3.34	1	87
RR- 6	RR- 41	5	3110	3.26	0	88
RR- 3	RR- 6	4	2495	3.25	1	87
RR- 8	LIMEBANK	9	5661	3.22	0	88
RR- 3	RR- 10	4	2543	3.19	1	87
CHAMPAGN	WELLINGT	2	1279	3.17	1	79
EDGEWORT	LAWN	1	644	3.15	0	88
RR- 6	RR- 25	4	2618	3.1	2	87
RR- 3	FLEWELLY	3	1971	3.09	2	87
RR- 23	CEDARHIL	3	2038	2.99	1	82
BEAUSEJO	JEANNEDA	8	5656	2.87	1	88
RR- 8	RR- 11	4	2867	2.83	3	87
FERGUSON	GAGE	1	731	2.78	0	85
PARENT	S.PATRIC	10	7310	2.78	2	88
BYRON	TWEEDSMU	4	2918	2.78	0	87
CARLETON	PREMIER	1	736	2.76	0	85
KNIGHTSB	LOCKHART	3	2219	2.74	0	88
CONROY	HUNTCLUB	11	8247	2.71	2	88
DALY	NICHOLAS	19	14228	2.71	7	87
HUNTCLUB	UPLANDS	15	11284	2.7	3	87
FISHER	MEADOWLA	27	20470	2.68	7	88
RR- 27	NINTHLIN	2	1531	2.65	2	88
BOURASSA	GLADWIN	3	2360	2.58	0	83
RR- 8	RR- 37	1	812	2.5	0	87
RR- 6	RR- 29	2	1626	2.49	0	84
RR- 13	JOCKVALE	5	4233	2.4	4	88
FREIMAN	RIDEAU	3	2542	2.39	1	88
GLADSTON	PRESTON	18	15675	2.33	5	87
BANK	WALKLEY	50	43488	2.33	17	88
CATHERIN	LYON	12	10565	2.3	1	88

database contains the following 6 sections and is illustrated by Table 6:

1. Location by alpha street names.
2. Total accident frequencies.
3. Traffic volume for the 12 hour period of 07:00 to 19:00.
4. Accident rate based on a million entering vehicles per annum.
5. Number of injury occurrences.
6. Year of traffic count.

The third database, RMOC Traffic Signal Installations, is comprised of an informal inventory of traffic signal installations provided within the Region between 1986 and 1989. This database contains the following 6 categories:

1. Location by alpha names.
2. Location by City name in Region.
3. Identifier of most recent traffic control installation.
4. Date of installation of most recent traffic control device.
5. Identifier of previous traffic control device.
6. Date of installation of previous traffic control device.

This database identifies the locations that have been converted to traffic signal controls during the study period and may be cross referenced with accident locations found in the previous two databases. A small sample of these locations are not found in the previous databases because they are newly signalled intersections that were implemented through development control agreements. In addition, cross referencing may be unsuccessful if no accidents have occurred at particular locations following the implementation of the countermeasure. Those locations experiencing no accidents are not included in the current Frequency Report regardless of the performance in previous years.

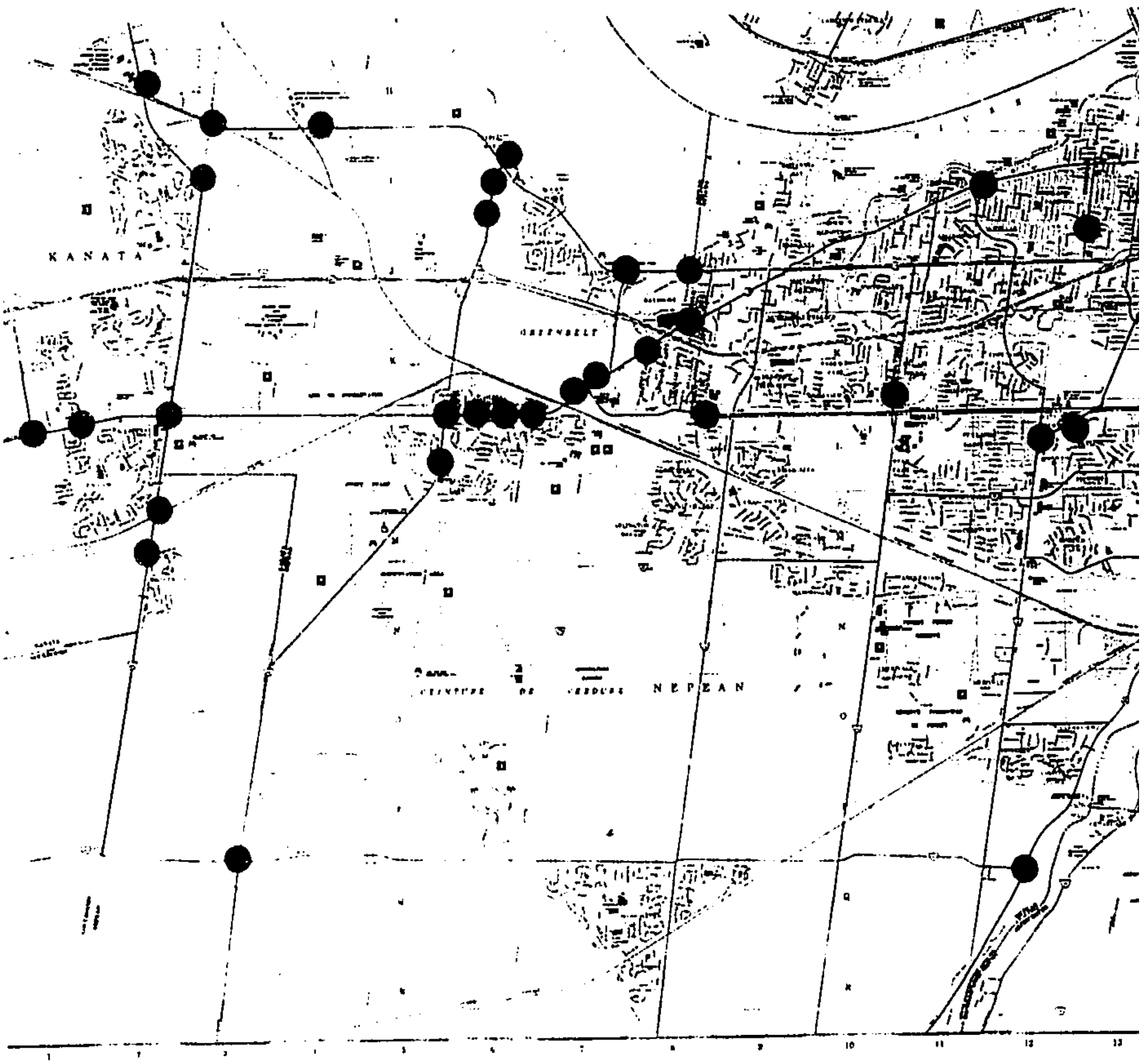
4.31 Data Preparation

Each of the aforementioned databases were constructed by the Region using very similar structural formats. This facilitated various extractions and exchanges of information between files. However, several problems were encountered concerning accident

Table 7
Map 1, Legend
RMOC Countermeasure Locations - 1986

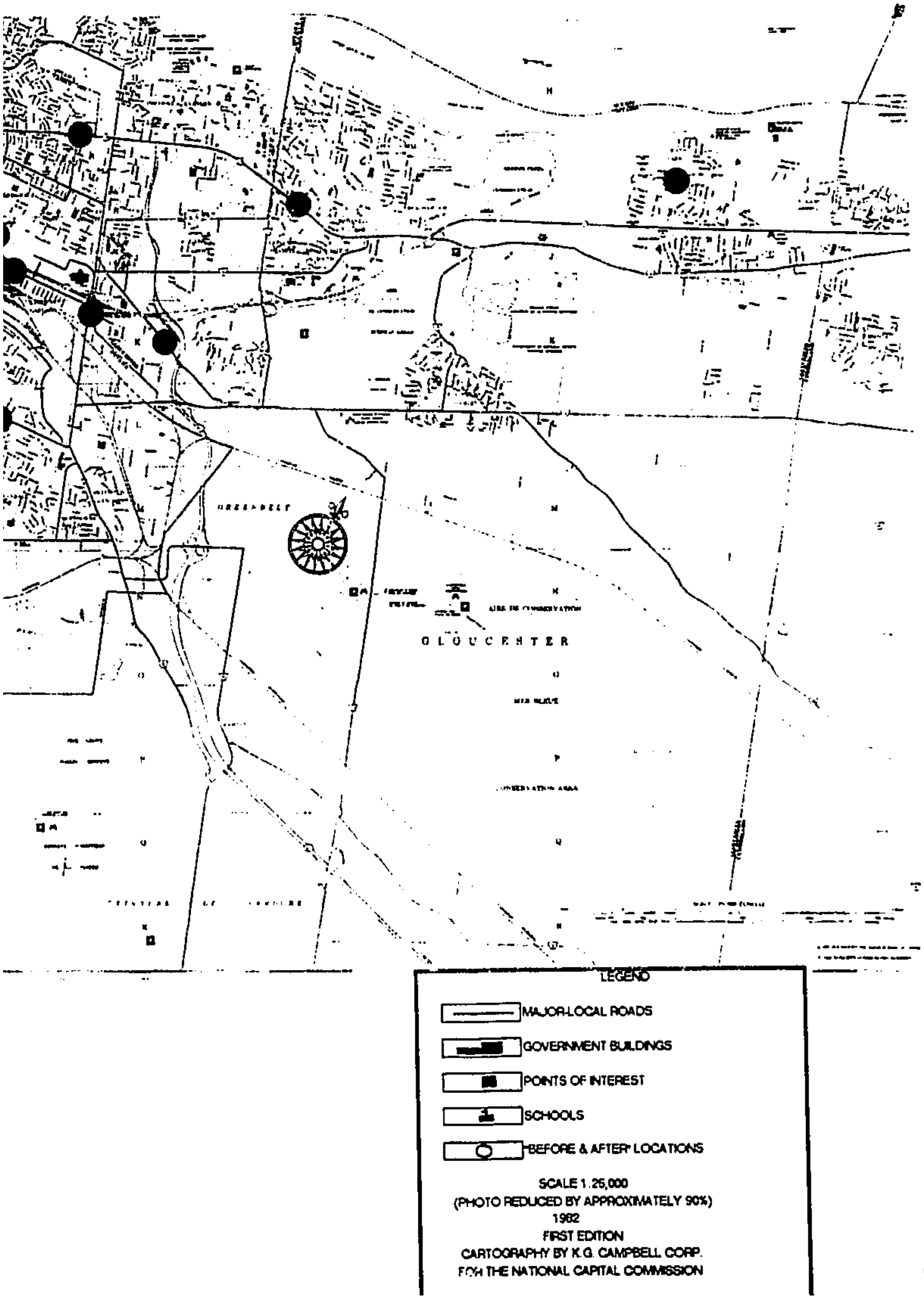
1	ACRES		CARLING	28	FIRE-STN	&	WOODROFF
2	ALTAVISTA		INDUSTRIAL	29	FISHER	&	SHILLINGTON
3	BANK		THIRD	30	FRANKTOWN	&	EAGLESON
4	BASELINE		GUTHRIE	31	FROBISHER	&	RIVERSIDE
5	BASELINE N		RICHMOND	32	HARTWELL	&	PRINCE OF WALES
6	BASELINE S		RICHMOND	33	HAZELDEAN	&	EAGLESON
7	BOTSFORD		SMYTH	34	HAZELDEAN	&	TERRY FOX
8	BOWESVILLE		HUNTCLUB	35	HAZELDEAN	&	CASTLEFRANK
9	BRIDLEPATH		HUNTCLUB	36	HWY- 15	&	HWY- 17
10	CANTIN		MONTREAL	37	HWY-417 N	&	VAN-PKW
11	CARLING		MOODIE	38	HWY-417 S	&	ST. LAURENT BLVD.
12	CARLING		D.R.E.	39	INDUSTRIAL	&	RIVERSIDE
13	CARLING		BAYSHORE	40	JEANNE D'ARC	&	VORLAGE
14	CARLING		MARCH	41	KINGEDWARD	&	SOMERSET
15	CARLING		HERZBERG	42	MARCH	&	HERZBERG
16	CARP ROAD		OLD HWY 7	43	MOODIE	&	BELL NORTHERN-N
17	CHURCHILL		DOVERCOURT	44	MOODIE	&	BELL NORTHERN-S
18	CLARENCE		DALHOUSIE	45	MOODIE	&	TYRELL
19	CLEARY		RICHMOND	46	OTT.STATION RD.	&	TREMBLAY
20	CLYDE		MERIVALE	47	RICHMOND	&	BAYSHORE
21	CLYDE		LOBLAWS	48	RICHMOND	&	NANAIMO
22	COVENTRY		VAN-PKW	49	RIDEAU	&	WURTEMBURG
23	CYRVILLE		STARTOP	50	ROBERTSON	&	LYNHAR
24	EAGLESON		STONEHAVEN	51	ROBERTSON	&	RICHMOND
25	EAGLESON		ROTHESAY	52	ROBERTSON	&	STINSON
26	FALLOWFIELD		HWY - 16	53	ROBERTSON	&	MOODIE
27	FALLOWFIELD		RICHMOND	54	ST.JOSEPH	&	ELWOOD

*** NOTE: LOCATION NUMBERS 16, 30 AND 36 ARE NOT ON THE MAP.


KANATA
NEPEAN


OTTAWA

FIGURE 2
OTTAWA - HULL & ENVIRONS
THE NATIONAL CAPITAL



location name changes, duplicate information records, missing information and various other factors that questioned the reliability and readability of the data. There was a great deal of background data preparation required in order to conduct the various complex data analysis stages. A detailed outline of the data preparation stages and the problems encountered are found in Appendix 2.

4.40 Evaluation Design

The approach taken in this study is based on a comparison of the traditional and the probabilistic methods of evaluating countermeasure effectiveness. The bulk of the analytic process is based on two primary source data tables summarizing the "before-and-after" accident locations and the "with-and-without" locations.

The first table constitutes the "before-and-after" information source and is comprised of the 54 locations that were converted from stop sign to traffic signal controls in 1986. The spatial distribution of these locations are illustrated by Figure 2 (Map) read in conjunction with the legend listed in Table 7. This "before-and-after" table is disaggregated into 54 subsections which delineate each of the unique locations. The individual subsection for each location summarizes the specific accident record information for the periods between 1985 and 1989, inclusive. An example of this information is shown in Table 8 and the complete data set may be found in Appendix 4.

The second table constitutes the "without countermeasures" information source and is comprised of approximately 1,100 locations that represent stop sign locations that were not converted to traffic signal locations in 1986. Approximately 60 of the "without" locations were converted to traffic signal locations in one of the subsequent years between 1987 and 1989. These locations remain in the data table but are disaggregated from the remainder of the group such that each year is found in a distinguishable set. An example of this information is shown in Table 9 and the complete data set may be found in Appendix 5.

Table 8
"Before-and-After" Database

YEAR		TYPE	LOCATION1		LOCATION2	VOLUME	ACC. FREQ	ACC. RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	NW	NS	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1985	0	TS	ALTAVIST	&	RIVERSID	35,064	30	2.3	1	9	10	9	0	2	2	0	3	5	2	7	3	3	0	3	0	8
1986	1	TS	ALTAVIST	&	INDUSTRI	32,986	15	1.2	0	2	8	4	0	1	1	1	0	3	2	2	1	1	0	3	0	4
1987	1	TS	ALTAVIST	&	INDUSTRI	39,760	23	1.6	0	6	11	6	0	0	2	0	1	8	3	1	1	5	0	2	0	11
1988	1	TS	ALTAVIST	&	INDUSTRI *	32,714	11	0.9	0	2	3	3	0	1	0	0	0	5	2	1	1	1	0	0	0	3
1989	1	TS	ALTAVIST	&	INDUSTRI	25,678	12	1.3	0	1	5	4	0	1	1	2	0	7	0	0	0	0	0	1	0	2
1985	1	PX	BANK	&	THIRD '79	12,683	8	1.7	0	1	1	3	1	2	0	0	0	0	0	0	5	0	0	0	0	0
1986	1	TS	BANK	&	THIRD	14,96[illegible]	6	1.1	0	1	3	4	1	1	1	0	0	1	0	0	1	0	0	1	1	2
1987	1	TS	BANK	&	THIRD	14,892	5	0.9	0	1	1	2	1	1	1	0	2	0	0	0	0	0	0	0	0	3
1988	1	TS	BANK	&	THIRD *	13,229	3	0.6	0	1	1	2	0	0	0	0	0	0	1	0	1	0	0	1	1	3
1989	1	TS	BANK	&	THIRD	11,565	2	0.5	0	0	2	1	0	0	0	0	1	0	1	0	0	0	0	0	0	2
1985	1	PX	BASELINE	&	GUTHRIE	14,106	9	1.7	0	1	5	2	1	0	0	0	0	0	0	3	0	5	0	0	0	0
1986	1	TS	BASELINE	&	GUTHRIE	15,153	4	0.7	0	0	1	0	0	0	1	0	0	0	0	2	0	1	0	0	0	2
1987	1	TS	BASELINE	&	GUTHRIE	15,151	2	0.4	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2	1	1
1988	1	TS	BASELINE	&	GUTHRIE	14,344	1	0.2	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
1989	1	TS	BASELINE	&	GUTHRIE	14,592	5	0.9	0	1	3	3	1	0	0	0	0	1	0	2	0	0	0	1	1	4
1985	1	PX	BOTSFORD	&	SMYTH	12,429	13	2.9	0	2	7	7	5	1	0	0	0	1	1	1	0	3	0	1	1	0
1986	1	PX	BOTSFORD	&	SMYTH	13,121	5	1.0	0	0	2	1	3	0	0	0	0	1	0	0	0	1	0	0	0	3
1987	1	TS	BOTSFORD	&	SMYTH	11,745	2	0.5	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1
1988	1	TS	BOTSFORD	&	SMYTH	15,026	2	0.4	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	1	1	1
1989	1	TS	BOTSFORD	&	SMYTH	10,012	3	0.8	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1
1985	1	SS	BOWESVIL	&	HUNTCLUB	11,207	4	1.0	0	1	3	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0
1986	1	TS	BOWESVIL	&	HUNTCLUB	10,871	4	1.0	0	2	1	2	2	0	2	0	0	0	0	0	0	0	0	0	0	0
1987	1	TS	BOWESVIL	&	HUNTCLUB	14,492	3	0.6	0	1	1	2	0	0	0	1	0	1	0	1	0	0	0	0	0	1
1988	1	TS	BOWESVIL	&	HUNTCLUB	12,837	4	0.9	0	0	1	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0
1989	1	TS	BOWESVIL	&	HUNTCLUB	15,688	5	0.9	0	0	2	2	0	1	0	0	1	2	0	0	0	1	0	0	0	3
1985	1	SS	BRIDLEPA	&	HUNTCLUB	10,855	1	0.3	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1986	1	TS	BRIDLEPA	&	HUNTCLUB	12,780	8	1.7	0	4	0	2	2	0	0	2	0	2	0	1	0	0	0	1	0	2
1987	1	TS	BRIDLEPA	&	HUNTCLUB	15,667	7	1.2	0	2	3	3	1	0	0	0	0	2	0	2	0	0	0	2	0	3
1988	1	TS	BRIDLEPA	&	HUNTCLUB	16,898	7	1.1	1	2	3	2	0	0	0	1	0	1	0	3	0	2	0	0	0	2
1989	1	TS	BRIDLEPA	&	HUNTCLUB	16,688	4	0.6	0	0	1	0	1	0	0	0	0	2	0	0	0	1	0	0	0	1
1985	1	SS	CANTIN	&	MONTREAL '83	14,497	9	1.7	0	3	2	3	2	0	4	0	0	1	0	2	0	0	0	0	0	4
1986	1	TS	CANTIN	&	MONTREAL	15,019	5	0.9	0	1	2	3	1	0	1	0	0	1	0	1	0	1	0	0	0	1
1987	1	TS	CANTIN	&	MONTREAL	14,850	3	0.6	0	0	1	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0
1988	1	TS	CANTIN	&	MONTREAL *	13,324	8	1.6	0	4	3	2	0	0	1	0	0	1	0	2	0	4	0	0	0	4
1989	1	TS	CANTIN	&	MONTREAL	12,090	4	0.9	0	2	1	2	0	1	0	0	0	1	0	1	0	1	0	0	0	2

Table 9
Without Countermeasures" Database

YEAR	TYPE	LOCATION1		LOCATION2	VOLUME		ACC. FREQ	ACC. RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1989	SS	ELIZABET	&	ROCHESTE	6838	84	7	2.8	0	2	3	4	4	0	0	0	1	0	0	1	0	0	0	1	0	3
1989	SS	RIVEROLD	&	RIVERSID			6	0.0	0	1	5	1	0	0	4	0	0	0	0	1	0	0	0	1	0	3
1989	SS	RR-15	&	SLACK	11384	87	6	1.4	0	0	0	2	0	0	1	1	0	0	0	0	1	1	0	2	0	0
1989	SS	MONTREAL	&	OLMSTEAD	7958	82	4	1.4	0	1	2	0	1	0	0	2	0	1	0	0	0	0	0	0	0	2
1989	SS	RR-13	&	LARKIN	11315	87	4	1.0	0	1	2	2	1	3	0	0	0	0	0	0	0	0	0	0	0	1
1989	SS	RR-57	&	HWY-17			4	0.0	0	1	1	1	0	0	0	2	0	0	0	0	0	2	0	0	0	3
1989	PX	COLDREY	&	KIRKWOOD	13431	88	3	0.6	0	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	2
1989	SS	HERON	&	KALADAR	21617	82	3	0.4	0	0	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	1
1989	SS	RR-52	&	CRAIGHEN	12137	86	3	0.7	0	0	1	2	0	0	3	0	0	0	0	0	0	0	0	0	0	1
1989	SS	RR-61	&	KATIMAVI	8784	89	3	0.9	0	1	3	2	0	0	1	1	0	0	0	0	1	0	0	0	0	1
1989	PX	BANK	&	STRATHCO	11638	84	2	0.5	0	1	1	2	0	1	0	0	0	0	1	0	0	0	0	0	0	1
1989	PX	BRANT	&	MCARTHUR	10884	81	2	0.5	0	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0
1989	SS	CANOTEK	&	SHEFFORD			2	0.0	0	0	2	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1
1989	PX	MARGUERI	&	MCARTHUR	11007	80	2	0.5	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1
1989	SS	CARLTN-U	&	COL.BY			1	0.0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
1989	SS	ELGIN	&	NEPEAN			1	0.0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
1989	PX	MELROSE	&	WELLINGT			1	0.0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1989	SS	REVELSTO	&	RIVERSID			1	0.0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	SS	RR-30	&	MERBLEUE			1	0.0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	SS	RR-27	&	RR-30E	16870	86	9	1.5	0	3	3	6	5	0	0	0	0	1	0	0	0	2	0	1	0	1
1988	SS	RR-15	&	NORICE	19654	86	7	1.0	0	2	3	4	0	0	1	6	0	0	0	0	0	0	0	0	0	1
1988	SS	HERON	&	WALKLEY	14965	81	6	1.1	0	1	4	3	1	0	0	0	0	1	0	1	0	0	1	2	1	3
1988	SS	MCLEOD	&	OCONNOR	13212	84	5	1.0	0	0	1	2	0	0	5	0	0	0	0	0	0	0	0	0	0	0
1988	PX	CRERAR	&	MERIVALE	14104	84	4	0.8	0	1	2	2	0	0	0	0	0	0	3	0	1	0	0	0	0	1
1988	SS	MAY	&	MCARTHUR	11205	86	4	1.0	0	2	1	1	0	0	0	1	0	1	0	1	0	1	0	0	0	2
1988	SS	OT.R.PKW	&	SLIDELL			4	0.0	0	1	2	3	0	2	0	1	0	1	0	0	0	0	0	0	0	2
1988	PX	ALTAVIST	&	100 S OF CALEDON			3	0.0	0	0	3	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0
1988	SS	CONROY	&	HUNTCLUB	7685	87	3	1.1	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0	1
1988	PX	HARDING	&	WALKLEY	19410	86	3	0.4	0	0	1	1	0	0	1	0	0	0	0	1	1	0	0	0	0	2
1988	SS	RR-63	&	BURRIS	15322	86	3	0.5	0	2	0	2	0	0	1	1	0	0	0	0	1	0	0	0	0	0
1988	SS	SUSSEX	&	YORK	17661	84	3	0.6	0	2	1	1	0	0	1	0	0	0	2	0	0	0	0	0	0	[illegible]
1988	SS	ALGONQ-C	&	LEES			2	0.0	0	0	0	2	1	0	0	0	0	0	0	0	0	1	0	0	0	0
1988	SS	COVENTRY	&	STLAU-SC	11005	89	2	0.5	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2	0	[illegible]
1988	PX	LISGAR	&	LYON			1	0.0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	[illegible]
1988	PX	RR-8	&	LONGISLA			1	0.0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	[illegible]

Chapter 5

Data Analysis

5.10 Data Analysis - Outline

The emphasis of this chapter is on the "before-and-after" distribution of traffic accidents at intersections that have undergone the transition from stop sign to traffic signal control devices in 1986. However, a less detailed study of the distribution of traffic accidents in the "with-and-without" perspective will follow in the next chapter. The Data Analysis chapter is comprised of several sections dealing with the distribution of accident patterns following the implementation of traffic safety countermeasures. The chapter is primarily composed of an evaluation of traffic safety countermeasures in terms of the Traditional and the Probabilistic methods in the "before-and-after" perspective.

The analysis begins with the Traditional Approach which includes a summary of accident frequencies for both Stop Sign and Traffic Signal locations as a whole. The Traditional method is comprised of a comparison of the annual accident statistics, following countermeasure implementation, to the "benchmark" accident performance that occurred in the previous year. The difference between the two figures represents the effectiveness of the safety countermeasure implementation.

The Traditional Approach summarizes the annual accident frequencies as a whole as well as focusing on the exclusive Stop Sign location perspective and the Traffic Control Signal Countermeasure perspective, respectively. The summary of these results is followed by a study of the pattern and distribution of annual accidents after the data has been standardized for traffic volume as an indication of "exposure of risk". It should be noted that difficulties were encountered when comparing traffic counts for individual locations to the counts outlined in the Traffic Control Signal Warrants outlined by the Province because of different reporting methods. The traffic counts by location are annual averages prorated by day (average daily trips ADT's), while the Warrants are outlined as hourly and daily figures.

The chapter continues with the "before-and-after" analysis using the Probabilistic Approach for evaluating the performance of safety countermeasures from one year to the next. The Probabilistic Approach is comprised of a comparison of the annual accident statistics, following countermeasure implementation, to the "benchmark" accident performance that is estimated to occur if no countermeasures were put in place. The estimates differ from previous years' statistics because they have been tempered by the "regression to the mean" effect. The difference between the current and estimated figures represents the effectiveness of the safety countermeasure implementation.

The Probabilistic Approach section begins with a description of the procedure used to calculate accident estimates that serve as the "benchmark" measures in place of the previous years', or, 1986 accident performance. The estimates include the Least Squares and Linear Function estimates described in Chapter 3, sections 3.41 and 3.42. The estimates are calculated using a method proposed by Hauer (1984) and the results are illustrated both in tabular and graphical formats. In addition, an attempt is made to measure the significance of the estimates using linear regression analysis.

5.20 Traditional Approach - "Before-and-After" Analysis

The first step in the Traditional Approach to accident countermeasure evaluation is the calculation of a series of frequency distribution tables for the number of accidents occurring at stop sign and countermeasure locations during 1986 and 1987. The 1986 calculations are based on locations of the stop sign nature as well as the 54 locations introduced to traffic signals in 1986. It is very important to note that the 1987 accident calculations are based on the very same locations as the 1986 sample but with the "crash" performance experienced in 1987.

In order to maintain comparability, the 1987 distribution does

Table 10
Accident Frequency Distribution
Stop Sign and Countermeasure Locations

Accident Frequencies	Total Accidents 1987	1986	Variance	Stop Sign Accidents 1987	1986	Variance	Countermeasure Accidents 1987	1986	Variance
1	464	668	-31%	460	664	-31%	4	4	0%
2	327	424	-23%	307	402	-24%	20	22	-9%
3	312	375	-17%	279	357	-22%	33	18	83%
4	202	256	-21%	189	228	-17%	13	28	-54%
5	105	160	-34%	87	130	-33%	18	30	-40%
6	91	120	-24%	86	114	-25%	5	6	-17%
7	81	126	-36%	81	126	-36%	0	0	0%
8	51	88	-42%	37	56	-34%	14	32	-56%
9	25	36	-31%	22	27	-19%	3	9	-67%
10	34	40	-15%	23	30	-23%	11	10	10%
>10	223	239	-7%	58	66	-12%	165	173	-5%
Total	1915	2532	-24%	1629	2200	-26%	286	332	-14%

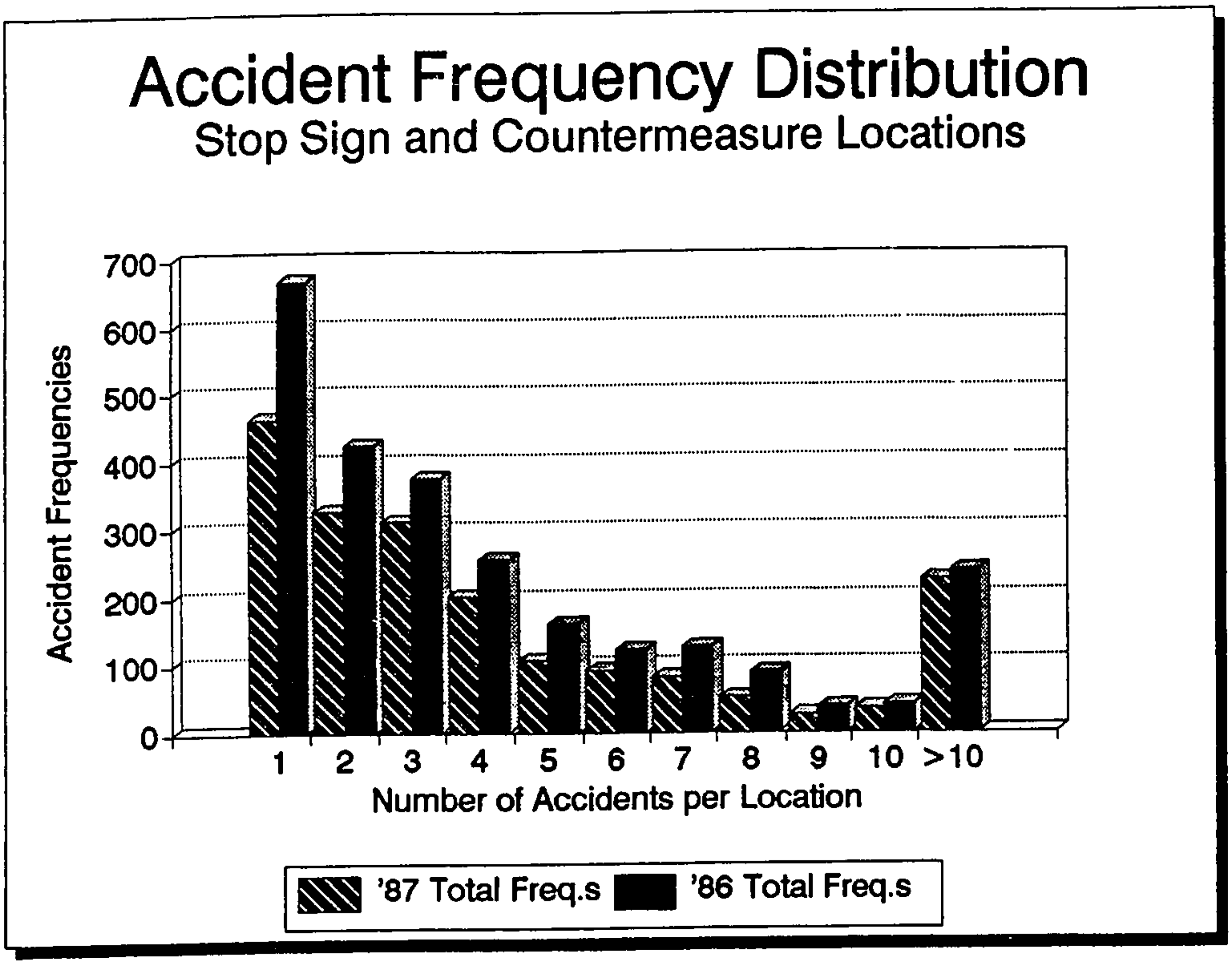

Accident Frequency Distribution
Stop Sign and Countermeasure Locations
Accident Frequencies
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
8
9
10
>10
Number of Accidents per Location
'87 Total Freq.s
'86 Total Freq.s

Figure 3

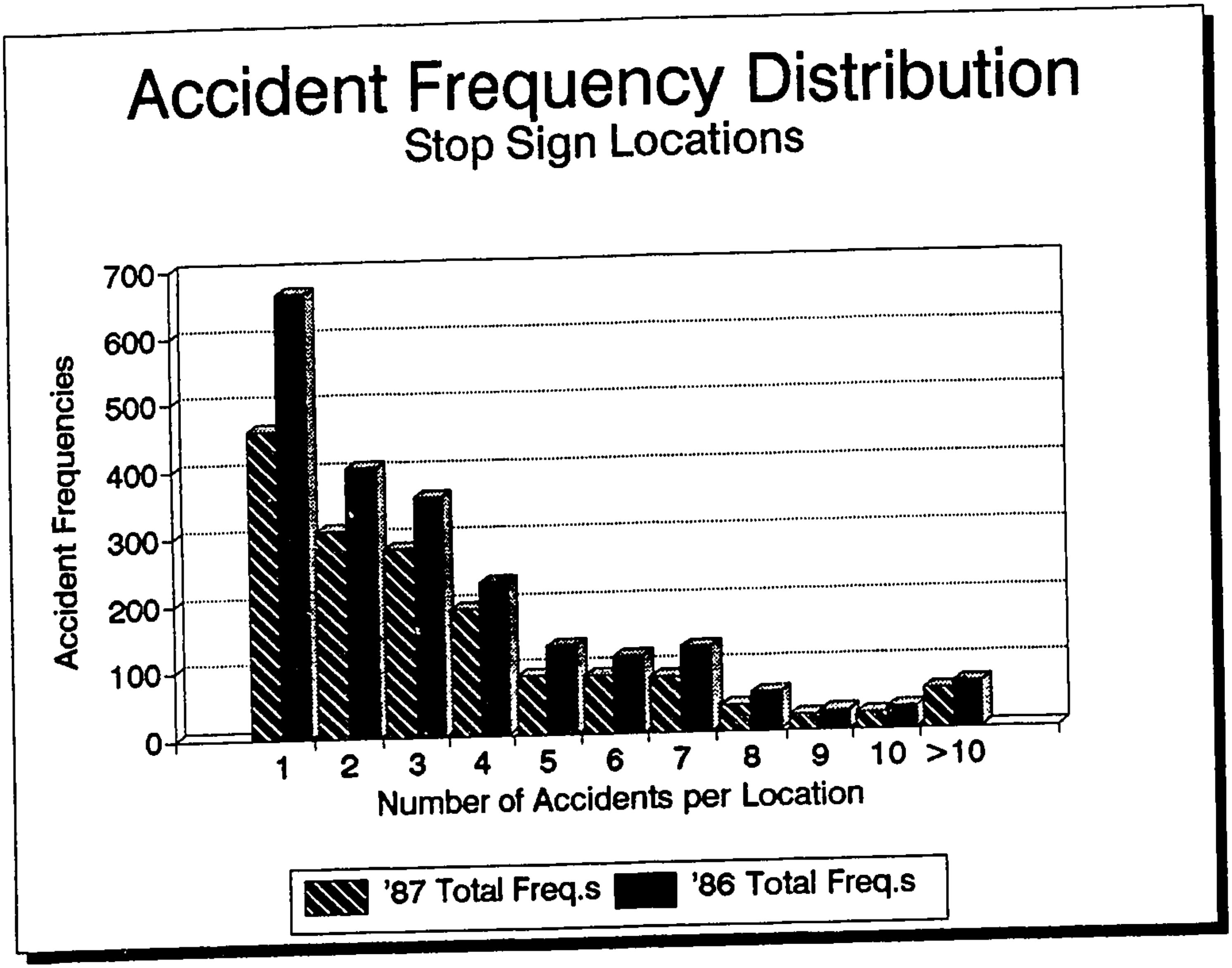
not include frequencies from locations that were exempt from the 1986 sample. In other words, there are no new locations added to the original sample of 54 intersections. The results are listed in Table 10 and is also presented in a graphical format in Figures 3 through 5. An explanation of the calculations and results are highlighted by the three categories listed as sections 5.21, 5.22 and 5.23.

5.21 Accident Frequencies Total

This section includes both stop sign and countermeasure locations. The information illustrated in Table 10 and Figure 3 indicate that there were 617 fewer accidents in 1987 than in 1986 which is approximately a 24% drop in accidents, overall. The decrease is evident in each category of accident frequencies. For example, the locations that experienced "1" accident frequency dropped 31% from 668 accidents in 1986 to 464 accidents in 1987. Meanwhile, the locations that experienced "2" accidents dropped by approximately 23% and the locations that experienced "3" accidents dropped by approximately 17% from one year to the next.

The trend continues for the remainder of the categories with an occasional increase or decrease at certain locations. For example, in 1986 there were 4 locations that exhibited 10 accident frequencies (or 40 accidents for the "10 accidents per location" category). However, the number of accidents fell to 34 for the same 4 locations in 1987. In other words, at least one of these locations experienced less than the 10 accidents exhibited in the previous year.

Under the Traditional Approach, the Total Accident Frequencies for both Stop Sign and Countermeasure locations represent a substantial drop in traffic accidents from one year to the next. However, it is unclear as to which locations have experienced the decline in traffic accidents. The locations in question must be broken down into those that remained Stop Sign locations and those that were converted to Signalized locations.



Accident Frequency Distribution
Stop Sign Locations
Accident Frequencies
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
8
9
10
>10
Number of Accidents per Location
'87 Total Freq.s
'86 Total Freq.s

Figure 4

5.22 Accident Frequencies: No Countermeasures

This section includes only those locations with stop signs in 1986 and remained as stop sign locations in 1987. This information, listed in Table 10 and Figure 4, illustrates that there were 571 fewer accidents in 1987 than in 1986 at locations that remained stop sign controlled. This decrease translates into approximately a 26% decrease in the number of accidents at non-countermeasure locations and approximately 92% of the entire decrease in accidents as a whole. That is to say that the majority of the overall drop in accidents in the Region occurred at locations that underwent no countermeasure treatment whatsoever!

The distribution of the accident reduction is similar to that of the previous section. The locations that experienced "1" accident frequency dropped 31% from 664 accidents to 460 accidents in 1987. The locations that experienced "2" accidents fell by approximately 24% and the locations that experienced "3" accidents dropped by approximately 22%. Meanwhile, the remaining categories fell in a similar pattern to that of the combined Stop Sign and Countermeasure locations.

The natural decline in traffic accidents seems to be substantial on the surface. A decrease of 26% from one year to the next by doing nothing at all is phenomenal considering that traffic volumes grew over the same period of time (RMOC, 1989). Initially, the accident researcher must ask "what will happen to the results if the data is standardized for traffic volume?" Unfortunately, this becomes a very difficult task because very few stop sign locations are accompanied by consistent annual traffic counts. For example, the RMOC data contains traffic counts for only 25% of the stop sign, or, non-countermeasure locations (RMOC, 1989) and careful analysis of Appendix 5 (the "Without" Countermeasures Database) indicates that several of the traffic volume counts are either missing, or, not current. The lack of current and historical traffic counts for such a small sample from one year to the next increases the difficulty of conducting standardized frequency distribution analysis. The analysis may be

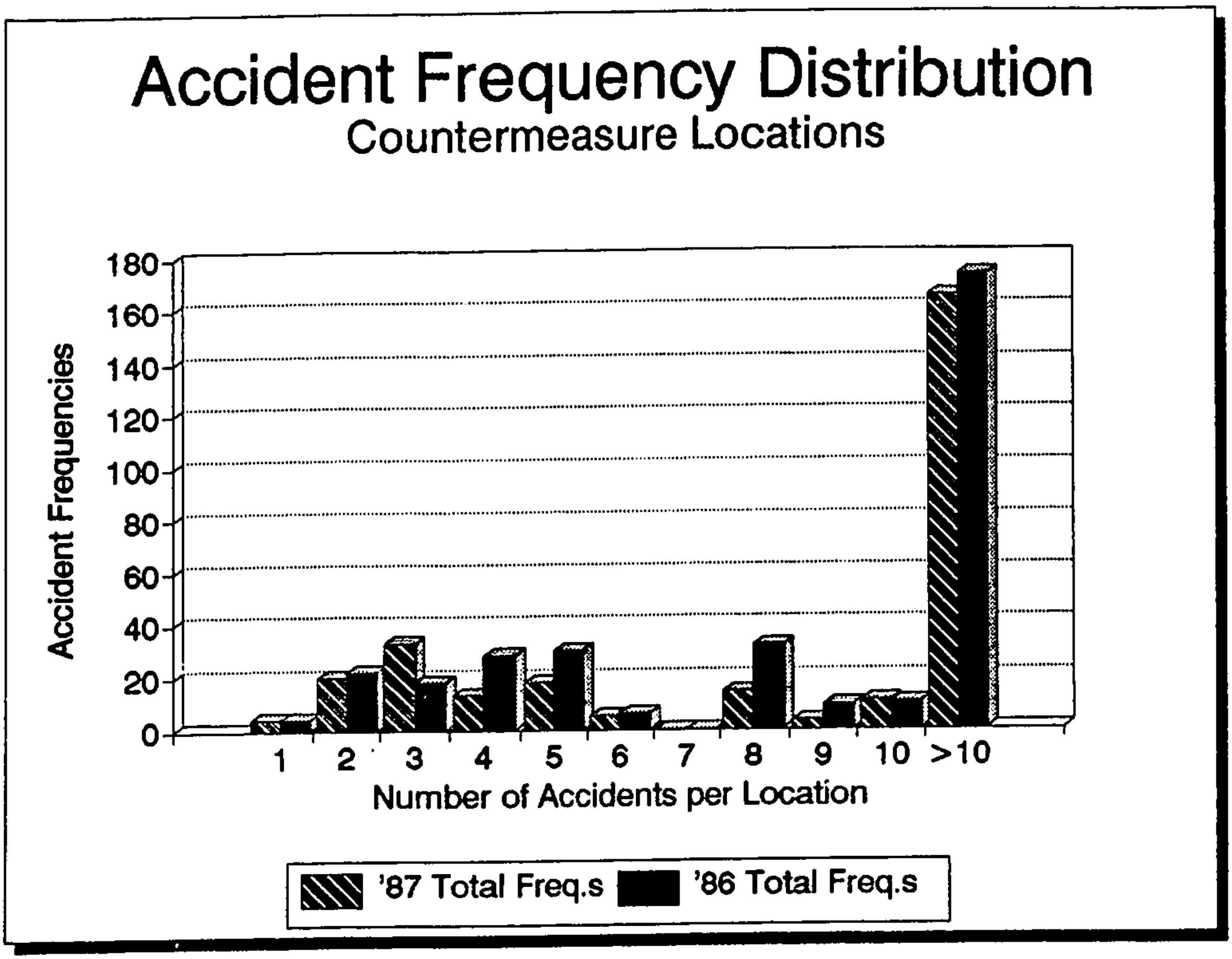

Accident Frequency Distribution
Countermeasure Locations
Accident Frequencies
0
20
40
60
80
100
120
140
160
180
1
2
3
4
5
6
7
8
9
10
>10
Number of Accidents per Location
'87 Total Freq.s
'86 Total Freq.s

Figure 5

more precise by working with the actual countermeasure locations.

5.23 Accident Frequencies: Countermeasures

This section includes only those locations that were introduced to traffic signals in 1986. This information, exhibited in Table 10 and Figure 5, illustrates that there were 46 fewer accidents in 1987 than in 1986 (a drop of approximately 14%) at locations that were converted from stop sign to traffic signal control devices. This decrease amounts to 8% of the entire decrease in the number of total accidents, whereas the number of accidents at the remaining Stop Sign locations dropped by approximately 92%. The decline in the raw number of accidents at countermeasure locations is much less encouraging than expected when viewed from this perspective.

The distribution of this decline is varied over the accident frequency categories. According to Table 10, the number of accidents at locations with "1" accident remained the same while the number of accidents at locations with "2" accidents dropped by 2 accidents. The number of locations with "3" accidents actually rose by 15 accidents, or 83% more than the previous year. However, the remainder of the accident categories represent a substantial redistribution of accidents moving downward on the "number of accidents per location" scale.

The accident reductions, as a function of countermeasure implementation, is less encouraging than initially expected in the Traditional Approach. The results indicate a small variance in the accident frequencies, from one year to the next, following safety countermeasure implementation when compared to the natural reduction in traffic accidents as a whole. However, this particular analysis and subsequent results do not consider the standardization of the data, in terms of changes in traffic volume, for comparative purposes. Instead of looking at the raw accident frequencies for comparison, it is more prudent to add the traffic volume factor, representing "risk exposure", on a location specific basis. Afterall, a location with 20 annual accidents with a traffic volume of 1 million is actually much safer, on average, than the location with 5 annual accidents and a traffic volume of 1,000, assuming your not one of the victims, of course.

5.24 Standardized Countermeasure Analysis

The standardization of the countermeasure locations for exposure to traffic volume is more manageable than the standardization of the non-countermeasure locations. The majority of the traffic counts exist for the "before-and-after" locations and is current for each year. The accident rate is calculated based on 1,000,000 entering vehicles per annum and the formula is listed in section 3.50 of Chapter 3. The results are summarized in Table 11 and graphically displayed in Figure 6.

According to Table 11, approximately 65% of the Countermeasure locations, between 1986 and 1989, exhibited accident rates between the range of 0 and 1 accidents per million entering vehicles. Approximately 30% of the Countermeasure locations exhibited accident rates between the range of 1 and 2 accidents per million entering vehicles and the remaining 5% exhibited accident rates of more than 2 accidents per million entering vehicles.

Interestingly, the results for 1985 are somewhat reversed from the other years. Only 44% of the Countermeasure locations exhibited accident rates between the range of 0 and 1 accidents per million entering vehicles. Approximately 31% of the Countermeasure locations exhibited accident rates between the range of 1 and 2 accidents per million entering vehicles in 1985. The final 25% of the Countermeasure locations exhibited accident rates of more than 2 accidents per million entering vehicles in 1985.

The results of the introduction of the safety countermeasures indicate an increase at the lower end of the accident rate scale and a decrease at the higher end, over time. For example, the area graph presented in Figure 6 indicates the various accident rates in the Region between 1985 and 1989. The highest rate (more than 2 accidents per million entering vehicles) is represented by the cross hatched section at the top of the graph. Note that this area

Table 11
"Before-and-After" Accident Rates
per Million Entering Vehicles
(# of Locations per Accident Rate)

Rates for Locations:	0.0	0.5	1.0	1.5	2.0	>2.0
1985	3	6	15	8	9	13
1986	2	12	19	9	7	5
1987	5	14	18	8	7	2
1988	4	15	18	10	5	2
1989	5	10	25	8	2	4

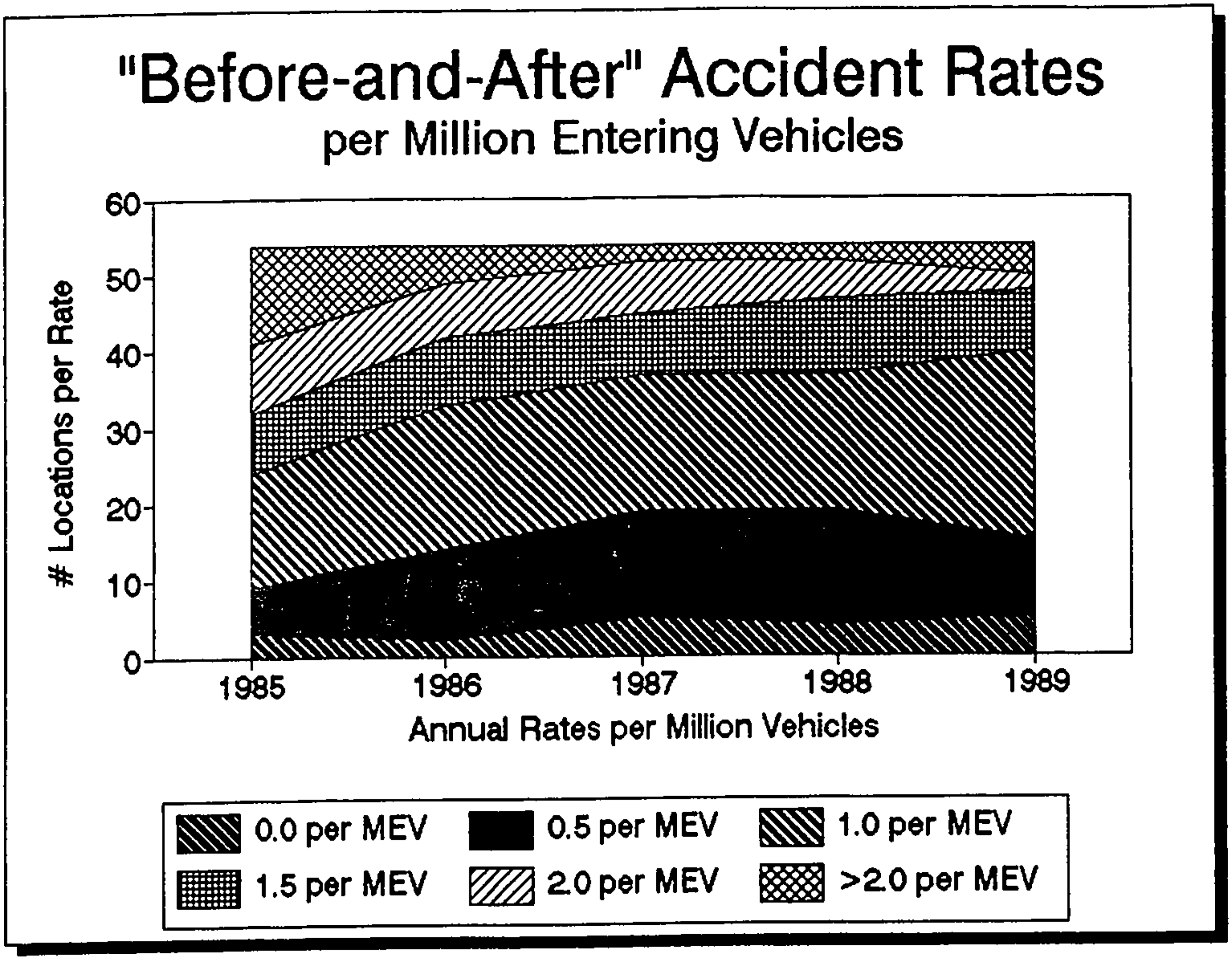

"Before-and-After" Accident Rates
per Million Entering Vehicles
Locations per Rate
0
10
20
30
40
50
60
1985
1986
1987
1988
1989
Annual Rates per Million Vehicles
0.0 per MEV
0.5 per MEV
1.0 per MEV
1.5 per MEV
2.0 per MEV
>2.0 per MEV

Figure 6

includes 13 locations in 1985 and is found between the 40 and 50 marks on the vertical axis of the graph. In 1986, the year of countermeasure implementation, the number of locations that are qualified as greater than 2 accidents per million entering vehicles has dropped significantly from 13 to 5 locations. The area graph continues to narrow for this highest accident rate category through to 1989.

Similarly, those locations found at the lower end of the accident rate scale show a slight widening or growth in accidents as time goes on. According to Table 11, the accident rate category of 1 accident per million entering vehicles is at a level of 15 locations in 1985 and grows to 25 locations by 1989. This indicates that accident frequencies at the fixed countermeasure locations are working themselves down towards the lower end of the "annual accident frequency" scale each succeeding year.

The standardized results illustrate a dramatic drop in the number of locations with accident rates greater than 2 per million entering vehicles. Meanwhile, the remaining lower accident rate categories have remained somewhat constant or slightly higher in progressive years. Theses results seem to coincide with Regional Policy outlined by the Traffic Warrants produced by the Province. This policy is that traffic signal countermeasures are to be implemented at locations that exhibit high traffic rates (at least 5 accidents per year for the last 3 years) which are a result of high traffic volumes and accident frequencies over a prolonged period of time (720 vehicles each hour during the heaviest 8 hour period during the day). In other words, the safety countermeasures have been located, presumedly at high volume locations, in correspondence with the Warrants, and have exhibited the desired outcome of a significant drop in both accidents, and the accident rate.

The Standardized Accident Analysis highlights the effectiveness of the countermeasures more explicitly than the raw frequency distribution analysis by considering fluctuations in traffic flow in relationship to the number of accidents occurring from one year to the next. The use of the data in Chart (Table 11) and the Area Graph (Figure 6) provide an excellent visual display of the trends but these tools may be even more useful if the duration of the respective inclines and declines of accident frequencies could be measured and controlled to enhance the desired accident reduction results.

The standardization of the accident data into rates based on "exposure to risk" presents a more realistic, and in this case, a more optimistic perspective on the effect of traffic countermeasures. However, the use of the 1986 actual accident data as the "benchmark" comparison to the 1987 performance may be misleading. For example, the implementation of all traffic signals in 1986 did not necessarily occur on January 1, 1986 for the countermeasure locations. They were likely spread throughout the entire year. In fact, the records for the implementation of the traffic signal control devices indicate that they are scattered randomly throughout the year. Therefore, it is suggested that a more appropriate "benchmark" comparison measure be taken. Perhaps a probability estimate of the number of accidents expected in 1987 if no countermeasure was implemented would serve as a more appropriate "benchmark" figure than the actual 1986 accidents.

5.30 Traditional Approach Summary

The Traditional Approach began with an analysis of the Total Accidents that occurred in the RMOC region between 1985 and 1989. Evidence of an overall drop in the number of accidents was significant. However, it was difficult to determine if the decline in the number of accidents was a result of countermeasure implementation, or simply, representative of an inherent decline. The analysis continued with an evaluation of those locations that remained stop sign controlled. These non-countermeasure locations exhibited a significant drop of close to 26% in annual accidents between 1986 and 1987 without the introduction of traffic signal control devices.

The locations that received traffic control signals in 1986 were evaluated in terms of annual accident reduction and the figures indicated a drop of approximately 8% between 1986 and 1987. Initially, this performance was less encouraging than anticipated. However, the statistical evidence did indicate that some very high annual accident frequency locations were either eliminated or shifted down to a lower position on the "number of accidents per location" scale.

In order to gain a more objective perspective, the countermeasure locations were standardized using traffic volume as a surrogate variable for "exposure to risk". The result was a series of accident rates that statistically improved the overall effectiveness of the countermeasure implementation at the 54 RMOC locations. For example, The highest rate was "More than 2 accidents" per Million Entering Vehicles. This figure represented 25% of the entire sample in 1985 but dropped by 10% in 1986 during the countermeasure implementation period. In 1987, the year following the introduction of traffic control signals, the same figure dropped an additional 50%. The standardized results lend a more objective, and often more optimistic, perspective on the outcome of safety countermeasure applications, however, there must be sufficient "risk exposure" data available to conduct the standardization process.

5.40 Probabilistic Approach - "Before-and-After" Analysis

The Probabilistic Approach in traffic accident research is comprised of calculating a "benchmark" estimate of the number of accidents that may be expected in succeeding years. The resulting estimate is compared to what actually happened in those years. The variance between the two is expected to give a more accurate indication of the performance of a safety countermeasure than using the previous years' unadjusted accidents as the "benchmark".

The estimated "benchmark" is calculated based on historic data that has been adjusted to reflect the average mean accidents for the entire geographic region in question. The first estimate is known as a Least Squares Estimate and the second estimate is known as a Linear Function Estimate. The detailed formulae have been described in sections 3.41 and 3.42 of Chapter 3.

The Probabilistic Approach section begins with a brief synopsis of the procedure for calculating the probability estimates. The calculated estimates are juxtaposed with their 1986 and 1987 "actual" counterparts for comparative purposes. The section continues with the application of the 2 estimates to the Countermeasure locations as the revised "benchmark" level of comparison. This application phase is followed by the final section on "significance testing" using standard regression analysis.

5.41 Estimated Probability Calculations

Table 12 outlines the calculation of both Least Squares and Linear Function estimates and the formulae are represented by E1 and E2, respectively, at the top of the table. The components of the formulae refer to the cell addresses listed by columns "B" through "K" and rows "19" through "43". The cell addressing technique is similar to that which is used in Lotus123.

The second column (B) in Table 12 represents the number of accidents that occur per location between the range of 1 and 22. The third column (C) represents the number of "stop sign" and "countermeasure" locations that exhibit the respective number of accidents in 1986. Please note that the number of intersections with "0" accidents in 1986 is a rough estimate given by the Transportation Department at the Region. Only an estimate may be furnished because of the method by which RMOC records the accident data (further details regarding the RMOC data base may be found in Appendix 2). The presence of this figure is required to maintain logical consistency with Hauer's Probabilistic method.

There were 1,174 locations distributed among the various accident frequency categories between 1 and 22, in 1986. For example, there were 668 locations with only 1 accident occurrence annually. Meanwhile, there were 125 locations with 3 accident occurrences annually. In addition, there were an estimated 544

Table 12

Accident Frequency Distribution: Total; Stop Sign; Countermeasure Locations 1986 & 1987

Estimated Probability Calculations of Traffic Accidents based on 1986.

	B	C	D	E	F	G	H	I	J	K
ROW NUMBER	NUMBER OF ACCIDENTS (X)	1986 INTERSECTIONS TOTAL N(X)	1986 ACCIDENTS TOTAL N(X)*(X)	1987 ACCIDENTS [M(X)]	1987 AVERAGE ACCIDENTS M(X)/N(X)	1987 ESTIMATES # ACCIDENTS [E1(X)]	1987 SMOOTHED ESTIMATES [E1) y=mx+b	1987 ESTIMATES # ACCIDENTS [E2(X)]	XBAR	S^2
19	0	544	0	1161	2.13	1.23	4.13	0.50	1.47	0.69
20	1	668	668	464	0.69	0.63	4.21	1.16		0.09
21	2	212	424	327	1.54	1.77	4.29	1.82		0.03
22	3	125	375	312	2.50	2.05	4.36	2.48		0.17
23	4	64	256	202	3.16	2.50	4.44	3.15		0.24
24	5	32	160	105	3.28	3.75	4.52	3.81		0.23
25	6	20	120	91	4.55	6.30	4.59	4.47		0.24
26	7	18	126	81	4.50	4.89	4.67	5.13		0.32
27	8	11	88	51	4.64	3.27	4.75	5.80		0.27
28	9	4	36	25	6.25	10.00	4.83	6.46		0.13
29	10	4	40	34	8.50	0.00	4.90	7.12		0.17
30	11	0	0	0	0.00	4.00	4.98	7.78		0.00
31	12	6	72	57	9.50	2.17	5.06	8.45		0.39
32	13	1	13	9	9.00	21.00	5.14	9.11		0.06
33	14	2	28	30	15.00	7.50	5.21	9.77		0.18
34	15	1	15	23	23.00	32.00	5.29	10.43		0.11
35	16	2	32	43	21.50	8.50	5.37	11.09		0.25
36	17	1	17	4	4.00	0.00	5.44	11.76		0.14
37	18	0	0	0	0.00	0.00	5.52	12.42		0.00
38	19	0	0	0	0.00	0.00	5.60	13.08		0.00
39	20	2	40	41	20.50	0.00	5.68	13.74		0.40
40	21	0	0	0	0.00	0.00	5.75	14.41		0.00
41	22	1	22	16	16.00	0.00	5.83	15.07		0.25
42										
TOTAL LOCATIONS		1718								
TOTAL ACCIDENTS	253		2532	1915	158.11					
TOTAL ESTIMATE						113.33	110.43	174.52		4.36

Annotations:

Column B : Assumption: What happened "before" treatment is a good indication of what would happen 'after' if treatment was not implemented. (also known as accident frequency categories)

Column C : The number of intersections found in the 1986 data sample; includes 544 intersections with zero accidents. The 544 stop sign locations with zero accidents in 1986 are merely a rough estimate by RMOC (actuals are unknown).

Column D : The total number of accidents, in 1986, resulting from multiplying columns B and C.

Column E : The number of accidents that occurred in 1987 at the fixed set of 1986 intersections listed in " Column C. " Please note that this column delineates total 1987 accident frequencies as per the respective 1986 accident frequency category. However, note that the 1,161 figure in the first category repesents the accident locations originating in Column C that experienced zero accidents in 1987. Therefore, this figure should not be construed as representing accidents, but simply as locations with zero accidents.

Column F : This illustrates the average number of accident per frequency category in 1987: Column E divided by Column C.

Column G : E1(x) = (x+1) * n(x+1)/n(x) ... or in spreadsheet calculated format: ($B19+1)*(C20/C19).

Column H : This is the E1 estimate smoothed by using Y=MX+B where the X-Coeff. is 0.077 and the Constant is 4.13 based on the regression between columns B and G.

Column I : E2(x) = x + (xbar / sample variance) * (xbar - x) ... or in spreadsheet calculated format: +B19+($J$19/$K$45)*($J$19-B19).

Column J : XBAR = sum of x * n(x) / sum of n(x) ... or in spreadsheet calculated format: +D44/+C43.

Column K : Sample Variance (S^2) = (xbar - x) squared * n(x) / sum of n(x)... or in spreadsheet calculated format: (($J$19-B19)^2)*(C19/$C$43).

locations of a Stop Sign nature that had no accidents in 1986, bringing the total number of intersections to 1,718.

The fourth column (D), in Table 12, is the product of columns (B) and (C) and represents the total number of accidents in 1986 for both "stop sign" and "countermeasure" locations. There were 2,532 accidents at "stop sign" and "countermeasure" locations in 1986. The accidents are distributed among the various levels of accident frequencies. For example, the 125 locations with 3 annual accidents have a total of 375 accident frequencies.

The 1987 accidents are analyzed in terms of the fixed set of 1,174 accident locations arising from the 1986 database in order to provide a direct comparison of accident performance from one year to the next. Note, this is exclusive of the 544 locations in 1986 that were estimated to have "0" accidents (locations with zero accidents are never included in the RMOC databases). The fifth column (E), in Table 12, summarizes the total number of accidents occurring in 1987 at the same set of locations found in the 1986 database indicated by column (C). There were a total of 1,915 accidents at the "stop sign" and "countermeasure" locations in 1987.

The annual accident frequency categories in 1987 exhibited 312 accidents that are comparable to the 125 locations that exhibited 3 annual accidents (375 total frequencies) in 1986. Similarly, the 64 locations that exhibited 4 annual accidents in 1986 (256 total accidents) experienced a drop to 202 total accidents in 1987 for the same category. This indicates that several of the 64 locations experienced less than 4 of the annual accidents exhibited by the previous year.

The changes in the number of accidents for the fixed set of locations becomes more apparent by dividing the 1987 accidents by the number of fixed locations for each frequency category. The result is an average number of accidents in 1987 for the locations put forth in 1986. The results are calculated in the sixth column (F) and are comparable to the 1986 version in column (B). For example, there were 125 locations with 3 annual accidents in 1986 for a total of 375 accidents. However, the same 125 locations experienced 303 total accidents or an average of 2.5 annual accidents per location, in 1987.

The final six columns of Table 12 are comprised of the calculated Raw Least Squares Estimates (E1), the Smoothed Least Squares Estimates; the Linear Function Estimates (E2), and the Mean and the Mean minus the Annual Accident Frequency category squared. The last two columns are used in the calculation of the Linear Function Estimates (E2).

5.42 Least Squares Estimate

The seventh column (G), in Table 12, represents the calculated Least Squares Estimate (E1) of the number of accidents per location. The calculated estimate is an attempt to predict the average number of accidents per location in 1987 that may be expected without safety countermeasure implementation. The results are comparable to column "B"; the actual accidents per location in 1986, and "F"; the average accidents per location in 1987. Smoothed versions of the E1 estimate follows in columns "H" and "I".

The Raw, or Unsmoothed Least Squares estimate predicts a total of 114.5 accidents for the fixed set of 1986 locations. The predicted level falls well below the 160 average accidents that actually occurred in 1987. However, the predicted figures, according to accident frequency category, vary slightly in comparison to the 1987 averages on the lower end of the scale (ie. 1,2,3 annual accidents per location). According to Table 12, the predicted average accidents for the frequency level of 1 annual accident is 0.63 and the actual average in 1987 was 0.69. Similarly, the predicted values for locations with 2,3, and 4 accidents were predicted to have 1.77, 2.05 and 2.50 accidents in 1987 if no countermeasures were implemented. However, the 1987 results indicate actual values of 1.54, 2.50 and 3.16, respectively with countermeasures implemented at 54 locations.

In fact, the results indicate that exactly one half of the 22 estimates result in predictions that are lower than what actually happened in 1987 and the remaining 11 estimates result in figures that are higher than what happened in 1987. These results may be disconcerting; afterall, one expects that all accidents must drop with the introduction of countermeasures from one year to the next. However, it should be noted that, at this point, the complete Stop Sign and Countermeasure database is being used as a whole. Only 54 of the 1,174 locations received countermeasures during 1986. Therefore, while some locations may experience a decrease in accidents, others may experience an increase, or a higher level than predicted.

For example, at the frequency level of 9 annual accidents and higher, the predicted values begin to vary significantly from those that actually occurred in 1987. The predicted average of 10 accidents per location for the annual frequency level of 9 is far greater than the average of 6.25 incurred in 1987. But the next category of 10 accidents per location, E1 predicts an estimate of 0 accidents for 1987, while an average of 6.25 accidents actually occurred. Similarly, a prediction is made for 2.17 accidents for the annual frequency level of 12 while the actual figure for 1987 was 9.5 annual accidents. But in the next category of 13 accidents per location, there are 28 accidents predicted using E1 and only 9 annual accidents actually developed in 1987.

These wild fluctuations continue as the estimates are made for the accident frequency categories that are on the higher end of the scale (ie. 10 through 22 annual accidents per location). It seems that the predictive power of the raw estimate begins to fail when dealing with frequency levels that show zero accidents in the base year of 1986.

Therefore, the smoothed version of the Least Squares estimate E1 was introduced in attempt to improve the predictive power of the measure. The estimated data was smoothed by using the slope and constant calculated by the regression output where the independent variable was the number of accident frequencies category and the dependent variable was the raw calculation of E1. The results are illustrated in column "H" of Table 12. The resulting calculations led to a slope of 0.08 and a constant of 4.13. These figures were used with the given x-intercepts in the equation of a line to calculate the ensuing coordinates. The result was a smooth line in which 64% of the estimates where higher than that which occurred in 1987. This result seemed desirable because the overall predictions were less than the previous year but slightly higher than the following year when the countermeasures had been applied.

While these results are adequate, the curve fitting process may be replaced by a less complicated method of estimate calculation which uses the sample mean and variance as the main components. This method is also proposed by Hauer and is called the Linear Function Estimate.

5.43 Linear Function Estimate

The column (I), in Table 12, represents the calculated Linear Function Estimate (E2) of the average number of accidents per location. This calculated estimate is also an attempt to predict the average number of accidents in 1987 that may be expected without safety countermeasure implementation. The sum of the Linear Function estimate falls below the actual number of accidents that occurred in 1986 but it remains higher than the levels experienced in 1987. The Linear Function estimate predicts a total of 178 accidents for the fixed set of 1986 locations. This is approximately 13% higher than the 158 average annual accidents that occurred in 1987 and approximately 30% below the 1986 level of accident frequency categories.

The predicted estimates are lower than the 1986 accident levels, however, they are marginally higher than the 1987 results for approximately 70% of the annual frequency levels "1" through "22". The cases where the estimates are lower than the 1987 actuals exhibit small variances for many of the categories, especially, at the lower end of the scale (ie. accident frequencies 1 through 13). For example, the categories of 2 and 3 accident frequencies illustrated predicted estimates of 2.48 and 3.15

respectively, while the actual averages for 1987 came in at 2.50 and 3.16, respectively.

The variances between the estimates and the 1987 actual accident averages became more extreme between the accident frequency categories of 14 and 22. For example, the categories of 14 and 15 accident frequencies illustrated predicted estimates of 9.77 and 10.43, respectively. Meanwhile, the actual averages for 1987 came in at 15 and 23 respective. These variances may result from a number of sources. As described in the previous section, the data includes both stop sign and countermeasure locations. Therefore, the 1987 levels may reflect increases attributed to non-countermeasure locations, changes in traffic volume, changes in street configuration as well as a host of other possibilities.

It is interesting to note, however, that the E2 estimates begin to lose their predictive power, in a similar fashion as the E1 estimates, as the categories move into the upper range of annual average accidents per intersection. It is in these upper ranges where the incidence of regular accident occurrences becomes less consistent and one may observe changes from 0 to 40 accidents between adjacent accident categories. This seems to be a leading indication that both estimates have difficulty dealing with large or, uneven fluctuations in the data between the various accident categories.

5.44 Application of the Estimates to Countermeasure Locations

The Probabilistic Approach of evaluating the implementation of safety countermeasures is more apparent when the previously calculated estimates are applied to "before-and-after" locations. This evaluative approach was introduced by Hauer (1984) as Table 5, San Fransico Accident Frequencies - "Before and After", in section 3.42 of Chapter 3. The Least Squares and Linear Function estimates are multiplied by the 1986 countermeasure locations to determine the total number of accidents that would have occurred at these locations in 1987 without any countermeasure implementation. The results are compared both in whole and by the various accident frequency levels (ie. 1,2,3...annual accidents per location) to the actual traffic accident performance experienced in 1987 with the safety countermeasures in place.

The application of the estimates is expected to provide figures that fall slightly below their counterparts for 1986 because of the natural reduction of accidents as a result of the "regression to the mean" effect. In addition, the estimates are expected to be somewhat higher than the 1987 accident performance because the countermeasure locations are expected to have fewer accidents than the estimates because of the enhanced safety effect of the newly signalized locations.

5.45 Application of Least Squares Estimates

The results are summarized in Table 13 and Figure 7: Base Year Application Model - "Before-and-After" Accident Analysis. Table 13 is divided into 12 columns that are labelled A, B, C through L. Column A illustrates the accident frequency categories 0 through 22. Columns B and C exhibit the total accident frequencies experienced for each of the categories for the periods 1985 and 1986. It should be noted that the frequencies must be divided by the accident frequency categories in order to determine the number of accident locations at each interval. For example, in 1986 there were 22 total accident frequencies for the accident frequency category of two. Therefore, there were 11 locations that incurred the 22 total accidents. The ensuing estimates are applied against the actual number of locations and not against the total number of accident frequencies.

The results of the application of the Least Squares estimates are identified in column E: "E1 Estimate of Expected '87 Accidents" and in column G: "E1 Smoothed Expected '87 Accidents". The Raw Least Squares estimate, E1, computes a total of 186 expected accident frequencies in 1987 for the newly signalized locations if no countermeasures had been implemented. Meanwhile, the Smoothed Least Squares estimate computed a total of 240 accident frequencies in 1987 for the newly signalized locations if no countermeasures

Table 13
Base Year Application Model
"Before-and-After" Accident Analysis

A Accident Frequency Level	B 1985 Inter-Sections	C 1985 Accidents	D 1986 Inter-Sections	E 1986 Accidents	F E1 Raw Estimate (Table 12)	G E1 Estimate Expected '87 Accidents Column D x F	H E1 Smoothed Estimate (Table 12)	I E1 Smoothed Expected '87 Accidents Column D x H	J E2 Estimate (Table 12)	K E2 Estimate Expected '87 Accidents Column D x J	L 1987 Inter-Sections	M 1987 Accidents	N 1988 Inter-Sections	O 1988 Accidents	P 1989 Inter-Sections	Q 1989 Accidents
0	3	0	2	0	1.23	2.52	4.13	2.52	0.50	0.00	5	0	4	0	4	0
1	4	4	4	4	0.63	2.52	4.21	16.84	1.16	4.64	7	7	7	7	5	5
2	2	4	11	22	1.77	19.47	4.29	47.19	1.82	20.02	9	18	7	14	7	14
3	6	18	6	18	2.05	12.30	4.36	26.16	2.48	14.88	8	24	7	21	8	24
4	7	28	7	28	2.50	17.50	4.44	31.08	3.15	22.05	5	20	7	28	11	44
5	4	20	6	30	3.75	22.50	4.52	27.12	3.81	22.86	1	5	1	5	2	10
6	2	12	1	6	6.30	6.30	4.59	4.59	4.47	4.47	3	18	6	36	2	12
7	4	26	0	0	4.89	0.00	4.67	0.00	5.13	0.00	2	14	3	21	2	14
8	4	32	4	32	3.27	13.08	4.75	19.00	5.80	23.20	1	8	1	8	0	0
9	4	36	1	9	10.00	10.00	4.83	4.83	6.46	6.46	4	36	2	18	1	9
10	4	40	1	10	0.00	0.00	4.90	4.90	7.12	7.12	1	10	2	20	2	20
11	0	0	0	0	0.00	0.00	4.98	0.00	7.78	0.00	1	11	2	22	2	22
12	1	12	3	36	2.17	6.51	5.06	15.18	8.45	25.35	0	0	0	0	3	36
13	3	39	1	13	28.00	28.00	5.14	5.14	9.11	9.11	0	0	1	13	0	0
14	0	0	1	14	7.50	7.50	5.21	5.21	9.77	9.77	0	0	0	0	1	14
15	0	0	1	15	32.00	32.00	5.29	5.29	10.43	10.43	1	15	1	15	0	0
16	0	0	1	16	8.50	8.50	5.37	5.37	11.09	11.09	1	16	1	16	0	0
17	0	0	1	17	0.00	0.00	5.44	5.44	11.76	11.76	0	0	0	0	1	17
18	3	54	0	0	0.00	0.00	5.52	0.00	12.42	0.00	1	18	0	0	2	36
19	0	0	0	0	0.00	0.00	5.60	0.00	13.08	0.00	1	19	0	0	0	0
20	0	0	2	40	0.00	0.00	5.68	11.36	13.74	27.48	0	0	0	0	0	0
21	0	0	0	0	0.00	0.00	5.75	0.00	14.41	0.00	1	21	0	0	0	0
22	0	0	1	22	0.00	0.00	5.83	5.83	15.07	15.07	1	22	1	22	1	22
Total	51	327	54	332	113.33	186.18	110.43	240.53	178.51	245.76	53	282	53	266	54	299

See Attached Anotations.

Annotations: Table 13

Column A : Accident Frequency Categories

Column B : The number of countermeasure intersections that existed in 1985.
(note there are only 51 intersections listed; the remaining 3 were identified as: 1 at frequency categories 24 and 2 at 30, respectively.

Column C: The number of accidents that occurred in 1985 (the product of Columns A & B).

Column D : The number of countermeasure intersections that existed in 1986.

Column E : The number of accidents that occurred in 1986 (the product of Columns A & D).

Column F : The Least Squares E1 Raw Estimate as calculated in Table 12.

Column G: The Least Squares Raw Estimate applied to Column D; the 1986 intersections within respective frequency categories.

Column H : The Least Squares E1 Smoothed Estimate as calculated in Table 12.

Column I : The Least Squares Smoothed Estimate applied to Column D; the 1986 intersections within respective frequency categories.

Column J : The Linear Function E2 Estimate as calculated in Table 12.

Column K : The Linear Function Estimate applied to Column D; the 1986 intersections within respective frequency categories.

Column L : The number of countermesure intersections that existed in 1987.
(note there are only 53 intersections listed; the remaining intersection was found in frequency category 23).

Column M The number of accidents that occurred in 1987 (the product of Columns A & D).

Column N : The number of countermesure intersections that existed in 1988.
(note there are only 53 intersections listed; the remaining intersection was found in frequency category 30).

Column O : The number of accidents that occurred in 1988 (the product of Columns A & D).

Column P : The number of countermesure intersections that existed in 1989.

Column Q : The number of accidents that occurred in 1989 (the product of Columns A & D).

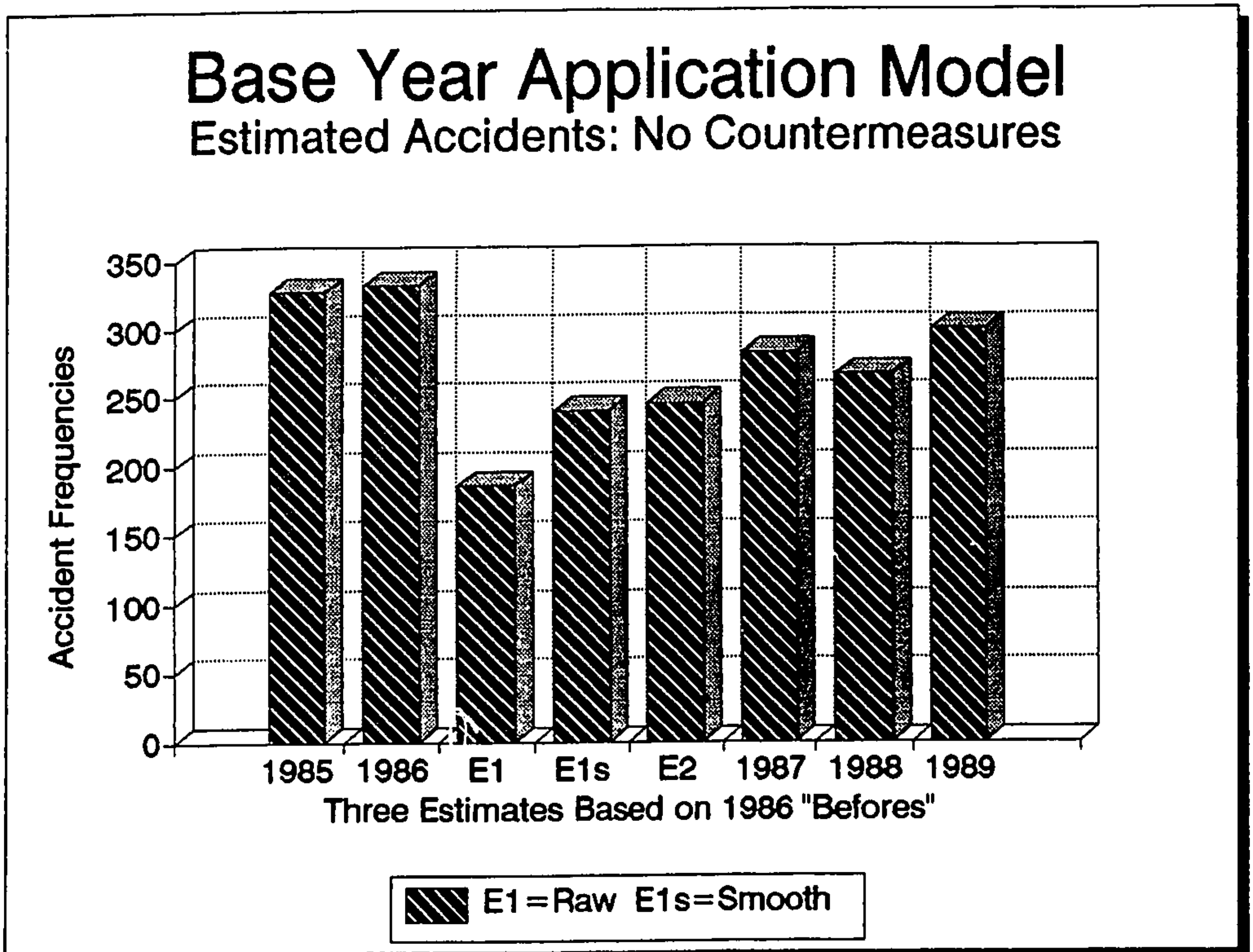

Base Year Application Model
Estimated Accidents: No Countermeasures
350
300
250
200
150
100
50
0
Accident Frequencies
1985
1986
E1
E1s
E2
1987
1988
1989
Three Estimates Based on 1986 "Befores"
E1=Raw E1s=Smooth

Figure 7

had been implemented. In 1986, there were 332 total accidents and in 1987, with safety countermeasures in place, the figure actually dropped to 282 total accidents.

5.451 Raw Least Squares Approach

The results of the Raw Least Squares Approach, on the whole, are discouraging. The estimate predicts that there would have been 186 traffic accidents in 1987 if no countermeasures had been implemented. However, the 1987 accident performance indicated 282 accidents. All things being equal, the countermeasure locations should have experienced less accidents than the estimated 186 accidents predicted to occur if no countermeasures had been put into place.

According to the overall statistics, the Least Squares Approach is suggesting a number of conclusions: first, the allocation of the safety countermeasures failed miserably and may have actually created more accidents than predicted if nothing had been done whatsoever, or, second, the estimate is a failure and may not be relied upon. On the other hand, the estimates may well be correct, and the countermeasures may have also prevented several accidents from occurring if one were to assume that other factors such as an increase in traffic volume or a change in intersection configuration were to have taken place to alter the expected mean number of accidents at some of the particular locations. Unfortunately, there is no conclusive evidence that may lead one to accept any of these conclusions.

There are a number of instances where the Raw E1 predicted values seem logical at various levels of annual accident frequencies per location. For example, for the level of 2 annual accidents per location, the 1986 value was 22 accidents, the predicted value was 19.5 and the actual 1987 figure was 18. Similarly, for the level of 5 annual accidents per location, the 1986 value was 30 accidents; the predicted level was 22.5 and the actual 1987 performance was only 5 total annual accidents. These results are what one would logically expect: the predicted accident figures are expected to be lower than 1986 because of the effect of the "regression to the mean". Likewise, it is logical that the 1987 accident performance with countermeasures will be lower than the predicted estimates because the estimates are based on what would have happened with no countermeasures. In essence, the conservative nature of the estimates reduce the effective impact of the safety countermeasures statistically (as opposed to using the previous year as the benchmark) by reducing the gap between the "before-and-after" accident frequency variance.

There are also several differences between the Raw E1 estimates and 1987 performance for the various levels of accident frequencies that should not go unnoticed. For example, for the level of 3 annual accidents per location, the 1986 performance indicates 18 accidents; the predicted value indicates 12.3 accidents and the 1987 experience was 24 accidents. Another example, for the level of 15 annual accidents per location, indicates that in 1986 there were 15 accidents; the predicted value was 32.0 accidents and the actual 1987 value was 15 accidents. The situation becomes more temperamental with the introduction of "zero accidents" in the base 1986 accident frequencies. Invariably, there will be zero accidents for particular annual accident levels in 1986 and the resulting prediction is also zero. However, in all instances several accidents occurred at these levels in the actual 1987 database.

5.452 Smoothed Least Squares Approach

The results of the Smoothed Least Squares Approach, on the other hand, are less discouraging than the raw estimates. As stated earlier, the smoothed estimates predict 240 overall accidents for 1987 if no counter measures had been implemented. This is substantially less than the 332 accidents experienced in 1986. However, in 1987 there were approximately 282 accidents at the various 54 countermeasure locations. Although the smoothed estimate is a substantially better fit than the raw estimate on the whole, it is still less than what actually happened in 1987.

Once again, it becomes strikingly evident that the countermeasure allocation may have failed miserably; or, the estimates are simply a failure and may not be relied upon; or, perhaps there are factors such as increased traffic volume, changes in street configurations or something else that had taken place and resulted in a change of the overall expected mean number of accidents.

A closer look at each of the particular smoothed estimates as they are applied to the individual accident frequency levels reveals a much more discouraging picture than just the overall summary. There is only one case where the estimate is close to the number of accidents that occurred in 1987. In the case of the accident frequency category of 3 accidents per location which exhibited 18 accidents in 1986, the smoothed estimate predicted 26 accidents for 1987. In 1987, there were 24 accidents at the same locations. The remaining categories, however, do not enjoy the same success. There are several cases where the estimates are extremely higher than what actually occurred in 1987 and there are equally as many cases were the estimates are extremely lower than what actually occurred in 1987.

For example, for the locations falling under the accident frequency categories of 1, 2, and 4, the 1986 figures were 4, 22 and 28, respectively. The smoothed predictions were 16.8, 47.1 and 31.1, respectively. The actual outcome in 1987 exhibited 7, 18 and 20, respectively. Similarly, for the accident frequency categories of 9, 10 and 11, the 1986 figures were 9, 10, and 0, respectively. The smoothed predictions were 4.8, 4.9 and 0, respectively. Meanwhile, the actual outcome in 1987 was 36, 10 and 11, respectively.

As in the case with the raw E1 estimates, the smoothed E1 estimates seem to become more volatile and less accurate with the introduction of 0's in the base cases as well as large fluctuations in between the various base case accident frequency categories. The individual cases are exceedingly inaccurate in both directions while leaving the overall figure seemingly accurate.

5.453 Least Squares Approach Summary

The first observation resulting from the application of the Raw and Smoothed Least Squares Estimate Model is that in a general, or in the analysis of the sum of the estimates, the countermeasure allocation seems to have failed miserably because the estimates are lower than what actually occurred in the period which was being predicted. This may indicate that the estimates are simply a failure and may not be relied upon; or, perhaps there are factors such as increased traffic volume, changes in street configurations or some other socio-geographic variable that has resulted in a change of the overall expected mean number of accidents.

In addition, the predictive capabilities of the Least Squares approaches are limited by the introduction of zero's into the base year figures of the application model. The estimated results preceding and following the base year annual accident category recorded as zero tends to be significantly higher or lower than the actual results experienced in the following year. There is no pattern to the variance in the estimates between the base year and the following year in this respect. The weakness of the model extends to situations where both previous year and the estimated results are zero but the following, or, "after" year actually produces accident figures.

These predictive problems with the model are related to another common factor: large fluctuations in the number of accidents between adjacent accident frequency categories in the base year. There is no apparent pattern to the problem. In some cases there will be a high base year figure followed by a relatively high prediction, only to be completed by a low actual figure in the following year and vice versa. The most apparent solution is to increase the database size and, perhaps, structure, in order to eliminate the occurrences of zero and, or large deviations in the adjacent base year annual accident frequency categories. The other solution is to apply another model, such as the Linear Function method of estimation.

5.46 Application of the Linear Function Estimates

The results of the application of the Linear Function Estimates are also summarized in Table 13 and Figure 7: Base Year Application Model - "Before-and-After" Accident Analysis. The results are identified in column I: "E2 Estimate of Expected '87 Accidents". The Linear Function Estimate, E2, computes a total of 246 annual accident frequencies in 1987 at the newly signalized locations if no countermeasures had been implemented. As previously described, there were 332 total annual accidents in 1986 and the figure dropped to 282 total annual accidents in 1987. These results, on the whole are similar to the smoothed E1 estimates such that the estimates are more conservative than the previous year but they are also lower than the actual outcome in the following year.

Ultimately the desired result would been estimates that were lower than the previous year but slightly higher than the following year, thereby illustrating the success of the countermeasures. This not being the case may lead one to a similar conclusion found in the Raw and Smoothed Least Squares Approach. This was the observation that, in general, the countermeasure allocation seems to have failed miserably because the estimates are lower than what actually occurred in the period which was being predicted. This may indicate that the estimates are simply a failure and may not be relied upon; or, perhaps the data requires standardization in terms of increased traffic volume; changes in street configurations; or, some other socio-geographic variable that has resulted in a change of the overall expected mean number of accidents. Perhaps, more simply, the answer may be that the estimates were calculated, based on an atypical year: 1987.

While all the E2 estimates are lower than the 1986 base figures, there are only nine cases where the Linear Function estimates are higher than the 1987 actual outcome. For example, according to the calculations in Table 13, the categories of 2, 4, and 8 accident frequencies (with values of 22, 28 and 32 in 1986), the predicted values were 20.0, 22.1 and 23.2, respectively. The actual results in 1987 were 18, 20 and 8, respectively. Similar trends hold true for the categories of 12, 13, 14, 17 and 20 annual accident frequencies per location, as well.

The remainder of the predictions at the various annual accident levels were substantially lower than the 1987 actual outcome. For example, accident frequency category 3 exhibited a total of 18 accidents in 1986, only 14.8 were predicted and in 1987 24 actually occurred. Similar discrepancies arose for the categories of 6, 7, 10, 11, 15, 16, 18, 19, 21, and 22 annual accident frequencies. It is interesting to note that in the majority of these cases, the base year (1986) accident frequencies either contained a 0 or a large jump in the number of accidents, either upwards or downwards, between adjacent accident frequencies.

5.461 Linear Function Approach Summary

The extreme variations between the Linear Function estimates and the actual 1987 results are difficult to interpret. However, the problems are very similar to those encountered in the Raw and Smoothed Least Squares Estimate approach.

The predictive capabilities of both models seem to be limited by the introduction of zero's into the base year figures of the application model. The calculated estimates for adjacent accident frequency categories to the "0" category tends to be significantly higher or lower than the actual results experienced in the following year. The model's also share an additional weakness regarding the large fluctuations in the number of accidents between adjacent accident frequency categories in the base year. Any such fluctuations lead to wide discrepancies between the predicted values and the subsequent actual occurrences.

In addition, both the E1 and E2 approaches encountered the general problem that the allocation of the countermeasures seems to have failed because the estimates are lower than what actually occurred in the period which was being predicted. This may indicate that the estimates are simply a failure and may not be relied upon; or, perhaps there are factors such as increased traffic volume, changes in street configurations or some other socio-geographic variable that has resulted in a change of the overall expected mean number of accidents.

A brief overview regarding the individual history and subsequent rationale for the countermeasure implementation helps explain the latter variances to some extent. There were two locations of the 54 that were signless before having traffic signals introduced by the Region in 1986 (Frobisher/Riverside, Carling/DRE). There were an additional 4 locations in the Riverside/Altavista/Hwy 417 vicinity that received temporary and re-located permanent traffic signals in 1986 for the major road re-alignment project that was conducted during 1986-87. Similarly, there was major OC Transitway work under way at a location in the St. Laurent/Tremblay area leading to temporary traffic signal implementations. Similar road re-configuration led to the introduction of traffic signals at 4 intersections in the Bayshore area. An additional 9 locations throughout the Region received replacement traffic signals following major road re-alignment projects.

These types of projects, in conjunction with the introduction of new land use systems, affect the traffic generated at various locations throughout the Region. The subsequent changes in traffic flow and volume irrevocably altered the mean number of accidents in the Region from one year to the next. Therefore, it was be no surprise that the predictive quality of the estimates may be questioned. Perhaps a study alternative would be to remove such extraordinary cases from the exercise before applying the models, but, unfortunately, if all extraordinary cases were taken from the data base, there would be very little data left to measure and from which to draw conclusions.

The next section consists of an attempt to measure the significance of the application of the estimates in comparison to the 1987 outcome through regression analysis.

5.47 Regression Analysis - Least Squares and Linear Functions

The Least Squares and Linear Function Estimates were evaluated in terms of their ability to predict the actual 1987 accident frequency performance by application of a standard regression analysis model. Although, the two estimates were not intended to predict the actual 1987 accident frequencies, they were expected to estimate the number of accidents at the countermeasure locations if the safety enhancements had not been implemented. The accident estimates were expected to be more conservative than the 1986 figures (regression to the mean effect) and slightly higher than the 1987 figures (safety countermeasure effect). Therefore, it should be expected that the estimates are closely related to the 1987 actual outcome. This relationship may be measured, in terms of significance, by the application of regression analysis to test the strength of the predictions.

In the regression analysis, the dependent variable is represented by the 1987 actual accident performance. The independent variables are the 1986 actual figures and the two estimates of the 1987 "before-and-after" locations if no countermeasure had been implemented. The regression analysis was conducted for two different data sets: the Countermeasure Locations were tested exclusively (results illustrated by Table 14), and, both the Stop Sign and Countermeasure Locations were tested as a whole (results illustrated by Table 15).

The two regression analysis exercises were conducted based on two different data summary formats. The first format consisted of the Accident Frequency Categories summarized in ascending order starting 0,1,2,3, through to 22 (represented by left hand side of the Table). The second format consisted of the Accident Frequency Categories summarized in ascending order starting 0,1,2,3 through 10 and followed by a final category of Greater than 10 (represented by the right hand side of the Table). This step was taken in order to aggregate some of the data which contained a high degree of zeros in various annual accident categories.

5.48 Regression Analysis: Countermeasure Locations

The regression analysis results for the Countermeasure Location "before-and-after" analysis are summarized in Table 14. It represents the results of the regression analysis with the application of 1986 actual accidents, Least Squares and Linear Function Estimated accidents to the actual 1987 accident results. The left side of the Table represents the annual accident categories broken down 0 through 22 while the right side of Table 14 represents the annual accident frequencies categorized 0 through 10 and a final category >10.

The regression output for the "Frequencies 0 through 22" section are highlighted by the R-Squared and the X-Coefficient. The tests were conducted beginning with 1986 actual accidents compared to 1987 actual accidents. This resulted in a R-Squared of 0.102418 and an X-Coefficient of -0.24541. The results were neither significant nor encouraging with regards to the existence of a linear relationship between the two variables.

The Raw Least Squares, or 1987 estimate without countermeasures (E1) was compared to the 1987 actual accidents and the R-Squared dropped to 0.000238 and the X-Coefficient dropped to 0.015. Once again, the results were very discouraging: very little evidence of a linear relationship between the variables. The relationship between the estimate and the 1987 results may be sufficiently nonlinear to produce the zero correlation.

The Smoothed Least Squares estimate (E1A) was compared to the 1987 actual accidents and the R-Squared improved marginally to 0.001043 and the X-Coefficient rose to 0.025213. These results were not exactly overwhelming but they were an improvement over the simple Raw Least Squares estimates.

The Linear Function, or 1987 estimate without countermeasure (E2) was compared to the 1987 actual accidents. The results were an R-Squared of 0.077419 and an X-Coefficient of -0.29157. The results were hardly significant, however, the Linear Function estimate seemed to exhibit a stronger relationship, between the 1987 actual accidents, than both the Raw and Smoothed Least Squares

Table 14
Regression Analysis: Countermeasure Locations
Least Squares and Linear Function Estimates

Dependent Variable = Y = 1987
Independent Variables = X = 1986, E1, E1A and E2

Annual Accident Frequency Categories:
Frequencies 1 through 22.

'86-'87	Regression Output:	
Constant		16.04201
Std Err of Y Est		9.268241
R Squared		0.102418
No. of Observations		23
Degrees of Freedom		21
X Coefficient(s)	-0.24541	
Std Err of Coef.	0.158536	

E1-'87	Regression Output:	
Constant		12.35802
Std Err of Y Est		9.781566
R Squared		0.000238
No. of Observations		23
Degrees of Freedom		21
X Coefficient(s)	0.015	
Std Err of Coef.	0.211953	

E1A -'87	Regression Output:	
Constant		12.21183
Std Err of Y Est		9.777631
R Squared		0.001043
No. of Observations		23
Degrees of Freedom		21
X Coefficient(s)	0.025213	
Std Err of Coef.	0.170282	

E2-'87	Regression Output:	
Constant		15.60647
Std Err of Y Est		9.396422
R Squared		0.077419
No. of Observations		23
Degrees of Freedom		21
X Coefficient(s)	-0.29157	
Std Err of Coef.	0.219644	

Annual Accident Frequency Categories:
Frequencies 1 through >10

'86-'87	Regression Output:	
Constant		6.245998
Std Err of Y Est		12.52956
R Squared		0.862277
No. of Observations		12
Degrees of Freedom		10
X Coefficient(s)	0.634874	
Std Err of Coef.	0.080236	

E1-'87	Regression Output:	
Constant		2.651646
Std Err of Y Est		13.878
R Squared		0.831038
No. of Observations		12
Degrees of Freedom		10
X Coefficient(s)	1.384141	
Std Err of Coef.	0.197363	

E1A-'87	Regression Output:	
Constant		2.005803
Std Err of Y Est		26.21264
R Squared		0.397221
No. of Observations		12
Degrees of Freedom		10
X Coefficient(s)	1.081795	
Std Err of Coef.	0.421413	

E2-'87	Regression Output:	
Constant		5.152207
Std Err of Y Est		13.04886
R Squared		0.850624
No. of Observations		12
Degrees of Freedom		10
X Coefficient(s)	0.91252	
Std Err of Coef.	0.120925	

estimate.

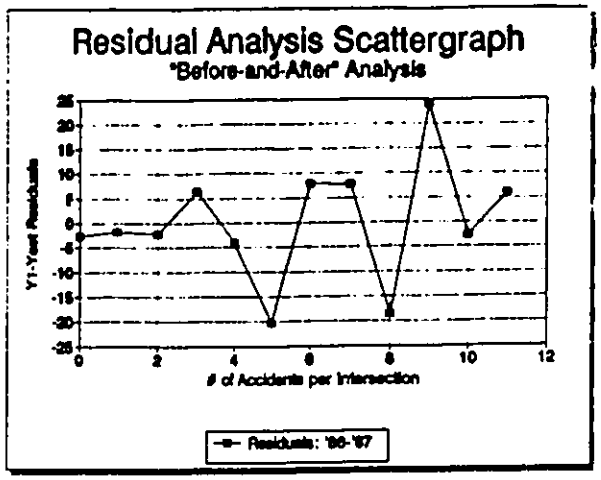
The regression analysis was next applied to a collapsed set of data: the "Frequencies 0 through 10 and the category >10". The data was aggregated in this manner because there was not enough representative data for all the categories, particularly between 11 to 20 accident frequencies. Once again, the test was conducted beginning with the 1986 actual accidents compared to the 1987 actual accidents. This resulted in an R-Squared of 0.862277 and an X-Coefficient of 0.634874. These results were much more encouraging with a high significance factor and a movement of the X-Coefficient towards unity.

The Raw Least Squares, or 1987 estimate without countermeasures (E1) was compared to the 1987 actual accidents and the R-Squared was 0.831038 which was accompanied by the X-Coefficient of 1.384141. The results indicate evidence of a strong relationship between the Least Squares estimate and the 1987 actual annual accidents.

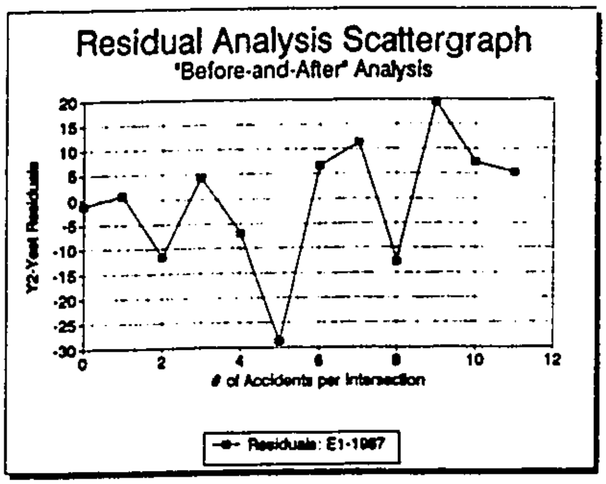
The Smoothed Least Squares estimate (E1A) in the collapsed format was also compared to the 1987 actual accidents. According to Table 14 the R-Squared actually dropped to 0.397221 followed by a corresponding X-Coefficient of 1.081795. It is suspected that the drop in the strength of the relationship between the smoothed estimates and the 1987 results may be a result of the large variances found in the majority of the accident frequency categories between 10 and 22. The smoothing effect results in larger variances between the relatively low estimates and the much higher accident rates found with locations that have 10 annual accidents or more.

The Linear Function, or 1987 estimate without countermeasures (E2) was compared to the 1987 actual accidents. The R-Squared was 0.850624 and the X-Coefficient was 0.91252. Once again, there is evidence of a stronger relationship between the Linear Function estimate and the 1987 actual figures. In fact, the relationship is, once again, stronger than that of the Raw and Smoothed Least Squares estimates, based on the results of the R-Squared and X

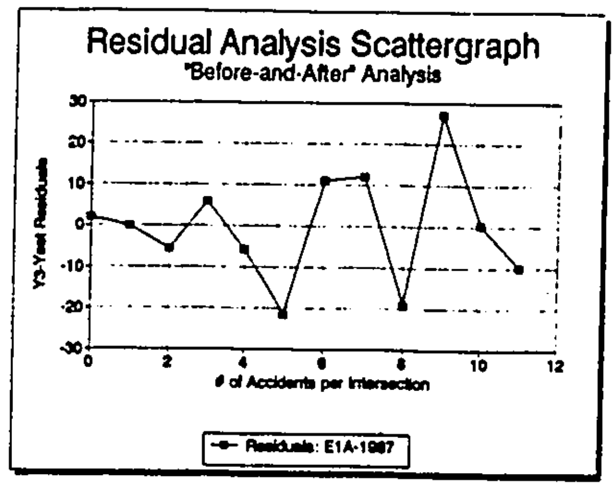
Figure 8



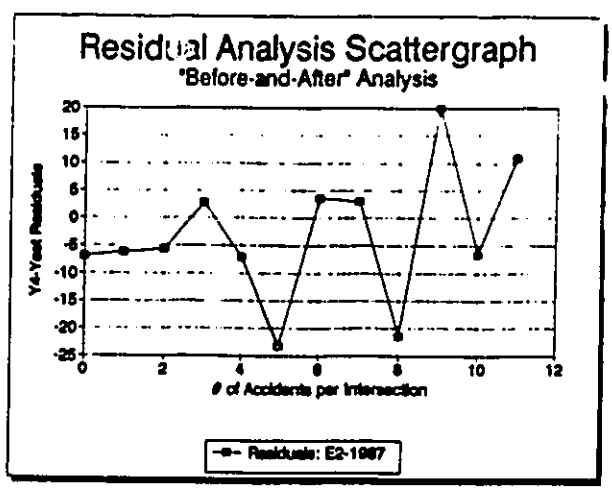
Residual Analysis Scattergraph
"Before-and-After" Analysis
Y1-Yest Residuals
# of Accidents per Intersection
Residuals: '86-'87



Residual Analysis Scattergraph
"Before-and-After" Analysis
Y2-Yest Residuals
# of Accidents per Intersection
Residuals: E1-1987



Residual Analysis Scattergraph
"Before-and-After" Analysis
Y3-Yest Residuals
# of Accidents per Intersection
Residuals: E1A-1987



Residual Analysis Scattergraph
"Before-and-After" Analysis
Y4-Yest Residuals
# of Accidents per Intersection
Residuals: E2-1987

-Coefficient measures.

It should be noted, however, that the results of the application of the regression analysis of the E1, E1A and E2 estimates to the "Frequencies 0 through 10 and >10" are suspected of autocorrelation. The residuals taken from the difference between the "Y Variable" and the "Y Estimate" were plotted in a scattergraph shown in Figure 8. Normally, the residuals are expected to be randomly distributed throughout the length of the analysis. However, in the cases of the Raw Least Squares (E1), the Smoothed Least Squares (E1A), and the Linear Function (E2) estimates, the distribution of the residuals indicate a definite cyclical trend consisting of two cycles. This evidence tends to point towards autocorrelation which means that the confidence level in the strength of the linear relationship between the variables is low. Further evidence contributing to the cyclical nature of the residual analysis may be provided through the application of the Durbin-Watson test for significance, however, it was felt the exercise would be redundant considering the graphical results.

5.49 Regression Analysis: Stop Sign and Countermeasure Locations

The regression analysis results for the Stop Sign and Countermeasure Location analysis are summarized in Table 15. The accident frequencies for the two types of locations were combined for the 1986 and 1987 databases. The Least Squares and Linear Function models were applied to the new 1986 database in order to calculate a new set of estimates for the stop sign and countermeasure locations as a whole. The results were also put through the regression analysis in attempt to identify an improvement in the significance level of the estimates with the use of a larger database.

Table 15 illustrates the results of the regression analysis with the application of 1986 actual accidents, the Raw and Smoothed Least Squares and Linear Function Estimated accidents to the actual 1987 accident results. The left side of the Table represents the annual accident categories broken down 0 through 22 while the right

Table 15

Regression Analysis: Stop Sign and Countermeasure Locations

Least Squares and Linear Function Estimates

Dependent Variable = Y = 1987

Independent Variables = X = 1986, C1, C2

Annual Accident Frequency Categories:
Frequencies 1 through 22

'86-'87	Regression Output:	
Constant		-16.5346
Std Err of Y Est		143.847
R Squared		0.697343
No. of Observations		23
Degrees of Freedom		21
X Coefficient(s)	1.123633	
Std Err of Coef.	0.161535	

E1-'87	Regression Output:	
Constant		78.05458
Std Err of Y Est		244.8469
R Squared		0.123124
No. of Observations		23
Degrees of Freedom		21
X Coefficient(s)	0.740375	
Std Err of Coef.	0.431161	

E1A-'87	Regression Output:	
Constant		101.1401
Std Err of Y Est		244.7863
R Squared		0.123558
No. of Observations		23
Degrees of Freedom		21
X Coefficient(s)	0.14848	
Std Err of Coef.	0.086295	

E2-'87	Regression Output:	
Constant		36.30527
Std Err of Y Est		203.4944
R Squared		0.394305
No. of Observations		23
Degrees of Freedom		21
X Coefficient(s)	0.884933	
Std Err of Coef.	0.239338	

Annual Accident Frequency Categories:
Frequencies 1 through >10

'86-'87	Regression Output:	
Constant		-52.6403
Std Err of Y Est		206.5758
R Squared		0.611985
No. of Observations		12
Degrees of Freedom		10
X Coefficient(s)	1.205359	
Std Err of Coef.	0.303508	

E1-'87	Regression Output:	
Constant		224.2037
Std Err of Y Est		330.0411
R Squared		0.009565
No. of Observations		12
Degrees of Freedom		10
X Coefficient(s)	0.222883	
Std Err of Coef.	0.717209	

E1A-'87	Regression Output:	
Constant		220.9697
Std Err of Y Est		324.0525
R Squared		0.045182
No. of Observations		12
Degrees of Freedom		10
X Coefficient(s)	0.084038	
Std Err of Coef.	0.122167	

E2-'87	Regression Output:	
Constant		101.2782
Std Err of Y Est		288.9891
R Squared		0.240631
No. of Observations		12
Degrees of Freedom		10
X Coefficient(s)	0.734751	
Std Err of Coef.	0.412754	

side of the Table represents the annual accident frequencies categorized 0 through 10 and a final category >10.

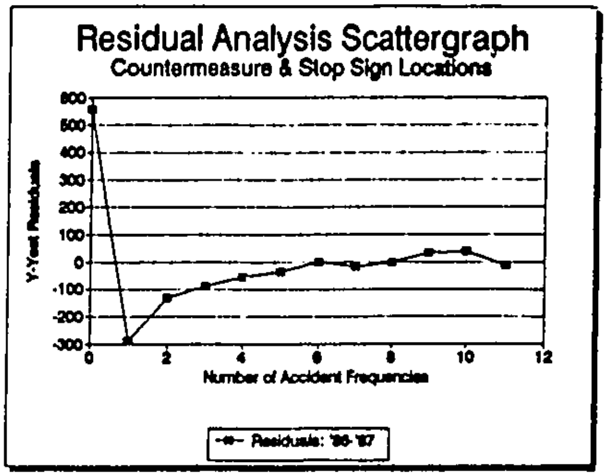
The regression output for the "Frequencies 0 through 22" section are highlighted by the R-Squared and the X-Coefficient. The tests were conducted beginning with 1986 actual accidents compared to 1987 actual accidents. This resulted in a R-Squared of 0.697343 and an X-Coefficient of 1.123633. The results were much more significant and encouraging than the analysis with disaggregated (ie. categories 11 through 22 were not collapsed into one) countermeasure locations alone, with regards to the existence of a linear relationship between the two variables.

The Raw Least Squares, or 1987 estimate without countermeasures (E1) was compared to the 1987 actual accidents and the R-Squared dropped to 0.123124 and the X-Coefficient jumped to 0.740375. Once again, the results were very encouraging: a stronger linear relationship seems to exist between the variables in the case of the combined stop sign and countermeasure locations as opposed to the countermeasure locations exclusively.

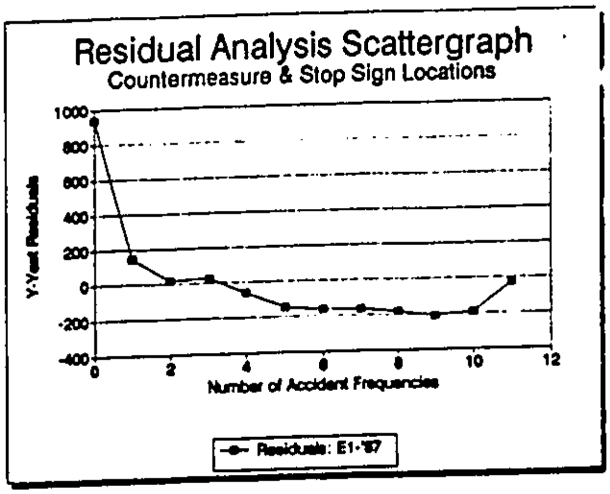
The Smoothed Least Squares estimate (E1A) was also calculated with a vast improvement over the exclusive countermeasure application. The R-Squared resulted in 0.123558 and the X-Coefficient was 0.14848. The results were much better than the same analysis conducted on the countermeasure locations alone. However, the results were weaker than the relationship between the Raw Least Squares estimate and the 1987 accident frequencies for the combined stop sign and countermeasure locations.

The Linear Function, or 1987 estimate without countermeasure (E2) was compared to the 1987 actual accidents. The results were an R-Squared of 0.394305 and an X-Coefficient of 0.884933. The results of the relationship between the LInear Function Estimates and the 1987 figures were, once again, more significant than the Raw and Smoothed Least Squares estimates. These results tend to indicate that the Linear Function Estimates are the stronger of the three measures, both in terms of exclusive application to the countermeasures alone and in application to stop sign and

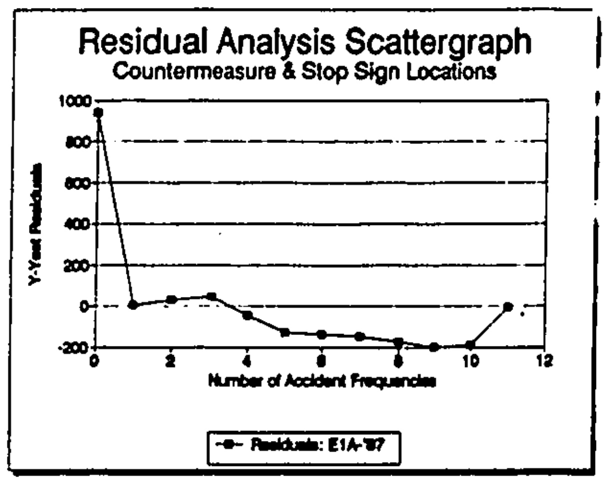
Figure 9



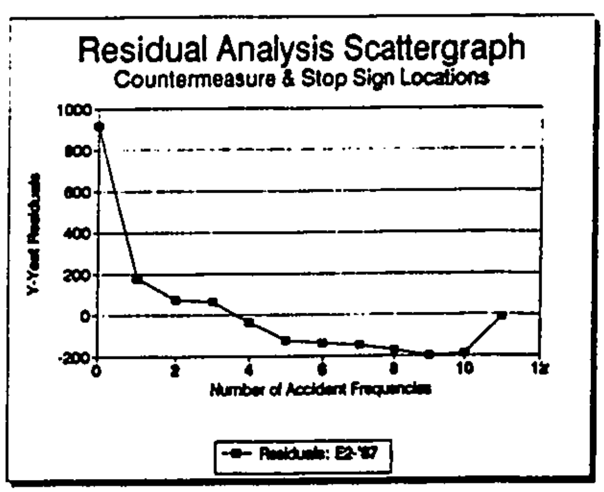
Residual Analysis Scattergraph
Countermeasure & Stop Sign Locations
Y-Year Residuals
Number of Accident Frequencies
Residuals: '86-'87



Residual Analysis Scattergraph
Countermeasure & Stop Sign Locations
Y-Year Residuals
Number of Accident Frequencies
Residuals: E1-'87



Residual Analysis Scattergraph
Countermeasure & Stop Sign Locations
Y-Year Residuals
Number of Accident Frequencies
Residuals: E1A-'87



Residual Analysis Scattergraph
Countermeasure & Stop Sign Locations
Y-Year Residuals
Number of Accident Frequencies
Residuals: E2-'87

It should be noted, once again, that the results of the application of the regression analysis of both the E1, E1A and E2 estimates are suspected to have some degree of autocorrelation. The residuals taken from the difference between the "Y Variable" and the "Y Estimate" were plotted in a scattergraph shown in Figure 9. Normally, the residuals are expected to be randomly distributed throughout the length of the analysis. However, in the cases of the Raw Least Squares (E1), the Smoothed Least Squares (E1A), and the Linear Function (E2) estimates, the distribution of the residuals indicate a definite cyclical trend consisting of one cycle. This evidence tends to point towards autocorrelation which means that the confidence level in the strength of the linear relationship between the variables is low.

The simple regression analysis applied to the countermeasure locations seems to be inappropriate for the existing data. The evidence of autocorrelation may be the result of a number of situations: insufficient data; non-linear relationships; and the absence of additional multiple variables that may explain the relationship more succinctly. In order to test for these conditions more information is required.

5.50 Probabilistic Approach Summary

In summary, the Raw and Smoothed Least Squares and Linear Function Estimates proved difficult with respect to the amount of data required in accident databases; with respect to the method in which they are calculated; and with respect to the method in which they are interpreted. In addition, there is some question as to the application of a meaningful test of significance for the final results.

The Raw Least Squares Estimate, in this study, provided a very conservative prediction of the number of accidents that would be expected to occur if no countermeasure had been implemented. The Raw, Smoothed Least Squares, and Linear Function Estimates predicted accidents that were significantly less or somewhat close to the number of accidents that actually occurred in 1987. This led to some questions as to whether or not the allocation of the countermeasures failed miserably, or if the estimates were simply invalid, altogether. This conclusion also sparked the need for some sort of standardization technique that should correct the bias arising from a change in the general accident mean during the year in which the countermeasures were implemented. That is to say that most sites may require individual attention in order to determine significant changes in traffic flow and volume as a result of any number of socio-geographic features in the environment. The measures, in their current existence, do not presently account for the impact from such variables.

In addition, there were significant variances between the estimated and the actual figures, especially as one moved upward along the scale of the annual accident frequency categories (9,10,11 accidents per location). This seemed to coincide with the fact that the predictive power of each of the estimates was hampered when the calculations that involved zeros in the base year. This led to substantial variations in the estimate from one level of accident frequency to the next. The conservative nature of the estimates and the lack of predictive consistency failed to extinguish all doubt towards the reliability of the estimates as a whole.

The Linear Function Estimate was the stronger measure of the three. The initial calculations were much easier to calculate then the previous two measures and the overall estimate was below 1986 levels and was also lower than the 1987 levels. However, the gap between the estimated number of accidents expected to happen if no countermeasure was implemented and the number of accidents that occurred following the countermeasure implementation, was very small. Once again, this seemed to indicate that the countermeasures failed to reduce the number of accidents significantly, or the estimates simply were not measuring the change in the mean number of accidents during the immediate period.

An attempt was made to measure the significance or power of each of the estimates. Unfortunately, the regression analysis was not as helpful as anticipated. The initial application of the regression test to the Countermeasure Locations with the full number of frequency categories between 0 and 22 resulted in very low significance levels. In this application, both of the Least Squares estimates were weaker than the Linear Function Estimate in terms of the R-Squared and the X-Coefficient. In addition, the residuals were plotted for each case as a preliminary indication for autocorrelation and, unfortunately, what should have been a random patterns were identified as a clearly defined cyclical trends.

The regression analysis was also applied in a similar fashion on the frequency categories 1 through 10 and greater than 10 in hopes of improving the results. The measures of significance were actually worse. However, this may be a result of the fact that the number of "0" category accident locations were estimated roughly in 1986 by RMOC. This estimate is feared to be underestimated and this may be the cause of peculiar results when the stop sign and countermeasure locations were combined. There was also a suggestion of autocorrelation at this end of the analysis and, once again, and the suspicions were verified by the plotting of residuals on scattergraphs.

Finally, the regression analysis also illustrates that the 1986 and 1987 data exhibits a stronger relationship than either of the estimates and 1987. This may be just by chance of atypical years, however, the results are significant.

Chapter 6
Supplementary Data Analysis

6.10 Supplementary Data Analysis - Outline

The core data analysis, in this research paper, has been focused on the evaluation of traffic signal implementation throughout the Regional Municipality of Ottawa-Carleton in 1986. The evaluation has strictly concentrated on the distribution of accident frequencies and estimates from one year to the next. The Traditional analysis dealt with the "Before-and-After" annual accident frequencies as well as a "Standardized" countermeasure analysis based on changes in traffic volume. The Probabilistic analysis dealt with the calculation and application of estimated annual traffic accident estimates that were to act as a more appropriate "evaluation benchmark" than simply using the previous years' accident performance.

The results of the aforementioned analysis were enlightening in terms of highlighting the pattern and distribution of traffic accidents "Before-and-After" safety countermeasure implementation, however, the two different methods exhibited certain weaknesses and did not consider the multiple components that may be involved in the circumstances preceding and following the road traffic accident. As mentioned in the opening chapter, these components are comprised of a variety of variables, geographic in nature, derived by the movement of vehicles as determined by land use systems, residential patterns, street geometries, population densities, location of workplace, shopping centres and other generators of traffic.

In effort to complement the preceding analysis, this Supplementary Analysis chapter is designed to study the relationships of the multiple components with traffic accidents. The emphasis taken in this chapter is twofold. The first section is comprised of an Alternative Variable Frequency Analysis of components chosen by RMOC that are associated with the circumstances prior to and following the traffic accident. The second section is comprised of an analysis of the accident performance at locations that are "With-and-Without" traffic control signals, in effort to appraise the allocation of traffic signals in 1986. The appraisal stage is comprised of a discussion concerning the justification of the "Before-and-After" traffic signal allocations. This is accomplished through the study of the spatial factors influencing traffic volume and patterns in close proximity to the "Before-and-After" locations in question.

6.20 Alternative Variable Frequency Analysis

The Alternative Variable Frequency Analysis section is comprised of a traditional description of various components of the accident frequencies from on year to the next. The data is taken from aforementioned 54 locations that were appointed traffic signal control devices in 1986. The Alternative Variable components, not all geographic in nature, include: Impact in Daylight/Darkness; Impact on Dry/Wet and Icy Roads; Impact during Peak/Non-Peak Travelling Hours; the number of Pedestrian Injuries resulting from the Impact; the number of Total Injuries resulting from the Impact; and, finally, the various Directional Movements of the Vehicles Prior to Impact.

Each of these components are discussed separately in the following subsections and the data is summarized in Table 16 and Figure 10. The Table contains annual accident frequency categories ranging between 0 and 5 as well as a category of annual accident frequencies greater than 5. The locations included in the study are the previously mentioned 54 countermeasure locations that received traffic signals in 1986. The annual accident frequencies are illustrated for each of the locations between 1985 and 1989.

The accident frequencies for each of the categories have not been standardized by traffic volume to create accident rates. It is understood that a degree of accuracy is subsequently lost, however, it was felt that the interpretation of accident rates would be far more difficult than dealing with the raw frequencies, exclusively. The reason why the "accident rates" would be difficult to interpret is related to the small amount of representative data available for the various categories. This is directly related to the small size of the 54 case data set. The resulting "accident rates" fall between a range of 0 and 2, accidents per million entering vehicles, on average, when using the RMOC standardization equation listed in Section 3.31 of Chapter 3. For example, the range for accident rates in the Darkness/Daylight Hours category fall between 0 and 1.25 while the range for the Pedestrian Injury category falls between 0 and .50.

This is a very small range over which the rates are distributed and, hence, it becomes difficult to visualize what a rate of change of 0.50 to 0.25 accidents per million entering vehicles, represents over the span of a year. In addition, a large number of accident records fall into the category of "zero" occurrences per million entering vehicles for many of the Alternate Variable categories. That is to say that a substantial number of accidents in RMOC occur, for example, during daylight hours, under dry pavement conditions and at off-peak hours. Therefore, many of the "accident rates" are found clustered at the lower end of the scale and are often difficult to identify using simple data frequency analysis.

The analysis of the raw accident frequencies, on the other hand, offers a more immediate indication of the change in the distribution of accidents for a particular category. Naturally, significant swings in the traffic volume experienced from one year to the next must be considered in the analysis. However, in the case of the Regional Municipality of Ottawa-Carleton, the overall traffic volume change between 1986 and 1987 for the 54 locations in question was an increase of 3%; between 1987 and 1988 it was less than 1%; and between 1988 and 1989 there was a decrease of the volume by 3%. In terms of absolute figures, the 3% represents approximately 25,000 additional miles over the 900,000 annual average miles for the 54 intersections in 1986.

According to the intersection matrix in Appendix 4, the locations experiencing the greatest swings in traffic volume between 1986 and 1989 (>5,000 annual average volume variance) include Alta Vista Drive/Industrial Road; Vanier Parkway/Hwy 417 Interchange; St. Laurent Blvd./Hwy 417 Interchange; Hunt Club Road Locations; Bells Corners Strip Locations; Bayshore Shopping Centre and the Kanata Eagleson Road strip locations. These figures should be considered throughout the following Alternate Variable Frequency Analysis.

6.21 Accident Frequencies: Daylight/Darkness

Less than half of the total number of countermeasure locations exhibited accidents during daylight hours. Approximately 63% of the countermeasure locations experienced accidents during hours of darkness in 1985. This figure dropped to 57% in 1986 and to 54% in 1987. However, in 1988 and 1989, the distribution of accidents occurring in darkness, rose to 57% and 69% of the total accidents, respectively.

The distribution of the number of accidents that occurred during darkness varied significantly over the given study period. According to Table 16, the total number of accidents for the countermeasure locations was 85 in 1985. This figure was 84 in 1986 as the countermeasures were implemented randomly throughout the year. The number of accidents fell to 79 in 1987, thereby identifying the positive impact of the countermeasure implementation. The annual accident frequencies continued to fall in 1988 to 68 accidents, but in 1989 the figure rose to 71.

It is suspected, however, that the countermeasures alone are not the cause of the accident reduction during darkness. There were likely additional site improvements made at the various countermeasure locations contributing to the increased safety for traffic flow. For example, it is suspected that the lighting arrangements at the highway interchange locations were up-graded at the same time of the traffic signal allocations. Likewise, similar up-grades may have been implemented along the Eagleson Road area in Kanata and residential development began to flourish and similarly along March Road/Carling as the Kanata Business Park

Table 16 - Alternative Variable Analysis

"Before-and-After" Analysis
Accident Frequencies: Daylight/Darkness

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	20	0	23	0	25	0	23	0	17	0
1	16	16	8	8	14	14	15	15	23	23
2	7	14	10	20	6	12	6	12	7	14
3	5	15	3	9		0	4	12	4	12
4	2	8	7	28	2	8	3	12		0
5		0	1	5	2	10	1	5	1	5
>5	4	32	2	14	5	35	2	12	2	17
Total	54	85	54	84	54	79	54	68	54	71

"Before-and-After" Analysis
Accident Frequencies: Dry/Wet and Icy Conditions

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	6	0	11	0	19	0	15	0	15	0
1	15	15	17	17	11	11	10	10	14	14
2	9	18	9	18	7	14	10	20	6	12
3	8	24	4	12	5	15	9	27	7	21
4	1	4	4	16	4	16	4	16	4	16
5	2	10	1	5	0	0	1	5	2	10
>5	13	95	8	68	8	66	5	42	6	55
Total	54	166	54	136	54	122	54	120	54	128

"Before-and-After" Analysis
Accident Frequencies: Peak/Non-Peak Travelling Times

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	9	0	11	0	12	0	13	0	14	0
1	12	12	20	20	15	15	16	16	16	16
2	7	14	7	14	10	20	9	18	7	14
3	8	24	6	18	7	21	7	21	8	24
4	7	28	2	8	4	16	5	20	4	16
5	4	20	1	5	3	15	1	5	2	10
>5	7	57	7	51	3	24	3	24	3	21
Total	54	155	54	116	54	111	54	104	54	101

Table 16 - Alternative Variable Analysis (Continued)

"Before-and-After" Analysis
Accident Frequencies: Pedestrian Injuries

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	50	0	48	0	47	0	49	0	48	0
1	3	3	5	5	7	7	5	5	5	5
2	1	2	1	2	0	0	0	0	1	2
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
>5	0	0	0	0	0	0	0	0	0	0
Total	54	5	54	7	54	7	54	5	54	7

"Before-and-After" Analysis
Accident Frequencies: Total Injuries

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	19	0	14	0	16	0	19	0	13	0
1	8	8	12	12	10	10	10	10	13	13
2	7	14	9	18	9	18	12	24	12	24
3	7	21	6	18	8	24	7	21	8	24
4	5	20	7	28	0	0	2	8	4	16
5	2	10	1	5	3	15	1	5	1	5
>5	6	47	5	35	8	55	3	24	3	22
Total	54	120	54	116	54	122	54	92	54	104

"Before-and-After" Analysis
Accident Frequencies: Right Angle "NE" Impact

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	32	0	41	0	44	0	44	0	41	0
1	15	15	7	7	10	10	6	6	12	12
2	4	8	5	10	0	0	3	6	0	0
3	0	0	1	3	0	0	1	3	0	0
4	1	4	0	0	0	0	0	0	0	0
5	2	10	0	0	0	0	0	0	1	5
>5	0	0	0	0	0	0	0	0	0	0
Total	54	37	54	20	54	10	54	15	54	17

Table 16 - Alternative Variable Analysis (Continued)

"Before-and-After" Analysis
Accident Frequencies: Right Angled "SE" Impact

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	36	0	40	0	45	0	47	0	45	0
1	12	12	12	12	8	8	4	4	8	8
2	5	10	1	2	1	2	1	2	1	2
3	1	3	1	3	0	0	2	6	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
>5	0	0	0	0	0	0	0	0	0	0
Total	54	25	54	17	54	10	54	12	54	10

"Before-and-After" Analysis
Accident Frequencies: Right Angled "SW" Impact

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	33	0	33	0	42	0	45	0	42	0
1	10	10	16	16	10	10	6	6	9	9
2	5	10	3	6	2	4	3	6	3	6
3	5	15	1	3	0	0	0	0	0	0
4	1	4	0	0	0	0	0	0	0	0
5	0	0	1	5	0	0	0	0	0	0
>5	0	0	0	0	0	0	0	0	0	0
Total	54	39	54	30	54	14	54	12	54	15

"Before-and-After" Analysis
Accident Frequencies: Right Angled "WW" Impact

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	40	0	42	0	44	0	46	0	42	0
1	10	10	10	10	8	8	5	5	11	11
2	3	6	2	4	2	4	2	4	1	2
3	0	0	0	0	0	0	1	3	0	0
4	0	0	0	0	0	0	0	0	0	0
5	1	5	0	0	0	0	0	0	0	0
>5	0	0	0	0	0	0	0	0	0	0
Total	54	21	54	14	54	12	54	12	54	13

Table 16 - Alternative Variable Analysis (Continued)

"Before-and-After" Analysis
Accident Frequencies: Opposing Directions "NS" Impact

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	39	0	42	0	38	0	37	0	39	0
1	7	7	6	6	5	5	8	8	8	8
2	2	4	1	2	4	8	4	8	3	6
3	4	12	1	3	3	9	2	6	2	6
4	0	0	1	4	0	0	0	0	0	0
5	0	0	0	0	0	0	1	5	0	0
>5	2	16	3	23	4	33	2	19	2	13
Total	54	39	54	38	54	55	54	46	54	33

"Before-and-After" Analysis
Accident Frequencies: Opposing Directions "EW" Impact

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	34	0	31	0	37	0	35	0	33	0
1	12	12	11	11	7	7	9	9	11	11
2	1	2	4	8	2	4	3	6	5	10
3	2	6	2	6	3	9	4	12	1	3
4	0	0	2	8	2	8	0	0	1	4
5	3	15	1	5	1	5	2	10	0	0
>5	2	27	3	26	2	14	1	7	3	28
Total	54	62	54	64	54	47	54	44	54	56

"Before-and-After" Analysis
Accident Frequencies: Same Directions "NN" Impact

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	34	0	38	0	40	0	36	0	37	0
1	13	13	9	9	6	6	11	11	9	9
2	3	6	3	6	1	2	6	12	2	4
3	3	9	2	6	4	12	0	0	2	6
4	0	0	1	4	1	4	1	4	2	8
5	0	0	0	0	1	5	0	0	1	5
>5	1	9	1	6	1	6	0	0	1	6
Total	54	37	54	31	54	35	54	27	54	38

Table 16 - Alternative Variable Analysis (Continued)

"Before-and-After" Analysis
Accident Frequencies: Same Directions "EE" Impact

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	34	0	37	0	37	0	30	0	38	0
1	10	10	11	11	14	14	16	16	8	8
2	6	12	4	8	1	2	4	8	4	8
3	2	6	2	6	1	3	3	9	3	9
4	0	0	0	0	0	0	1	4	0	0
5	0	0	0	0	1	5	0	0	1	5
>5	2	12	0	0	0	0	0	0	0	0
Total	54	40	54	25	54	24	54	37	54	30

"Before-and-After" Analysis
Accident Frequencies: Same Directions "SS" Impact

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	35	0	35	0	40	0	34	0	40	0
1	8	8	10	10	10	10	13	13	9	9
2	3	6	3	6	1	2	3	6	2	4
3	4	12	2	6	1	3	1	3	1	3
4	1	4	3	12	0	0	1	4	0	0
5	2	10	0	0	0	0	1	5	0	0
>5	1	6	1	6	2	17	1	11	2	13
Total	54	46	54	40	54	32	54	42	54	29

"Before-and-After" Analysis
Accident Frequencies: Same Directions "W1W1" Impact

Accidents	1985		1986		1987		1988		1989	
per Location	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s	Locations	Freq.s
0	41	0	38	0	34	0	35	0	37	0
1	8	8	11	11	12	12	11	11	12	12
2	0	0	3	6	4	8	4	8	4	8
3	4	12	2	6	3	9	2	6	0	0
4	0	0	0	0	0	0	2	8	1	4
5	1	5	0	0	1	5	0	0	0	0
>5	0	0	0	0	0	0	0	0	0	0
Total	54	25	54	23	54	34	54	33	54	24

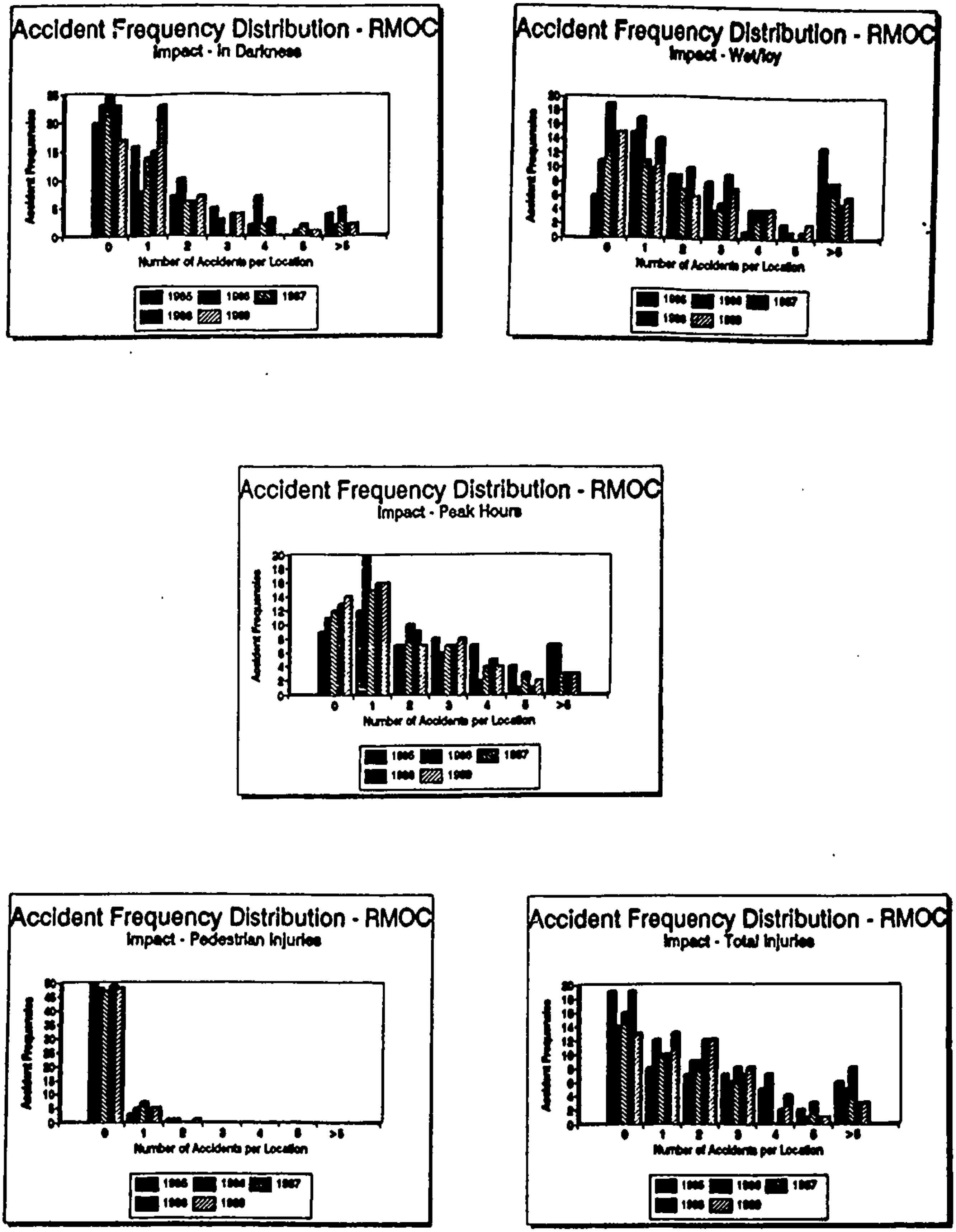
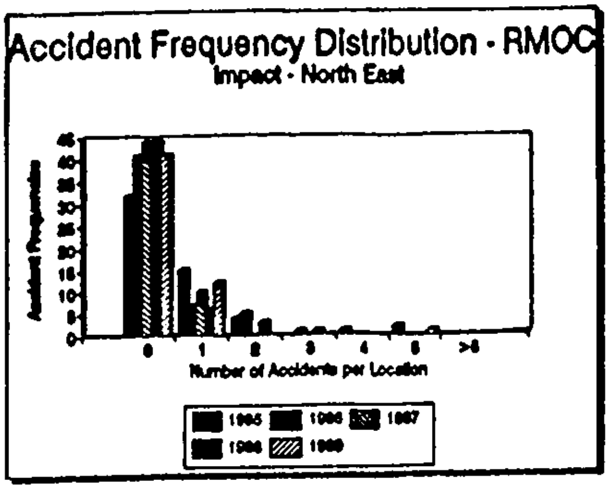
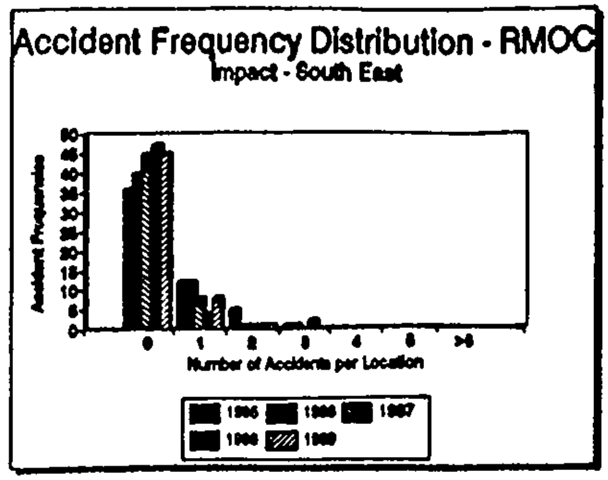
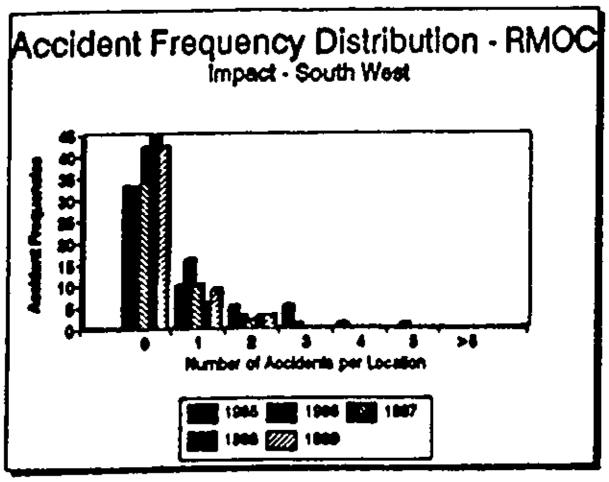
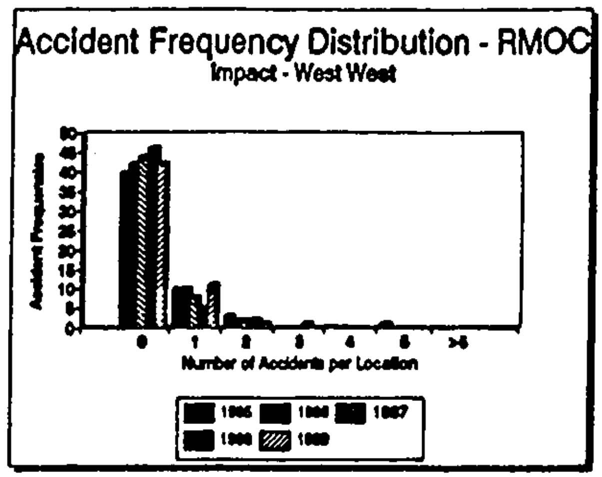

Accident Frequency Distribution - RMOC
Impact - In Darkness
Number of Accidents per Location
Accident Frequency Distribution - RMOC
Impact - Wet/Icy
Number of Accidents per Location
Accident Frequency Distribution - RMOC
Impact - Peak Hours
Accident Frequencies
Number of Accidents per Location
Accident Frequency Distribution - RMOC
Impact - Pedestrian Injuries
Number of Accidents per Location
Accident Frequency Distribution - RMOC
Impact - Total Injuries
Number of Accidents per Location

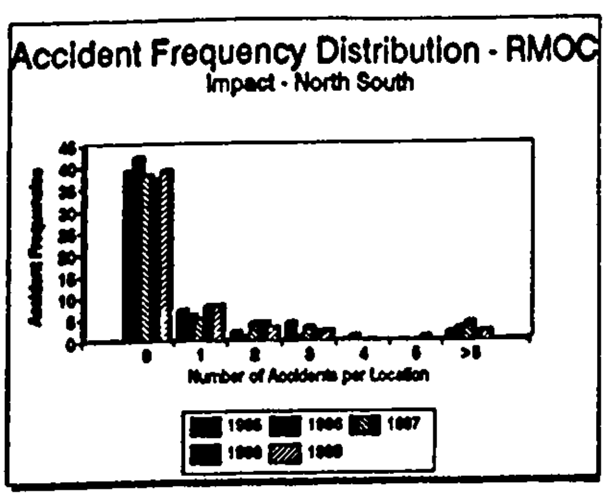
Figure 10











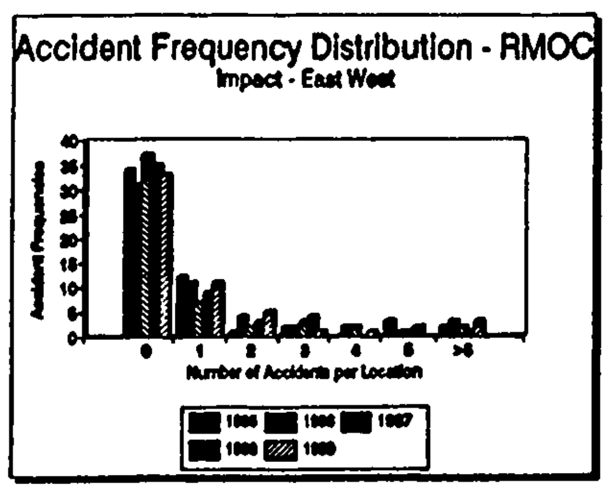
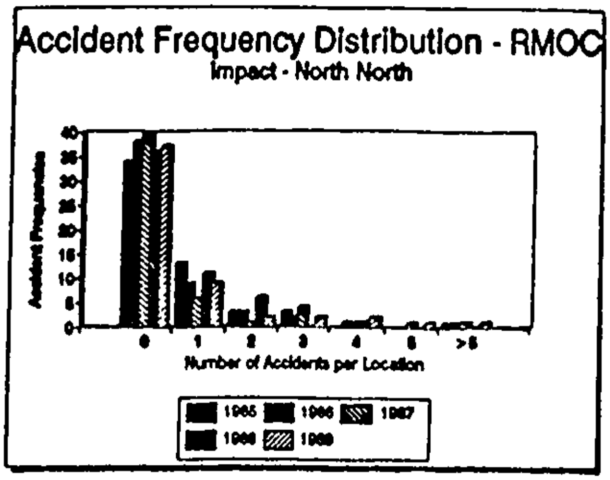
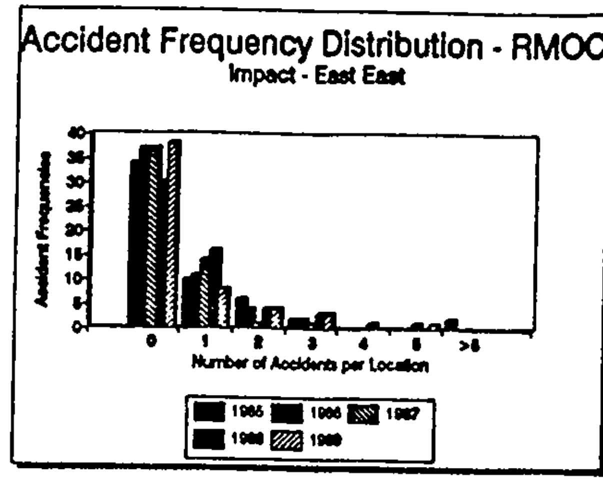
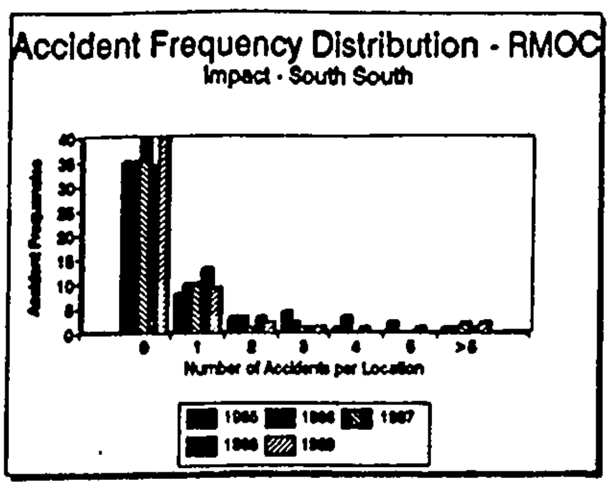


Figure 10 (Continued)







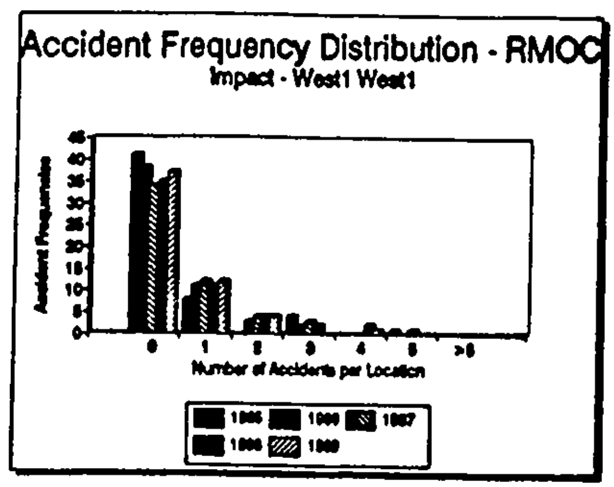


Figure 10 (Continued)

continued to grow.

The total number of accidents in darkness, following the countermeasure implementation, dropped between 1985 and 1989. The significant impact of the countermeasures was not felt until 1987 which indicated the greatest drop in the number of accident frequencies for the 54 locations. This stands to reason as the 1986 countermeasures were implemented randomly throughout that year, thus, explaining the time lag in accident reduction.

The distribution of the accidents, following the 1986 implementation, indicated a slight increase at the lower end of the annual accident frequency scale (those locations experiencing 1 or 2 annual accidents) and a marginal decrease at the higher end of the scale (those locations experiencing 7, 8 and 9 annual accidents). But for the most part the pattern of accidents in darkness has remained unchanged.

6.22 Accident Frequencies: Dry/Wet and Icy Conditions

Less than one quarter of the total number of countermeasure locations experienced accident frequencies during dry roadway conditions. Approximately 89% of the countermeasure locations experienced accidents during wet and icy conditions in 1985. This figure dropped to 80% in 1986 and to 65% in 1987. However, in 1988 and 1989, the number of accidents occurring in Wet and Icy Conditions rose to 72% of the total accidents, during both years.

The distribution of the number of accidents that occurred during wet and icy conditions varied significantly over the given study period. According to Table 16, the total number of accidents at the study locations was 166 in 1985. The effects of the countermeasures seems to have taken effect in a short period of time as the accident figure dropped by 30 accidents to a total of 136 accidents in 1986. The number of accidents fell, once again, to 122 in 1987, thereby reinforcing the positive impact of the countermeasure implementation on the number of accidents during wet and icy conditions. The annual accident frequencies continued to fall in 1988 to 120 accidents, but in 1989 the figure rose to 128.

The number of accidents in wet and icy conditions, following the countermeasure implementation, dropped significantly between 1985 and 1989. The greatest impact of the countermeasure implementation, during wet and icy conditions, was experienced very quickly between 1985 and 1986, and was highlighted by a drop of 30 accidents from the 1985 levels. It should be noted that the implementation of the 1986 countermeasures were distributed throughout the entire 1986 year; they were not all implemented on January 1st. Therefore, it is merely conjecture to conclude that the drop in accidents was solely attributable to the countermeasure implementation. There may be other external factors at work.

It is difficult to determine if the distribution of the accidents has shown any sort of redistribution along the annual accident frequency scale following the implementation of the safety devices. The pattern remains randomly distributed as positive and negative variances between the annual accident frequency levels of 1 and 14 over the study period.

6.23 Accident Frequencies: Peak/Non-peak Travelling Times

It should be noted that Peak Hours refers to the time periods between 7:00 and 9:30 a.m. as well as 3:30 and 6:00 p.m. on any given day. Once again, less than one quarter of the total number of countermeasure locations experienced accident frequencies during non-peak hours. Approximately 83% of the countermeasure locations experienced accidents during peak travelling times in 1985. This figure dropped to 80% in 1986 and to 78% in 1987. However, in 1988 and 1989, the number of accidents occurring during Peak Hours were 76% and 78% of the total number of accidents, respectively.

The distribution of the number of accidents that occurred during peak travelling times varied significantly over the given study period. According to Table 16, the total number of accidents for the countermeasure locations was 155 in 1985. The effects of the countermeasures seems to have occurred in a relatively short period of time as the number of accidents dropped to 116 in 1986. The number of accidents fell, once again, to 111 in 1987 (to a lesser degree), reinforcing the positive impact of the countermeasure implementation. The annual accident frequencies continued to fall in 1988 to 104 accidents and to 101 accidents in 1989.

The number of accidents during peak travelling times, following the countermeasure implementation, dropped significantly between 1985 and 1989. The greatest impact of the countermeasure implementation was experienced very quickly between 1985 and 1986, and was highlighted by a drop of 39 accidents from the 1985 levels.

It should be noted, once again, that the implementation of the 1986 countermeasures were distributed throughout the entire 1986 year. Therefore, it is merely speculation that the reduction in accidents is solely attributable to the countermeasure implementation. There may be other variables that may be attributed to the change in accident volume. Although evidence is currently inconclusive, there may be a relationship between the changes exhibited in Peak Hour Accident distribution and the changing "journey to and from work" changes that were briefly discussed under the Socio-Economic factors section at the beginning of Chapter 2.

The distribution of the accidents at Peak Hours remains relatively unchanged from one year to the next following the implementation of the safety devices. The pattern remains randomly distributed, both positively and negatively, between the annual accident frequency levels of 1 and 12 over the study period.

6.24 Accident Frequencies: Pedestrian Injuries

More than three quarters of the total number of countermeasure locations experienced accident frequencies without any pedestrian injuries. Approximately 7% of the countermeasure locations experienced accidents with pedestrian injuries in 1985. This figure rose to 11% in 1986 and to 13% in 1987. However, in 1988 and 1989, the number of accidents involving pedestrian injury dropped marginally to 9% and 11% of the total accidents, respectively.

The distribution of the number of accidents that involved pedestrian injury varied significantly over the given study period. According to Table 16, the total number of pedestrian injuries for the countermeasure locations was 5 in 1985. This figure rose to 7 in 1986 as the countermeasures were implemented randomly throughout the year. The number of pedestrian injuries remained at 7 in 1987, reinforcing the negative impact of countermeasure implementation. The annual pedestrian injury occurrences dropped to 5 in 1988 but in 1989 the figures rose to 7, once again.

The number of annual pedestrian injuries at the 54 study locations, following the countermeasure implementation, increased between 1985 and 1989. The number of injuries rose by 2 between 1985 and 1986 and remained at the 1986 level in 1987. The statistics clearly indicate that the introduction of traffic signal devices increases the number of pedestrian injuries, at least in this study scenario. This outcome is not surprising when certain behaviourial traits are considered such as impatient pedestrians crossing against a red light, or, a motorist making a right hand turn while failing to give right of way to a pedestrian. Naturally, these causal implications are merely conjecture and currently offer no statistical merit to the analysis but they are considerations that may be studied at a later date.

6.25 Accident Frequencies: Total Injuries

It should be noted that Total Injuries refers to both pedestrian injuries and those injured as occupants of the vehicle(s) involved in a crash. Approximately, one quarter of the total number of countermeasure locations experienced accident frequencies without any injuries, whatsoever. Approximately 65% of the countermeasure locations experienced accidents with injuries in 1985. This figure rose to 74% in 1986 and dropped slightly to 70% in 1987. In 1988, the number of accidents involving Total Injuries dropped 65% but by 1989 approximately 76% of the total accidents resulted in human injuries.

The distribution of the number of accidents that involved injuries varied over the given study period. According to Table 16, the total number of injuries for the countermeasure locations was 120 in 1985. This figure dropped to 116 in 1986 as the countermeasures were implemented randomly throughout the year. The number of injuries jumped to 122 in 1987 thereby reinforcing the negative impact of the countermeasure implementation on the occurrence of total injuries. The annual total injury frequencies dropped to 92 in 1988 but in 1989 the figure rose to 104, once again.

The number of annual total injuries at the 54 study locations, following the countermeasure implementation, dropped on average, between 1985 and 1989. However, the injury levels were not consistent from one year to the next. For example, the injuries dropped by 4 between 1985 and 1986 but rose above the 1985 levels in 1987. There was a drastic decline in the number of injuries in 1988 which remains unexplainable.

The distribution of the total accident injuries, following the 1986 countermeasure implementation, indicated a marginal increase at the lower end of the annual accident frequency scale (those locations experiencing 1, 2, and 3 annual injuries) and a subsequent decrease at the higher end of the scale (those locations experiencing 8 and 12 annual accidents). But for the most part the pattern of total injuries remained unchanged.

6.26 Accident Frequencies: Directional Movement prior to Impact

The Directional Movement of the vehicles prior to crash impact was recorded by RMOC based on the compass directions for three categories. The first category consists of "Right-Angle" accidents which is similar to a "broad-sided" impact. The compass directions include NE, SE, SW, and WW for this category. The second category is comprised of crashes from "Opposing Directions" which are representative of "head-on" collisions and include the directions of NS and EW. The final category is based on accidents occurring while the vehicles are travelling in the "Same Direction" which are commonly referred to as "rear-ended" accidents and include the compass directions of NN, EE, SS, W1W1. This sequence is maintained both in the Tabular and Graphic presentations of the data.

The directionality of the vehicles prior to crash impact is an important consideration for the "before-and-after" analysis following traffic safety countermeasure implementation. The traffic safety countermeasure may lead to a reduction, or even an increase, of accident frequencies and severity of the crash for vehicles travelling in particular directions. This information is important to the traffic accident researcher in order to appraise the impact of countermeasure installations and may also lead to improved decision-making for future safety countermeasure applications.

There were significant changes in the volume and distribution of accident frequencies for the various categories of vehicle direction prior to crash impact. Those accidents occurring at Right Angles fell by over 50% following the implementation of the traffic control signals. The accidents occurring between vehicles travelling in Opposing Directions rose slightly in the first years and actually dropped by 10% two years after the implementation of the countermeasure. The accidents occurring between vehicles travelling in the Same Direction dropped approximately 10% in the first year but slowly began to rise to the "before" levels after a few years.

The annual accident frequency statistics for the vehicles travelling and crashing at Right Angles stood at 122 accidents in 1985. The number of accidents fell to 81 by the end of 1986 while the traffic signal control devices were implemented throughout the year. The accident frequency figure dropped to 46 accidents in 1987 to reinforce the positive impact of the safety countermeasures. The figures rose slightly in 1988 and 1989 to 51 and 55 accidents, respectively.

These results were very encouraging in light of the considerable drop in the number of accident frequencies. According to the statistical details in Table 16, the reductions in Right Angled accidents were experienced by each of the compass categories of NE, SE, SW, and WW. However, the categories of NE, and SW experienced the majority of the benefits of the safety countermeasures between 1985 and 1987 with approximately 75% and 65% reductions in the total number annual accidents. The SE and WW directions followed with 60% and 40% reductions, respectively.

The annual accident frequency statistics, according to Table 16, for the vehicles travelling and crashing in Opposing Directions stood at 101 accidents in 1985. The number of accidents increased, marginally to 102 by the end of 1986 while the traffic signal control devices were implemented throughout the year. The accident frequency level remained at 102 during 1987 which added some question as to the positive impact of the safety countermeasures. The figures finally dropped, unexplainably, in 1988 and 1989 to 90 and 89 annual accidents, respectively.

The pattern of accidents, according to Table 16, for the Opposing Direction category was somewhat confusing. It seems that the category of vehicles travelling in a NS direction exhibited a decrease of 1 accident between 1985 and 1986. However, the number of accidents jumped by 17 to 55 accidents in 1987 and dropped to 46 and 33 accidents in the subsequent years 1988, and 1989 respectively. On the other hand, vehicles travelling in an EW direction peaked at 64 accidents in 1986 but fell to 47 in 1987. This represented a 17 accident reduction from the 1985 level. The annual accident figure continued to drop to 44 in 1988 but rose again in 1989 to 56 annual accidents.

The annual accident frequency statistics for the vehicles travelling and crashing in the Same Direction stood at 148 accidents in 1985. The number of accidents fell to 119 by the end of 1986 while the traffic signal control devices were implemented throughout the year. The accident frequency figure began to rise to 125 accidents in 1987, thereby questioning the positive impact of the safety countermeasures. The figures rose again in 1988 to 139 annual accidents and the figure dropped back to 121 in 1989.

These results were somewhat encouraging in terms of a steady drop in annual accidents, excepting the unexplainable increase experienced, temporarily, in 1988. According to Table 16, the reductions in Same Direction accidents were initially experienced by each of the compass categories of NN, EE, SS, and W1W1. However, the categories of EE and SS were the only two categories that exhibited a continuous decline in annual accidents over the study period, excepting the 1988 performance, once again. The NN and W1W1 categories initially began to fall in 1986 but rose again by 1987 and may be best described as remaining "status quo" over the study period.

6.30 Alternative Variable Frequency Analysis Summary

In summary, the Alternative Variable Frequency Analysis has led to various, inconclusive, findings for this sample of accident data. The introduction of Traffic Signal Control devices as a safety countermeasure, and any subsequent site improvements, have resulted in the following, generalized, impacts at locations throughout the RMOC region. The pattern of accidents occurring in Darkness decreased by a marginal amount following the implementation of the countermeasure. The volume of Wet and Icy accidents dropped significantly over the study period, however, there is no conclusive evidence that this was a direct result of the introduction of the safety countermeasures. The number of accidents occurring during Peak Hours of travel dropped significantly and was exhibited almost immediately following the implementation of the safety countermeasures.

The number of Pedestrian Injuries actually rose following the introduction of the traffic signalization at the 54 locations, however, it is inconclusive as to whether this was a result of higher traffic volume or a function of behaviourial traits. There was no definite change exhibited in the pattern of the Total Injury frequencies and there was very little evidence of a consistent pattern over the years. In addition, there was no indication as to the severity of the injuries encountered in both the Pedestrian and Total categories during the "before-and-after" periods.

Finally, the introduction of the safety countermeasures seems to have contributed to a significant change in the number and pattern of accidents based on the directional movement of vehicles prior to crash impact. The number of Right Angled accidents dropped substantially in volume and did not rise significantly during the 3 year post-implementation period. On the other hand, the accidents resulting from vehicles travelling in Opposing Directions rose, marginally, in the immediate years following countermeasure implementation but began to drop, slowly, as time passed. The number of accidents that occurred between vehicles travelling in the Same Direction dropped substantially in the first year following the traffic signal implementation, however, unlike the Right Angled collisions, the accident frequencies slowly began to rise thereafter. There was some indication of a change in the pattern of the traffic accidents. Evidence from Table 16 illustrated marginal increases at the lower end of the annual accident frequency scale accompanied by an offsetting decline in accidents at the higher end of the scale.

These conclusions are based upon the changes of the categorical, non-standardized, frequency distributions and have in no way been tested for significance or multivariate analysis. There was no test as to the strength of each component in terms of its role in the overall circumstances preceding the accident. It is felt that there is currently insufficient representative data for each of the categories to qualify such analysis. However, the statistics do offer valuable insight as to the types of outcomes that may be expected with the introduction of traffic signal control devices in the RMOC region.

6.40 "With-and-Without" Countermeasure Analysis - Outline

The purpose of the "With-and-Without" analysis is to identify the 1986 Stop Sign locations with high accident frequencies and, or, accident rates that were not allocated traffic signal control devices. The Stop Sign location accident frequencies and rates are compared to those exhibited by Countermeasure installations in 1986. The comparison is conducted to identify the Stop Sign locations that exceeded the number of accident frequencies and, or, rates exhibited by the Countermeasure locations in 1986.

The results of the "With-and-Without" comparison, naturally gives rise to the question: Why did "high risk" 1986 Stop Sign Locations fail to receive traffic control signals when it was clear that several of the 1986 Countermeasure locations did not exceed the accident levels of the Stop Sign locations. This question is very difficult to answer without looking at the specific details involved in each traffic signal control application that was accepted, or, disapproved. The purpose of this section is to appraise the performance of the "With-and-Without" locations as a whole and not to appraise the countermeasure applications on an individual basis. However, some speculative comments may give an indication of what factors are involved in the decision-making process of traffic signal allocation.

The "With-and-Without" section begins with a discussion of spatial factors that may play a role in the allocation of traffic signal devices. These factors include items that are not formally presented in the Municipal Traffic Safety Policies or in the Provincial Warrant Guidelines. The spatial factors to be discussed are summarized in Table 17 based on the categories of Residential, Rural, Commercial and Institutional spatial influences.

This introductory "spatial influence" section will be followed by tabular and graphical presentation that outline the inventory of "high risk" Stop Sign locations in light of the accident levels exhibited by the 1986 Countermeasure locations. The differences in accident levels between the Stop Sign and Countermeasure locations are summarized in Table 18 based on a summary of accident frequencies for the "Without" and the "With" locations. The analysis is conducted a second time based on the distribution of the accident rates (standardized by traffic volume) exhibited by the same locations.

The results of the comparative analysis illustrate the suspected inconsistent application of the formalized Countermeasure requirements by RMOC from a generalized perspective. However, the results are discussed in terms of opportunity for improvement of both data collection and the subsequent analysis. This is expected to provide some direction that may be taken for future research concerning the formal introduction of geographic variables in the decision making process for traffic safety countermeasure allocations.

6.50 Spatially Influencing Factors - Introduction

As indicated by Sections 2.30, Transportation System Management, Regional Policy, in Chapter 2, there are very strict and formal requirements that must be satisfied in order to procure funding for traffic control signal installations from the Province. However, this does not address the role played spatial factors in the occurrence of traffic accidents. Likewise, it does not address the role that these factors may play in the future allocation of traffic signals in RMOC. Unfortunately, there is very little evidence currently available to support this premise.

If in fact spatial factors do play a major role in the decision making process then, perhaps, they should be included in the formalized documentation surrounding the requirements for the successful implementation of traffic control signals. However, caution must prevail such that spatial factors do not unduly restrict or permit the countermeasure allocations in a discriminating manner. Afterall, a citizen's group, or, neighbourhood, may be denied a warranted traffic signal installation by mere formality. On the other hand, the municipality may suffer from a proliferation of redundant traffic signal installations a result of several variables initiating the application process.

The factors chosen as "spatial influences" to the traffic accident and subsequent countermeasure allocation are drawn from the traditional traffic generators found throughout the geographic fabric in North America. They include Residential Factors, Rural

Factors, Commercial Factors and Institutional Factors and Traffic Volume for the particular intersections. Each of these categories are disaggregated into more specific categories so as to include any unique spatial influences in close proximity to the 54 countermeasure sites in question.

An informal scoring system, based on relative proximity, was arranged to rank the intensity and influence of the multiple spatial influences on traffic flow at each of the sites. Referring to Table 17, for example, the intersection at Acres Road and Carling Avenue is believed to be influenced by Low Density Residential, a small Strip Mall, and to a lesser extent, Andrew Haydon Waterfront Park. Therefore, the scores were allocated 3, 2, 1, respectively, (based on proximity to the intersection) for a total of 6 "influence points" overall. These scores serve as a primitive measure of land use intensity in close proximity to the sitre in question. It should be noted, however, that cumulations of the scores may be misleading as opposed to studying them by themselves.

In another example, at Altavista Drive and Industrial Road, the score was allocated 3 for Commercial Industrial Park and 2 for High Density Residential, resulting in a total of only 5 "influencing points" overall. If a particular spatial influence was not in close proximity, than that location did not receive a score for the category. The scoring system may be construed as subjective and, hence, "contrived" in terms of ranking within the various categories. However, each of the locations were observed by the researcher on a site specific basis to ensure that the facts were legitimate. Naturally, there were more recent developments that have been added to the site following the 1986 traffic signal implementation, however, it is believed that these were excluded from the analysis. In any event, there may be a chance of incorrect allocation of land uses for a particular location (ie. residential v.s. commercial in terms of importance), however, if this were suspected, any adverse effect would be alleviated by simply concentrating on the aggregated Grand Total figures.

TABLE 17

SPATIAL INFLUENCE SCORES: DETAIL TABLE

LOCATIONS:				ROADWAYS:	RESIDENTIAL:			RURAL:
				TRAFFIC VOLUME	LOW	HIGH	RESID. TOTAL	FARMLAND TOTAL
1	ACRES	&	CARLING	12759	3		3	
2	ALTAVISTA	&	INDUSTRIAL	32986		2	2	
3	BANK	&	THIRD	14985	2		2	
4	BASELINE	&	GUTHRIE	15153	3		3	
5	BASELINE N	&	RICHMOND	17939	2		2	
6	BASELINE S	&	RICHMOND	27325	2		2	
7	BOTSFORD	&	SMYTH	13121	2		2	
8	BOWESVILLE	&	HUNTCLUB	10871				
9	BRIDLEPATH	&	HUNTCLUB	12780	3		3	
10	CANTIN	&	MONTREAL	15019		3	3	
11	CARLING	&	MOODIE	11409	2		2	
12	CARLING	&	D.R.E.	7883				2
13	CARLING	&	BAYSHORE	15064		3	3	
14	CARLING	&	MARCH	12005				2
15	CARLING	&	HERZBERG	7061				2
16	CARP ROAD	&	OLD HWY 7	4960	2		2	
17	CHURCHILL	&	DOVERCOURT	8631	3		3	
18	CLARENCE	&	DALHOUSIE	10238	2		2	
19	CLEARY	&	RICHMOND	10935	3		3	
20	CLYDE	&	MERIVALE	36245	2		2	
21	CLYDE	&	LOBLAWS	19793				
22	COVENTRY	&	VAN-PKW	34386	2		2	
23	CYRVILLE	&	STARTOP	10871				
24	EAGLESON	&	STONEHAVEN	6849	3		3	
25	EAGLESON	&	ROTHESAY	8576	3		3	
26	FALLOWFIELD	&	HWY - 16	10446				3
27	FALLOWFIELD	&	RICHMOND	7564				3
28	FIRE-STN	&	WOODROFF	18019	2		2	
29	FISHER	&	SHILLINGTON	15050	3		3	
30	FRANKTOWN	&	EAGLESON	6140				3
31	FROBISHER	&	RIVERSIDE	20654		3	3	
32	HARTWELL	&	PRINCE OF WALES	17656				
33	HAZELDEAN	&	EAGLESON	25890	2		2	
34	HAZELDEAN	&	TERRY FOX	8580	3		3	
35	HAZELDEAN	&	CASTLEFRANK	14148	3		3	
36	HWY- 15	&	HWY- 17	4600	2		2	
37	HWY-417 N	&	VAN-PKW	49216	2		2	
38	HWY-417 S	&	ST. LAURENT BLVD.	25170				
39	INDUSTRIAL	&	RIVERSIDE	32986		2	2	
40	JEANNE D'ARC	&	VORLAGE	11027	3		3	
41	KINGEDWARD	&	SOMERSET	13370	1		1	
42	MARCH	&	HERZBERG	12845				2
43	MOODIE	&	BELL NORTHERN-N	8810	2		2	
44	MOODIE	&	BELL NORTHERN-S	9847	2		2	
45	MOODIE	&	TYRELL	11639	3		3	
46	OTT.STATION RD.	&	TREMBLAY	12641				
47	RICHMOND	&	BAYSHORE	22474		2	2	
48	RICHMOND	&	NANAIMO	18653	3		3	
49	RIDEAU	&	WURTEMBURG	23749		3	3	
50	ROBERTSON	&	LYNHAR	27654	1		1	
51	ROBERTSON	&	RICHMOND	24124	1		1	
52	ROBERTSON	&	STINSON	24998	1		1	
53	ROBERTSON	&	MOODIE	37062	1		1	
54	ST.JOSEPH	&	ELWOOD	11362	3		3	

TABLE 17
SPATIAL INFLUENCE SCORES: DETAIL TABLE
(CONTINUED)

COMMERCIAL:							
CBD TYPE	STRIP MALL	SHOPPING CENTER	TOURIST AREA	BUSINESS PARK	TRANSP. TERMINAL	INDUSTRIAL PARK	COMM. TOTAL
	2						2
						3	3
3							3
			1				1
			1				1
					1		1
				2			2
	2						2
				3			3
	2	1					3
				3			3
				3			3
			3				3
3			1				4
	2						2
	3						3
	2	3					5
						3	3
	2						2
		3					3
						2	2
	2						2
	3						3
		2				3	5
						3	3
	2						2
				3			3
				3			3
				3			3
					3		3
		3					3
1							1
	3						3
	3						3
	3					2	5
	3						3
	2						2

TABLE 17
SPATIAL INFLUENCE SCORES: DETAIL TABLE
(CONTINUED)

INSTITUTIONAL:								
HOSPITAL	SCHOOL	CHURCH	FIRE STATION	SPORTS FACIL.	PARK LAND	ARMY/POLICE BASES	INST. TOTAL	GRAND TOTAL
					1		1	6
								5
				1			1	6
								3
3							3	6
3							3	6
1	3	2					6	8
				2		3	5	6
								5
								5
								5
						3	3	5
								6
								5
								5
								5
								3
								6
		1					1	6
								5
								5
			1			3	4	6
								3
								5
		2	1				3	6
								3
								3
			3		1		4	6
					2		2	5
								3
	2						2	5
	3				2		5	5
				1			1	6
								5
				1			1	6
								5
						3	3	5
								5
					1		1	6
			1				1	6
	3		2				5	6
								5
								5
								5
		1					1	4
								3
								5
								3
						2	2	6
								4
			2				2	6
								6
								4
1							1	6

6.51 Residential Land Use Influences

The majority of the traffic control signal installations at the 54 study locations are influenced by residential development in some way or form. The results in Table 17 indicate that the majority of the residential influences are of a Low Density nature. This category is typified residential development that include single family homes, low rise condominiums, town houses and 2-3 story "walk-up" apartments. Several of the Low Density residential influenced locations are found throughout the City of Kanata. Other Low Density residential influences are found throughout the Region; from the beginning of east end development in Orleans, to established neighbourhoods such as Huntclub, Fisher Heights and Westboro.

The traffic signal allocations to the City of Kanata are of particular interest because it experienced a residential boom during the mid-1980's. The residential growth at that time was concentrated in neighbourhoods such as Bridlewood, GlenCairn and Katimavik. Typical locations that received traffic control signals were Eagleson/Stonehaven, Eagleson/Rothsay, Hazeldean/Castlefrank, and Hazeldean/Terry Fox. The traffic volume at these particular locations was less than 10,000 annual average daily vehicle trips. However, the traffic signal allocations were likely influenced by projections found within Development Control Agreements.

As discussed in Chapter 2, section 2.39, Development Control Agreements play a major role in traffic signal allocations in residential developments throughout the Region. These agreements are also used for commercial and industrial development proposals, however, the main emphasis remains with residential development. In most cases, the Development Control Agreement uses calculated population projections for the particular project to calculated traffic flow estimates for peak and non-peak hours of travel. The resulting traffic flow estimates often govern the subsequent street configuration and, particularly, the traffic signal installations.

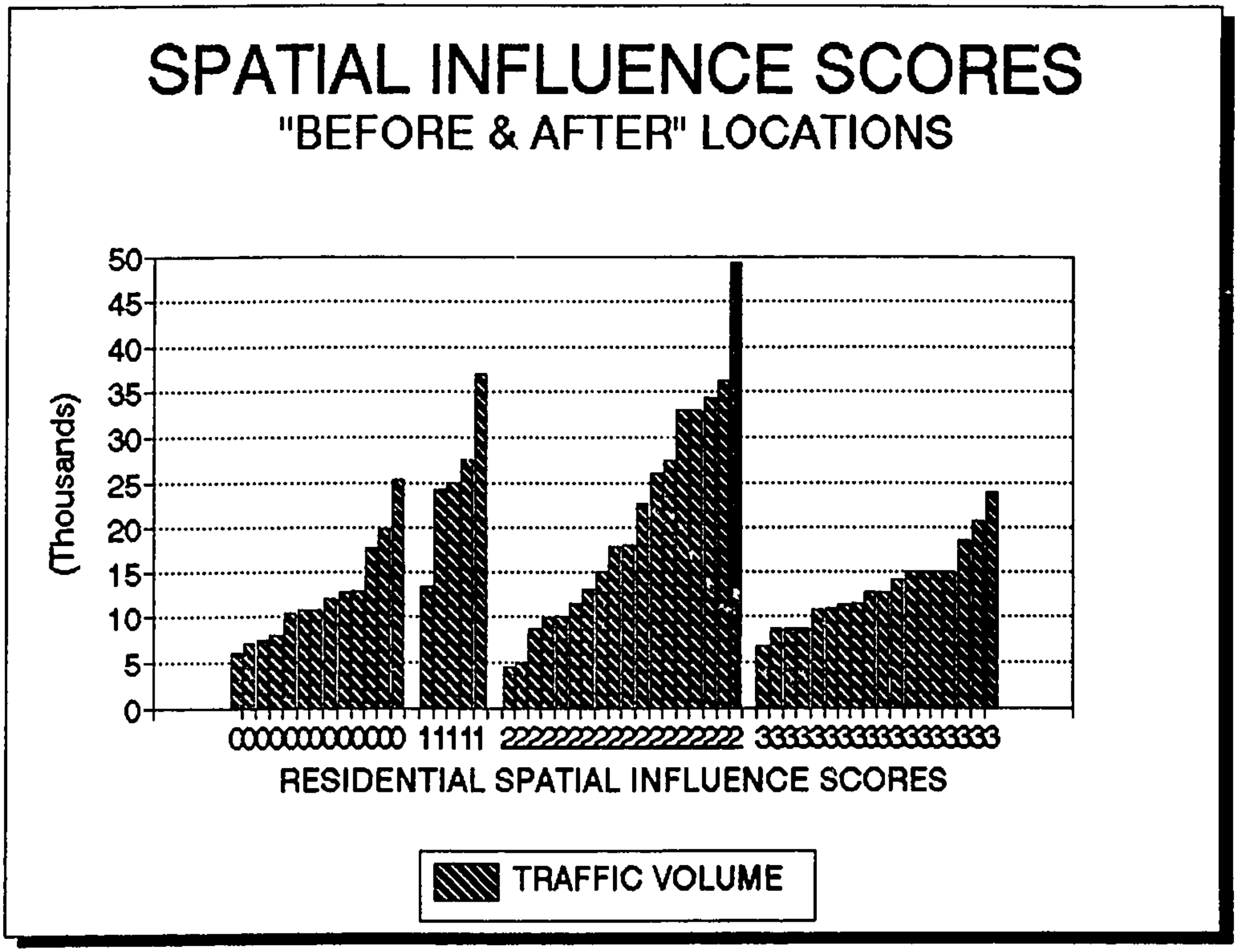
The High Density residential category is typified by "high rise" apartment complexes found at locations such as

Rideau/Wurtenburg, Bayshore/Richmond, Industrial/AltaVista, and Frobisher/Riverside. These locations are accompanied by fairly high levels of traffic volume, greater than 15,000 annual average daily trips. Many of these locations are located on Collector and Arterial roadways that contain trips that do not necessarily originate or end at these locations. The traffic is often by-passing these locations with other origin-destinations in mind.

The scores for the residential categories were summed to give a total of residential influence scores. These results were cross referenced with the actual traffic volume levels for 1986 and are presented in Figure 11. This figure represents the residential scores for each of the 54 traffic control signal locations in terms of 3 for "primary influence", 2 for "secondary influence" (the next greatest influence after the Commercial or Institutional categories), 1 for "marginal influence", and 0 for no influence. The scores are ranked in ascending order along the x-axis and the traffic volume is presented in ascending order along the y-axis. Figure 11 serves to illustrate the intensity of traffic volume as it is related to the primary, secondary and marginal residential influenced intersections.

The intersections with residential land use as the "primary" influence in close spatial proximity exhibit a steady traffic volume between the range of 10,000 and 15,000 annual average daily trips. On the other hand, the intersections with "secondary" residential land use influence exhibit much higher traffic volumes that fall more between the 20,000 to 35,000 annual average daily trip range. This strengthens the fact that there is additional traffic that is being produced by a more "primary" source of land use influence. The same result seems to hold for the "marginal" influence category which also exhibits very high traffic volume in the range of 25,000 annual average daily trips.

Low and High Density residential developments exert influence on the flow of traffic and, hence, the allocation of traffic signals. However, the influence is not exclusive. In the majority of the cases there are other spatial features in close proximity


SPATIAL INFLUENCE SCORES
"BEFORE & AFTER" LOCATIONS
(Thousands)
50
45
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25
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000000000000 11111 222222222222222222 333333333333333333
RESIDENTIAL SPATIAL INFLUENCE SCORES
TRAFFIC VOLUME

Figure 11

that offer additional influence on the traffic flow an pattern of the particular area. It is the cumulation of these influences that ultimately govern the volume and flow of traffic for a particular location. It is the cumulative results that are considered during the allocation of the traffic control signals.

6.52 Rural Land Use Influences

As indicated in Chapter 2, approximately 2,500 square kilometres of the total area covered by the Regional Municipality of Ottawa-Carleton is of a rural nature. In 1986 there were a number of rural traffic control signal allocations. The 3 primary locations included Fallowfield/Hwy 16 and Fallowfield/Richmond. These locations, surrounded primarily by farmland, represented 2 main thoroughfare points for inhabitants of the burgeoning community of Barrhaven, in the City of Nepean. Therefore, it is more likely that the residential development and not the rural landscape that warranted the allocation of these traffic control signals.

Similarly, another set of traffic control signals was installed outside of the town of Richmond, Ontario, at Franktown/Eagleson Roads. It is believed that this was also a function of growing commuter traffic into the City of Ottawa from outlying areas. The same argument may be made for the locations in the Kanata North Business Park Area which are surrounded by vast amounts of farmland. The traffic at these locations is influenced by commuter traffic resulting from land use other than the immediate rural landscape.

6.53 Commercial Land Use Influences

The features that fall under the category of Commercial land use influences are also summarized in Table 17 by 7 different categories. The CBD Type category includes retail strip developments of a traditional downtown type nature and is typified by the retail development found along Rideau Street between the Market and the Rideau River, and the Bank Street section found in the Glebe. The Strip Mall category comprises the typical drive-in strip mall that contains a Mac's Milk Store, Donut Shop, and other convenience type outlets. The Shopping Centre Category consists large retail developments that are typified by the presence of 1 or more national "anchor" type stores and several "franchise" or "chain" retail operations (ie. Bayshore, St. Laurent Shopping Centres). The Tourist Area category in this land use matrix is comprised of the historic Market Area in downtown Ottawa and the Flea Market located in Stittsville, Ontario. The Business Park category is comprised of Office Building complexes, and light warehousing districts. Business Parks a typified by locations such as the Kanata North Business Park which houses Canada's High Technology Centre, and the Antares Business Park near Hunt Club Bridge and Highway 16. The Transportation Terminal category consists of the Airport and the Train Station. Finally, Industrial Parks are comprised of warehousing districts and heavy industrial manufacturing areas.

The Commercial land use category that exhibited the highest frequency of presence in close proximity to the 54 study locations was the Strip Mall category. These locations were typified by locations with intense shopping areas such as Bells Corners and the Merivale Road stretch but also included neighbourhood locations in Orleans, Kanata and Westboro. Many of the Strip Mall locations were accompanied by Shopping Centre land use, particularly, along Merivale Road, Bayshore and the St. Laurent Shopping Centre. The Strip Malls often exhibit this land use clustering behaviour in order to capture shoppers on their way to and from the shopping centre.

Shopping Centre expansion played a major role in traffic flow production and subsequently the allocation of traffic control signals throughout the Region. During the mid 1980's the expansion of the Bayshore Shopping Centre, in the west end of Ottawa, was nearing completion of the planning stages and construction was beginning on the multi-million dollar addition of a third floor to the existing structure. The 2 major access points to and from the

Shopping Centre were located at the Richmond/Bayshore and the Carling/Bayshore intersections.

The expansion of the Shopping Centre was accompanied by a large expansion of the existing auto parkade and was expected to generate more than 2,400 vehicle trips per hour during peak hour periods in the afternoon (RMOC Trip Generation Manual, 1990). The Richmond/Bayshore intersection was particularly unique with the merging on-off ramps of Highway 417, the Queensway. This intersection was already signalized but underwent major roadway geometry restructuring and traffic signal realignment as a result of the expansion of the parkade for the shopping centre. The Carling/Bayshore intersection became signalized because of a combination of high accident frequencies (12 annual accidents in 1985), high annual accident rates (2.2 accidents per MEV in 1985) and increased traffic flow anticipated by the increased shopping trip generators.

The CBD Type category exhibited strong influence at 2 locations: Bank/Third in the Glebe, and Clarence/Dalhousie on the fringe of the Market. The traffic control signals are necessary at these locations because of the vehicular and pedestrian congestion that is present, particularly on weekends. Similarly, the Stittsville Flea Market coupled with the beginnings of residential development prompted the allocation of traffic control signals to Old Hwy 7/Carp Road.

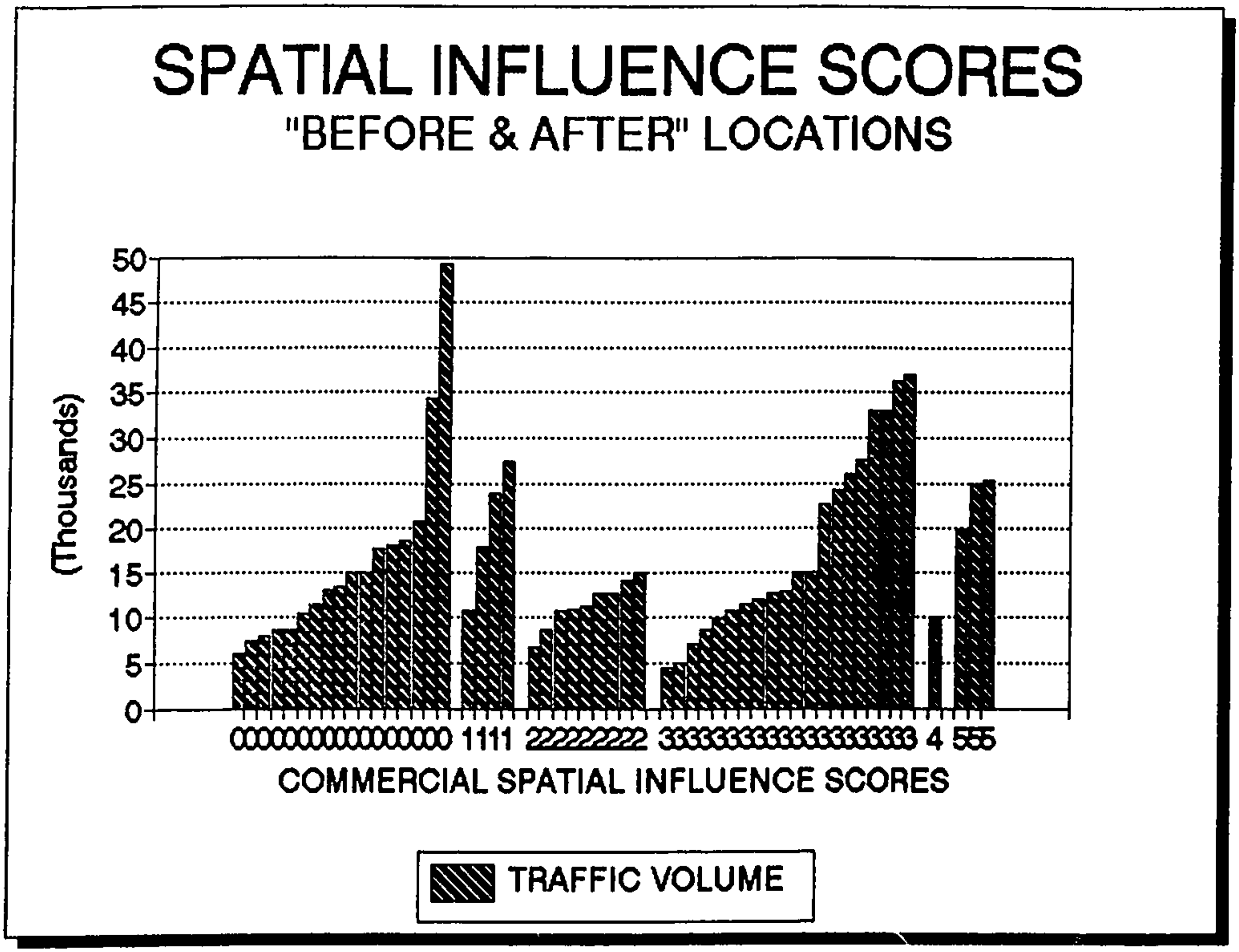
There were 3 primary Business Park locations that contributed to the need for traffic control signals in the Region. These included the Bell Northern Research Centre on Moodie Drive, the Kanata North Business Park and to a lesser extent a complex located at Bridlepath/Hunt Club. The need for signals based on this land use is derived from traffic flow calculations for the journey to and from work. The calculations are similar to those used in Development Control Agreements and are derived from the Regional Trip Generation Manual. Using the Kanata North Business Park as the example, the RMOC manual predicted 7,200 daily vehicle trips in and out of the area during 1988 with approximately 1,370 occurring during the morning peak hours while the remaining 1,245 receded with the evening tidal flow (RMOC Trip Generation Manual).

The primary Industrial Park land use influences found in the 1986 allocation of traffic signals were limited to 3 locations: Eastway Gardens (St. Laurent, south of Hwy. 417), Industrial Road Area and Cyrville Road Area. These industrial areas produce significant volumes of traffic flow of a heavy nature. The types of vehicles travelling to and from these areas are heavy trucks, tractor trailers, motor coaches and a multitude of service vehicles and delivery trucks. In addition, many of these locations are in close proximity and link up with Collector and Arterial streets in order to gain quick access to major highways for the transport of goods and services.

The "influence scores" for the aforementioned categories were summarized into a total commercial land use category and were cross-referenced with traffic flows in Figure 12. The methodology used was exactly as that used in the Residential section. The intersections with Commercial land use as the "primary" influence in close spatial proximity exhibit a steady traffic volume between the range of 10,000 and 35,000 annual average daily trips. On the other hand, the intersections with "secondary" commercial land use influence exhibit much lower traffic volumes that fall more between the 5,000 to 10,000 annual average daily trip range. This may indicate that there is a distance decay relationship associated with the volume of traffic at an intersection and the proximity of commercial land use. The intersections that receive "marginal" and "zero" influence from the commercial land use exhibit traffic volumes between the range of 10,000 and 25,000 annual average daily trips. This may indicate that there are other land uses in close proximity that influence the flow of traffic.

6.54 Institutional Influences

There are several cases where traffic control signals have been implemented as a result of vehicular and pedestrian traffic generated by various institutional facilities throughout the


SPATIAL INFLUENCE SCORES
"BEFORE & AFTER" LOCATIONS
(Thousands)
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0000000000000000 1111 22222222 3333333333333333333 4 555
COMMERCIAL SPATIAL INFLUENCE SCORES
TRAFFIC VOLUME

Figure 12

Region. Institutional facilities that influence the installation of traffic control signals include hospitals, schools, churches, fire stations, sports facilities, parkland and military/police bases and academies. These institutional land uses are also summarized in Table 17 under the aforementioned categories.

The influence of an institutional land use in the allocation of a traffic control signal is typified by an installation, in 1986, at the Fire Station location on Woodroff near Baseline Road and similarly, but at later date that year, at Laurier, near King Edward. These installations were not at intersection locations and did not meet the formal requirements of the Provincial Warrants in terms of historic accident and traffic trends. However, the signals were placed for the convenience of the Fire Trucks to egress the street in a quick and unimpeded fashion during emergency situations.

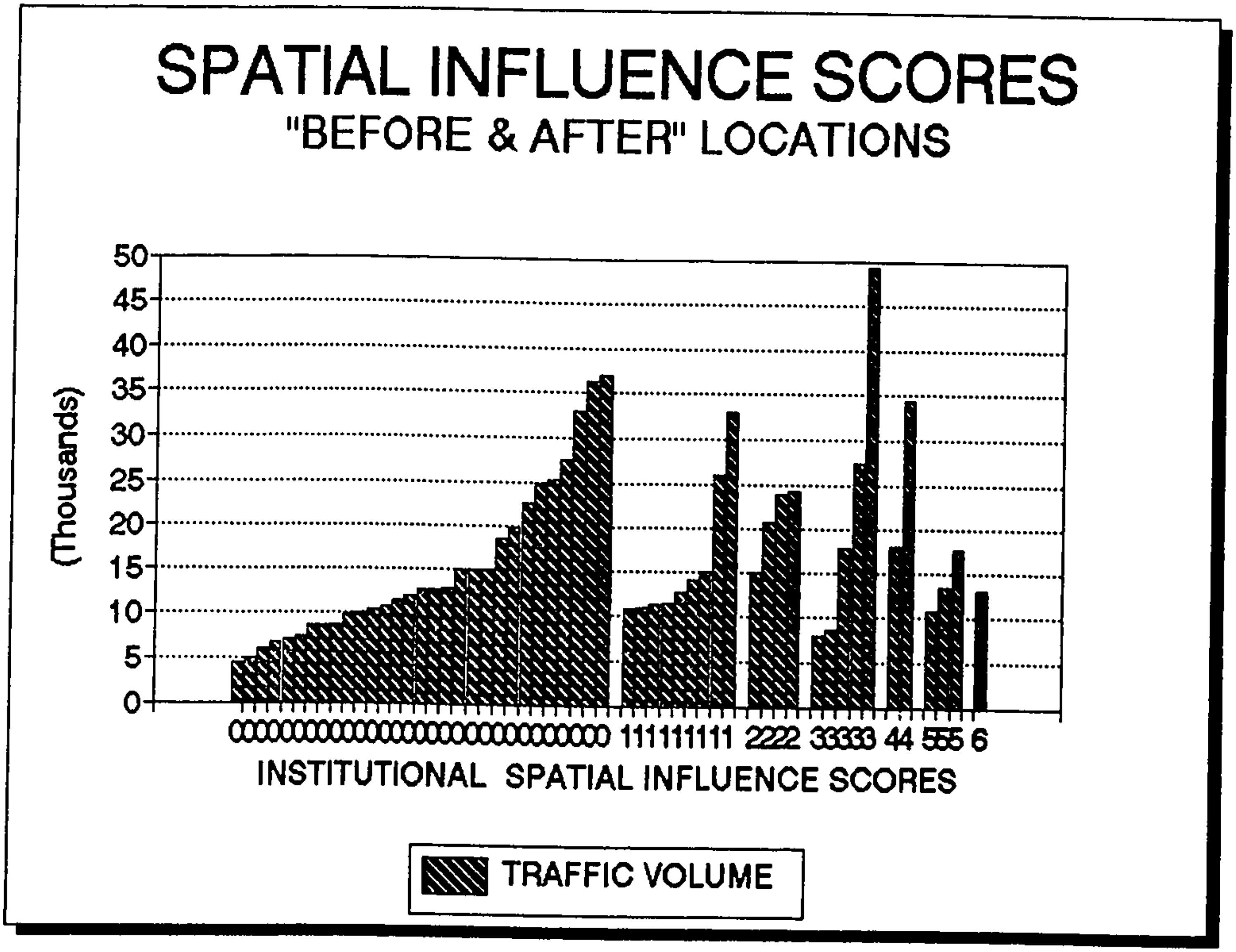
An example of a Military/Institutional land use that influences the allocation of traffic control signals is illustrated by the 1986 installation at Carling/D.R.E.. This location is found on Carling Avenue near the Kanata North Business Park and is the entrance to the Department of National Defence "Shirley's Bay" Shooting Range. There were no accidents at this locations in either 1985 nor 1986. However, the signals were likely installed for the convenience of commuter traffic of those employed at the location. A second set of traffic control signals was installed at Coventry/Vanier Pkwy which is the entrance to RCMP Headquarters. This installation, however, had experienced significant numbers of accidents in the past and also met traffic volume warrants as the Vanier Parkway is an Arterial commuting route for many people. An additional set of traffic control signals was installed at Bowlesville/Huntclub which the main entrance to the Uplands Army Base in Ottawa. The army base actually contains a mix of residential, commercial and institutional land uses located within the premises which generate more than 10,000 annual average daily vehicle trips.

The next most prominent institutional categories include schools and hospitals. The primary hospital traffic signal location was at Baseline/Richmond Roads which is close proximity to the Queensway-Carleton Hospital in the west-end. However, it should be noted that the intersection is also influenced substantially by commuter and shopping trip traffic as it located between the Bayshore Shopping Centre and Bells Corners. The installations in close proximity to schools include Botsford/Smyth which is adjacent to both a church and secondary school. There was an installation at Somerset/KingEdward which served both Ottawa University students and heavy commuter traffic between downtown and the Queensway.

Finally, there was an installation at Hartwell/Prince of Wales which is found along the fringes of the experimental farm. This installation is somewhat confusing as to the land use influences affecting traffic volume. Vehicular traffic along Prince of Wales may be categorized as commuter, tourist (experimental farm), and residential. The vehicular traffic along Hartwell is primarily of a tourist nature (experimental farm & Rideau River Locks) and the pedestrian traffic is generated by students at Carleton University, tourists and bicyclists using the parkland bike paths.

Figure 13 is a cumulation of the institutional land use scores cross referenced with traffic volume in 1986. These scores are somewhat more difficult to interpret because the traffic volumes vary widely within the "primary", "secondary", and "marginal" score segments.

The "primary" scores (ranging 3 through 6) for locations with institutional land use in close proximity indicate varying traffic volumes between 10,000 and 40,000 annual average daily trips. The variance may be attributed to the fact that some institutional uses influence traffic on an irregular basis or only on particular days of the week. For example, churches normally influence traffic patterns on Sunday mornings, and sports facilities may offer attractions on varying week nights or primarily on weekends when people are not working. Similarly, traffic resulting from hospital and fire station use varies randomly on an as-need basis.



SPATIAL INFLUENCE SCORES
"BEFORE & AFTER" LOCATIONS
(Thousands)
50
45
40
35
30
25
20
15
10
5
0
000000000000000000000000000000 11111111 2222 33333 44 555 6
INSTITUTIONAL SPATIAL INFLUENCE SCORES
TRAFFIC VOLUME

Figure 13

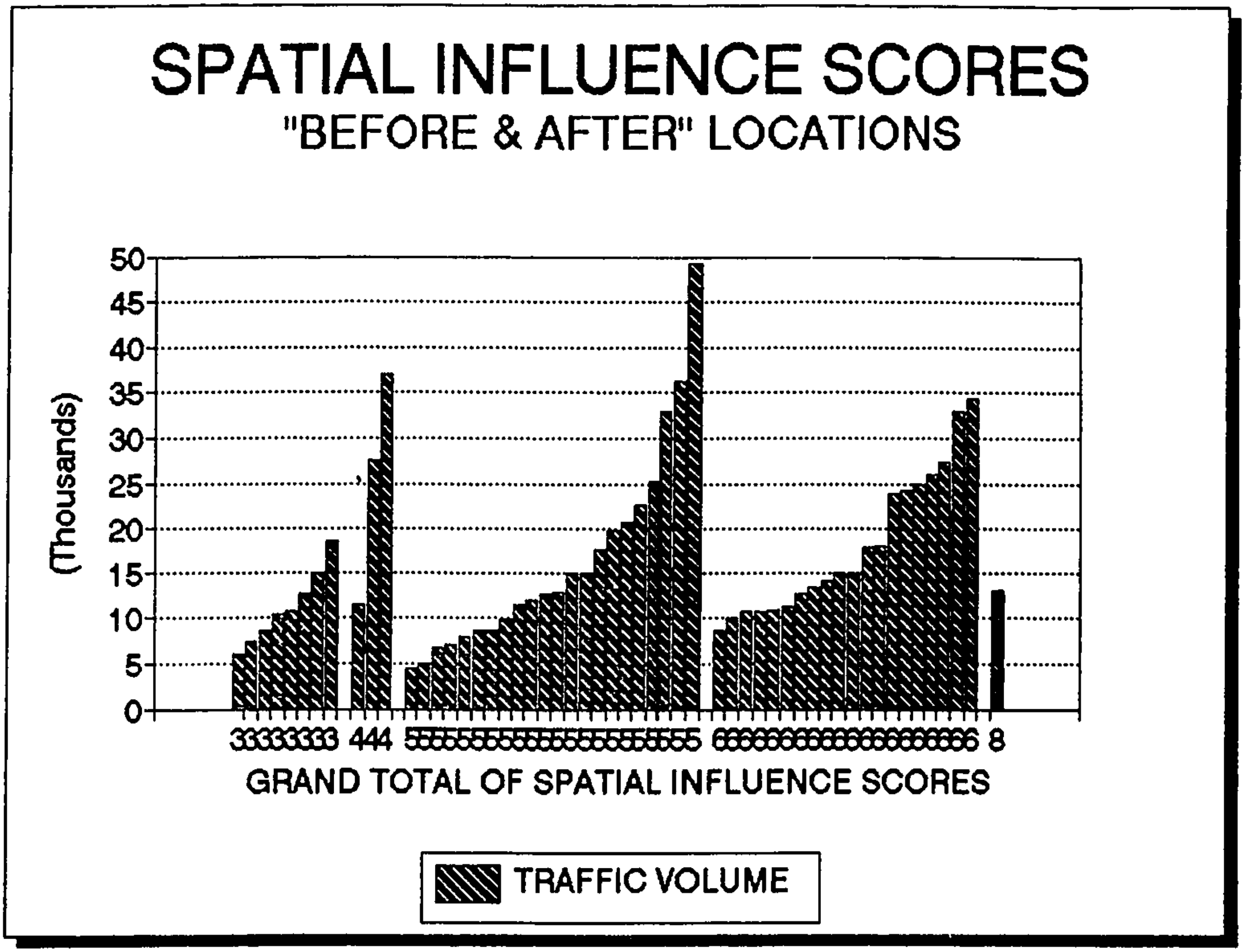
The intersections influenced by institutional land use based on the "secondary", "marginal" and "zero" score levels contain a more regular pattern of traffic volume. The volume levels exhibited are between the 10,000 and 20,000 range and may indicate the regular traffic patterns produced by the influence of residential and commercial land uses. Nonetheless, these conclusions are speculative and their validity may be improved through some type of multivariate statistical analysis to measure the strengths of the particular influences.

6.55 Grand Total of Land Use Influences

In attempt to study the land use component influences as a whole, the sub-categories within residential, commercial and institutional were summarized and added together to illustrate the grand total of the possible land use influences on traffic volume and subsequent traffic signal installations. The results were cross reference with the traffic flows and are depicted in Figure 14.

The aggregation of the data tends to "smooth" out the effect of the spatial influences as a whole. For example, the intersections that receive "primary" (scores of 6-8), "secondary" (scores of 5), and "marginal" (scores of 3-4) influence from the land uses as a whole, tend to exhibit similar traffic volume trends. The average traffic volume seems to fall between the range of 10,000 to 25,000 in all cases. However, there are at least 21 countermeasure locations that are influenced by more than two of the residential, commercial, and institutional land uses in close proximity. There are at least 22 countermeasure locations that are influenced by more than one of the residential, commercial and institutional land uses in close proximity. Finally, there are at least 11 countermeasure locations that are influenced by at least one of the residential, commercial and institutional land uses in close proximity.

Unfortunately, this analysis does not measure the magnitude of the influence by the particular land uses on the subsequent



SPATIAL INFLUENCE SCORES
"BEFORE & AFTER" LOCATIONS
50
45
40
35
30
25
20
15
10
5
0
(Thousands)
3333333 444 5555555555555555555555 66666666666666666666 8
GRAND TOTAL OF SPATIAL INFLUENCE SCORES
TRAFFIC VOLUME

Figure 14

traffic flows. It only identifies that the influence is present. The magnitude and the order in which the particular categories influence the traffic flows and traffic signal allocation may be achieved through the application of various multivariate statistical analysis. However, as stated earlier, it is felt that there is currently insufficient representative data within the current database to conduct such analysis in the detail required.

6.60 "With-and-Without" Countermeasure Comparisons

As described in previous chapters, there were approximately 2,532 accident frequencies that occurred in 1986. Approximately, 2,200 of these frequencies occurred at 1,122 locations that remained Stop Sign locations with no improvement in terms of safety countermeasure devices. There were approximately 54 locations (exhibiting 332 accidents) in 1986 that received safety countermeasure devices in the form of traffic control signals. However, there is some doubt as to the appropriate allocation of the safety devices. That is to say that it is suspected that there were certain locations that remained Stop Sign in nature when, in fact, they may have required safety countermeasure installations more than those that received traffic signals in 1986.

6.61 Accident Frequency Analysis

The complete breakdown of the accident frequencies for the "With-and-Without" locations is summarized in Table 18 and categorized along the annual accident frequency scale (ie. 1,2,3 annual accident frequencies per location). It should be noted that the analysis of the "Without" locations relies on 1986 accident data, exclusively. Unfortunately, the previous 3 years to 1986 were not included in the database because of clarity of data and time constraints. The results are expected to be somewhat misleading with respect to the past history of the "Without" locations. For example, a "Without" location may have exhibited more than 5 annual accident frequencies (the Provincial Warrant

Table 18

"With-and-Without" Countermeasure Analysis

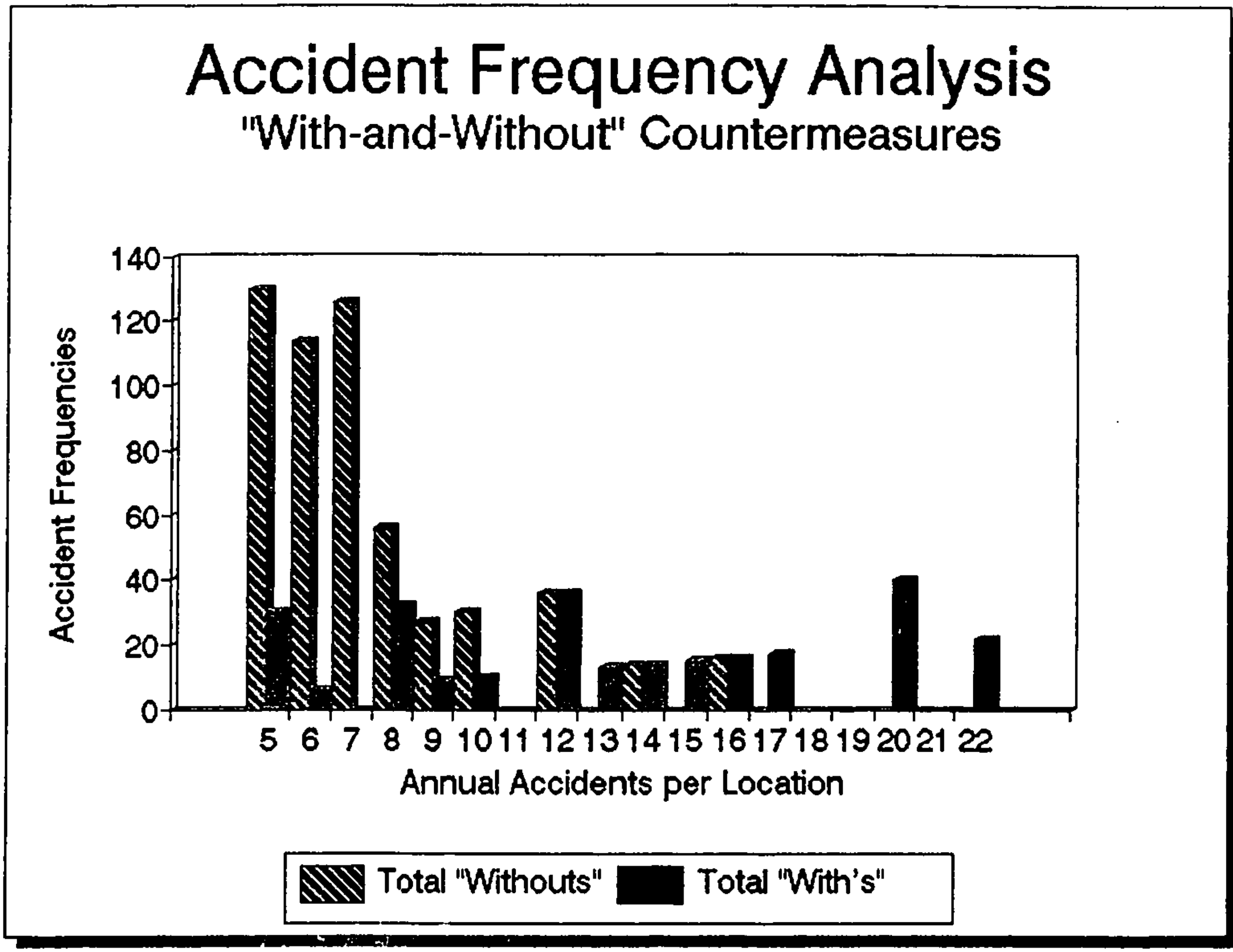
Accident Frequency per Location	Total "Without" Locations	Total "Without" Frequencies	Total "With" Frequencies	Accident Rate per Location (per MEV)	Total "Without" Rates	Total "With" Rates
0	0	0	0	0	884	2
1	664	664	4	0.5	35	12
2	201	402	22	1	95	19
3	119	357	18	1.5	47	9
4	57	228	28	2	19	7
5	26	130	30	2.5	17	4
6	19	114	6	3	7	1
7	18	126	0	3.5	1	
8	7	56	32	4	0	
9	3	27	9	4.5	5	
10	3	30	10	5	2	
11	0	0	0	5.5	4	
12	3	36	36	6	2	
13	0	0	13	6.5	2	
14	1	14	14	7	0	
15	0	0	15	7.5	1	
16	1	16	16	8	1	
17			17			
18			0			
19			0			
20			40			
21			0			
22			22			
Total	1122	2200	332		1122	54

Minimum) in 1986 rendering it eligible for a safety countermeasure upgrade. However, the location may have exhibited less than 5 annual accident frequencies for the 3 years prior. Therefore, the interpretation of the results is based loosely on the 1986 accident occurrences and is subject to scrutiny of the analysis of data taken from prior years.

The results indicate that there were 1,122 Stop Sign locations in 1986 that exhibited a total of 2,200 accidents for the various levels of annual accidents per location. Approximately 1,041 of these locations (1,651 accident frequencies) represented accidents for the categories of 1 through 4 annual accidents per location. Meanwhile, the remaining 81 Stop Sign locations (549 accident frequencies) represented accidents for the categories 5 through 16 annual accidents per location. The results also indicate that the 54 Countermeasure locations in 1986 exhibited a total of 332 accidents for the various levels of annual accidents per location. Approximately, 28 of these locations (72 accident frequencies) represented accidents for the categories of 1 through 4 annual accidents per location. Meanwhile, the remaining 26 Countermeasure locations (260 accident frequencies) represented accidents for the categories 5 through 22 annual accidents per location.

The 81 "Without" locations are juxtaposed with the respective "With" countermeasure locations on Figure 15. The results indicate that there were more "without" locations with accident frequencies between the levels of 5 and 10 annual accidents per location than the "with" frequencies for 1986 locations. Perhaps the "Without" locations should have been addressed before the 28 Countermeasure locations, with annual accidents frequencies of less than 5, were awarded traffic signals in 1986.

The statistics suggest that there were several Stop Sign locations that required safety countermeasure applications. The results give rise to the question: "Why were 28 locations given Traffic Control Signals in 1986 with annual accidents frequencies of less than 5 when there were 81 Stop Sign locations with accidents more than 5 annual accidents?" The answers to the



Accident Frequency Analysis
"With-and-Without" Countermeasures
Accident Frequencies
0
20
40
60
80
100
120
140
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Annual Accidents per Location
Total "Withouts"
Total "With's"

Figure 15

question are multi-faceted. Several of the 81 Stop Sign locations may not have exhibited the minimum 5 annual accidents for the last 3 years. The Stop Sign locations may not have met the traffic volume requirements. The accident frequencies at Stop Sign locations should be standardized by traffic volume to illustrate the "real" risk factor. Perhaps a number of the Stop Sign locations were within 300 feet of an existing traffic signal location thereby cancelling the application by reason of proliferation avoidance. Finally, RMOC Council may have waived the Provincial Warrants in favour of the Countermeasure location application for traffic control signals based on physical, geographic and political factors.

On a lighter note, the results also indicate that the 1986 Countermeasure allocation addressed the 3 worst locations in the Region with respect to accident frequencies. There were 2 locations that exhibited 20 annual accident frequencies each and 1 location that exhibited 22 annual accident frequencies. In addition, the intersections that exhibited annual accident frequencies between 11 and 17 per location were split evenly such that half of the locations remained Stop Sign locations while the other half were awarded traffic control signals.

6.62 Accident Rates Analysis

The accident frequencies for the "Without" locations have been standardized by traffic volume, where possible, in attempt to determine which "Without" locations exhibited higher accident rates than the 1986 Countermeasure locations. As outlined in Appendix 2, there were less than 25% "Without" locations that contained traffic volume counts. This relates to only 238 locations of the total 1,122 "Without" intersections that exhibited traffic counts in the database. It should also be noted that the dates for the traffic counts vary from 1978 through 1986 on a very inconsistent and random basis. Therefore, it is very difficult to draw current conclusions from the data analysis.

The initial results of the accident rates analysis, tenuous

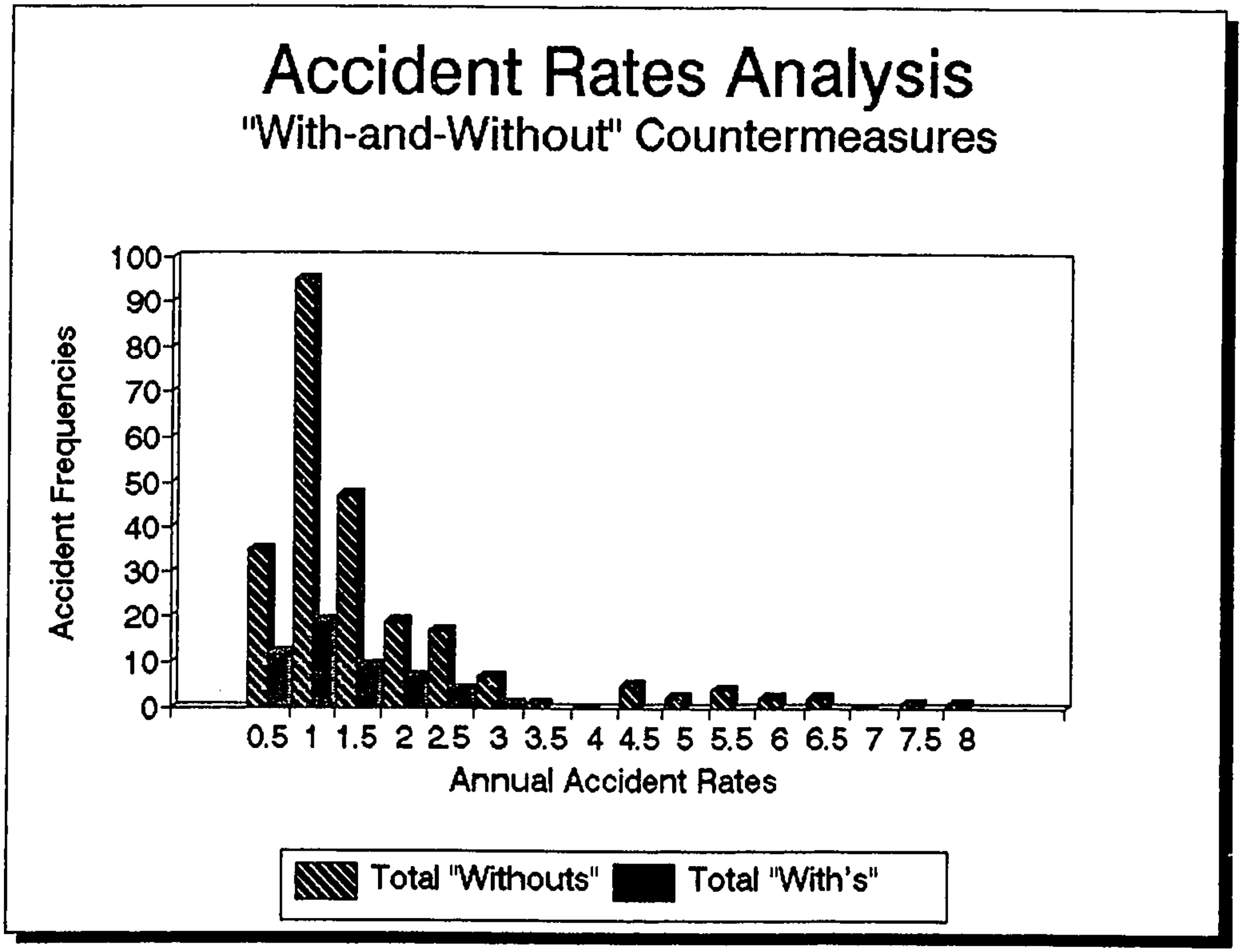

Accident Rates Analysis
"With-and-Without" Countermeasures
Accident Frequencies
100
90
80
70
60
50
40
30
20
10
0
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8
Annual Accident Rates
Total "Withouts"
Total "With's"

Figure 16

at best, are illustrated in Table 18, "With-and-Without" Accident Rates Analysis - Categories 0.0 through 8.0. The summary is very difficult to read as a result of the large number of locations that exhibited zero accidents per MEV. There were 884 locations with a zero accident rate or no traffic counts which represented more than 75% of the total location database. The information for this category was virtually meaningless because of the large number of missing traffic count cases in the database.

The accident rate database was disaggregated to highlight the 25% sample of the locations for which traffic counts were recorded. The result was 238 locations between the accident rates levels of 0.5 through 8.0 accidents per MEV. The results are summarized in Figure 16, "With-and-Without" Accident Rates Analysis - Categories 0.5 through 8.0. According to these results, there were approximately 196 Stop Sign locations (82%) that exhibited accident rates between the levels of 0.5 and 2.0 accidents per MEV. The equivalent for the Countermeasure locations was 49 or 91% of the total number of locations. There was no doubt that several of the Stop Sign locations required the installation of additional safety countermeasures. In fact, approximately 42 Stop Sign locations exhibited accident rates greater than 2 accidents per MEV. There were only 5 Countermeasure locations that exhibited accident rates greater than 2 accidents per MEV.

The evaluation of the application of the Countermeasure locations indicates that there may well have been more appropriate locations that should have received traffic control signals. This does not necessarily mean that the "With" locations that were allocated traffic control signals have exhibited ineffective results to the safety devices. The countermeasure locations, while not having experienced the countermeasure for the full year, have enjoyed the measure for some part of 1986. The comparison of the "With-and-Without" locations should be viewed such that the 1986 Countermeasure locations have already exhibited a drop in accident levels as a result of the countermeasure effectiveness for the partial year.

The results of the "With-and-Without" analysis are inconclusive but there are several flaws within the analysis that must be recognized as uncontrollable by the researcher at present. First, the evaluation of the allocation of traffic safety countermeasures should be exercised on the valid "before" period. In the case of the RMOC countermeasures, the analysis should have included the accident data for the "before" periods 1983, 1984 and 1985 in correspondence with the requirements of the Provincial Warrants. The details of each of the prior years' performance should be analyzed for adherence to the RMOC policies and the Provincial Warrants.

Second, the database should be complete with respect to the traffic volume count information for the "Without" locations. The "Without" traffic counts supplied in the RMOC database were sparse and failed to illustrate current trends. The presence of missing data in the analysis adds a question of doubt as to the integrity of the data and subsequent outcome of the results.

Third, the "With-and-Without" analysis should be carried out on a site specific basis (that is on each possible countermeasure application) in order to identify any specialized external factors that are peculiar to the particular situation.

Finally, the measurement of effective or inappropriate allocations of safety countermeasures should be measured by the variance between the "after" results of the Countermeasure locations and the estimate of the accident frequency results of the "Without" locations if a countermeasure was in fact implemented. The estimate may be calculated in a similar fashion as the aforementioned Probabilistic Approach, however, the method requires further investigation and improvement.

At the present time, it would be extremely difficult to meet all of the above requirements and it would be particularly difficult to apply the "Without" estimate requirement. In addition, the results may be too generalized to provide any new insight as to the impact of the countermeasures. The intersections, in most municipalities grow into situations that are very unique unto themselves both in terms of political decision-making and the site specific layout of physical components.

6.70 "With-and-Without" Countermeasure Analysis Summary

There are several factors that influence the allocation of traffic control signals within the RMOC Region. Many of these factors have been formalized through Warrants developed by the Province and guidelines outlined by RMOC policies and standing committees dealing with safety improvement. These are summarized in Chapter 2. In addition, there are several other influencing factors, some geographic in nature and some that are not, that either remain unwritten or are formalized through site specific applications for traffic signals in the Region.

A number of examples of these factors were given in section 6.20 of this chapter. These examples were taken from the database developed by RMOC and included items such as weather conditions, diurnal periods, direction of traffic and patterns of injury. The resulting data frequency analysis proved interesting, however, the results were inconclusive because of a number of reasons. The data was unable to be interpreted after being "standardized" for traffic volume. There was insufficient representative data to conduct more sophisticated multivariate analysis.

An additional database was created by the researcher outlining various geographic land use categories that are thought to influence the flow and pattern of traffic at a particular location when in close or immediate proximity to one another. These spatial factors included residential, commercial and institutional land uses throughout the Region. Each of the categories were designed top include various site specific land uses that affected the 54 countermeasure locations in question. The land uses were ranked in order of importance based on proximity to the site and summarized with reference to the respective traffic volume counts. The results indicated a suspected belief that land use plays a significant role in the traffic generated at a particular location.

However, the evidence was inconclusive as to the magnitude and distribution of the amount of influence that may be exerted by the various categories for a particular site.

The aforementioned, comprehensive list of factors, is by no means complete. There are new factors that become apparent with every new application for countermeasure installation. In fact, what may be deemed an influencing factor in one situation may have very little relevance in a subsequent application. This corresponds to the fact that each intersection, although its components may be standardized to some extent, remains unique from all others as the surrounding neighbourhood undergoes change during its maturation process.

The factors that influence traffic signal allocations must be considered when evaluating the "With-and-Without" countermeasure inventory of a particular area. In the case of RMOC, there is an indication that several 1986 Stop Sign locations merit traffic control signal installations. However, the evidence is inconclusive because of missing data for the 3 years prior to 1986. In addition, there always seems to be that "exception to the rule" where external or extenuating circumstances made the actual 1986 countermeasure installation more appealing than addressing the other 1986 Stop Sign locations.

These extenuating circumstances refer to the land uses that have an extraordinary effect on the number of vehicular trips generated for the area in question. These components are not listed specifically in an RMOC policy manual or in the Provincial Warrants. However, there is an indirect relationship between the variables and the policy statements. The relationship exists and is measured by the current and estimated traffic volume resulting from the changes in the land use trip generators.

The "With-and-Without" analysis was applied using the Traditional Approach in terms of Accident Frequencies and an attempt was made to reapply the analysis after standardizing the data for traffic volume. There were a number of flaws identified in the process that were highlighted as opportunities for improvement.

The opportunities for improvement included the addition of more historical data with higher integrity levels. They also included the application of the analysis to a more appropriate "before" period to encourage a more succinct comparison of the countermeasure application to policy requirements. It was also suggested that a site specific analysis may be more appropriate in order to identify the physical, geographic and political components influencing the application. Finally, it was proposed that the evaluation would be more complete it included a variance analysis of the difference between the accident frequency performance of the Countermeasure locations, following the installation, and the estimated performance of the Stop Sign locations if a countermeasure had been implemented.

Chapter 7

Conclusions

7.10 Traffic Control Signal Allocation - Overview

There were 3 key socio-geographic questions that were asked at the outset of this study. The first question dealt with the motivation behind the concepts of traffic management techniques. The second question asked to what extent did major land uses determine the application of safety countermeasures. The third question addressed the relationship between countermeasure applications and traffic volume and flow. These questions were designed to identify the processes and policies involved in the application and allocation of traffic control signals in the RMOC area.

The aforementioned questions were answered at various stages throughout the study. The motivation directing traffic management issues was discovered to be a municipal mandate for the provision of an effective, economical, and safe environment for the operation of vehicles and pedestrian mobility within the RMOC area. In the case of the RMOC, the individual Municipalities are responsible for the provision of the physical system on the Lower Tier. The RMOC is responsible for the Upper Tier physical system described in Chapter 2, section 2.20, the Regional Road System. Meanwhile, the various area police departments are responsible for the on-going use and users of the RMOC transportation system.

Additions and adjustments to the physical system are carried out by various departments within the area municipalities and the Transportation Management Department of RMOC. The various Upper and Lower Tier groups are responsible for specific types of transportation system development but approval for major projects remains in the realm of RMOC. The RMOC Transportation Management Department, and sections therein, attempt to accomplish this task through use of a variety of policy guidelines and operational tools, provided both internally and by the Province. Examples of these programs, policies and tools were outlined in Chapter 2, section 2.30, Transportation System Management. They include programs such as the Intersection Improvement Program, the Safety Improvement Program and the Traffic Accident Analysis System. The key information sources used in this decision making process include Traffic Surveys and Land Use Studies for the surrounding area; the Traffic Accident Reports provided by the various police departments; and the Traffic Control Warrants provided by the Province.

These tools, geographic by nature, present valuable insight to the second and third questions: "To what extent do major land uses determine the application of safety countermeasures?" and "What is the relationship between countermeasure applications and traffic volume and flow?" Major land uses and any subsequent changes made to them are directly responsible for the number of vehicular and person trips generated at any one time. In addition, there is a direct relationship between traffic flow volume and the allocation of traffic control signals to an intersection. Therefore, it stands to reason that various land uses, and the subsequent traffic generated, are directly related to the allocation of traffic control signals. There are several examples of the impact of changes to major land uses on traffic control signals listed in Chapter 6, section 6.50, Spatially Influencing Factors. In addition, the Region has attempted to measure the actual impact of key land use factors on the distribution of volume of traffic flow within the bounds of the Region. The results of these measures are summarized in the RMOC Trans Trip Generation Manual, published in 1989.

The RMOC Transportation Management Department deals with the allocation of traffic control signals based on the traffic volume specifications outlined by the Provincial Warrants. The hazardous sites in question are scrutinized as to the existing traffic volume and trip generating land uses in close proximity to the site. As outlined in the Trip Generation Manual by RMOC, different land use types produce various different types and volumes of traffic. The

Warrants require that certain traffic volume specifications are satisfied in addition to particular levels of historic traffic accident activity before a traffic control signal will be granted. Therefore, by definition, the types of land use activity determine the character of the traffic flows for a particular area and, hence, the type of countermeasure devices used to manage the situation.

One of the main requirements, under the Provincial Warrants, include that a historic trend of no less than 5 accidents per year for the last 3 years must have occurred at the location in question. The second most important requirement indicates that at least 750 vehicles must pass through the intersection each hour for the heaviest 8 hours during the day for the location in question. That relates to a minimum of 6,000 vehicular movements in one day. The average daily volume for the 1986 Countermeasure locations was approximately 16,700 vehicular movements in 1986.

The evidence for the applications is normally derived from the Annual Accident Frequency Reports and the Traffic Survey results described in Section 2.30 of Chapter 2. However, if the traffic count figures are unavailable, estimates are derived from the, aforementioned, Trans Trip Generation Manual produced by RMOC. This manual outlines peak and non-peak hour vehicle and person trips for virtually every land use that exists within the limits of RMOC. Without going into further detail, it is obvious that the administration of the traffic control signal allocations by RMOC is both a rigorous and complex exercise.

7.20 Traffic Control Signal Evaluation - Overview

Shortly after this study began, it was discovered that the RMOC administrators did not have a formal evaluation procedure in place to determine the effectiveness of the countermeasure installation. The evaluation practices, or, "post mortem" studies, were foregone in place of the rigorous policy requirements that were successfully met prior to the awarding of the countermeasure. However, on occasion, a traditional evaluation study was completed, upon request of Senior Managers or Council members.

Following an extensive literary search, a number of documents were identified by authors such as Council, Hauer et al., Kates, Roberge, and Treat that dealt with the application and evaluation processes related to safety countermeasure implementations. The overriding theme in the readings dealt with various approaches to safety effectiveness, however, there was no clear identification of a standardized theoretical approach to risk reduction.

The main components of risk reduction were identified as risk determination and risk evaluation. The risk determination phase was comprised of risk identification and risk estimation. The risk identification stage consisted of the statistical screening of hazardous areas to highlight the problem. The risk estimation stage consisted of measuring the magnitude of the risk through some form of hazard index.

In the case of traffic control signal allocation in RMOC, the risk determination phase has been used extensively. The hazardous locations were identified through the compilation of the accident reports and theoretically choosing the locations with 5 annual accidents for the last 3 years. The magnitude of the risk was measured based on the current traffic volume present at the location, or, by predicted volume levels based on trips generated by the ensuing land use. The results of the analysis were compared to the standards outlined in the Provincial Warrants document and the decision is made as to the allocation of the traffic control signals.

The risk evaluation phase was generally defined by the use of "before-and-after" safety countermeasure studies and "with-and-without" safety countermeasure studies. These studies were largely comparative in nature and application was done on a site specific basis. The two popular approaches to determining the effectiveness of countermeasures were described as the Traditional Approach and the Probabilistic Approach.

The Traditional Approach was comprised of the measurement of the variance between the accident frequency levels for the periods directly before and immediately following the installation of the safety countermeasures. In each case the Traditional Approach made use of the previous years results as the "benchmark" comparison figure for the accident performance following the countermeasure implementation.

The mechanics of the Probabilistic Approach were similar to that of the Traditional Approach. However, the Probabilistic Approach attempted to estimate the "benchmark" comparison figure to reflect the "regression to the mean" effect for the countermeasure locations in question. This new approach was expected to give a more realistic measure of the effectiveness of the countermeasure performance.

In the absence of a formal evaluation process by RMOC, this study attempted to create an evaluation process to review the effectiveness of countermeasure locations in the RMOC. The method of evaluation was comprised of three basic steps. First, a review was made of the spatial distribution of traffic accidents at Stop Sign and Traffic Signal locations. Second, a review was made of the accident and traffic volume statistics "before-and-after" the countermeasure implementation. Third, an appraisal of the effectiveness of the countermeasures was made using both the Traditional and Probabilistic Approaches.

7.30 Countermeasure Evaluation Process - Comments

The formal evaluation process put forth in this study has given some indication as to the effectiveness of the geographic allocation of traffic control signals in RMOC. The results of the Traditional Approach, as summarized in Table 10, section 5.20 of Chapter 5, indicate that the installation of traffic signals at the 54 locations throughout the RMOC region resulted in a drop of approximately 8% in overall accidents between 1986 and 1987 which relates to a 14% decrease for the countermeasure locations alone. However, it is not clear that the reduction was directly attributable to the countermeasure implementation. The Traditional Approach also indicated that the number of accidents, at intersections that remained of the Stop Sign nature between 1986 and 1987, dropped by approximately 25% of the overall accidents.

In both cases, it is very difficult to determine if the accident reduction was a result of a natural decline in the number of accidents, a result of the existing or newly implemented countermeasures, a result of major structural changes made at each particular location, or, because of the presence of specific geographical components peculiar to the location in question. The data was standardized by traffic volume in attempt to review the pattern of the data in terms of a common risk factor. The results indicated a more significant drop in the accident rate following the introduction of the traffic control signals.

Further investigation into traffic accident analysis methods led to the introduction of the Probabilistic Approach. This method seemed to be more sophisticated than the Traditional Approach and was expected to offer additional insight to the analysis. The Probabilistic Approach was applied to the data so that the comparative "benchmark" would be an estimate of the number of accidents that would have happened if the countermeasures had not been implemented. This would reduce the bias in the countermeasure comparative analysis by incorporating the "regression to the mean" effect. Once again, this bias is illustrated by the 26% natural reduction in traffic accidents for the Stop Sign locations between 1986 and 1987 that was exhibited in Table 10 of Chapter 5; section 5.22; the Traditional Approach for Non-Countermeasure locations..

As indicated by the summary in Table 13, section 5.40 of Chapter 5, the results of the Probabilistic Approach were difficult to interpret. The first application, the Least Squares Estimate, provided a very conservative estimate of the number of accidents that would have occurred at the 54 locations if no countermeasures had been implemented. In fact, the raw estimate was approximately 35% less than the number of actual accidents that occurred in 1987 with the countermeasures in place. Meanwhile, the smoothed estimate was approximately 15% less than the number of actual accidents that occurred in 1987 with the countermeasures in place.

The desired result would have been for the estimates to fall somewhere in between the 1986 figures and the actual 1987 figures. However, such was not the case. The overall predictions for both the raw and smoothed Least Squares Estimates were simply too far off the mark to provide any meaningful results.

Unfortunately, the Linear Function Estimate was equally as difficult to interpret. This estimate predicted that the number of accidents, if no countermeasures were implemented, would drop to 246 estimated accidents in 1987 from the 342 actual accidents in 1986. This overall change indicates that the Linear Function estimate of accidents occurring in 1987 if no countermeasures had been put into place, was approximately 13% lower than the what happened in 1987 with the countermeasures in place.

As illustrated in the closing statements in Chapter 5, the results of the Probabilistic method indicate that the failure of the 1987 actual accidents to fall below the estimate values (if no countermeasure had been put into place) indicates that the allocation of the traffic countermeasures throughout 1986 failed miserably. If the countermeasures had been allocated more efficiently, the number of accidents in 1987 would have fallen well below the estimated figures. On the other hand, the procedure used to calculate the estimates may have been too conservative, or, the measures must be adjusted to account for new developments that may affect traffic volume and flow during the year of countermeasure implementation. That is to say that more attention must be given to each of the countermeasure sites, individually, such that the estimating measures will incorporate any number of socio-geographic features (ie. additions of new shopping malls, office complexes, institutional facilities, etc.) that may affect the volume and flow, and hence, the overall accident mean.

The Probabilistic Approach encountered a number of other opportunities for improvement with regards to the results illustrated on an individual accident category basis. The predictive power of the estimates, as they moved from one accident frequency category (ie. 1,2,3..22) to the next, was hampered by base cases with zero's or large changes in the number of accidents in adjacent frequency categories. The presence of these fluctuations led to substantial variations in the resulting estimates. These variations invariably led to large gaps between the estimates and the resulting accidents that actually occurred in the following year.

Nonetheless, the Traditional and Probabilistic Approaches have provided a good indication of the changes in the pattern of accidents following the implementation of safety countermeasures. The Traditional Approach indicated a favourable reduction in the number of accidents following the introduction of accident countermeasures. The Probabilistic Approach provided a more detailed appraisal by considering the "regression to the mean" effect. This more sophisticated approach indicated that the drop in the number of accidents was unsatisfactory when measured against the number of accidents that should have occurred if no countermeasures had been put into place. However, the significance levels of the Probabilistic measures were very low when tested with a simple form of regression analysis of significance. In addition, it remains difficult to determine if the accident reduction was a result of the existing or newly implemented countermeasures; a result of major structural changes made at each particular location; or, because of the presence of specific geographical components peculiar to the location in question.

In attempt to identify the other components that played a role in accident reduction from one year to the next, an analysis was made of the Alternative Variables associated with the accident locations. The Alternative Variables were comprised of components of both a physical and behaviourial nature that were associated with the particular location. They included crashes during Daylight/Darkness, Dry/Wet Road Conditions, Peak/Non-Peak Travelling Time, Pedestrian/Total Injury and the various Directional Movements of Vehicles Prior to Impact. The analysis was conducted using the Traditional Approach as opposed to a type of multivariate analysis because of the small size of the database.

The results were very interesting but it should be stressed that the conclusions drawn are of a speculative nature. It seems that the introduction of the countermeasures has reduced the number of accidents that occur during wet and icy road conditions as well as during the peak hours of travel between 07:00 - 09:30 and 15:30 - 18:00. Oddly enough, the number of pedestrian injuries rose following the introduction of the safety countermeasures. There were also significant impacts on the directionality of the vehicles prior to impact. For example, the number of "broad-sided" right angled accidents dropped significantly and the number of "head-on" accidents rose, marginally. Finally, the number of "rear-end" accidents dropped immediately but began to rise shortly thereafter.

In order to identify more specific geographic components that may play a factor in the allocation of traffic control signals, a new database was created using the traditional traffic generators that are distributed throughout the geographic fabric of the Regional Municipality of Ottawa-Carleton. Specific land use found in the areas of Residential, Rural, Commercial and Institutional influences were identified and placed in a land use inventory matrix. The particular land uses were weighted according proximity to the countermeasure locations and speculative conclusions were drawn as to the influence that may have been applied to the particular locations. The results, while interesting, failed to offer any solid statistical evidence of the distribution and magnitude of any sort of influence from these land use factors. This may, perhaps, be achieved using multivariate statistical techniques on a database holding a larger representative sample of the various land use categories outlined.

The aforementioned variables are all, in some way, contributing factors to the circumstances surrounding an accident occurrence. Particular factors have been identified as geographic in nature. Others are not. It is suspected that some of the factors are related and it is also suspected that others are not. Therefore, it seems imperative that the impact these factors must be measured in terms of individual influence and multiple factor influence on traffic flows and subsequent traffic control signal allocations. This may be accomplished through various multi-variate and log linear techniques, however, an representative database must be created or found. This would permit the identification of the role played by each factor may be identified both individual and in combination with other influencing factors. The results may even lead to the identification of a "hybrid" sort of factor that may be classified under the heading of socio-geographic factors.

In attempt to further evaluate the allocation of the countermeasures by RMOC in 1986, a "With-and-Without" analysis was conducted to identify the Stop Sign locations that exhibited higher accident rates than the locations that received countermeasures in 1986. The results indicated that there were several Stop Sign locations that exhibited higher rates than the countermeasure locations. However, arguments were made, in favour of the countermeasure locations, concerning the lack of historic Accident and Traffic Count data for the Stop Sign locations. In addition, it was mentioned that the analysis should have dealt with 1985 as the "before" year so that the impact of the countermeasure implementations throughout 1986 were omitted to permit a "clean" comparative analysis. It was also suggested that the "With-and-Without" analysis consider the variance between the "after" results of the countermeasure locations and the estimate of the accident frequency results of the "Without" locations if a countermeasure was in fact implemented, in a manner similar to the Probabilistic Approach.

7.40 Accident Database Comments

The accident database furnished by the Transportation Management branch of RMOC seemed very useful, at the outset, for both the Traditional and Probabilistic Approaches to safety countermeasure allocation evaluation. However, there are a few immediate drawbacks that are addressed in Appendix 2. Many of the problems encountered in the estimate measurements are likely a result of the poor integrity of the RMOC database. There are several inconsistencies with respect to the reporting of accident activity at locations from one year to the next. For example, there are discrepancies from one year to the next with regards to the names and locations of particular intersections. This problem may be avoided by geocoding the locations in all databases. This would simplify future data extractions and subsequent analysis in terms of both Relational Database Analysis and Geographic Information System applications. Other inconsistencies include the ommission of locations from the database if no accidents occur in a particular year. These leads to erroneous estimates of the number accident free locations in any given year. Accurate and substantiated data is required if any sort of sophisticated analysis or estimates are expected to be developed with some level of integrity.

In addition, a number of the aforementioned socio-geographic components must be added to the database to permit further analysis to identify the "true" impact made by a countermeasures. Naturally, these developments are subject to a cost-benefit priortization with other projects within the Transportation Management Department, especially under the current times of economic recession in Canada and war in the Middle East. However, until that point is reached, it remains very difficult to clearly understand the impact of traffic signals on accident frequencies. Hence, it is difficult to comment on, or, draw conclusions as to the strengths and weakness's in the RMOC and Provincial Warrant policies regarding traffic signal allocations.

7.50 Regional Policy Comments

As mentioned previously, it is very difficult to draw conclusions, or, comment on current RMOC policy and the Provincial Warrants, in terms of traffic control signal allocation and evaluation without knowing the "true" impact of the safety countermeasure on accident frequencies. The policy regarding traffic control signal allocation is rigorous but appropriate in terms of the cost involved in traffic signal installations (approximately $80,000 per intersection without site improvements). The guidelines outlined in section 2.38 of Chapter 2 highlight the various requirements by both RMOC and the Provincial Warrants. The guidelines are appropriate in that they are designed to address intersections and situations with high accident rates and substantial traffic volume. In addition, the built-in components restricting the proliferation of traffic signals are also commendable.

The only other comment that may be made, at this point, is with regard to the waiving of the requirements by Council for "special cases". There were examples of "special cases" given in section 5.50 of Chapter 5, Informal Factors - Countermeasure Implementation. These influences varied from "mega-project" proposals both in commercial and municipal scenario's, to institutional and convenience factors. The problem is not so much with the applications, or, influences themselves, but, rather, with the lack of formalized documentation outlining when "special cases" should prevail. An inventory of this nature may serve as a useful guideline for RMOC staff and help streamline discussions at Council in reaction to "special case" influences. In addition, it may help limit the further proliferation of resources.

7.60 Future Research

As previously mentioned, the ideal conditions for safety countermeasure allocation evaluation would have to include the introduction of a model to address the socio-geographic components and their impact on traffic accidents. This goal may be accomplished using a strategy that combines Relational Database Analysis and Geographic Information System applications.

The GIS applications could involve a variety of data modules that provide many of the socio-geographic components required to measure the impact of countermeasures on accident frequencies. Primarily, this would include population, economic, land use and traffic volume information as well as many other subordinate variables. The resulting information, extracted from the GIS, could be manipulated using the Relational Database Model in order to measure the composition and strength of the various components. The analysis of the subsequent results is limitless when left up to the imagination.

Better yet, if all vehicle operators and pedestrians were to "slow down", "obey the rules of the road", "don't drink and drive", and "watch out for that other guy" then there would be a whole lot less accidents to evaluate!

Appendix 1

MINIMUM REQUIREMENTS FOR INSTALLATION OF TRAFFIC SIGNALS FOR TWO LANE ROADWAYS

LOCATION ________________ AT ________________

MUNICIPALITY ________________ DATE OF SURVEY ________________

	WARRANT	DESCRIPTION	MINIMUM REQUIREMENT FOR TWO-LANE ROADWAYS: FREE FLOW — OPERATING SPEED GREATER THAN OR EQUAL TO 70 km/h	MINIMUM REQUIREMENT FOR TWO-LANE ROADWAYS: RESTRICTED FLOW — OPERATING SPEED LESS THAN 70 km/h	COMPLIANCE: SECTIONAL %	COMPLIANCE: ③ ENTIRE %
INTERSECTION	1. MINIMUM VEHICULAR VOLUME	①A Vehicle Volume, All Approaches for Each of the Heaviest 8 Hours of an Average Day, and	480	720		
		①④B Vehicle Volume, Along Minor Streets for Each of the Same 8 Hours	120	170		
	2. DELAY TO CROSS TRAFFIC	①A Vehicle Volume, Along Major Street for Each of the Heaviest 8 Hours of an Average Day, and	480	720		
		②B Combined Vehicle and Pedestrian Volume Crossing the Major Street for Each of the Same 8 Hours	50	75		
	3. ACCIDENT HAZARD	A Total Reported Accidents of Types Susceptible to Correction by a Traffic Signal, per 12 Month Period Averaged Over a 36 Month Period, and	5			
		B Adequate Trial of Less Restrictive Remedies, Where Satisfactory Observance and Enforcement Have Failed to Reduce the Number of Accidents, and	YES ☐ NO ☐			
		C Fulfillment of Either of the Above Warrants (Minimum Vehicular Volume or Delay to Cross Traffic) to the Extent of 80% or More.	YES ☐ NO ☐			
	4. COMBINATION WARRANT	Two or More of the Above Warrants (1, 2 or 3) Satisfied to the Extent of 80% or More.	YES ☐ NO ☐			
MID-BLOCK	5. MINIMUM PEDESTRIAN VOLUME	A Pedestrian Volume Crossing the Major Street Average per Hour for the Heaviest 8 Hours of an Average Day, and	120	240		
		①B Vehicle Volume Along Major Street Average Per Hour for the Same 8 Hours.	290	575		

NOTES: ① Vehicle Volume Warrants (1A), (2A) and (5B) for Roadways Having Two or More Moving Lanes in one Direction Should Be 25% Higher Than Values Given Above.

② For Definition of Crossing Volume Refer to Note ④ on the Signal Warrant Analysis Form B2.03.08

③ The Lowest Sectional Percentage Governs the Entire Warrant.

④ For "T" Intersections the Values for Warrant (1B) Should Be Increased by 50%

February, 1982

B.2.03.08 TRAFFIC SIGNAL WARRANT ANALYSIS FORM FOR INTERSECTION CONTROL.

Minimum warrants for installation of traffic signals for roadways with two or more lanes.

Major street.............................; MULTI LANE YES ☐ NO ☐
Minor street.............................

Street Name				
Channelized	NB	SB	EB	WB
Turns				

FREE FLOW CONDITIONS (RURAL) ☐
RESTRICTED FLOW CONDITIONS (URBAN) ☐

WARRANT 1 – MINIMUM VEHICULAR VOLUME

100 % SATISFIED – YES ☐ NO ☐
80 % SATISFIED – YES ☐ NO ☐

		MINIMUM REQUIREMENTS (80% SHOWN IN BRACKETS)				PERCENTAGE WARRANT									
APPROACH LANES		1		2 or MORE		HOUR ENDING									
FLOW CONDITION		FREE FLOW ☐	RESTR FLOW ☐	FREE FLOW ☐	RESTR FLOW ☐									TOTAL ACROSS	
A. ALL APPROACHES		480 (385)	720 (575)	600 (480)	900 (720)										
	100% FULFILLED														
	80% FULFILLED														SECTIONAL PERCENT
	ACTUAL % IF BELOW 80% VALUE														
														TOTAL DOWN	*8*
B. MINOR STREET BOTH APPROACHES		120* (95)*	170* (135)*	120* (95)*	170* (135)*									TOTAL ACROSS	
	100% FULFILLED														
	80% FULFILLED														SECTIONAL PERCENT
	ACTUAL % IF BELOW 80% VALUE														
														TOTAL DOWN	*8*

*FOR 'T' INTERSECTIONS THESE VALUES SHOULD BE INCREASED BY 50%

T-INTERSECTION YES ☐ NO ☐

WARRANT 2 – DELAY TO CROSS TRAFFIC

100 % SATISFIED – YES ☐ NO ☐
80 % SATISFIED – YES ☐ NO ☐

		MINIMUM REQUIREMENTS (80% SHOWN IN BRACKETS)				PERCENTAGE WARRANT									
APPROACH LANES		1		2 or MORE		HOUR ENDING									
FLOW CONDITION		FREE FLOW ☐	RESTR FLOW ☐	FREE FLOW ☐	RESTR FLOW ☐									TOTAL ACROSS	
A. MAJOR STREET BOTH APPROACHES		480 (385)	720 (575)	600 (480)	900 (720)										
	100% FULFILLED														
	80% FULFILLED														SECTIONAL PERCENT
	ACTUAL % IF BELOW 80% VALUE														
														TOTAL DOWN	*8*
B. TRAFFIC CROSSING MAJOR STREET		50 (40)	75 (60)	50 (40)	75 (60)									TOTAL ACROSS	
	100% FULFILLED														
	80% FULFILLED														SECTIONAL PERCENT
	ACTUAL % IF BELOW 80% VALUE														
														TOTAL DOWN	*8*

Warrant 3 - Reported Accidents

Year	19	19	19	ANNUAL AVG.
Total				
Preventable				

100 % SATISFIED - YES ☐ NO ☐
80 % SATISFIED - YES ☐ NO ☐

A. Reportable accidents within a 12 month period averaged over 36 consecutive months susceptible to correction by a traffic signal.		
WARRANT VALUE	AVERAGE ANNUAL PREVENTABLE	FULFILLED
5	......	......%
B. Adequate trial of less restrictive remedies has failed to reduce accident frequency.		100% - Yes ☐ 0% No ☐
C. Either Warrant 1 (Minimum Vehicular Volume) or Warrant 2 (Delay to Cross Traffic) satisfied 80% or more.		100% - Yes ☐ 0% No ☐

WARRANT 4 - COMBINATION WARRANT

SATISFIED - YES ☐ NO ☐

Used if no warrant satisfied 100%

REQUIREMENT	WARRANT SATISFIED 80% OR MORE	FULFILLED
Two Warrants Satisfied 80%	Warrant 1 - Minimum Vehicular Volume - Yes ☐ No ☐ Warrant 2 - Delay to Cross Traffic - Yes ☐ No ☐ Warrant 3 - Accident Experience - Yes ☐ No ☐	- Yes ☐ No ☐

CONCLUSION: TRAFFIC SIGNALS WARRANTED - YES ☐ NO ☐

WARRANT 5 - FOR MID-BLOCK SIGNAL

100 % SATISFIED - YES ☐ NO ☐

APPROACH LANES	MINIMUM REQUIREMENT 1		2 or MORE		TOTAL	AVERAGE
FLOW CONDITION	FREE FLOW	RESTR. FLOW	FREE FLOW	RESTR. FLOW	8 HOURS	1 HOUR
A. PEDESTRIANS CROSSING MAJOR ST.	120	240	120	240		
B. MAJOR STREET BOTH APROACHES	290	575	365	720		

NOTES: 1. The warrant values are based on annual average daily traffic (AADT) which approximates May and October traffic.

2. For warrants 1,2,3 and 4, each hourly volume must exceed the minimum requirements for the warrant to be 100% satisfied.

3. For warrant 5 the 8 hour average must exceed the minimum requirements for the warrant to be 100% satisfied

4. The crossing volume is defined as:

(1) Left turns from both minor street approaches
(2) The heaviest through volume from the minor street
(3) 50% of the heavier left turn movement from major street when both of the following criteria are met:
(a) The left turn volume > 120 vph
(b) The left turn volume plus the opposing volume > 720 vph
(4) Pedestrians crossing the major street

February, 1982

Appendix 2

Appendix 2

Data Preparation

A2.1 Introduction

The analysis of the policy requirements concerning traffic signal implementation by the Region was a complex exercise that involved the manipulation of several database structure. The individual databases were structured in a similar format which facilitated various extractions and data exchanges between files. However, several problems were encountered concerning accident location name changes, duplicate and missing information and other factors that questioned the reliability of the data. Therefore, it is appropriate to discuss the problems encountered during the data preparation and manipulation stages and the steps taken to ensure the integrity of how the information was maintained.

A2.2 Background Problems

The accident frequency report, traffic volume and installation inventory databases provided by the Region were configured in a minicomputer database format but were imported as Ascii text to facilitate analysis within a Lotus 123 environment. The Frequency Ranking Report of Traffic Collision Locations text files were imported into Lotus 123 on an individual basis for the periods of 1985 through 1989. These files were presented in a formal report format and required conversion into a database structure to permit any sort of statistical analysis. Each of the 5 files were imported into Lotus 123 in an Ascii text format but it was impossible to manipulate the individual fields of the records. Therefore, each of the files were parsed such that the multiple fields of each record were assigned to particular cells in the lotus spreadsheet for further manipulation. This exercise was particularly time consuming because the report contained numerous page headers defining the various traffic management devices; traffic signals, stop signs, yield signs, cross walks, etc. It was necessary to filter out the page headers and repetitive titles as part of the conversion of the report into a database. In addition, the data was disaggregated within the file into the various categories that indicated the type of traffic management device. The exercise resulted in 5 very large Lotus 123 files that contained approximately 2,200 records with 22 fields of information.

The importing and parsing exercise was also carried out on the RMOC Accident Rates Database. This process was less time consuming because the information was already in a database structure with no dissimilar fields. In addition, there was no need to identify various categories of information because the fields for each record were simply comprised of alphabetic location identifiers followed by accident frequencies, 12 hour traffic volumes, the calculated accident rate and the year the traffic count was taken. The result was a very large file that contained approximately 7,000 records representing the annual traffic volume counts compiled at the Region between 1978 and 1989.

The importing and parsing exercise was carried out a third time for the RMOC Traffic Signal Installation Inventory database. The procedure was not nearly as rigourous as the database merely contained 131 records. The fields for each record were similar in size and format and posed no significant problem during the preparation stage.

In order to get a feel for the data, each of the databases were sorted and resorted based on various fields presented by the records. The review of the information resulted in the following report presentations. The Ranking database was primarily sorted by total accident frequency and secondarily by ascending alphabetic order of location. The Frequency database did not require sorting by year as each of the 5 files represented an individual year of accident data. The RMOC Accident Rates database was primarily sorted in ascending alphabetic order of location and secondarily by the descending year of volume taken. For example, the data displayed for Albert and Bank streets begin with the record indicating the 1989 traffic volume and concluded several records later with the 1978 traffic volume, if such a count was taken. The RMOC Traffic Signal Installation Inventory database was disaggregated into 5 sections, each representing the annual signal installations between 1985 and 1989. These records were sorted primarily in ascending alphabetic location and secondarily by date of installation.

A2.3 Constructing the "Before-and-After" File

The next step in the data preparation stage involved the creation of a "before-and-after" traffic signal location file and a "with-and-without" traffic signal file for the ensuing analysis. The base year 1986 was chosen for the analysis because it contained 54 signal installations out of the total of 131 installations between 1985 and 1989. The creation of the "before-and-after" file required the extraction of a subfile containing the 1986 signal installations from the "inventory" database. The subfile was combined with each of the successive annual Accident Frequency Ranking databases in order to identify the records indicating accident performance over time at the particular locations. However, it was necessary to rearrange the data fields in the traffic signal inventory subfile to represent the same field composition as the frequency files. In addition, a unique identifier was given to each "inventory" record to facilitate quick identification after being combined into the frequency files. The combined files were resorted by ascending alphabetic location such that the traffic signal installation record was piggybacked with the traffic accident record for the particular year. The file was then scanned from top to bottom for the uniquely identified signal installation records. When such a record was found, a unique identifier was assigned to the "piggybacked" accident record and the search continued. The file was resorted to group the 54 accident records together after the total number of locations were found and uniquely identified. These accident records were extracted into an individual subfile and the entire exercise was repeated for each of the subsequent accident frequency files.

The result was five subfiles (1985 through 1989) that contained the accident records for the locations that received traffic signal installations in 1986. The five files were combined together and resorted in ascending alphabetic order by location and ascending order of year. The result was a "before-and-after" type accident location file that highlights progressive accident performance of a location between 1985 and 1989. The information displayed in Appendix 3 is an example of the resulting database.

The data preparation process for the "before-and-after" file up to this point was fairly routine and was automated with macro commands to some extent. However, there were some difficulties encountered with respect to matching the alpha location identifiers between the signal installation locations and the accident frequency locations. For example, the intersection at Coventry Road and the Vanier Parkway was identified as Alta Vista Drive and RCMP Headquarters prior to 1986. The locations are clearly the same, however, the names changed over time as a result of a change in the intersection configuration or Queensway (Highway 417) construction. An example of major intersection reconfiguration is illustrated by the Alta Vista and Riverside Drive intersection that was completely changed in 1986 and resulted in 2 new intersections: Alta Vista Drive/Industrial Road and Riverside Drive/Industrial Road.

The frequency of the name change problem became particularly predominant with the Regional Road locations where, for example, RR 248 became RR 36 and RR 220 became RR 38 in 1986. There were 24 locations out of the 54 that presented this "name change" problem. These locations first arose as problem areas because locational matches were not found between the 1986 signal installation records and the 1985 accident records. The problem was presented to RMOC and after some research the name changes were discovered and subsequently, the complete accident records were added to the "before-and-after" database. This type of problem may have been avoided if the location identifiers in the database were geocoded coordinates as opposed to alphabetic identifers.

The next step in the preparation process was the addition of the traffic volume information to the "before-and-after" data base in order to standardize the accident frequencies for exposure. This process was initiated by combining the 1986 traffic signal installation subfile with the RMOC accident Rates database. However, the subfile required revision to include the name change locations discovered previously. The revised subfile was combined with the Accident Rates database in order to identify the volume figures for the successive years of the installation inventory locations. The combined files were resorted to "piggyback" the matching alphabetic locations and the scanning process began in order to allocate the unique identifiers to the traffic volume records. The file was resorted and the traffic volume record were extracted into a new subfile. The newly created volume subfile was printed in hard copy and the appropriate volume figures were distributed to a new field in the "before-and-after" accident record file.

The resulting file proved interesting, however, there was evidence of missing data as well as cases where there were unusually large changes in traffic volume from one year to the next. These cases were highlighted and cross referenced with the original traffic volume file to ensure the extraction process was successful. The cases that remained questionable were presented to the staff at RMOC for clarification. The RMOC staff found a small fraction of incorrect traffic counts which explained some of the variances from one year to the next. This phenomena was also explained by causes such as intersection reconstruction, street paving projects and Queensway construction. The remaining missing data represented less than 10% of the total number of traffic counts. The missing data cases were sporadically distributed throughout the file. In most instances, the traffic count was missing for only 1 year out of the 5 years surveyed for each locations. The RMOC staff explained that traffic counts were not necessarily taken annually for each location because some locations maintain relatively constant volumes of traffic from one year to the next. Therefore, the traffic count was not taken in order to reduce costs or to initiate a traffic count in a location that warranted study. Consequently, the missing counts were estimated based on the average of the previous performance and the volumes experienced in following years.

There were only two additional locations that had no counts whatsoever. These locations were at Highway 16 and Fallowfield Road as well as the intersection at Highway's 15 and 17 at Carleton Place. The RMOC staff indicated that the two locations fell under the jurisdiction of the Province. The Provincial traffic division was contacted in Kingston and the information was provided promptly.

The next step in the data preparation process for the "before-and-after" file was comprised of recalculating the accident rate formula based on the revised traffic counts. The intersection accident rate was calculated using the formula provided by the Region based on the number of accidents standardized by "one million entering vehicles" for an annualized period. The formula is as follows:

Rate=((# of accidents)*(10)^6)/(365 days)*24hr.AADT)).

The formula was added to the "before-and-after" database because the accident rates imported from the RMOC Accidents Rates database were the value results. The actual formula was required to recalculate the rates for the locations with the revisions made for errors and missing data.

The final step taken to complete the "before-and-after" file was comprised of adding more common names to the Regional Road locations to enhance the identification of the geographic locations. The common names for the Regional Roads are identified in Appendix 4. For example, RR-38 was actually Carling Avenue and RR-63 was Merivale Road. There were 3 locations in particular were the Regional Road represented more than 1 alphabetic name. For instance, RR-49 could represent Eagleson Road or March Road depending on the location of the cross street. This feature was shared by RR-59 which was Moodie Drive and Richmond Road. The most interesting example is RR-36 which underwent a name change for each city in the Region. For example, in Ottawa it starts off as Wellington but changes to Richmond Road and to Robertson Side Road in Nepean. In Kanata it becomes Hazeldean Road and in Stittsville it is called Old Highway #7. Once again, the lack of consistency tends to add confusing elements to the analysis and may be rectified by a geocode coordinate system.

2.4 Constructing the "With-and-Without" File

The preparation of the "with-and-without" file was actually a compilation of all the "without" stop sign and pedestrian cross walk accident locations taken from the 1986 accident file. The data was extracted based on the stop sign and cross walk identifiers and resulted in a very large file with approximately 1,100 records. The records were sorted in descending order of accident frequency to enhance readability.

The next step in the preparation process was the addition of the traffic volume information in order to standardize the "without" file with the Accident Rates database in a similar fashion as the "before-and-after" file building process. However, major memory problems were encountered. The Accident Rates database contained more than 7,000 records and the computing equipment used in this project would not allow the addition of the 1,100 "without" records.

The first inclination was to convert the data into a genuine database format in order to permit the cumbersome sorting and extraction process. However, this exercise in itself was believed to be time consuming and implied the loss of the computing ability of Lotus 123. Therefore, the traffic volume counts were taken from the "hard copy" and added to the existing file of "without" records. As it turned out, approximately 250 of the 1,100 locations actually contained traffic volume counts in the Accident

Rates database and the manual process was not very time consuming.

The next step in the preparation process was comprised of the addition of the accident rate formula in order to ensure consistency with "before-and-after" file. The identical standardization formula was used and no problems were encountered. The addition of the accident rates permitted the file to be sorted on several levels. First, the file was disaggregated by filtering out the "without" locations that were converted to traffic signal locations in the subsequent years: 1987, 1988 and 1989. Nonetheless, the composition of the entire data set remained 1986 accident frequency records. Each of these categories (including the 1986 "withouts") were sorted primarily by descending accident rate and secondarily by alphabetic location identifier. This format was expected to enable more specialized analysis. The "without" table may be found in Appendix 5.

The number of traffic counts applied to actual locations in the "without" file was comprised of less than 25% of the entire file. The counts were not taken by RMOC or any other source for the remaining locations. However, a brief overview of the file seemed to indicate that the majority of high accident frequency locations were allocated traffic counts. Furthermore, the missing traffic counts for "high frequency" accident locations would simply beg the question "why not" in the ensuing analysis.

Appendix 3

Appendix 3
Common Names for Regional Roads

RR- 05	Carp Road
RR- 10	Franktown Road
RR- 12	Fallowfield Road
RR- 16	Acres = Baseline Road
RR- 16N	Baseline Road North
RR- 16S	Baseline Road South
RR- 17	Merivale = Clyde Avenue
RR- 34	St. Joeseph Blvd.
RR- 36	Wellington = Richmond = Roberstson = Hazeldean = Old Hwy 7.
RR- 38	Carling Avenue
RR- 49	Eagleson = March Road
RR- 59	Richmond = Moodie Drive
RR- 61	Terry Fox Drive
RR- 63	Merivale Road
RR- 128	Cyrville Road

Appendix 4

Appendix 4

"Before-and-After" Database

YEAR		TYPE	LOCATION1		LOCATION2	VOLUME	ACC. FREQ	ACC. RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1985	0	TS	ALTAVIST	&	RIVERSID	35,064	30	2.3	1	9	10	9	0	2	2	0	3	5	2	7	3	3	0	3	0	8
1986	1	TS	ALTAVIST	&	INDUSTRI	32,986	15	1.2	0	2	8	4	0	1	1	1	0	3	2	2	1	1	0	3	0	4
1987	1	TS	ALTAVIST	&	INDUSTRI	39,750	23	1.6	0	6	11	6	0	0	2	0	1	8	3	1	1	5	0	2	0	11
1988	1	TS	ALTAVIST	&	INDUSTRI *	32,714	11	0.9	0	2	3	3	0	1	0	0	0	5	2	1	1	1	0	0	0	3
1989	1	TS	ALTAVIST	&	INDUSTRI	25,678	12	1.3	0	1	5	4	0	1	1	2	0	7	0	0	0	0	0	1	0	2
1985	1	PX	BANK	&	THIRD '79	12,683	8	1.7	0	1	1	3	1	2	0	0	0	0	0	0	5	0	0	0	0	0
1986	1	TS	BANK	&	THIRD	14,985	6	1.1	0	1	3	4	1	1	1	0	0	1	0	0	1	0	0	1	1	2
1987	1	TS	BANK	&	THIRD	14,892	5	0.9	0	1	1	2	1	1	1	0	2	0	0	0	0	0	0	0	0	3
1988	1	TS	BANK	&	THIRD *	13,229	3	0.6	0	1	1	2	0	0	0	0	0	0	1	0	1	0	0	1	1	3
1989	1	TS	BANK	&	THIRD	11,565	2	0.5	0	0	2	1	0	0	0	0	1	0	1	0	0	0	0	0	0	2
1985	1	PX	BASELINE	&	GUTHRIE	14,106	9	1.7	0	1	5	2	1	0	0	0	0	0	0	3	0	5	0	0	0	0
1986	1	TS	BASELINE	&	GUTHRIE	16,163	4	0.7	0	0	1	0	0	0	1	0	0	0	0	2	0	1	0	0	0	2
1987	1	TS	BASELINE	&	GUTHRIE	15,151	2	0.4	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2	1	1
1988	1	TS	BASELINE	&	GUTHRIE	14,344	1	0.2	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
1989	1	TS	BASELINE	&	GUTHRIE	14,592	5	0.9	0	1	3	3	1	0	0	0	0	1	0	2	0	0	0	1	1	4
1986	1	PX	BOTSFORD	&	SMYTH	12,429	13	2.9	0	2	7	7	5	1	0	0	0	1	1	1	0	3	0	1	1	0
1986	1	PX	BOTSFORD	&	SMYTH	13,121	5	1.0	0	0	2	1	3	0	0	0	0	1	0	0	0	1	0	0	0	3
1987	1	TS	BOTSFORD	&	SMYTH	11,745	2	0.5	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1
1988	1	TS	BOTSFORD	&	SMYTH	15,025	2	0.4	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	1	1	1
1989	1	TS	BOTSFORD	&	SMYTH	10,012	3	0.8	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1
1985	1	SS	BOWESVIL	&	HUNTCLUB	11,207	4	1.0	0	1	3	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0
1986	1	TS	BOWESVIL	&	HUNTCLUB	10,871	4	1.0	0	2	1	2	2	0	2	0	0	0	0	0	0	0	0	0	0	0
1987	1	TS	BOWESVIL	&	HUNTCLUB	14,492	3	0.6	0	1	1	2	0	0	0	1	0	1	0	1	0	0	0	0	0	1
1988	1	TS	BOWESVIL	&	HUNTCLUB	12,837	4	0.9	0	0	1	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0
1989	1	TS	BOWESVIL	&	HUNTCLUB	15,688	5	0.9	0	0	2	2	0	1	0	0	1	2	0	0	0	1	0	0	0	3
1985	1	SS	BRIDLEPA	&	HUNTCLUB	10,865	1	0.3	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1986	1	TS	BRIDLEPA	&	HUNTCLUB	12,780	8	1.7	0	4	0	2	2	0	0	2	0	2	0	1	0	0	0	1	0	2
1987	1	TS	BRIDLEPA	&	HUNTCLUB	15,667	7	1.2	0	2	3	3	1	0	0	0	0	2	0	2	0	0	0	2	0	3
1988	1	TS	BRIDLEPA	&	HUNTCLUB	16,898	7	1.1	1	2	3	2	0	0	0	1	0	1	0	3	0	2	0	0	0	2
1989	1	TS	BRIDLEPA	&	HUNTCLUB	18,588	4	0.6	0	0	1	0	1	0	0	0	0	2	0	0	0	1	0	0	0	1
1985	1	SS	CANTIN	&	MONTREAL '83	14,497	9	1.7	0	3	2	3	2	0	4	0	0	1	0	2	0	0	0	0	0	4
1986	1	TS	CANTIN	&	MONTREAL	15,019	5	0.9	0	1	2	3	1	0	1	0	0	1	0	1	0	1	0	0	0	1
1987	1	TS	CANTIN	&	MONTREAL	14,550	3	0.6	0	0	1	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0
1988	1	TS	CANTIN	&	MONTREAL *	13,324	8	1.6	0	4	3	2	0	0	1	0	0	1	0	2	0	4	0	0	0	4
1989	1	TS	CANTIN	&	MONTREAL	12,098	4	0.9	0	2	1	2	0	1	0	0	0	1	0	1	0	1	0	0	0	2

Appendix 4

"Before-and-After" Database

YEAR		TYPE	LOCATION1		LOCATION2	VOLUME	ACC.	ACC.	NON	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT	ONE	PED	TOT
							FREQ	RATE/MEV	REP														SPEC	VEH	INJ	INJ
1985	1	PX	CHURCHIL	&	DOVERCOU	9,560	6	1.7	0	0	2	2	1	1	0	1	0	0	2	1	0	0	0	0	0	0
1986	1	TS	CHURCHIL	&	DOVERCOU	8,631	3	1.0	0	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0
1987	1	TS	CHURCHIL	&	DOVERCOU	9,344	3	0.9	0	0	1	2	0	1	0	0	2	0	0	0	0	0	0	0	0	1
1988	1	TS	CHURCHIL	&	DOVERCOU	9,104	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	1	TS	CHURCHIL	&	DOVERCOU	7,795	3	1.1	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	2
1985	1	SS	CLARENCE	&	DALHOUSI	6,956	7	2.8	0	2	3	1	2	0	3	2	0	0	0	0	0	0	0	0	0	1
1986	1	TS	CLARENCE	&	DALHOUSI	10,238	3	0.8	0	3	1	1	0	0	1	0	1	0	0	0	1	0	0	0	0	1
1987	1	TS	CLARENCE	&	DALHOUSI	14,473	4	0.8	0	2	1	0	0	0	0	2	0	1	0	0	0	0	0	1	1	2
1988	1	TS	CLARENCE	&	DALHOUSI	10,558	2	0.5	1	2	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0
1989	1	TS	CLARENCE	&	DALHOUSI	8,918	4	1.2	0	1	3	1	0	0	1	0	1	0	1	0	1	0	0	0	0	1
1985	1	SS	CLEARY	&	RICHMOND	10,532	3	0.8	0	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0
1986	1	TS	CLEARY	&	RICHMOND	10,935	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	1	TS	CLEARY	&	RICHMOND	11,479	1	0.2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
1988	1	TS	CLEARY	&	RICHMOND	11,264	1	0.2	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
1989	1	TS	CLEARY	&	RICHMOND	10,280	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	1	TS	ALTAVIST	&	RCMP-HQ	35,381	18	1.4	0	1	10	9	0	0	1	0	10	0	1	0	5	1	0	0	0	4
1986	1	TS	COVENTRY	&	VAN-PKW	34,386	20	1.6	0	4	6	7	0	0	0	2	9	0	2	0	4	2	0	1	0	5
1987	1	TS	COVENTRY	&	VAN-PKW	36,547	22	1.6	0	5	7	12	1	0	0	1	9	0	5	0	3	3	0	0	0	6
1988	1	TS	COVENTRY	&	VAN-PKW	35,796	30	2.3	0	4	11	14	0	1	0	2	8	1	1	0	11	3	0	3	1	10
1989	1	TS	COVENTRY	&	VAN-PKW	30,383	17	1.5	0	3	5	11	0	0	0	0	7	0	5	0	3	1	0	1	0	7
1985	1	NC	WOODROFF	,	ADIRONDA TO BASELINE	15,609	7	1.2	0	2	1	5	0	0	0	2	0	0	3	0	2	0	0	0	0	1
1986	1	TS	FIRE-STN	&	WOODROFF *	18,019	2	0.3	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0
1987	1	TS	FIRE-STN	&	WOODROFF *	18,622	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	1	TS	FIRE-STN	&	WOODROFF	20,429	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	1	TS	FIRE-STN	&	WOODROFF	19,891	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985		SS	FISHER	&	SHILLING	13,113	4	0.8	0	1	1	1	0	1	0	0	1	0	1	0	0	0	0	1	0	2
1986	1	TS	FISHER	&	SHILLING	15,050	2	0.4	0	0	1	2	0	2	0	0	0	0	0	0	0	0	0	0	0	1
1987	1	TS	FISHER	&	SHILLING	13,272	2	0.4	0	0	2	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
1988	1	TS	FISHER	&	SHILLING	14,001	1	0.2	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
1989	1	TS	FISHER	&	SHILLING	16,722	3	0.5	0	2	1	1	0	0	0	0	0	0	1	0	0	0	0	2	0	1
1985	0		FROBISHE	&	RIVERSID	21,186	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	1	SS	FROBISHE	&	RIVERSID	20,654	2	0.3	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1
1987	1	TS	FROBISHE	&	RIVERSID	21,557	6	0.8	0	1	3	0	0	0	0	1	1	1	3	0	0	0	0	0	0	3
1988	1	TS	FROBISHE	&	RIVERSID *	21,336	2	0.3	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
1989	1	TS	FROBISHE	&	RIVERSID	21,115	1	0.1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Appendix 4
"Before-and-After" Database

YEAR		TYPE	LOCATION1		LOCATION2	VOLUME	ACC. FREQ	ACC. RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1985	1	PX	HARTWELL	&	PRINCEOF *	16,264	8	1.3	0	0	7	2	1	1	2	0	0	0	3	0	1	0	0	0	0	0
1986	1	PX	HARTWELL	&	PRINCEOF	17,656	8	1.2	0	0	6	2	0	1	1	0	0	0	3	0	3	0	0	0	0	4
1987	1	TS	HARTWELL	&	PRINCEOF	15,256	1	0.2	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1988	1	TS	HARTWELL	&	PRINCEOF *	15,800	2	0.3	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0
1989	1	TS	HARTWELL	&	PRINCEOF	16,343	1	0.2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
1985	1	SS	HWY- 15	&	HWY- 17 *	4,600	5	3.0	0	2	1	3	1	0	3	0	0	0	0	0	0	0	0	1	0	0
1986	1	TS	HWY- 15	&	HWY- 17 *	4,600	3	1.8	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1
1987	1	TS	HWY- 15	&	HWY- 17	3,958	1	0.7	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1988	1	TS	HWY- 15	&	HWY- 17 *	4,600	3	1.8	0	0	1	1	0	0	2	0	1	0	0	0	0	0	0	0	0	1
1989	1	TS	HWY- 15	&	HWY- 17	5,241	6	3.1	0	1	1	3	1	0	2	0	1	1	0	0	0	1	0	0	0	4
1985	1	TS	ALTAVIST	&	HWY-417N	41,292	7	0.5	0	1	3	6	0	0	0	0	0	0	3	0	4	0	0	0	0	2
1986	1	TS	HWY-417N	&	VAN-PKW	49,216	14	0.8	0	2	5	9	0	0	2	0	0	0	4	0	6	1	0	1	0	4
1987	1	TS	HWY-417N	&	VAN-PKW	39,199	15	1.0	0	4	2	10	0	0	0	1	0	0	0	0	11	0	0	3	0	6
1988	1	TS	HWY-417N	&	VAN-PKW	35,796	13	1.0	0	3	2	8	0	0	2	1	1	0	4	0	5	0	0	0	0	3
1989	1	TS	HWY-417N	&	VAN-PKW	33,959	12	1.0	0	2	4	8	0	0	0	1	0	0	3	0	7	0	0	1	0	4
1985	0	NC	S.LAUREN	,	TRANSIT TO TREMBLAY	30,188	18	1.6	0	4	5	6	0	0	0	0	1	0	9	0	6	0	0	2	0	3
1986	1	TS	HWY-417S	&	S.LAUREN	25,170	22	2.4	0	8	7	12	0	1	0	1	6	1	6	0	4	2	0	1	0	7
1987	1	TS	HWY-417S	&	S.LAUREN	23,992	16	1.8	0	7	3	6	0	1	1	2	3	1	6	0	0	2	0	0	0	6
1988	1	TS	HWY-417S	&	S.LAUREN	29,781	9	0.8	0	1	2	1	0	3	0	0	0	1	2	2	1	0	0	0	0	0
1989	1	TS	HWY-417S	&	S.LAUREN	44,431	12	0.7	1	1	3	2	1	2	0	0	0	0	6	2	0	0	0	1	0	2
1985	0	TS	ALTAVIST	&	RIVERSID	35,064	30	2.3	1	9	10	9	0	2	2	0	3	5	2	7	3	3	0	3	0	8
1986	1	TS	INDUSTRI	&	RIVERSID	32,986	12	1.0	0	2	4	8	0	0	0	0	3	0	1	0	3	3	0	2	0	4
1987	1	TS	INDUSTRI	&	RIVERSID	39,750	18	1.2	1	5	5	6	0	0	2	0	3	0	3	0	6	2	0	2	0	5
1988	1	TS	INDUSTRI	&	RIVERSID *	36,917	10	0.7	0	3	1	3	0	0	0	3	2	0	0	0	4	1	0	0	0	2
1989	1	TS	INDUSTRI	&	RIVERSID	34,083	18	1.4	0	6	7	9	0	0	1	1	2	0	4	0	6	1	0	3	1	8
1985	1	SS	JEANNEDA	&	VORLAGE '84	8,794	3	0.9	0	0	1	1	1	0	2	0	0	0	0	0	0	0	0	0	0	1
1986	1	SS	JEANNEDA	&	VORLAGE	11,027	4	1.0	0	2	2	1	0	0	1	0	0	2	0	1	0	0	0	0	0	2
1987	1	TS	JEANNEDA	&	VORLAGE	10,656	2	0.5	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	2
1988	1	TS	JEANNEDA	&	VORLAGE	11,501	2	0.5	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
1989	1	TS	JEANNEDA	&	VORLAGE	11,536	2	0.5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
1985	1	TS	KINGEDWA	&	SOMERSET '83	11,071	4	1.0	0	2	1	3	0	0	0	0	2	0	1	0	0	0	0	1	1	1
1986	1	TS	KINGEDWA	&	SOMERSET	13,370	5	1.0	0	4	0	0	0	0	0	0	2	0	0	0	2	0	0	1	0	2
1987	1	TS	KINGEDWA	&	SOMERSET	10,948	4	1.0	0	0	2	1	0	0	0	0	1	0	0	0	1	0	0	2	1	2
1988	1	TS	KINGEDWA	&	SOMERSET *	11,038	4	1.0	1	0	3	3	0	0	0	0	1	0	0	0	1	2	0	0	0	0
1989	1	TS	KINGEDWA	&	SOMERSET	11,127	3	0.7	1	0	2	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0

Appendix 4
"Before-and-After" Database

YEAR		TYPE	LOCATION1		LOCATION2	VOLUME	ACC. FREQ	ACC. RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	WW	NB	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1985	1	SS	OT.STNRD	&	TREMBLAY *	12,641	1	0.2	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1986	1	SS	OT.STNRD	&	TREMBLAY *	12,641	4	0.9	0	1	1	1	0	0	0	0	0	0	3	0	0	0	0	1	0	0
1987	1	TS	OT.STNRD	&	TREMBLAY	17,750	1	0.2	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
1988	1	TS	OT.STNRD	&	TREMBLAY *	12,641	3	0.7	0	0	1	2	0	0	0	0	0	1	0	2	0	0	0	0	0	1
1989	1	TS	OT.STNRD	&	TREMBLAY	7,531	2	0.7	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0
1985	1	SS	RIDEAU	&	WURTEMBU	16,719	5	0.8	0	1	3	1	0	0	0	0	0	3	0	0	0	0	0	2	2	3
1986	1	TS	RIDEAU	&	WURTEMBU	23,749	5	0.6	0	3	1	1	0	0	0	0	0	1	0	2	0	0	0	2	2	2
1987	1	TS	RIDEAU	&	WURTEMBU	21,343	6	0.8	0	1	3	4	0	0	1	0	0	3	0	1	0	0	0	1	1	3
1988	1	TS	RIDEAU	&	WURTEMBU *	20,438	7	0.9	1	2	5	5	0	0	1	0	0	0	0	3	0	2	0	1	1	3
1989	1	TS	RIDEAU	&	WURTEMBU	19,532	3	0.4	0	1	1	1	0	0	0	0	0	1	0	1	0	0	0	1	1	2
1985	1	SS	CARP ROAD	&	OLD HWY 7	4,204	8	5.2	0	1	4	3	1	2	3	0	0	1	0	0	0	0	0	1	0	5
1986	1	TS	CARP ROAD	&	OLD HWY 7	4,960	4	2.2	0	2	1	2	2	0	0	0	0	1	0	0	1	0	0	0	0	2
1987	1	TS	CARP ROAD	&	OLD HWY 7	4,702	4	2.3	0	1	1	2	0	1	0	0	2	0	0	1	0	0	0	0	0	1
1988	1	TS	CARP ROAD	&	OLD HWY 7	6,688	3	1.2	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	1	0	2
1989	1	TS	CARP ROAD	&	OLD HWY 7	6,294	2	0.9	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2
1985	1	SS	FRANKTOW	&	EAGLESON	5,888	10	4.7	0	1	4	2	5	1	1	0	0	0	0	1	0	0	0	2	0	6
1986	1	SS	FRANKTOW	&	EAGLESON	6,140	1	0.4	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1987	1	TS	FRANKTOW	&	EAGLESON	6,566	2	0.8	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	2
1988	1	TS	FRANKTOW	&	EAGLESON	7,238	1	0.4	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
1989	1	TS	FRANKTOW	&	EAGLESON	6,638	2	0.8	0	1	2	2	1	0	0	0	0	0	0	1	0	0	0	0	0	0
1985	1	SS	FALLOWFIE	&	HWY- 16 *	10,499	5	1.3	0	0	3	3	0	3	0	0	0	1	1	0	0	0	0	0	0	1
1986	1	SS	FALLOWFIE	&	HWY- 16	10,446	3	0.8	0	0	1	1	0	3	0	0	0	0	0	0	0	0	0	0	0	1
1987	1	TS	FALLOWFIE	&	HWY- 16	9,756	7	2.0	0	1	5	3	0	1	0	0	0	0	4	0	2	0	0	0	0	3
1988	1	TS	FALLOWFIE	&	HWY- 16 *	10,517	6	1.6	0	1	3	4	0	3	0	0	0	0	1	0	1	0	0	1	0	2
1989	1	TS	FALLOWFIE	&	HWY- 16	11,278	4	1.0	0	1	3	3	0	0	0	0	0	0	3	0	0	0	0	1	0	3
1985	1	TS	FALLOWFIE	&	RICHMOND	6,390	4	1.7	0	1	3	1	0	1	1	1	1	0	0	0	0	0	0	0	0	3
1986	1	TS	FALLOWFIE	&	RICHMOND	7,564	5	1.8	0	2	2	1	0	0	3	1	0	0	1	0	0	0	0	0	0	3
1987	1	TS	FALLOWFIE	&	RICHMOND	8,660	3	0.9	0	2	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	1
1988	1	TS	FALLOWFIE	&	RICHMOND	9,498	4	1.2	0	1	2	0	0	0	2	0	0	1	1	0	0	0	0	0	0	1
1989	1	TS	FALLOWFIE	&	RICHMOND	9,169	3	0.9	0	1	0	1	0	0	1	0	1	0	0	0	0	1	0	0	0	1
1985	1	SS	ACRES	&	CARLING	13,560	10	2.0	0	3	5	6	4	0	1	1	0	1	0	1	0	0	0	2	0	2
1986	1	TS	ACRES	&	CARLING	12,759	3	0.6	0	0	2	1	0	0	0	0	1	1	0	1	0	0	0	0	0	1
1987	1	TS	ACRES	&	CARLING	15,746	10	1.7	0	7	3	6	1	0	0	0	1	4	0	3	0	0	0	1	0	3
1988	1	TS	ACRES	&	CARLING *	16,462	6	1.0	0	2	3	3	1	0	0	0	0	2	0	1	0	0	0	2	0	3
1989	1	TS	ACRES	&	CARLING	17,177	4	0.6	0	1	0	1	0	0	0	0	0	2	0	2	0	0	0	0	0	1

Appendix 4
"Before-and-After" Database

YEAR		TYPE	LOCATION1		LOCATION2	VOLUME	ACC. FREQ	ACC. RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1985	1	TS	BASELINEN	&	RICHMOND '84	16,207	5	0.8	0	1	2	2	0	0	0	0	0	3	0	2	0	0	0	0	0	3
1986	1	TS	BASELINEN	&	RICHMOND	17,939	9	1.4	0	5	2	4	0	0	1	0	0	4	0	1	2	0	0	1	0	6
1987	1	TS	BASELINEN	&	RICHMOND	17,552	3	0.5	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	1	0	2
1988	1	TS	BASELINEN	&	RICHMOND	16,918	4	0.6	0	1	2	0	0	0	0	0	0	3	0	0	1	0	0	0	0	2
1989	1	TS	BASELINEN	&	RICHMOND	17,005	3	0.5	0	1	1	2	1	0	0	0	0	1	0	0	1	0	0	0	0	1
1985	1	TS	BASELINES	&	RICHMOND	22,530	18	2.2	0	7	4	11	1	0	0	1	0	13	1	0	0	0	0	2	0	7
1986	1	TS	BASELINES	&	RICHMOND	27,325	12	1.2	0	2	8	3	0	0	0	1	0	8	1	1	0	1	0	0	0	7
1987	1	TS	BASELINES	&	RICHMOND	25,128	9	1.0	0	4	4	2	1	0	0	0	0	6	0	1	0	0	0	1	0	5
1988	1	TS	BASELINES	&	RICHMOND	24,341	10	1.1	0	5	2	4	1	0	0	0	0	7	1	0	0	0	0	1	0	5
1989	1	TS	BASELINES	&	RICHMOND	26,704	18	1.8	0	11	0	13	0	0	0	0	0	13	0	1	0	0	0	4	0	7
1985	1	TS	CLYDE	&	MERIVALE	34,057	9	0.7	0	4	2	7	0	0	0	1	2	0	1	0	2	3	0	0	0	3
1986	1	TS	CLYDE	&	MERIVALE	36,245	12	0.9	0	4	4	9	0	0	1	1	1	5	0	0	1	3	0	0	0	3
1987	1	TS	CLYDE	&	MERIVALE	37,219	9	0.7	0	2	3	4	0	0	0	0	3	3	0	0	1	1	0	1	0	3
1988	1	TS	CLYDE	&	MERIVALE	36,603	15	1.1	0	3	6	7	0	0	1	2	3	3	2	1	1	2	0	0	0	8
1989	1	TS	CLYDE	&	MERIVALE	35,403	10	0.8	0	1	4	5	1	0	2	1	1	2	0	0	1	2	0	0	0	3
1985	1	PX	ST.JOSEPH	&	ELWOOD '84	9,479	4	1.2	0	0	4	2	1	0	0	0	0	0	0	2	0	0	0	1	1	1
1986	1	PX	ST.JOSEPH	&	ELWOOD *	11,362	2	0.5	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1
1987	1	TS	ST.JOSEPH	&	ELWOOD	13,244	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	1	TS	ST.JOSEPH	&	ELWOOD	14,557	2	0.4	0	0	1	2	0	0	0	0	0	0	0	1	0	1	0	0	0	0
1989	1	TS	ST.JOSEPH	&	ELWOOD	15,045	2	0.4	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
1985	1	TS	RICHMOND	&	BAYSHORE	22,453	24	2.9	0	7	5	6	2	1	0	0	0	14	0	2	3	0	0	2	0	12
1986	1	TS	RICHMOND	&	BAYSHORE	22,474	17	2.1	0	3	3	7	1	1	1	0	0	11	0	1	2	0	0	0	0	9
1987	1	TS	RICHMOND	&	BAYSHORE	21,899	4	0.5	0	1	2	1	0	0	0	0	0	0	0	0	1	2	0	1	1	3
1988	1	TS	RICHMOND	&	BAYSHORE *	21,413	6	0.8	0	1	1	3	2	0	0	0	0	0	0	1	2	1	0	0	0	2
1989	1	TS	RICHMOND	&	BAYSHORE	20,926	4	0.5	0	1	2	1	0	0	0	0	1	0	2	0	1	0	0	0	0	1
1985	1	SS	HAZELDEAN	&	CASTLEFR	11,313	8	1.9	1	1	2	3	1	0	3	0	1	2	0	0	1	0	0	0	0	3
1986	1	TS	HAZELDEAN	&	CASTLEFR	14,148	8	1.5	0	1	3	2	0	1	1	0	0	3	1	0	0	0	0	2	1	6
1987	1	TS	HAZELDEAN	&	CASTLEFR	13,079	6	1.3	0	1	2	3	0	0	0	1	0	5	0	0	0	0	0	0	0	2
1988	1	TS	HAZELDEAN	&	CASTLEFR	14,668	7	1.3	1	4	1	3	0	0	1	0	2	3	0	0	0	1	0	0	0	2
1989	1	TS	HAZELDEAN	&	CASTLEFR	14,526	11	2.1	0	2	4	4	0	1	2	1	2	1	0	1	1	1	0	1	0	5
1985	1	TS	ROBERTSOI	&	LYNHAR	28,482	6	0.6	0	1	2	2	0	0	0	1	1	0	0	2	1	1	0	0	0	2
1986	1	TS	ROBERTSOI	&	LYNHAR	27,654	3	0.3	0	0	1	1	0	0	0	0	0	0	0	1	0	1	0	1	1	3
1987	1	TS	ROBERTSOI	&	LYNHAR	27,955	8	0.8	0	1	4	2	1	0	0	0	2	0	0	0	0	3	0	2	1	2
1988	1	TS	ROBERTSOI	&	LYNHAR	31,068	6	0.5	0	1	4	3	2	0	0	0	1	0	1	1	0	1	0	0	0	2
1989	1	TS	ROBERTSOI	&	LYNHAR	31,481	7	0.6	0	3	3	4	0	0	0	0	0	0	0	3	0	4	0	0	0	4

Appendix 4
"Before-and-After" Database

YEAR		TYPE	LOCATION1		LOCATION2	VOLUME	ACC.	ACC.	NON	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT	ONE	PED	TOT
							FREQ	RATE/MEV	REP														SPEC	VEH	INJ	INJ
1985	1	TS	RICHMOND	&	NANAIMO	16,984	10	1.6	0	3	2	6	1	2	1	0	3	1	0	2	0	0	0	0	0	3
1986	1	TS	RICHMOND	&	NANAIMO	18,653	13	1.9	0	4	3	4	2	1	1	0	1	2	0	3	0	1	0	2	0	3
1987	1	TS	RICHMOND	&	NANAIMO	18,775	9	1.3	0	2	3	3	0	0	0	0	0	3	0	5	0	1	0	0	0	6
1988	1	TS	RICHMOND	&	NANAIMO	20,873	6	0.8	0	1	2	3	0	0	0	0	0	0	0	3	2	1	0	0	0	2
1989	1	TS	RICHMOND	&	NANAIMO	20,560	10	1.3	0	2	4	6	1	0	1	0	0	2	0	5	0	0	0	1	0	3
1985	1	SS	ROBERTSO	&	RICHMOND	19,659	4	0.6	0	1	3	1	0	0	0	0	0	1	1	1	0	1	0	0	0	0
1986	1	TS	ROBERTSO	&	RICHMOND	24,124	4	0.5	0	0	2	2	1	0	0	0	0	2	1	0	0	0	0	0	0	0
1987	1	TS	ROBERTSO	&	RICHMOND	26,068	2	0.2	0	0	2	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1
1988	1	TS	ROBERTSO	&	RICHMOND	24,700	3	0.3	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	1
1989	1	TS	ROBERTSO	&	RICHMOND	20,928	4	0.5	0	1	2	1	1	0	0	1	0	0	0	1	0	0	0	1	1	3
1985	1	TS	HAZELDEAN	&	EAGLESON	22,857	13	1.6	1	3	6	3	0	1	2	1	3	1	0	1	2	1	0	1	0	4
1986	1	TS	HAZELDEAN	&	EAGLESON	25,890	20	2.1	0	6	8	8	1	0	1	1	8	1	2	3	0	2	0	1	0	4
1987	1	TS	HAZELDEAN	&	EAGLESON	27,028	19	1.9	0	7	4	8	0	2	0	0	10	0	2	1	1	3	0	0	0	7
1988	1	TS	HAZELDEAN	&	EAGLESON	26,516	22	2.3	0	6	7	7	1	1	0	0	11	0	2	0	3	3	0	1	0	4
1989	1	TS	HAZELDEAN	&	EAGLESON	27,965	22	2.2	0	1	8	8	5	0	1	0	6	1	1	2	0	2	0	4	0	3
1985	1	TS	ROBERTSO	&	MOODIE	29,413	13	1.2	0	0	4	4	0	0	0	0	6	1	0	3	1	0	0	2	0	4
1986	1	TS	ROBERTSO	&	MOODIE	37,062	16	1.2	0	4	8	8	0	1	2	0	4	0	1	1	4	1	0	2	0	4
1987	1	TS	ROBERTSO	&	MOODIE *	35,925	21	1.6	0	8	5	12	0	1	1	1	8	2	1	1	1	1	0	4	0	7
1988	1	TS	ROBERTSO	&	MOODIE	34,787	16	1.3	0	6	4	4	0	2	0	0	3	1	1	4	1	4	0	0	0	3
1989	1	TS	ROBERTSO	&	MOODIE	30,078	14	1.3	0	3	3	5	0	1	1	1	3	1	1	3	1	2	0	0	0	3
1985	1	SS	HAZELDEAN	&	TERRY FOX	8,759	10	3.1	0	3	4	6	0	1	3	5	0	0	0	0	0	0	0	1	0	5
1986	1	TS	HAZELDEAN	&	TERRY FOX	8,580	8	2.6	0	0	3	5	0	0	5	1	0	0	0	2	0	0	0	0	0	3
1987	1	PGRD	HAZELDEAN	&	TERRY FOX	11,666	1	0.2	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
1988	1	TS	HAZELDEAN	&	TERRY FOX *	12,418	9	2.0	0	0	4	4	0	0	1	0	1	5	0	0	1	1	0	0	0	3
1989	1	TS	HAZELDEAN	&	TERRY FOX	13,170	11	2.3	0	2	3	3	0	0	0	0	0	8	0	1	1	0	0	1	0	2
1985	1	TS	ROBERTSO	&	STINSON	21,772	2	0.3	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0
1986	1	TS	ROBERTSO	&	STINSON	24,993	2	0.2	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	2
1987	1	TS	ROBERTSO	&	STINSON	23,546	2	0.2	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
1988	1	TS	ROBERTSO	&	STINSON	22,813	3	0.4	0	0	3	0	0	0	0	0	0	1	0	1	0	0	0	1	1	1
1989	1	TS	ROBERTSO	&	STINSON	21,610	7	0.9	0	1	2	1	1	0	0	1	0	0	0	3	0	1	0	1	0	1
1985	1	TS	CARLING	&	BAYSHORE	14,985	12	2.2	0	2	3	5	0	0	1	1	0	5	1	1	1	0	0	2	0	0
1986	1	TS	CARLING	&	BAYSHORE	15,064	10	1.8	0	4	3	3	0	0	0	0	0	7	1	1	0	0	0	1	0	2
1987	1	TS	CARLING	&	BAYSHORE	13,280	11	2.3	0	2	6	4	0	0	0	1	0	4	1	1	0	2	0	2	0	6
1988	1	TS	CARLING	&	BAYSHORE	18,125	4	0.6	0	2	2	1	0	0	0	0	0	3	0	0	0	1	0	0	0	2
1989	1	TS	CARLING	&	BAYSHORE	22,024	9	1.1	0	5	3	4	0	0	0	1	1	3	0	0	0	1	0	3	2	3

Appendix 4
"Before-and-After" Database

YEAR		TYPE	LOCATION1		LOCATION2	VOLUME	ACC. FREQ	ACC. RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1985	0	NIL	CARLING	&	D.R.E.	10,728	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	NEW	CARLING	&	D.R.E.	7,883	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	1	TS	CARLING	&	D.R.E.	11,236	2	0.5	0	0	2	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
1988	1	TS	CARLING	&	D.R.E.	11,797	1	0.2	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1989	1	TS	CARLING	&	D.R.E.		1	0.0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1985	1	SS	CARLING	&	HERZBERG '84	11,630	3	0.7	0	1	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	1
1986	1	TS	CARLING	&	HERZBERG	7,061	2	0.8	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1
1987	1	TS	CARLING	&	HERZBERG	8,970	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	1	TS	CARLING	&	HERZBERG	9,484	5	1.4	0	0	4	2	3	0	0	0	1	0	0	1	0	0	0	0	0	2
1989	1	TS	CARLING	&	HERZBERG *	9,227	2	0.6	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2
1985	1	SS	CARLING	&	MARCH	8,240	3	1.0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	2
1986	1	SS	CARLING	&	MARCH	12,005	1	0.2	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1987	1	TS	CARLING	&	MARCH	11,787	2	0.5	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1
1988	1	TS	CARLING	&	MARCH	13,008	6	1.3	0	1	4	3	0	0	0	0	2	0	2	0	1	1	0	0	0	0
1989	1	TS	CARLING	&	MARCH *	12,398	3	0.7	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	2
1986	1	TS	CARLING	&	MOODIE	10,885	9	2.3	0	0	7	7	1	0	0	0	1	1	0	1	0	1	0	4	0	6
1986	1	TS	CARLING	&	MOODIE	11,409	4	1.0	0	0	0	3	0	0	0	0	0	4	0	0	0	0	0	0	0	1
1987	1	TS	CARLING	&	MOODIE	14,515	3	0.6	0	1	2	2	0	0	0	0	0	0	0	1	0	1	0	1	0	2
1988	1	TS	CARLING	&	MOODIE	13,708	4	0.8	0	0	2	2	1	0	0	0	0	2	0	1	0	0	0	0	0	1
1989	1	TS	CARLING	&	MOODIE *	14,112	6	1.2	0	1	6	2	1	0	0	0	0	4	0	0	0	1	0	0	0	2
1985	1	SS	MARCH	&	HERZBERG	8,579	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	1	SS	MARCH	&	HERZBERG	12,845	1	0.2	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
1987	1	TS	MARCH	&	HERZBERG	10,530	1	0.3	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1988	1	TS	MARCH	&	HERZBERG	12,053	3	0.7	0	0	1	2	0	0	0	1	0	0	2	0	0	0	0	0	0	0
1989	1	TS	MARCH	&	HERZBERG	13,738	4	0.8	0	3	1	3	0	0	0	0	0	0	4	0	0	0	0	0	0	1
1985	1	SS	EAGLESON	&	ROTHESAY	8,422	1	0.3	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1986	1	SS	EAGLESON	&	ROTHESAY	8,576	2	0.6	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
1987	1	TS	EAGLESON	&	ROTHESAY	11,296	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	1	TS	EAGLESON	&	ROTHESAY	13,229	1	0.2	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1989	1	TS	EAGLESON	&	ROTHESAY *	12,263	1	0.2	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1985	1	SS	EAGLESON	&	STONEHAV	6,590	1	0.4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
1986	1	TS	EAGLESON	&	STONEHAV	6,849	2	0.8	0	2	1	2	0	0	0	0	1	0	0	0	0	0	0	1	0	1
1987	1	TS	EAGLESON	&	STONEHAV	7,385	3	1.1	0	1	1	3	0	0	0	1	0	0	0	0	0	1	0	1	0	0
1988	1	TS	EAGLESON	&	STONEHAV	9,407	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	1	TS	EAGLESON	&	STONEHAV	12,142	4	0.9	0	2	1	3	0	0	0	0	0	0	0	0	2	0	0	2	0	0

Appendix 4
"Before-and-After" Database

YEAR		TYPE	LOCATION1		LOCATION2	VOLUME	ACC.	ACC.	NON	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT	ONE	PED	TOT
							FREQ	RATE/MEV	REP														SPEC	VEH	INJ	INJ
1985	1	TS	MOODIE	&	BNR-N	8,057	3	1.0	0	2	0	2	0	0	0	0	0	0	0	0	1	0	0	2	0	0
1986	1	TS	MOODIE	&	BNR-N	8,810	1	0.3	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
1987	1	TS	MOODIE	&	BNR-N	8,850	1	0.3	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1988	1	TS	MOODIE	&	BNR-N *	9,900	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	1	TS	MOODIE	&	BNR-N	10,950	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	1	TS	MOODIE	&	BNR-S	8,057	2	0.7	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	1	TS	MOODIE	&	BNR-S	9,847	2	0.6	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0	1
1987	1	TS	MOODIE	&	BNR-S	9,872	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	1	TS	MOODIE	&	BNR-S *	11,236	1	0.2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
1989	1	TS	MOODIE	&	BNR-S	12,699	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	1	SS	MOODIE	&	TYRELL	9,754	3	0.8	0	0	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	2
1986	1	TS	MOODIE	&	TYRELL	11,639	2	0.6	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0
1987	1	TS	MOODIE	&	TYRELL	14,731	3	0.6	0	0	2	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0
1988	1	TS	MOODIE	&	TYRELL	13,091	2	0.4	0	1	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	2
1989	1	TS	MOODIE	&	TYRELL *	13,911	4	0.8	0	1	1	1	0	0	0	0	2	0	0	0	0	0	0	2	1	1
1985	1	SS	CLYDE	&	LOBLAWS	20,843	7	0.9	0	0	4	1	1	0	1	0	0	1	1	0	3	0	0	0	0	4
1986	1	TS	CLYDE	&	LOBLAWS	19,793	5	0.7	0	2	1	2	2	0	1	0	0	0	0	0	1	0	0	1	1	4
1987	1	TS	CLYDE	&	LOBLAWS	18,770	9	1.3	0	0	2	0	1	0	1	0	6	0	1	0	0	0	0	0	0	5
1988	1	TS	CLYDE	&	LOBLAWS	19,083	11	1.6	0	3	2	6	1	1	0	1	5	0	0	0	2	0	0	1	0	6
1989	1	TS	CLYDE	&	LOBLAWS	13,945	4	0.8	0	0	1	3	0	1	0	0	0	0	1	0	2	0	0	0	0	2
1985	1	SS	CYRVILLE	&	STARTOP	10,577	4	1.0	0	0	1	2	0	0	0	2	0	1	0	0	0	0	0	1	0	2
1986	1	TS	CYRVILLE	&	STARTOP *	10,871	2	0.5	0	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0
1987	1	TS	CYRVILLE	&	STARTOP	11,164	4	1.0	0	0	4	4	0	0	0	0	0	0	3	0	0	1	0	0	0	2
1988	1	TS	CYRVILLE	&	STARTOP	10,905	4	1.0	0	0	0	2	2	0	0	0	0	0	0	2	0	0	0	0	0	1
1989	1	TS	CYRVILLE	&	STARTOP	10,029	1	0.3	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
1985	F	SS	LOCATION1	&	LOCATION2	841,663	411	1.3	4	85	155	166	37	25	39	21	39	62	37	42	46	25	0	38	5	120
1986	F	TS	LOCATION1	&	LOCATION2	904,211	332	1.0	0	84	116	136	20	17	30	14	38	64	31	25	40	23	0	30	7	116
1987	F	TS	LOCATION1	&	LOCATION2	931,289	305	0.9	1	79	111	122	10	10	14	12	55	47	35	24	32	34	0	32	7	122
1988	F	TS	LOCATION1	&	LOCATION2	936,440	296	0.9	5	68	104	120	15	12	12	12	46	44	27	37	42	33	0	16	5	92
1989	F	TS	LOCATION1	&	LOCATION2	910,401	299	0.9	3	71	101	128	17	10	15	13	33	56	38	30	29	24	0	34	7	104

Appendix 5

Appendix 5
Without Countermeasures" Database

YEAR	TYPE	LOCATION1		LOCATION2	VOLUME		ACC.	ACC.	NON	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT	ONE	PED	TOT
							FREQ	RATE/MEV	REP														SPEC	VEH	INJ	INJ
1989	SS	ELIZABET	&	ROCHESTE	6838	84	7	2.8	0	2	3	4	4	0	0	0	1	0	0	1	0	0	0	1	0	3
1989	SS	RIVEROLD	&	RIVERSID			6	0.0	0	1	5	1	0	0	4	0	0	0	0	1	0	0	0	1	0	3
1989	SS	RR- 15	&	SLACK	11384	87	6	1.4	0	0	0	2	0	0	1	1	0	0	0	0	1	1	0	2	0	0
1989	SS	MONTREAL	&	OLMSTEAD	7958	82	4	1.4	0	1	2	0	1	0	0	2	0	1	0	0	0	0	0	0	0	2
1989	SS	RR- 13	&	LARKIN	11315	87	4	1.0	0	1	2	2	1	3	0	0	0	0	0	0	0	0	0	0	0	1
1989	SS	RR- 57	&	HWY- 17			4	0.0	0	1	1	1	0	0	0	2	0	0	0	0	0	2	0	0	0	3
1989	PX	COLDREY	&	KIRKWOOD	13431	88	3	0.6	0	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	2
1989	SS	HERON	&	KALADAR	21617	82	3	0.4	0	0	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	1
1989	SS	RR- 52	&	CRAIGHEN	12137	86	3	0.7	0	0	1	2	0	0	3	0	0	0	0	0	0	0	0	0	0	1
1989	SS	RR- 61	&	KATIMAVI	8784	89	3	0.9	0	1	3	2	0	0	1	1	0	0	0	0	1	0	0	0	0	1
1989	PX	BANK	&	STRATHCO	11638	84	2	0.5	0	1	1	2	0	1	0	0	0	0	1	0	0	0	0	0	0	1
1989	PX	BRANT	&	MCARTHUR	10884	81	2	0.5	0	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0
1989	SS	CANOTEK	&	SHEFFORD			2	0.0	0	0	2	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1
1989	PX	MARGUERI	&	MCARTHUR	11007	80	2	0.5	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1
1989	SS	CARLTN-U	&	COL.BY			1	0.0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
1989	SS	ELGIN	&	NEPEAN			1	0.0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
1989	PX	MELROSE	&	WELLINGT			1	0.0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1989	SS	REVELSTO	&	RIVERSID			1	0.0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	SS	RR- 30	&	MERBLEUE			1	0.0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	SS	RR- 27	&	RR- 30E	16870	86	9	1.5	0	3	3	6	5	0	0	0	0	1	0	0	0	2	0	1	0	1
1988	SS	RR- 15	&	NORICE	19654	86	7	1.0	0	2	3	4	0	0	1	6	0	0	0	0	0	0	0	0	0	1
1988	SS	HERON	&	WALKLEY	14965	81	6	1.1	0	1	4	3	1	0	0	0	0	1	0	1	0	0	1	2	1	3
1988	SS	MCLEOD	&	OCONNOR	13212	84	5	1.0	0	0	1	2	0	0	5	0	0	0	0	0	0	0	0	0	0	0
1988	PX	CRERAR	&	MERIVALE	14104	84	4	0.8	0	1	2	2	0	0	0	0	0	0	3	0	1	0	0	0	0	1
1988	SS	MAY	&	MCARTHUR	11205	86	4	1.0	0	2	1	1	0	0	0	1	0	1	0	1	0	1	0	0	0	2
1988	SS	OT.R.PKW	&	SLIDELL			4	0.0	0	1	2	3	0	2	0	1	0	1	0	0	0	0	0	0	0	2
1988	PX	ALTAVIST	&	100 S OF CALEDON			3	0.0	0	0	3	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0
1988	SS	CONROY	&	HUNTCLUB	7656	87	3	1.1	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0	1
1988	PX	HARDING	&	WALKLEY	19410	86	3	0.4	0	0	1	1	0	0	1	0	0	0	0	1	1	0	0	0	0	2
1988	SS	RR- 63	&	BURRIS	15322	86	3	0.5	0	2	0	2	0	0	1	1	0	0	0	0	1	0	0	0	0	0
1988	SS	SUSSEX	&	YORK	17681	84	3	0.6	0	2	1	1	0	0	1	0	0	0	2	0	0	0	0	0	0	1
1988	SS	ALGONQ-C	&	LEES			2	0.0	0	0	0	2	1	0	0	0	0	0	0	0	0	1	0	0	0	0
1988	SS	COVENTRY	&	STLAU-SC	11006	89	2	0.5	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2	0	1
1988	PX	LISGAR	&	LYON			1	0.0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1988	PX	RR- 8	&	LONGISLA			1	0.0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1988	SS	RR- 27	&	HWY- 17N			1	0.0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1
1987	PX	RUSSELL	&	SOUTHVAL	15959	86	12	2.1	0	4	3	7	1	0	0	1	0	0	5	0	3	0	0	2	0	1
1987	SS	RR- 34	&	MISSOTTA	17192	86	8	1.3	0	0	2	3	7	0	0	0	0	0	1	0	0	0	0	0	0	5
1987	SS	BASELINE	&	COBDEN	19832	86	7	1.0	0	5	1	3	0	0	3	0	0	0	0	1	0	1	0	2	0	3
1987	PX	BEECHWOO	&	S.CHARLE	11928	84	7	1.6	0	2	5	1	1	0	0	2	0	0	0	2	0	2	0	0	0	1
1987	SS	RR- 36	&	CARBROOK	15388	86	7	1.2	0	2	0	1	5	1	0	0	0	1	0	0	0	0	0	0	0	5
1987	PX	WALKLEY	&	150 E OF HTHRGTNR	7479	88	7	2.6	1	1	3	2	0	0	0	0	0	0	0	4	0	2	0	1	1	2
1987	PX	HERON	&	SANDALWO	10757	87	5	1.3	0	1	1	3	0	1	0	0	0	0	0	2	0	0	0	2	0	3
1987	SS	ROCHESTE	&	SOMERSET	7657	86	5	1.8	0	1	2	1	1	0	0	3	0	1	0	0	0	0	0	0	0	1

Appendix 5

Without Countermeasures" Database

YEAR	TYPE	LOCATION1		LOCATION2	VOLUME		ACC.	ACC.	NON	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT	ONE	PED	TOT
							FREQ	RATE/MEV	REP														SPEC	VEH	INJ	INJ
1987	SS	FISHER	&	HOLLAND			4	0.0	0	3	0	1	0	0	0	0	0	0	0	0	1	0	0	3	0	2
1987	PX	JAMES	&	LYON	8243	87	4	1.3	0	1	1	3	0	0	3	0	0	0	0	0	1	0	0	0	0	1
1987	SS	RR- 5	&	RR- 5A	10166	89	4	1.1	0	0	3	2	0	0	0	0	0	0	4	0	0	0	0	0	0	1
1987	SS	RR- 34	&	S.JEAN	17696	88	4	0.6	0	0	1	2	0	1	0	0	0	1	0	2	0	0	0	0	0	1
1987	SS	ALBERT	&	BRONSON	11451	87	3	0.7	0	0	1	1	0	0	0	2	0	0	0	0	0	0	0	1	1	2
1987	SS	HWY- 17	&	HWY- 44			3	0.0	0	0	3	1	1	0	1	0	0	0	0	0	0	0	0	1	0	1
1987	SS	INDUSTRI	&	RUSSELL	13434	86	3	0.6	0	1	2	2	3	0	0	0	0	0	0	0	0	0	0	0	0	1
1987	SS	RR- 34	&	RR- 47	6760	86	3	1.2	0	1	1	1	2	0	0	0	0	0	1	0	0	0	0	0	0	0
1987	SS	RR- 36	&	WESTCLIF	14072	86	3	0.6	0	1	3	2	0	0	0	0	0	0	0	0	0	3	0	0	0	3
1987	SS	RR- 47	&	DESEPINE	4094	86	3	2.0	0	1	2	1	2	0	1	0	0	0	0	0	0	0	0	0	0	1
1987	PX	SAUNDRSN	&	SMYTH	13239	88	3	0.6	0	1	1	2	0	2	0	1	0	0	0	0	0	0	0	0	0	1
1987	SS	CHARLOTT	&	STEWART	9093	83	2	0.6	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
1987	PX	EMPRESS	&	SOMERSET	9378	87	2	0.6	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	1	2
1987	PX	MCCARTHY	&	PAULANKA	6103	86	2	0.9	0	0	1	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0
1987	SS	RR- 47	&	TOMPKINS	5070	86	2	1.1	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1
1987	SS	RR- 51	&	VIEWMOUN	10557	87	2	0.5	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1
1987	SS	SAVILLE	&	WOODROFF	9855	86	2	0.6	0	0	2	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0
1987	SS	RR- 16	&	QNSWAY-H			1	0.0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
1986	SS	IS.PARK	&	MERIVALE	10306	89	16	4.3	0	2	4	8	14	0	0	0	0	0	0	2	0	0	0	0	0	3
1986	SS	COPERNIC	&	LAURIER	6612	87	14	5.8	0	4	6	6	2	0	0	12	0	0	0	0	0	0	0	0	0	0
1986	SS	ARLINGTO	&	LYON			12	0.0	0	3	6	6	0	5	5	0	0	0	0	0	1	0	0	1	0	4
1986	SS	BANK	&	MCLEOD	7400	86	12	4.4	0	1	5	3	0	0	7	4	1	0	0	0	0	0	0	0	0	3
1986	SS	BL/BG-SW	&	RIVERSID			10	0.0	0	0	1	3	7	0	0	1	0	0	0	1	0	0	0	1	0	4
1986	SS	CLARENCE	&	CUMBERLA			10	0.0	0	6	3	4	5	0	1	3	1	0	0	0	0	0	0	0	0	2
1986	SS	NEPEAN	&	OCONNOR			10	0.0	0	5	3	7	0	7	0	0	0	0	0	0	3	0	0	0	0	1
1986	SS	COOPER	&	LYON			9	0.0	0	2	4	5	0	2	0	0	0	0	0	0	6	0	0	1	0	3
1986	SS	OT.R.PKW	&	WOODROFF	11137	78	9	2.2	0	1	6	3	1	2	0	0	0	0	3	2	0	0	0	1	0	1
1986	SS	CHAPEL	&	SOMERSET	4072	87	8	5.4	0	2	4	4	0	0	2	4	0	0	0	0	0	0	0	2	1	3
1986	SS	RAYMOND	&	ROCHESTE	6959	84	8	3.1	0	3	4	3	0	0	3	4	1	0	0	0	0	0	0	0	0	3
1986	SS	ARLINGTO	&	BRONSON	16724	86	8	1.3	0	4	2	2	1	0	1	0	1	0	3	0	1	0	0	1	1	3
1986	SS	BRONSON	&	IMPERIAL	24777	86	8	0.9	0	4	3	1	0	0	1	0	7	0	0	0	0	0	0	0	0	1
1986	SS	BANK	&	CECIL			8	0.0	0	1	3	2	0	6	0	0	2	0	0	0	0	0	0	0	0	3
1986	SS	BANK	&	EVANS			8	0.0	0	0	4	3	0	3	0	1	0	0	1	0	2	0	0	1	0	0
1986	SS	ELGIN	&	ISABELLA	7345	84	7	2.6	0	3	2	3	1	1	0	0	0	0	0	3	1	0	0	1	1	4
1986	SS	BYRON	&	CHURCHIL	7565	87	7	2.5	0	1	4	3	0	1	1	3	1	1	0	0	0	0	0	0	0	2
1986	SS	MERIVALE	&	RAVEN	10746	86	7	1.8	0	1	6	1	1	2	0	0	2	0	1	0	0	0	0	1	0	3
1986	SS	MACLAREN	&	OCONNOR	10964	88	7	1.7	0	2	2	2	0	0	7	0	0	0	0	0	0	0	0	0	0	5
1986	SS	BRITTANY	&	S.LAUREN	11436	86	7	1.7	0	1	5	3	0	0	0	2	3	0	1	0	0	0	0	1	1	3
1986	SS	BYRON	&	WOODROFF	11976	86	7	1.6	0	1	3	2	1	1	3	0	2	0	0	0	0	0	0	0	0	1
1986	SS	BANK	&	WILTON	15529	86	7	1.2	0	1	0	3	0	0	0	0	1	0	4	0	2	0	0	0	0	4
1986	SS	BASELINE	&	FARLANE	30377	86	7	0.6	0	2	5	4	4	0	0	1	0	2	0	0	0	0	0	0	0	2
1986	SS	DUROCHER	&	MONTREAL			7	0.0	0	0	6	3	0	0	0	1	1	4	0	0	0	1	0	0	0	3
1986	SS	GLOUCEST	&	LYON			7	0.0	0	0	2	3	0	0	6	0	0	0	0	0	0	1	0	0	0	0
1986	SS	HOLLAND	&	SPENCER			7	0.0	0	1	5	1	4	2	0	1	0	0	0	0	0	0	0	0	0	3

Appendix 5
Without Countermeasures" Database

YEAR	TYPE	LOCATION1		LOCATION2	VOLUME		ACC.	ACC.	NON	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT	ONE	PED	TOT
							FREQ	RATE/MEV	REP														SPEC	VEH	INJ	INJ
1986	SS	RR- 73	&	HWY- 16			7	0.0	0	2	3	4	1	1	3	1	0	1	0	0	0	0	0	0	0	6
1986	SS	RR- 28	&	RR- 35	2230	84	6	7.4	0	1	1	3	0	1	1	1	0	0	0	0	0	2	0	1	0	1
1986	SS	RR- 30	&	RR- 57	2537	87	6	6.5	0	0	4	3	2	1	2	0	0	0	1	0	0	0	0	0	0	3
1986	SS	RR- 30	&	BOYER	9406	87	6	1.7	0	0	4	3	0	1	4	0	0	0	0	0	0	1	0	0	0	1
1986	SS	BAY	&	SOMERSET	10034	84	6	1.6	0	2	2	4	2	0	0	0	0	0	0	3	0	1	0	0	0	1
1986	SS	KINGEDWA	&	OSGOODE	11001	86	6	1.5	0	1	0	3	1	0	1	3	0	0	1	0	0	0	0	0	0	2
1986	SS	BYRON	&	HOLLAND	12300	88	6	1.3	0	0	4	0	2	1	0	0	3	0	0	0	0	0	0	0	0	2
1986	SS	KENT	&	MCLEOD	13513	84	6	1.2	0	0	4	4	0	0	0	3	0	0	3	0	0	0	0	0	0	3
1986	SS	BANK	&	FOURTH	13675	79	6	1.2	0	0	3	3	2	0	3	1	0	0	0	0	0	0	0	0	0	1
1986	SS	LENESTER	&	MAITLAND	14039	84	6	1.2	0	2	2	3	0	4	0	0	1	0	1	0	0	0	0	0	0	0
1986	SS	HWY-417S	&	MAITLAND	17502	87	6	0.9	0	1	3	1	0	0	0	2	2	1	0	0	1	0	0	0	0	0
1986	SS	BOOTH	&	ELIZABET			6	0.0	0	1	3	1	1	5	0	0	0	0	0	0	0	0	0	0	0	2
1986	SS	COLONA-S	&	COLONADE			6	0.0	0	1	2	1	2	0	1	1	1	0	1	0	0	0	0	0	0	2
1986	SS	CYRVILLE	&	S.LAUREN			6	0.0	0	1	0	1	0	0	0	0	2	0	3	0	0	0	0	1	0	0
1986	SS	HOLLAND	&	RUSKIN			6	0.0	0	1	2	3	1	1	2	0	0	0	0	0	1	0	0	1	1	2
1986	SS	LYON	&	NEPEAN			6	0.0	0	2	2	4	0	1	0	0	0	0	0	0	5	0	0	0	0	1
1986	SS	MARIER	&	MONTFORT			6	0.0	0	3	3	3	0	0	3	2	0	0	0	0	1	0	0	0	0	2
1986	SS	RR- 3	&	RR- 6	2495	87	5	5.5	0	0	2	0	2	0	0	2	0	0	0	1	0	0	0	0	0	2
1986	SS	RR- 6	&	ALBERT	3121	87	5	4.4	0	1	0	3	0	0	1	2	0	2	0	0	0	0	0	0	0	1
1986	SS	FORTUNE	&	ORLEANS	5831	86	5	2.3	0	2	3	3	0	2	1	0	1	0	1	0	0	0	0	0	0	0
1986	PX	COBDEN	&	IRIS	6077	85	5	2.3	0	1	0	4	0	0	1	3	0	0	0	1	0	0	0	0	0	0
1986	PX	CATHERIN	&	PERCY	6570	82	5	2.1	0	0	3	1	0	0	3	0	0	0	0	0	0	2	0	0	0	3
1986	PX	PERCY	&	SOMERSET	7553	86	5	1.8	0	0	2	1	0	1	1	0	0	0	0	1	0	1	0	1	1	2
1986	PX	CHAMBERL	&	PERCY	8775	80	5	1.6	0	0	2	5	1	0	0	0	0	0	0	2	2	0	0	0	0	2
1986	SS	BANK	&	COOPER	9682	78	5	1.4	0	1	2	2	3	2	0	0	0	0	0	0	0	0	0	0	0	0
1986	SS	ELGIN	&	MACLAREN	10684	84	5	1.3	0	2	1	1	0	0	2	1	0	0	1	0	0	0	0	1	1	3
1986	SS	BRONSON	&	LAURIER	12638	82	5	1.1	0	0	2	1	0	0	1	2	0	1	0	0	0	0	0	1	1	3
1986	SS	RR- 34	&	EDGARBRA	12869	87	5	1.1	0	0	1	1	3	0	0	0	0	1	0	0	0	1	0	0	0	2
1986	SS	CUMMINGS	&	MONTREAL	14324	79	5	1.0	0	0	4	2	2	0	0	2	0	0	0	0	0	1	0	0	0	1
1986	SS	CARLING	&	MELROSE	15639	88	5	0.9	0	1	3	2	0	1	1	0	0	1	0	0	0	1	0	1	0	1
1986	SS	BASELINE	&	ROCKWAY	22829	87	5	0.6	0	3	3	5	1	0	0	0	0	2	0	2	0	0	0	0	0	2
1986	SS	ARMSTRON	&	HOLLAND			5	0.0	0	0	2	3	0	0	0	5	0	0	0	0	0	0	0	0	0	0
1986	SS	BEECHWOO	&	DOUGLAS			5	0.0	0	0	5	1	2	0	0	1	0	0	0	1	0	1	0	0	0	2
1986	SS	BELFAST	&	MICHAEL			5	0.0	0	3	3	3	0	1	0	0	2	0	0	2	0	0	0	0	0	1
1986	SS	BOYD	&	DOHENY			5	0.0	0	0	1	3	2	0	2	0	0	1	0	0	0	0	0	0	0	1
1986	SS	CAMBRIDG	&	SOMERSET			5	0.0	0	2	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	1
1986	PX	FISHER	&	TRENT			5	0.0	0	1	2	1	0	2	0	0	1	0	2	0	0	0	0	0	0	3
1986	SS	KENT	&	LISGAR			5	0.0	0	1	3	3	0	0	0	3	0	0	2	0	0	0	0	0	0	1
1986	SS	NELSON	&	OSGOODE			5	0.0	0	1	1	3	0	0	0	5	0	0	0	0	0	0	0	0	0	2
1986	SS	RR-114	&	NIXON			5	0.0	0	1	0	1	0	3	2	0	0	0	0	0	0	0	0	0	0	1
1986	SS	BAYSHORE	&	WOODRI-N	2184	86	4	5.0	0	0	2	4	1	0	0	0	1	0	1	1	0	0	0	0	0	1
1986	SS	RR- 30	&	RR- 47	3676	86	4	3.0	0	0	2	0	0	1	1	0	0	1	0	0	0	1	0	0	0	3
1986	SS	CASTLEFR	&	KATIMAVI	4832	87	4	2.3	0	1	3	2	1	0	0	1	0	1	1	0	0	0	0	0	0	1
1986	SS	RR- 8	&	RR- 10W	8728	86	4	1.9	0	0	3	0	2	0	0	0	0	1	1	0	0	0	0	0	0	0

Appendix 5

Without Countermeasures" Database

YEAR	TYPE	LOCATION1		LOCATION2	VOLUME		ACC FREQ	ACC. RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1986	SS	JEANNEDA	&	ORLEAN-S	6708	86	4	1.6	0	1	2	4	3	0	1	0	0	0	0	0	0	0	0	0	0	1
1986	SS	DALHOUSI	&	GUIGUES	6834	86	4	1.6	0	1	2	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0
1986	SS	BELL	&	GLADSTON	8361	88	4	1.3	0	0	1	1	0	0	3	0	1	0	0	0	0	0	0	0	0	2
1986	SS	RR- 30	&	PRESTWIC	8668	89	4	1.3	0	1	3	1	0	0	0	0	0	0	0	3	0	0	0	1	1	1
1986	PX	PATRICIA	&	RICHMOND	9398	87	4	1.2	0	1	1	3	0	0	0	0	0	0	0	1	0	3	0	0	0	1
1986	SS	INGLEWOO	&	PARKDALE	9409	84	4	1.2	0	1	2	1	0	2	0	0	0	1	0	0	1	0	0	0	0	1
1986	SS	BROOKFIE	&	FLANNERY	9452	85	4	1.2	0	0	3	3	0	3	0	0	0	0	0	0	0	0	0	1	0	0
1986	SS	FISHER	&	VIEWMOUN	10198	86	4	1.1	0	0	0	2	1	2	0	0	1	0	0	0	0	0	0	0	0	0
1986	SS	CARLING	&	WYLIE	11019	82	4	1.0	0	4	0	2	0	0	0	0	0	1	0	0	0	0	0	3	1	2
1986	SS	CLEGG	&	COL.BY	11145	82	4	1.0	0	1	0	3	0	0	0	1	1	0	0	0	2	0	0	0	0	2
1986	PX	HOLLAND	&	TYNDALL	11630	88	4	0.9	0	1	2	1	0	0	1	1	1	0	0	0	1	0	0	0	0	1
1986	SS	RR- 18	&	RR- 89	12020	86	4	0.9	0	0	3	0	0	0	0	2	1	0	0	0	0	0	0	1	0	0
1986	SS	MONA	&	MONTREAL	12425	89	4	0.9	0	1	0	1	2	0	0	0	0	0	0	1	0	1	0	0	0	2
1986	PX	GRENON	&	RICHMOND	13117	86	4	0.8	0	1	2	1	1	1	0	0	0	0	0	0	0	1	0	1	0	1
1986	SS	KELLY	&	PINECRES	13152	81	4	0.8	0	0	3	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0
1986	SS	PINECRES	&	S.STEPHE	13155	88	4	0.8	0	3	3	1	0	2	0	0	1	0	1	0	0	0	0	0	0	1
1986	SS	RR- 17	&	RR- 53	13400	86	4	0.8	0	1	3	2	0	0	1	0	0	0	0	0	0	0	0	3	0	0
1986	SS	RR- 16	&	BEAUMARI	13441	86	4	0.8	0	1	1	3	0	0	0	0	0	0	0	3	0	0	0	1	0	1
1986	SS	RR- 17	&	CLEOPATR	14008	86	4	0.8	0	1	4	2	3	1	0	0	0	0	0	0	0	0	0	0	0	1
1986	SS	BOYCE	&	CARLING	14011	86	4	0.8	0	4	1	1	0	0	0	1	0	1	0	1	0	0	1	0	0	1
1986	SS	BRONSON	&	MCLEOD	14362	80	4	0.8	0	0	2	2	0	0	1	3	0	0	0	0	0	0	0	0	0	1
1986	SS	FISHER	&	TUNIS	14660	84	4	0.7	0	0	3	0	0	1	1	0	0	0	1	0	1	0	0	0	0	2
1986	SS	FISHER	&	MCCOOEYE	14660	84	4	0.7	0	0	2	2	1	0	0	3	0	0	0	0	0	0	0	0	0	1
1986	SS	LYNDA	&	SMYTH	14877	88	4	0.7	0	1	2	2	2	0	0	0	0	0	0	1	0	1	0	0	0	0
1986	SS	CLEARVIE	&	IS.PARK	15784	82	4	0.7	0	1	2	2	1	1	1	0	0	0	0	0	1	0	0	0	0	1
1986	SS	COL.BY	&	MAIN	16624	89	4	0.7	0	2	2	1	0	0	0	0	0	2	1	0	0	1	0	0	0	2
1986	SS	RR- 50	&	PALMERST	19054	84	4	0.6	0	0	3	2	2	0	0	1	0	0	1	0	0	0	0	0	0	1
1986	SS	BASELINE	&	ERINDALE	23141	86	4	0.5	0	0	3	2	0	0	3	0	0	0	0	0	1	0	0	0	0	0
1986	SS	BANK	&	ECHO			4	0.0	0	1	1	3	2	1	0	0	0	0	0	0	1	0	0	0	0	0
1986	SS	BANTREE	&	SHEFFIEL			4	0.0	0	1	1	1	0	0	0	0	3	0	1	0	0	0	0	0	0	2
1986	SS	BAYSWATE	&	WELLINGT			4	0.0	0	2	1	3	0	3	0	0	1	0	0	0	0	0	0	0	0	0
1986	SS	COOPER	&	OCONNOR			4	0.0	0	1	2	1	0	1	1	0	0	0	0	0	2	0	0	0	0	0
1986	SS	COOPER	&	METCALFE			4	0.0	0	2	2	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	PX	DONALD	&	ELAINE			4	0.0	0	0	3	3	1	0	0	0	0	0	0	1	0	2	0	0	0	2
1986	SS	ELGIN	&	WAVERLEY			4	0.0	0	0	3	3	0	0	0	1	1	0	1	0	0	0	0	1	0	1
1986	SS	KENT	&	MACLAREN			4	0.0	0	0	1	2	0	0	0	0	0	0	4	0	0	0	0	0	0	0
1986	SS	LYON	&	MCLEOD			4	0.0	0	1	0	2	0	0	4	0	0	0	0	0	0	0	0	0	0	1
1986	SS	MICHAEL	&	PARISIEN			4	0.0	0	0	1	2	1	1	0	0	1	0	0	1	0	0	0	0	0	0
1986	SS	N.D.H.Q.	&	NICHOLAS			4	0.0	0	0	3	0	0	1	0	0	0	0	0	1	2	0	0	0	0	0
1986	SS	RR- 13	&	TIGHE			4	0.0	0	0	2	1	0	0	0	1	1	1	1	0	0	0	0	0	0	1
1986	SS	RR- 30	&	HWY-417E			4	0.0	0	1	2	2	3	0	0	0	0	0	0	0	0	0	0	1	0	2
1986	SS	RR- 35	&	HWY- 17			4	0.0	0	1	2	1	0	0	0	1	0	0	0	2	0	1	0	0	0	1
1986	SS	RR- 59	&	RICHMOND			4	0.0	0	1	3	1	0	0	0	1	1	0	2	0	0	0	0	0	0	1
1986	SS	AYLMER	&	SENECA	1075	89	3	7.6	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	1

Appendix 5

Without Countermeasures' Database

YEAR	TYPE	LOCATION1		LOCATION2	VOLUME		ACC. FREQ	ACC. RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1986	SS	CHAMPAGN	&	WELLINGT	1279	79	3	6.4	0	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	2
1986	SS	FRANCES	&	QUEENMAR	1645	84	3	5.0	0	0	2	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0
1986	SS	BAY	&	MACLAREN	1705	83	3	4.8	0	0	2	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0
1986	SS	NELSON	&	YORK	1951	79	3	4.2	0	0	1	2	0	0	1	0	0	2	0	0	0	0	0	0	0	2
1986	SS	CUMBERLA	&	S.ANDREW	2018	79	3	4.1	0	0	2	0	1	0	0	[illegible]	1	0	0	0	0	0	0	0	0	0
1986	SS	RR- 8	&	CR- 1NG	3325	86	3	2.5	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	2
1986	SS	RR- 26	&	RR- 33	3456	85	3	2.4	0	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3
1986	SS	RR- 25	&	RIDEAU	4064	87	3	2.0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	1	0	2
1986	SS	RR- 5	&	RR- 12	4201	87	3	2.0	0	0	3	2	1	1	0	1	0	0	0	0	0	0	0	0	0	1
1986	SS	RR-128	&	MEADOWBR	5012	89	3	1.6	0	2	1	2	0	0	0	0	0	1	0	2	0	0	0	0	0	2
1986	SS	RR- 13	&	BARNSDAL	5345	84	3	1.5	0	0	2	3	0	0	1	0	0	0	1	0	1	0	0	0	0	1
1986	SS	LUMBERMA	&	ORLEANS	5364	86	3	1.6	0	2	1	1	0	0	0	1	0	0	1	0	1	0	0	0	0	1
1986	SS	MEDHURST	&	WOODFIEL	5426	87	3	1.5	0	0	3	0	2	0	0	0	0	0	1	0	0	0	0	0	0	2
1986	SS	BEAUSEJO	&	JEANNEDA	5656	88	3	1.5	0	0	1	1	0	1	0	2	0	0	0	0	0	0	0	0	0	0
1986	SS	RR- 49	&	HOPESSID	6494	89	3	1.3	0	1	0	2	0	0	0	0	1	0	0	0	0	0	0	2	0	1
1986	PX	LAURIER	&	SWEETLAN	6600	80	3	1.2	0	1	1	2	0	0	0	0	0	0	0	2	0	0	0	1	0	0
1986	SS	PLEASANT	&	SAUNDRSN	6917	88	3	1 2	0	0	1	2	0	0	1	1	0	0	1	0	0	0	0	0	0	0
1986	SS	MCCARTHY	&	SOUTHMOR	7015	84	3	1.2	0	1	1	0	0	0	0	2	0	0	0	0	0	0	0	1	0	3
1986	SS	BRONSON	&	HERON & RAMP-J1	7435	79	3	1.1	0	0	1	2	0	0	0	3	0	0	0	0	0	0	0	0	0	0
1986	SS	ROAD-C	&	ROAD-E	7829	89	3	1.0	0	1	3	2	3	0	0	0	0	0	0	0	0	0	0	0	0	1
1986	PX	ARTHUR	&	GLADSTON	7857	80	3	1.0	0	0	3	1	0	0	0	0	0	0	0	2	0	1	0	0	0	0
1986	SS	FISHER	&	NORMANDY	8271	81	3	1.0	0	0	2	0	0	0	0	0	1	0	2	0	0	0	0	0	0	2
1986	SS	CHURCHIL	&	CLARE	8465	86	3	1.0	0	0	2	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0
1986	PX	RICHMOND	&	WESTERN	8760	83	3	0.9	0	1	0	1	0	0	1	0	0	0	0	1	0	0	0	1	1	2
1986	SS	LAURIER	&	NELSON	8841	85	3	0.9	0	0	1	3	1	0	0	1	0	1	0	0	0	0	0	0	0	2
1986	SS	LYON	&	MACLAREN	9021	82	3	0.9	0	2	0	1	0	0	2	0	0	0	0	0	1	0	0	0	0	1
1986	SS	GILMOUR	&	LYON	9062	82	3	0.9	0	0	2	1	0	1	0	0	0	0	0	0	2	0	0	0	0	1
1986	SS	RR- 61	&	NESS	9099	78	3	0.9	0	1	1	2	2	0	0	0	0	0	0	0	0	0	0	1	1	2
1986	SS	RR- 49	&	KLONDIKE	9195	86	3	0.9	0	2	0	1	1	1	0	0	1	0	0	0	0	0	0	0	1	3
1986	SS	RIDGE	&	RUSSELL	9383	87	3	0.9	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0
1986	SS	CHARLOTT	&	DALY	9413	81	3	0.9	0	1	3	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1
1986	SS	BOTELER	&	DALHOUSI	9873	79	3	0.8	0	1	1	1	0	2	0	0	0	0	0	0	0	0	0	1	0	2
1986	SS	RR- 38	&	GRANDVIE	11286	86	3	0.7	0	0	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0
1986	SS	HWY- 31	&	SIEVERIG	11741	89	3	0.7	0	0	0	3	0	0	0	0	0	0	0	0	3	0	0	0	0	2
1986	SS	RR- 38	&	BEDALE	12946	87	3	0.6	0	1	2	1	2	0	0	0	0	0	0	0	0	1	0	0	0	0
1986	SS	NORMANDY	&	PRINCEOF	13508	83	3	0.6	0	0	2	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0
1986	SS	BANK	&	PATTERSO	13546	79	3	0.6	0	0	2	1	0	0	1	2	0	0	0	0	0	0	0	0	0	2
1986	SS	RR- 30	&	STONEHEN	14086	81	3	0.6	0	0	2	1	0	0	2	0	0	1	0	0	0	0	0	0	0	1
1986	SS	FISHER	&	MALIBU	14276	86	3	0.6	0	1	2	1	0	1	0	0	0	0	1	0	0	0	0	1	1	1
1986	SS	BEECHWOO	&	CHARLEVO	14398	84	3	0.6	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2	1	2
1986	SS	RR- 59	&	TIMM	15189	86	3	0.5	0	1	0	1	0	2	0	0	0	0	1	0	0	0	0	0	0	2
1986	SS	RR- 34	&	BOYER	16684	86	3	0.5	0	1	2	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0
1986	SS	HALIFAX	&	WALKLEY	17087	83	3	0.5	0	2	0	2	0	1	0	0	0	1	0	0	1	0	0	0	0	0
1986	SS	MERIVALE	&	TRENTON	19304	82	3	0.4	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	1	0	1

Appendix 5
Without Countermeasures" Database

YEAR	TYPE	LOCATION1		LOCATION2	VOLUME		ACC FREQ	ACC. RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1986	SS	BRONSON	&	FIRST	20930	85	3	0.4	0	0	1	2	0	0	0	2	0	0	0	0	0	1	0	0	0	1
1986	SS	BANK	&	CAHILL	22559	86	3	0.4	0	2	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	2
1986	SS	ARMSTRON	&	HAMILTON			3	0.0	0	0	1	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0
1986	SS	AUGUSTA	&	BESSERER			3	0.0	0	0	1	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0
1986	SS	BALSAM	&	PRESTON			3	0.0	0	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1
1986	SS	BANK	&	NEPEAN			3	0.0	0	0	1	2	2	0	0	0	1	0	0	0	0	0	0	0	0	2
1986	SS	BANK	&	POWELL			3	0.0	0	1	1	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0
1986	SS	BANK	&	HOPEWELL			3	0.0	0	0	1	2	1	1	0	0	1	0	0	0	0	0	0	0	0	0
1986	SS	BATHGATE	&	CARSON-C			3	0.0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1
1986	SS	BATHGATE	&	PLUMBER			3	0.0	0	0	1	0	0	0	0	0	2	0	1	0	0	0	0	0	0	1
1986	SS	BESSERER	&	CHAPEL			3	0.0	0	0	2	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	SS	BLAKE	&	LAFONTAI			3	0.0	0	0	1	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0
1986	SS	BL/BG-SC	&	RIVERSID			3	0.0	0	1	2	2	0	3	0	0	0	0	0	0	0	0	0	0	0	1
1986	SS	BOOTH	&	ECCLES			3	0.0	0	1	1	3	0	1	1	0	1	0	0	0	0	0	0	0	0	1
1986	SS	BOTTRIEL					3	0.0	0	0	0	2	0	0	0	0	0	0	1	0	1	0	0	1	0	0
1986	SS	BREADNER	&	MCCARTHY			3	0.0	0	1	1	2	0	1	0	0	0	0	2	0	0	0	0	0	0	2
1986	SS	BRONSONP	&	COL.BY			3	0.0	0	0	1	2	0	0	0	0	0	1	1	1	0	0	0	0	0	0
1986	SS	BULLMAN	&	PARKDALE			3	0.0	1	0	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0
1986	SS	BYRON	&	ROOSEVEL			3	0.0	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
1986	SS	CARTIER	&	GILMOUR			3	0.0	0	1	0	2	0	2	0	1	0	0	0	0	0	0	0	0	0	1
1986	SS	CLARENCE	&	COBOURG			3	0.0	0	1	0	2	0	0	0	2	0	0	1	0	0	0	0	0	0	1
1986	SS	COL.BY	&	GRAHAM			3	0.0	0	1	2	1	0	0	1	0	0	0	1	0	0	0	0	1	0	1
1986	SS	ELGIN	&	FRANK			3	0.0	0	0	1	1	0	0	0	2	0	0	1	0	0	0	0	0	0	2
1986	SS	FLORA	&	LYON			3	0.0	0	1	1	3	0	1	0	0	0	0	0	0	2	0	0	0	0	0
1986	SS	FOURTH	&	PERCY			3	0.0	0	0	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	1
1986	SS	GILMOUR	&	MACDONAL			3	0.0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0
1986	SS	GOULBURN	&	SOMERSET			3	0.0	0	0	2	1	0	0	2	0	0	0	0	0	1	0	0	0	0	1
1986	SS	HAIG	&	HAMLET			3	0.0	0	0	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	2
1986	SS	HAMILTON	&	WELLINGT			3	0.0	0	0	0	1	1	0	0	2	0	0	0	0	0	0	0	0	0	3
1986	SS	HEARST	&	KATIMAVI			3	0.0	0	2	1	3	0	0	0	2	0	0	0	0	0	1	0	0	0	1
1986	SS	HWY- 16	&	RID-HTS			3	0.0	0	1	2	1	0	0	0	0	0	0	2	0	0	0	0	1	0	1
1986	SS	HWY- 17	&	COWAN			3	0.0	0	2	1	2	2	0	0	0	0	0	1	0	0	0	0	0	0	2
1986	SS	HWY- 17	&	MADAWASK			3	0.0	0	1	3	2	0	0	1	0	0	0	0	1	0	0	0	1	0	1
1986	SS	JAMES	&	PERCY			3	0.0	0	1	2	0	0	1	2	0	0	0	0	0	0	0	0	0	0	2
1986	SS	KINGEDWA	&	MINTO			3	0.0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0
1986	SS	LALLEMAN	&	MONTREAL			3	0.0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	1	1	1
1986	SS	MARLBORO	&	SOMERSET			3	0.0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	0	1
1986	SS	MCCOOEYE	&	MERIVALE			3	0.0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	0	0	0	2
1986	SS	MCCORMIC	&	WELLINGT			3	0.0	0	0	1	3	0	0	1	0	0	1	0	1	0	0	0	0	0	1
1986	SS	MCLEOD	&	PERCY			3	0.0	0	0	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0
1986	SS	METCALFE	&	NEPEAN			3	0.0	0	0	1	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	SS	NELSON	&	SOMERSET			3	0.0	0	0	2	2	2	0	0	1	0	0	0	0	0	0	0	0	0	1
1986	SS	NORMAN	&	PRESTON			3	0.0	0	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	1
1986	SS	OCONNOR	&	WAVERLEY			3	0.0	0	2	0	2	0	1	1	0	0	0	0	0	1	0	0	0	0	1

Appendix 5
Without Countermeasures' Database

YEAR	TYPE	LOCATION1		LOCATION2	VOLUME		ACC. FREQ	ACC. RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1986	SS	PARKDALE	&	SPENCER			3	0.0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	1
1986	SS	QN.ELIZ	&	SOMERSET			3	0.0	0	0	2	2	0	1	0	0	0	0	1	1	0	0	0	0	0	1
1986	SS	RICHMOND	&	WINONA			3	0.0	0	0	2	0	0	0	0	0	0	0	0	1	0	1	0	1	1	2
1986	SS	RR- 12	&	STEEPLH			3	0.0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	1
1986	SS	RR- 17	&	HWY- 16			3	0.0	0	2	1	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0
1986	SS	RR- 17	&	CHIPPEWA			3	0.0	0	2	1	3	0	1	0	1	0	0	0	0	1	0	0	0	0	0
1986	SS	RR- 26	&	RR- 27			3	0.0	0	1	0	1	0	0	0	1	0	0	0	0	0	2	0	0	0	3
1986	SS	RR- 30	&	MONTEREA			3	0.0	0	0	3	1	0	1	0	0	0	0	0	2	0	0	0	0	0	0
1986	SS	RR- 36	&	HARTIN			3	0.0	0	0	2	2	0	0	0	0	0	1	0	2	0	0	0	0	0	1
1986	SS	RR- 36	&	BELLVIEW			3	0.0	0	0	1	1	0	0	3	0	0	0	0	0	0	0	0	0	0	1
1986	SS	RR- 38	&	RANGE			3	0.0	0	0	3	1	1	0	0	0	0	0	0	2	0	0	0	0	0	1
1986	SS	RR- 61	&	BEAVERRI			3	0.0	0	0	1	1	0	0	1	0	0	0	0	2	0	0	0	0	0	3
1986	SS	RR- 52	&	BERTONA			3	0.0	0	0	1	2	0	0	2	0	0	0	0	1	0	0	0	0	0	2
1986	SS	RR-128	&	LABRIE			3	0.0	0	1	1	2	2	0	0	0	0	0	0	0	0	1	0	0	0	1
1986	SS	FAIRBANK	&	ROGER	962	88	2	5.7	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	1
1986	SS	RR- 12	&	RR- 45	1022	83	2	5.4	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1
1986	SS	RR- 27	&	EIGHTHLI	2024	85	2	2.7	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0
1986	SS	DOVERCOU	&	FRASER	2045	88	2	2.7	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1
1986	SS	METCALFE	&	STRATHCO	2338	83	2	2.3	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0
1986	SS	BROADVIE	&	BYRON	2393	88	2	2.3	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
1986	SS	RR- 14	&	HAWTHORN	2433	82	2	2.3	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
1986	SS	ALBION	&	CAHILL	2464	85	2	2.2	0	0	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	1
1986	SS	RR- 3	&	RR- 10	2543	87	2	2.2	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
1986	SS	RANGE	&	SOMERSET	2579	88	2	2.1	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1
1986	SS	RR- 28	&	CR- 7CU	2615	85	2	2.1	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	1
1986	SS	RR- 6	&	RR- 13W	3081	87	2	1.8	0	0	2	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1
1986	SS	RR- 13	&	JOCKVALE	3959	87	2	1.4	0	1	0	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0
1986	SS	RR- 28	&	WESTPK-S	4269	81	2	1.3	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
1986	SS	GLADSTON	&	ROSEMOUN	4628	80	2	1.2	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
1986	PX	BELMONT	&	RIVERDAL	4787	88	2	1.1	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0
1986	SS	RR-125	&	DAVIDSON	4968	87	2	1.1	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	1	0	0
1986	SS	PRINCESS	&	RCLF-PKW	5070	84	2	1.1	0	0	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	2
1986	SS	RR- 14	&	RR- 26N	5270	88	2	1.0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1
1986	SS	CHESTERT	&	VIEWMOUN	5277	87	2	1.0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	2
1986	SS	RR- 6	&	HWY- 31	5410	84	2	1.0	0	1	2	1	0	0	0	0	1	0	0	1	0	0	0	0	0	2
1986	SS	BEVERLEY	&	WESTMOUN	5904	87	2	0.9	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0
1986	SS	CLYDE	&	WOODWARD	6024	82	2	0.9	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1
1986	SS	CHIMO	&	KATIMAVI	6175	89	2	0.9	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	1
1986	SS	RR- 11	&	RR- 52S	6297	86	2	0.9	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1
1986	SS	ALBION	&	BRIDLEPA	6714	86	2	0.8	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
1986	SS	OTHELLO	&	PLEASANT	6714	88	2	0.8	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1
1986	SS	HOLLAND	&	SHERWOOD	6897	82	2	0.8	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0
1986	SS	BAXTER	&	IRIS	7124	85	2	0.8	0	0	2	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1
1986	SS	HAIG	&	PLEASANT	7274	88	2	0.8	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	2

Appendix 5
Without Countermeasures" Database

YEAR	TYPE	LOCATION1		LOCATION2	VOLUME		ACC. FREQ	ACC. RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1986	SS	HENDERSO	&	MANN	7431	83	2	0.7	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	1
1986	SS	BLOSSOM	&	KILBORN	7479	88	2	0.7	0	0	0	2	0	0	0	0	0	1	0	1	0	0	0	0	0	0
1986	SS	CHARLOTT	&	WILBROD	7483	86	2	0.7	0	1	0	2	1	0	0	0	1	0	0	0	0	0	0	0	0	0
1986	SS	RR- 36	&	SPRINGBR	7492	86	2	0.7	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
1986	SS	DOVERCOU	&	KIRKWOOD	7566	87	2	0.7	0	0	1	2	0	1	0	0	0	0	1	0	0	0	0	0	0	0
1986	SS	CHAMPLAI	&	JEANNEDA	7871	86	2	0.7	0	1	1	2	0	0	0	0	0	0	1	0	0	1	0	0	0	1
1986	SS	CLARE	&	KIRKWOOD	7980	86	2	0.7	0	2	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1
1986	SS	JULIAN	&	WELLINGT	8012	88	2	0.7	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1
1986	SS	BOOTH	&	PRIMROSE	8102	86	2	0.7	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1
1986	SS	HWY- 31	&	KINGSDAL	8499	89	2	0.6	0	2	1	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1
1986	SS	RR- 23	&	RR- 52	8587	86	2	0.6	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1
1986	SS	RR- 12	&	LARKIN	8897	87	2	0.6	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0
1986	SS	CHURCHIL	&	SCOTT	9113	83	2	0.6	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1
1986	SS	CUMMINGS	&	DONALD	9406	86	2	0.6	0	0	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1
1986	SS	ARGYLE	&	METCALFE	9698	89	2	0.6	0	1	1	2	0	0	0	0	0	0	0	1	0	0	0	1	0	0
1986	SS	KIRKWOOD	&	WOODWARD	9988	88	2	0.5	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0
1986	SS	CHAPEL	&	MANN	10194	86	2	0.5	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	1	1	2
1986	SS	KINGEDWA	&	TEMPLETO	10478	86	2	0.5	0	1	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0
1986	SS	BAY	&	GLADSTON	10805	84	2	0.5	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2
1986	SS	SERVICE	&	WALKLEY	10617	79	2	0.5	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
1986	SS	HEMLOCK	&	LANSDOWN	10711	88	2	0.5	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1
1986	SS	CYR	&	MCARTHUR	11259	82	2	0.5	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0
1986	SS	ALTAVIST	&	BILLINGS	11395	86	2	0.5	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1
1986	SS	LOCKHART	&	RICHMOND	12095	86	2	0.5	0	2	2	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0
1986	SS	ROSS	&	SCOTT	12201	82	2	0.4	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1
1986	SS	GOLDEN	&	RICHMOND	12663	83	2	0.4	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
1986	SS	RR- 34	&	MAISONNE	12822	87	2	0.4	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0
1986	SS	RR- 12	&	WOLFGANG	12930	87	2	0.4	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1
1986	SS	RR- 17	&	JAMIE	13222	89	2	0.4	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1
1986	PX	RR- 34	&	ELWOOD	13244	87	2	0.4	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1
1986	SS	BANK	&	SECOND	13568	80	2	0.4	0	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1
1986	SS	BANTON	&	WALKLEY	13582	89	2	0.4	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1
1986	SS	PARKDALE	&	TYNDALL	13605	88	2	0.4	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	2
1986	SS	BASELINE	&	MORRISON	14503	86	2	0.4	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	2
1986	SS	JOHN	&	SUSSEX	15993	87	2	0.3	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1
1986	SS	RR- 69	&	HWY- 16	17572	86	2	0.3	0	0	2	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1
1986	SS	ANOKA	&	BANK	20165	82	2	0.3	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1
1986	SS	RR- 36	&	VANIER	21046	87	2	0.3	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1
1986	SS	DATACENT	&	HERON	23594	83	2	0.2	0	0	2	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1
1986	SS	BANK	&	COLLINS	24713	83	2	0.2	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
1986	SS	BANK	&	SURREY	25349	87	2	0.2	0	0	1	1	0	0	0	2	0	0	0	0	0	0	0	0	0	1
1986	SS	BANK	&	NOTTINGH	26401	86	2	0.2	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1
1986	SS	BASELINE	&	CORDOVA	27766	86	2	0.2	0	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	1
1986	SS	DATACENT	&	RIVERSID	28449	87	2	0.2	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0

Appendix 5
Without Countermeasures' Database

YEAR	TYPE	LOCATION1		LOCATION2	VOLUME	ACC. FREQ	ACC. RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1986	SS	ABBOTSFO	&	BANNING		2	0.0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
1986	SS	ABERDEEN	&	PRESTON		2	0.0	0	2	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
1986	SS	ALBION	&	HTHRGTNR		2	0.0	0	0	0	2	0	0	0	1	0	0	0	0	0	1	0	0	0	0
1986	SS	ALEXANDE	&	SUSSEX		2	0.0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	0	0	0	1
1986	SS	ALTAVIST	&	WESMAR		2	0.0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	1	1
1986	SS	ALTAVIST	&	DALE		2	0.0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	1
1986	SS	ANCASTER	&	CARLING		2	0.0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
1986	SS	ARGYLE	&	QN.ELIZ		2	0.0	0	0	2	2	1	0	0	0	1	0	0	0	0	0	0	0	0	1
1986	SS	ARMSTRON	&	BAYVIEW		2	0.0	0	1	1	2	0	1	0	0	0	0	0	0	1	0	0	0	0	0
1986	SS	ATHLONE	&	RICHMOND		2	0.0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
1986	SS	BALSAM	&	ROCHESTE		2	0.0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2
1986	SS	BANK	&	JAMES		2	0.0	0	1	1	1	0	0	0	0	2	0	0	0	0	0	0	0	0	1
1986	SS	BANK	&	LISGAR		2	0.0	0	0	1	1	0	0	0	2	0	0	0	0	0	0	0	0	0	1
1986	SS	BARWELL	&	DUMAURIE		2	0.0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1
1986	SS	BASSANO	&	LOTTA		2	0.0	0	0	1	2	0	0	2	0	0	0	0	0	0	0	0	0	0	1
1986	SS	BATE.IS	&	CHAMPL-B		2	0.0	0	2	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
1986	SS	BAY	&	COOPER		2	0.0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	SS	BEAVERBR	&	VARLEY-E		2	0.0	0	0	1	2	0	0	1	0	0	0	0	0	0	1	0	0	0	0
1986	SS	BEECHWOO	&	CHAMPLAI		2	0.0	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
1986	SS	BESSERER	&	CHARLOTT		2	0.0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	SS	BOOTH	&	ELM		2	0.0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
1986	SS	BOOTH	&	WILLOW		2	0.0	0	2	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0
1986	PX	BOOTH	&	NORMAN		2	0.0	0	0	2	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0
1986	SS	BORTHWIC	&	MONTREAL		2	0.0	0	0	1	2	1	0	0	1	0	0	0	0	0	0	0	0	0	1
1986	SS	BOWESVIL	&	RIDEAU		2	0.0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	2
1986	SS	BREEZEHI	&	GLADSTON		2	0.0	0	1	1	2	0	1	0	0	0	0	0	1	0	0	0	0	1	1
1986	SS	BRONSON	&	RENFREW		2	0.0	0	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
1986	SS	BRONSON	&	COL.BY		2	0.0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
1986	SS	BYRON	&	HILSON		2	0.0	0	1	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0
1986	SS	CAMBRIDG	&	CARLING		2	0.0	0	1	0	2	0	0	1	0	0	0	0	0	0	0	0	1	0	1
1986	SS	CANTIN	&	MONTFORT		2	0.0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1
1986	SS	CARLING	&	RICHRDSN		2	0.0	0	0	1	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0
1986	SS	CARLING	&	FOX		2	0.0	0	0	2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
1986	SS	CARLING	&	TAVISTOC		2	0.0	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1
1986	SS	CARMEN	&	MCARTHUR		2	0.0	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
1986	SS	CAROLINE	&	WELLINGT		2	0.0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1
1986	SS	CARRUTHE	&	LADOUCEU		2	0.0	0	0	1	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0
1986	SS	CARRUTHE	&	LYNDALE		2	0.0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1
1986	SS	CARTIER	&	FRANK		2	0.0	0	0	2	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
1986	SS	CASTLEFR	&	KAKULU		2	0.0	0	1	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	1
1986	SS	CAVAN	&	LAROSE		2	0.0	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1
1986	SS	CHAPEL	&	STEWART		2	0.0	0	0	2	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0
1986	SS	CHAPMAN	&	SAUNDRSN		2	0.0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1
1986	SS	CHARTWEL	&	CRAIGHEN		2	0.0	0	0	2	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0

Appendix 5
"Without Countermeasures" Database

YEAR	TYPE	LOCATION1		LOCATION2	VOLUME	ACC. FREQ	ACC. RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1986	SS	CHESTERT	&	MULVAGH		2	0.0	0	0	2	1	0	0	0	1	0	0	0	0	0	0	0	1	1	1
1986	SS	CHESTNUT	&	LEES		2	0.0	0	1	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1
1986	SS	CHOMLEY	&	CORONATI		2	0.0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]
1986	SS	CLARENCE	&	WILLIAM		2	0.0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
1986	SS	CORNELL	&	DRAPER		2	0.0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
1986	SS	CRAIGHEN	&	IVYLEA		2	0.0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0
1986	SS	CUMMINGS	&	WELDON		2	0.0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0
1986	SS	CYR	&	MONTREAL		2	0.0	0	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
1986	SS	DAGMAR	&	HANNAH		2	0.0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1
1986	SS	DELACOLO	&	PARKDALE		2	0.0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1986	SS	DESCHAMP	&	OLMSTEAD		2	0.0	0	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	1
1986	PX	DONALD	&	30 W OF TELFORD		2	0.0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	2
1986	SS	EASTWOOD	&	MCARTHUR		2	0.0	0	0	1	2	0	0	0	0	0	1	0	1	0	0	0	0	0	1
1986	SS	FIFTH	&	OCONNOR		2	0.0	0	0	2	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0
1986	SS	FOSTER	&	PARKDALE		2	0.0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	1
1986	SS	FRANK	&	OCONNOR		2	0.0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
1986	SS	FRANK	&	QN.ELIZ		2	0.0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	1	0	0
1986	SS	GAGE	&	NAVAHO		2	0.0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0	1
1986	SS	GEORGE	&	KINGEDWA		2	0.0	0	0	2	2	0	1	0	0	0	0	0	0	1	0	0	0	0	0
1986	SS	GILMOUR	&	PERCY		2	0.0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
1986	SS	GLEBE	&	PERCY		2	0.0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	1	2
1986	SS	GRANGE	&	SPENCER		2	0.0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1
1986	SS	GRANVILL	&	MONTFORT		2	0.0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	1
1986	SS	GRENFELL	&	SLACK		2	0.0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	[illegible]
1986	SS	HAMILTON	&	SPENCER		2	0.0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	2
1986	SS	HANNAH	&	MARIER		2	0.0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	1
1986	SS	HERRIDGE	&	MAIN		2	0.0	0	0	2	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0
1986	SS	HINCHEY	&	SCOTT		2	0.0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
1986	SS	HURON	&	SCOTT		2	0.0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	1
1986	SS	HWY- 7	&	HWY-7133		2	0.0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	1	0	1
1986	SS	HWY- 17	&	CR- 6HU		2	0.0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1
1986	SS	HWY- 17	&	MORIN		2	0.0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1
1986	SS	HWY- 31	&	S.BERNAR		2	0.0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	2
1986	SS	HWY- 31	&	PARKWAY		2	0.0	0	0	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	2
1986	SS	IRVING	&	WELLINGT		2	0.0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
1986	SS	IS.PARK	&	MAILES		2	0.0	0	0	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	SS	JOLIETTE	&	S.MONIQU		2	0.0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1986	SS	KAKULU	&	PICKFORD		2	0.0	0	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	SS	LEIGHTON	&	RICHMOND		2	0.0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1
1986	SS	MACLAREN	&	PERCY		2	0.0	1	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1
1986	SS	MAITLAND	&	TERREBON		2	0.0	0	1	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	1
1986	SS	MCLEOD	&	METC-EXT		2	0.0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
1986	SS	METCALFE	&	PRETORIA		2	0.0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1
1986	SS	NAUGHTON	&	QUEENMAR		2	0.0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0

Appendix 5

Without Countermeasures' Database

YEAR	TYPE	LOCATION1		LOCATION2	VOLUME		ACC. FREQ	ACC RATE/MEV	NON REP	DARK	PEAK	WET	NE	SE	SW	WW	NS	EW	NN	EE	SS	WW	NOT SPEC	ONE VEH	PED INJ	TOT INJ
1986	SS	NORMAN	&	ROCHESTE			2	0.0	0	1	1	2	1	0	0	0	0	0	0	0	0	0	0	1	0	0
1986	SS	NOTREDAM	&	ORLEANS			2	0.0	0	0	1	2	0	0	1	0	1	0	0	0	0	0	0	0	0	0
1986	SS	PENDER	&	STARWOOD			2	0.0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0
1986	SS	PRESTON	&	PRIMROSE			2	0.0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1
1986	SS	PRESTON	&	S.ANTHON			2	0.0	0	1	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0
1986	SS	PRESTWIC	&	ROXDALE			2	0.0	0	1	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1
1986	SS	QN.ELIZ	&	WILTON & RAMP-C1			2	0.0	0	1	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0
1986	SS	RID-TERR	&	SPRINGFI			2	0.0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
1986	SS	ROSS	&	SPENCER			2	0.0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	1
1986	SS	RR- 2	&	RR- 3E			2	0.0	0	1	2	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0
1986	SS	RR- 5	&	FERNBANK			2	0.0	0	0	1	2	0	0	2	0	0	0	0	0	0	0	0	0	0	1
1986	SS	RR- 6	&	YORK			2	0.0	0	0	2	1	0	0	0	1	0	0	0	0	1	0	0	0	0	2
1986	SS	RR- 5	&	HWY-417N			2	0.0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1
1986	SS	RR- 13	&	WESSEX			2	0.0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1
1986	SS	RR- 17	&	STARWOOD			2	0.0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
1986	SS	RR- 30	&	BELCOURT			2	0.0	0	2	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	2
1986	SS	RR- 30	&	EASTPARK			2	0.0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1
1986	PX	RR- 30	&	52 W OF SOUTHPAR			2	0.0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	1
1986	SS	RR- 34	&	COUSINEA			2	0.0	0	1	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	1
1986	SS	RR- 38	&	CORKSTOW			2	0.0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0
1986	SS	RR- 49	&	CR- 5HU			2	0.0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	2
1986	SS	RR- 50	&	JASMINE			2	0.0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1
1986	SS	RR- 51	&	WITHROW			2	0.0	0	2	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	1
1986	SS	RR- 59	&	MOODIE			2	0.0	0	1	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	2
1986	SS	RR-107	&	DOWNPATR			2	0.0	0	0	1	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0
1986	SS	S.ANNE	&	SHAKESPE			2	0.0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	1
1986	SS	S.LAUREN	&	TAWNEY			2	0.0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1

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