EVALUATION OF THE RED LIGHT CAMERA ENFORCEMENT PILOT PROJECT

FINAL TECHNICAL REPORT

DECEMBER 2003

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Ontario

Ministry of Transportation
Ministère des Transports

Service Development & Improvement Branch
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Re: Evaluation of the Red Light Camera Enforcement Pilot Project

Please find attached an electronic copy of the Evaluation of the Red Light Camera Enforcement Pilot Project prepared by Synectics Transportation Consultants Inc., the firm retained jointly by municipalities and the province to conduct the study.

The evaluation covers the pilot period between November 2000 to November 2002.

If you have any questions regarding the evaluation, please contact Nadia Garisto at the Ministry of Transportation at (416) 235-4608.

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EXECUTIVE SUMMARY

Introduction

The *Red Light Cameras Pilot Projects Act, 1998*, was passed by the Ontario Legislature in December 1998 to enable designated municipalities in the province of Ontario to operate red light cameras for a two-year period. The Cities of Toronto, Hamilton, Ottawa and Regional Municipalities of Halton, Peel, and Waterloo participated in the original two-year pilot project, called the **Red Light Camera Enforcement Pilot Project**.[1]

Two treatments were implemented during the pilot project, namely:

- Automated enforcement using red light cameras; and
- Stepped-up police enforcement.

Ninety-five signalized intersections were selected for treatment by the municipalities as shown in **Exhibit 1**. These sites were selected based on their collision history among other factors. Of note, a public awareness campaign was conducted in a like manner throughout all participating municipalities and, therefore, considered a constant throughout the evaluation. Also, there was no signage at the treated intersections, nor any signs anywhere else within any of the participating municipalities indicating that any intersections had received special treatment.

Exhibit 1 – Signalized intersections selected for treatment

Treatment	Number
Red light camera	68
Stepped-up police enforcement	27
Total	**95**

As part of the pilot project, an evaluation study was undertaken to determine the combined impacts on safety of red light cameras and stepped-up police enforcement across the six municipalities. The key goals were to:

- Conduct a before and after evaluation study to assess the combined effect of two red light running treatments for intersections with a high incidence of red light running related collisions[2]: use of red light camera systems and stepped-up police enforcement (**safety evaluation**); and
- Assess the costs and performance of both treatments (**benefit - cost analysis**).

This evaluation study was conducted by a team from the firm Synectics Transportation Consultants Inc. under contract to the Ministry of Transportation, Ontario.

[1] At the close of the two-year pilot project, five of the six municipalities (Cities of Toronto, Hamilton, Ottawa and Regional Municipalities of Peel and Waterloo) formally requested the Province to extend legislation permitting continuation of the pilot project for an additional two years. On November 19th, 2002, the *Red Light Cameras Pilot Projects Extension Act, 2002*, received Royal Assent. This legislation enables designated municipalities to use red light cameras until November 20, 2004. The legislation also allows for repeal of the pilot end date, by an Order-In-Council, prior to November 20, 2004, which would make the legislation permanent.

[2] A collision is any incident in which bodily injury or damage to property is sustained as a result of the movement of a motor vehicle or of its load while a motor vehicle is in motion.

Sites used for safety evaluation

Forty-eight sites distributed throughout the six municipalities were selected for the safety evaluation and benefit - cost analysis. The forty-eight sites consisted of:

- Nineteen **red light camera** sites;
- Seventeen **stepped-up police enforcement** sites; and
- Twelve **local comparison** sites.

The twelve **local comparison** sites were included in the analysis as the researchers wanted to ascertain how the two treatments (red light camera and stepped-up police enforcement) may have affected collisions at sites having no direct treatment intervention. Combined, the forty-eight sites provide a means of estimating the overall impacts of the two treatments in affecting changes in safety at signalized intersections on a community-wide basis across the six municipalities.

Evaluating the safety performance of the sites

The state-of-the-art safety evaluation technique known as the Empirical Bayes (EB) method was used for deriving estimates of the overall effectiveness of the two treatments. This procedure is recognized as being an accurate, precise statistical tool for conducting safety evaluations of treatments when only valid collision data is available for the evaluation study locations during the before and after periods of treatment implementation.

The six participating municipalities provided annual collision and traffic volume data from 179 signalized intersections representing the time period 1995 to 1999.[3] This data was used to develop safety performance function (SPF) curves in order to estimate what the average safety performance (in yearly collision frequency) is expected to be at a group of typical signalized intersections representing a range of traffic volumes.

Combining the past 1995-1999 annual collision experience at each of the forty-eight signalized intersections with the derived SPF curves, the number of fatal, injury and property damage only collisions that would have been **expected** to occur if the treatments had not been implemented at each intersection during the first two years (November 20, 2000 – November 19, 2002) of the pilot project were estimated. In essence, the evaluation study team was able to estimate what the expected number of fatal, injury and property damage only collisions would have been had the treatments not been introduced. This prediction process was done using the EB method, and the final estimators are known as the EB estimators of safety.

These EB estimators for the forty-eight signalized intersections were then compared to the actual **(observed)** number of collisions that occurred at each of them in the first two years of the pilot project during which time the treatments were implemented.

A comparison between the *expected number of collisions if the treatments had not been implemented* (i.e. the EB estimators) and the *observed number of collisions that actually occurred with the treatments implemented* provides the basis for the safety effectiveness of the two treatments to be assessed at each of the forty-eight sites for the first two years of the pilot project.

[3] The 179 signalized intersections included the forty-eight study intersections used in this evaluation.

Exhibit 2 shows the percentage difference between the *expected* and *observed* number of fatal, injury and property damage only collisions in the first two years of the pilot project averaged over the forty-eight sites. A negative number indicates that the intersections on average performed **better** than expected, having less collision occurrence than what would have been expected had there been no treatments implemented. A positive number indicates the intersections on average performed **worse** than expected, having more collision occurrence than what would been expected had there been no treatments implemented.

This evaluation study not only considered all collision types combined, but also angle and rear-end collisions separately. These two collision types were of interest as past research (*NCHRP Synthesis 310 – Impact of Red Light Camera Enforcement on Crash Experience*) has shown angle collisions decrease at red light camera sites, but rear-end collisions may increase.

Exhibit 2 – Safety effectiveness

Signalized intersections[1]	**Percentage difference between expected and observed collisions**	
	Fatal and injury	**Property damage only**
All collision types	-6.8	+18.5
Angle collisions	-25.3	-17.9
Rear-end collisions	+4.9	+49.9

Notes:

[1] The signalized intersections consisted of nineteen red light camera, seventeen stepped-up police enforcement and twelve local comparison sites.

Interpretation of results

Exhibit 2 indicates that red light running treatments have:

- Contributed to a **6.8 per cent decrease** in fatal and injury collisions; and
- Contributed to an **18.5 per cent increase** in property damage only collisions.

These results show that the treatments have had an encouraging safety result as they have reduced the number of severe collisions from occurring thereby saving lives and reducing the number of individuals injured at intersections. However, these treatments have shown to have increased the number of less severe (non-injury) collisions.

Exhibit 2 indicates the red light running treatments have:

- Contributed to a **25.3 per cent decrease** in fatal and injury angle collisions; and
- Contributed to a **17.9 per cent decrease** in property damage only angle collisions.

The frequency of all angle collisions have been reduced with the implementation of the treatments, with the greatest benefit being realized for the fatal and injury collisions.

Finally, **Exhibit 2** indicates the red light running treatments have:

- Contributed to a **4.9 per cent increase** in fatal and injury rear-end collisions; and
- Contributed to a **49.9 per cent increase** in property damage only rear-end collisions.

The rear-end collision results are similar to findings in other red light camera studies (*NCHRP Synthesis 310*).

Benefit - cost analysis

The purpose of the benefit and cost analysis was to determine the net societal benefits of the pilot project through an assessment of all benefits and costs associated with the operation of red light cameras and stepped-up police enforcement during the first two years of the pilot project (November 20, 2000 – November 19, 2002) at the forty-eight evaluation study sites. All benefits and costs are representative of the first two years of the project. The following benefits were identified for inclusion in the benefit – cost analysis:

- **Collisions avoided –** societal cost savings due to a reduction in fatalities and injuries, reduced property damage, a reduced burden on the health care system and a reduced burden on emergency services.

A number of different costs were also identified. All capital purchases were annualized over five years. The following costs were identified for inclusion in the benefit – cost analysis:

- **Ongoing provincial costs related to operation of red light cameras (and stepped-up police enforcement) –** including the administrative costs, such as salaries of staff, operation of the Plate Registrant Data Requisition System and public education related to the operation of red light cameras and stepped-up police enforcement;
- **Municipal costs related to operation of red light cameras (and stepped-up police enforcement)** including public education related to the operation of red light cameras and stepped-up police enforcement and the cost of photographs required for evidence in court;
- **Red light camera capital costs –** the cost of acquiring the red light cameras and preparing the evaluation study sites for their use;
- **Municipal Joint Processing Centre capital costs –** all capital costs associated with the Municipal Joint Processing Centre established at the beginning of the pilot project for the purposes of reviewing photographs associated with red light running offences recorded by red light cameras;
- **Red light camera operating costs –** the cost of operating the red light cameras;
- **Municipal Joint Processing Centre operating costs –** all operating costs associated with the processing of photo sets at the Municipal Joint Processing Centre;

- **Fine revenue and fine dispositions imposed –** the value of red light running fines imposed by means of a red light running ticket produced as a result of a red light camera or a police officer recording a red light running violation at an evaluation study site, this is calculated as a negative (recovered) cost;
- **Court processing costs –** all costs associated with the prosecution of red light running offences; and
- **Stepped-up police enforcement costs –** all costs associated with carrying out stepped-up police enforcement deployments.

Exhibit 3 summarizes the net benefits and costs associated with the first two years of the project at the forty-eight evaluation study sites.

Exhibit 3 Estimated net benefits and costs: November 20, 2000 – November 19, 2002

Estimated net benefits and costs[1]	
Total net benefits[4]	$1,613,766
Total net costs	$1,026,805
Benefit-to-cost ratio	**1.57**
Notes: [1]The benefits and costs were calculated based on only the forty-eight study sites included in this evaluation.	

Interpretation of results

The benefit-to-cost ratio is **1.57.** Based on these findings, the Red Light Camera Enforcement Pilot Project has been shown to be economically viable, given that the social cost of collisions avoided exceeds the amount invested in the treatments at the forty-eight evaluation study sites. The EB analysis shows that an estimated forty-seven fatal and injury collisions were avoided as a result of the treatments, valued at $3,775,425.[4] Based on this, the pilot project has been shown to be a valid safety program for the province of Ontario, having achieved the objective of reducing fatal and injury collisions.

Conclusions and recommendations

Based on the results presented in this report, the Red Light Camera Enforcement Pilot Project has been shown to be an effective tool in reducing fatal and injury collisions, thereby preventing injuries and saving lives. For these reasons, it is the opinion of the evaluation study team that the pilot project has been worthwhile and would continue to be of benefit to any participating municipality.

It is recommended that collisions continue to be monitored and examined on a yearly basis to validate that the trend continues as presented in the evaluation study results.

[4] The $3,775,425 in fatal and injury collisions avoided is offset by a gain in property damage only collisions of $2,161,659, yielding a total net benefit of $1,613,766 as shown in **Exhibit 3**.

PART I – FOUNDATION FOR EVALUATION STUDY

1.0 INTRODUCTION

This section provides a brief history of the Red Light Camera Enforcement Pilot Project, states the purpose of the evaluation study, and provides an outline of the Technical Report.

1.1 THE RED LIGHT RUNNING ENFORCEMENT PILOT PROJECT

The Red Light Cameras Pilot Projects Act, 1998 (Bill 102) was passed in December 1998 by the Ontario Legislature to enable designated municipalities to test and evaluate the effectiveness of various enforcement options to address the problem of red light running at signalized intersections for a two-year period (November 20, 2000 – November 19, 2002). The pilot project is referred to as the *Red Light Camera Enforcement Pilot Project*. Those municipalities choosing to participate in the pilot project were to test red light cameras targeted at vehicles. As a requirement for their participation, the municipalities had to commit to:

- Use stepped-up, traditional police enforcement at other high-risk signalized intersections;
- Participate in a comprehensive 'before and after' statistical evaluation to determine the combined effect on safety of both red light camera systems and stepped-up police enforcement; and
- Reimburse the Province of Ontario for all of its costs associated with the pilot project.

In February 1999, the Ministry of Transportation, Ontario invited interested municipalities to attend a series of meetings in order to establish a shared understanding regarding the purpose of the pilot project, to address operational issues and to reinforce a partnership approach. Out of these early meetings, the Intersection Safety Program to Reduce Red Light Running Steering Committee was formed. The purpose of the Steering Committee was to oversee the pilot project, share resources, and expedite the process required to get the pilot project running. The committee consisted of representatives of both traffic and police staff from the City of Toronto, the City of Hamilton, the City of Ottawa, the Regional Municipality of Peel, the Regional Municipality of Halton, and the Regional Municipality of Waterloo in partnership with the Ministry of Transportation Ontario, the Ministry of Attorney General, and the Information and Privacy Commissioner/Ontario**.**

In March 1999, a number of Working Groups were formed to carry out specific tasks related to the pilot project and report back to the Steering Committee. The tasks of the various Working Groups are shown in **Exhibit 1.1**. Working Group 1 is responsible for the evaluation of the pilot project, among other tasks.

During the next year, the various Working Groups began their tasks including negotiations with various red light camera vendors, determining the evidence requirements for prosecuting red light runners and visiting several jurisdictions in the United States and Canada conducting red light camera programs to gain further insight into how to run a red light camera program.

Exhibit 1.1 Tasks of Working Groups

Number	Name	Key tasks
1	Evaluation	♦ Retain a consultant team for evaluating the effectiveness of the pilot project ♦ Carry out site selection for the evaluation study ♦ Conduct a before-after evaluation study using appropriate statistical methods ♦ Ensure police carry out stepped-up enforcement of red light running during the pilot project
2	Technical	♦ Select the method of recording red light camera violations ♦ Determine system specifications ♦ Select and manage a contractor to supply, install, maintain and operate the red light cameras
3	Legal	♦ Determine evidence requirements ♦ Provide legal advice and information to other Working Groups and Steering Committee ♦ Ensure compliance with privacy requirements
4	Municipal Joint Processing Centre	♦ Develop a process of laying charges ♦ Develop and manage a Municipal Joint Processing Centre for the purposes of reviewing evidence supplied by red light cameras ♦ Hire staff to review red light camera photographs
5	Public awareness	♦ Inform the public and media regarding the pilot project ♦ Carry out a public awareness campaign targeting red light runners
6	Prosecutions	♦ Develop a prosecution strategy ♦ Train prosecutors

In April 2000, Lockheed Martin IMS Systems and Services Canada Inc. (now Affiliated Computer Systems) was awarded a two-year contract to supply, install, maintain and operate red light cameras in the six participating municipalities, contingent on a proof of performance. The proof of performance was carried out in June – September 2000, resulting in Lockheed Martin being accepted as the vendor of choice. Collectively, eighteen red light cameras were purchased by the six participating municipalities for use at sixty-eight different sites. The rotation of the cameras purchased by each of the municipalities was left up to the discretion of each municipality.

November 20, 2000 was selected as the start date of the pilot project and in anticipation of that date, a publicity campaign was launched in the fall of 2000 to inform the public of the red light cameras and the penalties associated with red light running. The publicity campaign involved media releases, radio and bus shelter advertisements.

Lockheed Martin IMS Systems and Services Canada Inc. and the participating municipalities worked together to install red light cameras at sixty-eight sites throughout the fall of 2000 in anticipation of the launch date. On November 20, 2000, the red light cameras began operation. As required, stepped-up police enforcement was also carried out at twenty-seven sites during the two-year pilot project. These sites were located across the province of Ontario in the six participating municipalities.

In February 2002, five of the six municipalities (Cities of Toronto, Hamilton, Ottawa and Regional Municipalities of Peel and Waterloo) formally requested that the Government of Ontario extend the pilot project for an additional two years as preliminary results indicated that the red light cameras were effective. This gave Working Group 1 more time to complete this evaluation study. On November 19th, 2002, the *Red Light Cameras Pilot Projects Extension Act, 2002*, received Royal Assent. This legislation enables designated municipalities to continue to enforce red light camera violations until November 20, 2004. The legislation also allows for repeal of the pilot end date, by an Order-In-Council, prior to November 20, 2004, which would make the legislation permanent.

1.2 PURPOSE OF THIS EVALUATION STUDY

In August 1999, over a year prior to the beginning of the pilot project, the provincial government issued a Request for Proposal (RFP) for a consulting firm to evaluate the pilot project in conjunction with Working Group 1. The RFP stated the primary objective as being:

"*…to conduct a before and after study to assess the combined effect of two red light running countermeasures for intersections with a high incidence of red light running related collisions: use of red light camera systems and stepped-up police enforcement*." [pg 6 – Request for Proposal – Agreement No. 9035-A-000010B.]

The RFP also stated as a secondary objective that the "*the study conducted by the Consultant must assess the costs and performance of both countermeasures…*" [pg 6 – Request for Proposal – Agreement No. 9035-A-000010B.]

Based on the above objectives, Working Group 1 carried out this evaluation study of the pilot project with the following key tasks:

- Estimate the changes in fatal, injury and property damage only collisions that can be attributed to the presence of the red light cameras and stepped-up police enforcement (**safety evaluation**); and
- Evaluate the total benefits and costs associated with the first two years of the pilot project (**benefit-cost analysis**).

The purpose of this Technical Report is to summarize the main findings of this evaluation study and to present the results of the first two years of the pilot project.

1.3 OUTLINE OF TECHNICAL REPORT

The material presented in this report has, for the most part, been extracted from previous reports presented to Working Group 1. These include:

- Bibliography (Fall 1999);
- Guidelines on site selection (Fall 1999);
- Evaluation study methodology (Spring 2001);
- Before data report (Summer 2001);
- Evaluation study protocol (Summer 2001);
- Interim data report, Part I (Summer 2002); and
- Interim data report, Part II (Winter 2003).

This report is divided into three major parts:

The first part (Part I – Foundation for evaluation study) provides some introductory information regarding the pilot project, divided into two sections:

- **Section 1.0 –** Background information on the pilot project; and
- **Section 2.0 –** A description of the treatments being used in the pilot project.

The second part (Part II – Evaluation of safety at study sites) addresses the primary objective of this evaluation study in four sections:

- **Section 3.0 –** Methodology used for evaluating safety;
- **Section 4.0 –** Sites and the data involved in this evaluation study;
- **Section 5.0 –** Evaluation of the treatments using the after data; and
- **Section 6.0 –** Interpretation of the results and comparison to other study findings.

The third part (Part III – Benefit – cost analysis) addresses the secondary objective of this evaluation study in four sections:

- **Section 7.0 –** Methodology used for calculating the benefits and costs associated with the evaluation study;
- **Section 8.0 –** Benefit calculations;
- **Section 9.0 –** Cost calculations; and
- **Section 10.0 –** Calculation of the benefit – cost ratio.

Following the three parts are some concluding remarks on this evaluation study presented in **Section 11.0**.

Following the body of the report there are a number of Appendices provided, including:

- **Appendix A –** Stepped-up police enforcement data form;
- **Appendix B –** List of sites in this evaluation study;
- **Appendix C –** Red light running and posted speed limit violation data and analysis;
- **Appendix D –** EB method;
- **Appendix E –** Selected intersection characteristics;
- **Appendix F –** Collision data;
- **Appendix G –** Trending of volume data;
- **Appendix H –** SPF equation parameters; and
- **Appendix I –** Estimating the benefits and costs of the treatments on all signalized intersections.

2.0 TREATMENTS

During the course of the pilot project, two red light running treatments were implemented. They were:

- Automated enforcement using red light cameras; and
- Stepped-up police enforcement.

A third 'treatment' was also implemented, a publicity campaign notifying residents and visitors within the six municipalities of the pilot project. Each of these treatments is described in the sections below.

2.1 AUTOMATED ENFORCEMENT USING RED LIGHT CAMERAS

The red light cameras currently in use in the province of Ontario are operated and maintained by the vendor Affiliated Computer Systems (formerly Lockheed Martin IMS Systems and Services Canada Inc.). The vendor is also responsible for changing and developing all film.

Eighteen Gatsometer B.V (36mST–MC–GL4–ONT) red light cameras are in use in the pilot project. A red light camera includes a camera, poles, a flash unit, an enclosure, in-pavement inductive loop detectors, cabling and the traffic signal with its various components.

The camera is an industrial 35 mm camera, manufactured particularly for unattended operation in an outdoor environment. It uses wet film technology. It can hold a 30-metre roll of film and is able to capture 400 events before the film requires replacement. The camera is housed inside a ½ metre by ½metre by ½metre enclosure and is mounted on a pole, 20 metres in advance of the intersection. The enclosure is approximately 3.6 metres above the ground. The flash unit is adjacent to the stop bar, and provides additional illumination during the night to the camera. The inductive loop detectors are situated in the pavement on the approach just upstream of the stop bar. **Exhibit 2.1** shows a typical set up at an intersection.

For this evaluation study, the eighteen red light cameras were rotated among sixty-eight signalized intersection approaches. The enclosure is designed such that passing motorists cannot determine whether or not a camera is inside.

The red light camera unit photographs all vehicles on an approach traveling through the intersection after the traffic signal indication has changed to red on that approach. The photograph is taken of the vehicle and the vehicle licence, but not the driver of the vehicle. The first photograph is taken prior to the vehicle crossing the stop bar line as it activates the loop detectors as shown in **Exhibit 2.2**. The second photograph is taken while the vehicle is in the intersection as shown in **Exhibit 2.3**.

Exhibit 2.1 Typical set up of red light camera at an intersection

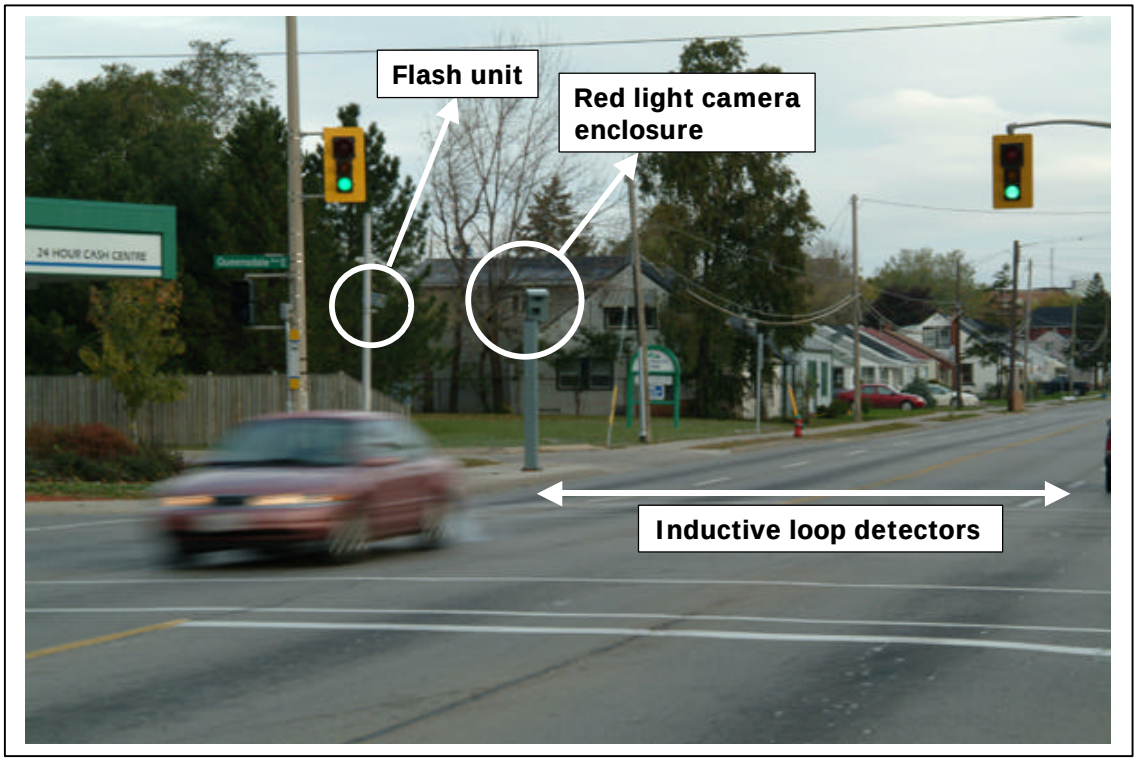


Exhibit 2.2 Position of vehicle when first photo taken

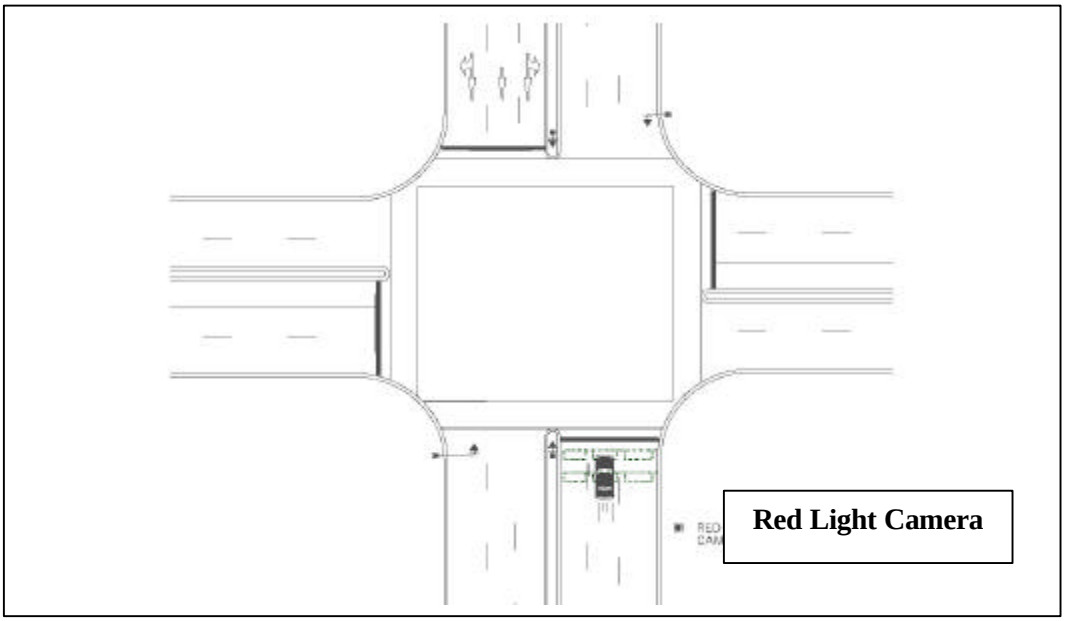
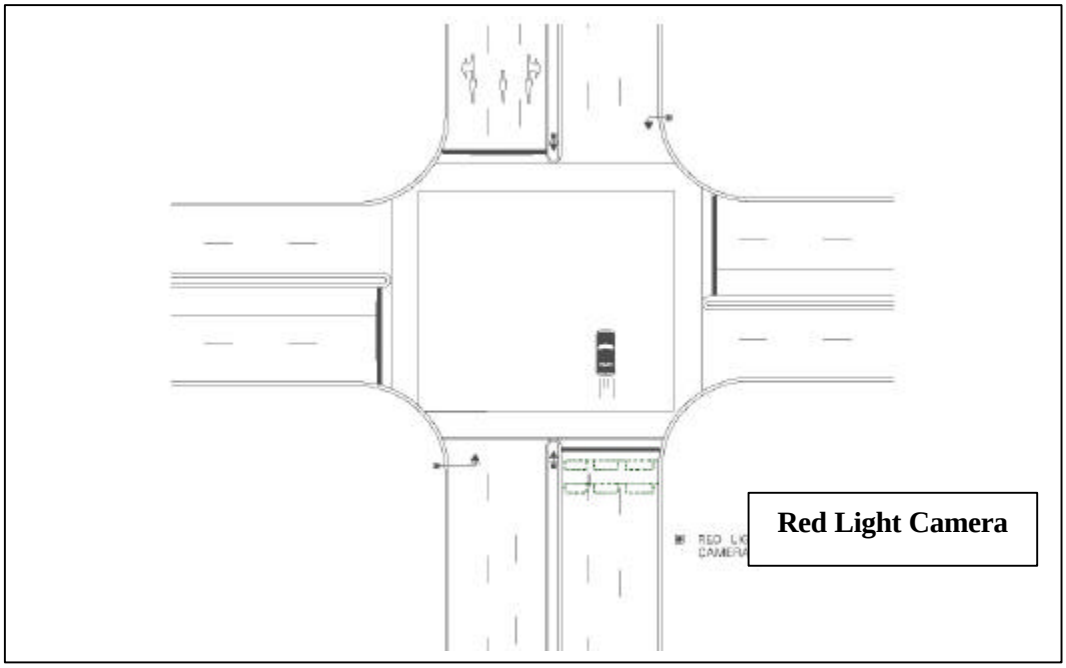


Exhibit 2.3 Position of vehicle when second photo taken



The vendor sends the developed film to the Municipal Joint Processing Centre where the images are reviewed by Provincial Offences Officers. The Municipal Joint Processing Centre performs several functions for the pilot project, primarily matching photo and plate information, laying of charges, and providing evidence to the Prosecutor for prosecution purposes. Municipal Joint Processing Centre staff review images taken by the red light camera system. If an offence has occurred, information is collected from the Ministry of Transportation, Ontario and the offence notice (ticket) is mailed to the owner of the vehicle. The set fine for running a red light is $190.00, including a $35.00 victim fine surcharge. The ticket must be mailed to the defendant within 23 days, of the offence being committed as set out by the *Provincial Offences Act*.

2.1.1 Signing of red light cameras

The Steering Committee chose not to use any signing indicating that an intersection had a red light camera, nor did they provide signing at the boundaries of their municipalities.

2.1.2 Ontario Public Service Employees Union (OPSEU) strike

In mid-March 2002, approximately four months into the second year of the pilot project, the Ontario Public Service Employees Union began a strike that lasted for several months. The strike impacted the pilot project as the Municipal Joint Processing Centre could not access the licence plate registration information to determine the vehicle owner until September 2002. As a result, while red light running violations could be recorded by the red light cameras, the licence plate number could not be matched to the vehicle owner and therefore, no tickets could be issued during that time period.

The media did not report that no one was being fined for red light camera related infractions. It is safe to assume that the public was unaware that charges were not being laid. It was also observed that there was no significant change in the level of violations occurring at the red light camera sites before, during or after the OPSEU strike, that could be attributed to the strike.

2.2 STEPPED-UP POLICE ENFORCEMENT ACTIVITY

An additional provincial requirement in the implementation of the pilot project was that the participating municipalities would agree to carry out stepped-up police enforcement directed against red light running at high-risk intersection approaches within their jurisdiction. Twenty-seven intersections distributed among the six municipalities were selected. The objective of the strategy was to provide an effective sustainable police presence using existing resources and allowing police flexibility to schedule enforcement blitzes.

The following guiding principles were established by Working Group 1 for the deployments:

- Each police service would conduct its stepped-up police enforcement effort as it normally would;
- Police services would achieve a total deployment time of 20 hours in each of years 1 and 2 of the pilot project. Time would only be made up to obtain this 20 hours if officers are diverted from this task to respond to non-traffic related and non-intersection related events;
- There would be no upstream speed enforcement at the intersection;
- Anomalies at the intersection (road repair work, wet/icy pavement etc.) would be avoided by re-scheduling stepped-up police enforcement blitzes; and
- All vehicle types (commercial, transit, etc.) would be treated in a similar manner.

Each of the police services selected a two-month time period within the first and second year of the pilot project to carry out their stepped-up police enforcement. As part of the agreement, they completed a form shown in **Appendix A** detailing the results of each deployment, for use by the Ministry of Attorney General and the evaluation study team. Further details regarding the stepped-up police enforcement carried out by the police services are presented in **Section 9**.

2.3 PUBLICITY CAMPAIGN

In conjunction with the introduction of the red light camera operations and the stepped-up police enforcement deployments, a publicity campaign was undertaken. The publicity campaign began in September 2000 in advance of the beginning of the pilot project. Advertising was placed on transit shelters, buses and on radio to convey the message that red light running is dangerous and could result in a fine if the motorist is caught. The outdoor advertising, shown in **Exhibit 2.4**, featured a funeral scene with the headline “It Won’t Kill You To Stop”. Next to this a traffic signal logo is shown with the message “Don’t Run A Red”. In addition, throughout the course of the pilot project, press releases were produced on a regular basis stating statistics on the number of tickets issued.

Exhibit 2.4 Outdoor advertising used for Red Light Camera Enforcement Pilot Project

PART II – EVALUATION OF SAFETY AT STUDY SITES

3.0 EVALUATION STUDY METHODOLOGY

As part of this evaluation study, Synectics Transportation Consultants Inc., together with Knowles Consultancy and IBI Group, were given the task of evaluating the effectiveness of the pilot project. This evaluation study was to have two key tasks:

- Estimate the changes in fatal, injury and property damage only collisions that can be attributed to the presence of the red light cameras and stepped-up police enforcement (**safety evaluation**); and
- Evaluate the total benefits and costs associated with the pilot project (**benefit-cost analysis**).

This section presents the methodology used for evaluating the safety effectiveness of the two treatments in four subsections:

- Site selection criteria;
- Observation periods;
- Evaluation study criteria; and
- Methodology proposed for evaluating effectiveness of treatments.

3.1 SITE SELECTION CRITERIA

The objective of this evaluation study was to assess the two treatments at signalized intersections with '*a high incidence of red-light running related collisions*'. Sites chosen for either the *red light camera* or *stepped-up police enforcement* treatment were selected by the municipalities from the signalized intersections in their jurisdiction. These were referred to as *first-tier sites*. From among the first-tier sites, a subset of sites was then selected by the consultant team for the evaluation study. These were referred to as *second-tier sites*. A complete list of all sites included in this evaluation study is presented in **Appendix B**.

While the first-tier sites all had either red light camera or stepped-up police enforcement treatments applied to them, only the second-tier sites were included in this evaluation study.

3.1.1 First-tier site selection

Sites selected for the red light camera operation and stepped-up police enforcement were chosen by the six municipalities according to their own site selection criteria. The municipalities identified signalized intersections within their jurisdiction having the highest total number of collisions normally associated with red light running (angle, left-turn, pedestrian or cyclist) for a five-year period prior to the beginning of the pilot project. These high collision locations were examined in detail to determine if the red light running was prevalent on a particular approach and from among them a set of high-risk approaches was selected. The rationale behind the choice of sites having a high number of red light running related collisions was that they would likely incur the most benefit in collision reduction in the pilot project. Generally speaking, the municipalities chose the sites with the highest collision counts to have a red light camera and the remaining to have stepped-up police enforcement.

As there was to be only one red light camera deployed at each site, a specific approach needed to be identified for treatment. The highest risk approaches were then chosen from among the above such that:

- **They were evenly distributed across the municipalities** – Based on previous research, it appeared that the benefits of the two treatments would 'spill over' to surrounding sites. Therefore, it was hoped that an even geographic distribution of sites would incur the most benefit to the communities as a whole;
- **They were not part of any other local safety initiative** – The sites selected were not to be part of any other safety initiative, such as Community Safety Zones, in which motorists traveling along a road section receive a double fine for any traffic violation. This exclusion would reduce the number of potential confounding factors in this evaluation study;
- **They were not and would not be undergoing any major road construction over the course of the project** – Major road construction would significantly alter traffic patterns at the sites, during and potentially afterwards if a major configuration of the intersection occurred. Exclusion of sites slated for major road construction removed another confounding factor in this evaluation study; and
- **The site did not have anything that would prevent the red light camera system from operating effectively –** As an example, the presence of metallic objects, embedded in the pavement on the approach to an intersection would interfere with the red light camera system. In some cases, the presence of bus shelters would prevent the red light camera from having a clear view of the intersection. Such sites may have been either rejected outright, or designated as a stepped-up police enforcement site.

In summary, a total of ninety-five sites were included in the initial first-tier site selection. Across the province, the municipalities operated eighteen red light cameras, rotated among sixty-eight sites. Each municipality had its own rotation program. They also selected twenty-seven sites to have stepped-up police enforcement deployment occurring for twenty hours both in the first and second year over the course of the pilot project.

3.1.2 Second-tier site selection

From among the sixty-eight red light camera and twenty-seven stepped-up police enforcement sites a subset of sites was chosen for this evaluation study. A number of intersections were also chosen anticipating that they could act as local comparison sites. These sites were signalized intersections that were located in the six participating municipalities, according to the same criteria described above.[5] A spillover effect from the treated intersections located in same municipalities was expected on the local comparison sites. Treated intersections were not signed, so any driver behaviour modification would be more likely to occur at any intersection throughout the municipality and not exclusively at treated intersections. Moreover, these local comparison sites were located in communities that were targeted by the same publicity campaign described in the previous section. In this respect, the local comparison sites could not be considered as 'untreated sites'.

[5] In the original evaluation study design, in addition to the Empirical Bayes method, the evaluation study team considered using two additional statistical methods (the Relative Risk Odds Ratio method and the Comparison Group method) for evaluating the safety effectiveness of the treatments. The proposed methods rely on a comparison and a treated group. The comparison group was to be a set of local comparison sites, in addition to a set of ten sites located in the cities of London and Windsor, referred to as distant comparison sites. The comparison group sites were checked to determine if they were compatible with the treated sites in terms of the collision history. Due to evaluation study design limitations in selecting the comparison group sites, the local and distant comparison sites could not be used as comparison sites for measuring the effectiveness of the treatments. Therefore, the Empirical Bayes method was used to carry out the safety evaluation of the two treatments on a group of forty-eight red light camera, stepped-up police enforcement and local comparison sites selected for the evaluation study.

The evaluation study sites selected by the consultant were matched such that a red light camera, stepped-up police enforcement and local comparison site would have similar characteristics in terms of:

- **Traffic control –** fixed time or actuated, duration of amber and red phase, cycle time;
- **Geometry –** number and type of lanes;
- **Operations –** volume, degree of saturation, presence of large vehicles;
- **Speed –** posted speed limit; and
- **Visibility –** type, number and placement of signal heads.

Each of the six municipalities provided information on the above for the purposes of the matching exercise. The focus of the matching was to ensure that the approaches with a treatment were similar to the comparison sites. As a result of the matching exercise, a total of forty-eight locations were selected for this evaluation study. These consisted of:

- Nineteen red light camera sites;
- Seventeen stepped-up police enforcement sites; and
- Twelve local comparison sites.

In summary, there were forty-eight sites included in this evaluation study, taken from a larger group of one hundred seven sites in the pilot project, as shown in **Exhibit 3.1**. Further information regarding the sites is shown in **Section 4.1**.

Exhibit 3.1 Number of evaluation study and pilot project sites

Site type	In evaluation study	In pilot project only[1]	Total
Red light camera	19	49	68
Stepped-up police enforcement	17	10	27
Local comparison	12	0	12
Total	48	59	107
Notes: 1 In pilot project but not in evaluation study.			

Exhibit 3.2 shows the location of the six municipalities that participated in the pilot project.

Exhibit 3.2 Location of participating municipalities

3.2 OBSERVATION PERIODS

Two distinct observation periods were decided upon: before and after, as shown in **Exhibit 3.3**. The before period was to be the period prior to the beginning of the pilot project, in order to allow baseline data to be collected for comparison with conditions during the actual pilot project itself. The same type of observation data was collected during the pilot project after period. The after period representing the first two years of the pilot project, would allow Working Group 1 to assess the effectiveness of the pilot project after it had been in progress for a reasonable period of time. As noted in Part I, the pilot project was extended beyond the second year, for five of the six participating municipalities. This report does not present any information beyond the second year of the pilot project.

Exhibit 3.3 Observation periods

Observation period	Dates
Before	January 1, 1995 – December 31, 1999
After (two years)	November 20, 2000 – November 19, 2002

3.3 EVALUATION STUDY CRITERIA

In evaluating the safety effectiveness of the two treatments, Working Group 1 chose to examine collision history.[6] A reduction in collisions, in particular the target collisions commonly affected by red light camera treatments, was viewed as being the *primary* expected outcome of the evaluation study, based on similar studies in other jurisdictions. A reduction in collisions (either as a whole or among a subgroup) is seen as an indicator of safety. In particular, the evaluation study team chose to examine collisions subgrouped by classification (fatal, injury, and property damage only) and collisions subgrouped by collision type (angle and rear-end). Further information on the collision data used in this evaluation study are presented in **Section 4**.

3.4 METHODOLOGY PROPOSED FOR EVALUATING EFFECTIVENESS OF TREATMENTS

The method used in this evaluation study is the Empirical Bayes (EB) method. This procedure is recognized as being an accurate, precise statistical tool for conducting safety evaluations of treatments when only valid collision data is available for the evaluation study locations during the before and after periods of treatment implementation. The EB method is superior to traditional methods (such as collision rates) because:

[6] The evaluation study team also collected data on red light running and posted speed limit violations. A reduction in red light running and posted speed limit violations was viewed as being a *secondary* expected outcome of the evaluation study. The two criteria were seen as indicators of aggressive driving behaviour. Red light running violations have often been used as a basis for evaluating red light camera initiatives. The measurement of posted speed limit violations was an additional behaviour from which it was hoped could provide some further insight into the behaviour of drivers as they approached traffic signals at the study sites in the evaluation. Further information on the data collected and the results of the analysis of the red light running and posted speed limit violation data are presented in **Appendix C**.

- It considers regression-to-the-mean;
- It produces more stable and precise estimates of safety; and
- It permits prediction of future expected collision frequencies.

A fuller description of the EB method is provided in **Appendix D**.

3.4.1 Safety performance functions (SPFs)

The EB method calculates expected collision frequencies through a combination of observed and estimated collision frequencies. The estimated collision frequencies are derived through the development of a Safety Performance Function (SPF) curve. The SPF relates the level of safety of an intersection to traffic volume and other relevant geometric factors. The function estimates the expected number of collisions based on traffic volume and other characteristics. The SPF is expressed as a frequency (collisions/year) for intersections.

A SPF is an equation that presents the mathematical relationship between collision frequency and volume based on a group of intersections with similar characteristics (i.e. signalized, same number of legs etc.). When collision frequency and volume are plotted, the equation can be developed that is represented by a line that is the best fit possible through the various points. Generally, SPF curves demonstrate that the expected number of collisions increases as traffic volume increases, and an SPF is curvilinear rather than a straight line. Because the line that plots an SPF is curved, the rate (rise/run) varies continuously along the curve.

As discussed earlier the EB Method requires various data inputs in order to compute the final treatment effectiveness estimators. One such input is what the expected number of target collision for a specific entity (i.e., intersection) in the 'after' period would have been had the entity not been treated. This is what has to be predicted. It involves the mixing of two pieces of information, collision records for a reference population that has similar traits and characteristics as the entities being treated, and collision records of the specific entities being treated. SPF curves are the means for estimating collisions for a reference population that has similar traits and characteristics of the entities being treated.

SPF curves are collision prediction equations for different types of facilities (road, vehicle, road-user characteristics) that are developed through the analyses of collision at a large collection of entities similar in traits and characteristics to that of the evaluation study (treatment) entities. They are created through Multivariate Regression Modeling Methods.

As part of this evaluation study, SPF curves were developed for 179 urban signalized intersections.

3.4.2 Data requirements for developing SPFs

For the purposes of this evaluation study, traffic volume counts and collision records were requested for a representative group of intersections located within the six municipalities involved in the evaluation study for up to five years prior to the beginning of the pilot project (1995-1999). These intersections are almost all urban and suburban four legged intersections.

The collision data used as input into the development of the SPF curves is based on the collision history at the following sites as summarized in **Exhibit 3.4**.

Exhibit 3.4 Sites used for SPF curve development

Description	Number
Sites also included in evaluation study	48
Sites located within evaluation study area	121
Sites located outside of evaluation area	10
Total number of sites used for SPF curve development	**179**

Every intersection in the group chosen for the SPF curve development had the following characteristics:

- A traffic signal operating at the intersection continuously during the five years prior to the beginning of the pilot project;
- Four legs; and
- No major road infrastructure or safety improvements that would affect the collision or volume counts during the before period.

Separate SPF curves were developed for:

- Fatal and injury collisions;
- Property damage only collisions;
- Fatal and injury angle collisions;
- Property damage only angle collisions;
- Fatal and injury rear-end collisions; and
- Property damage only rear-end collisions.

A collision prediction equation was developed for each of the above using yearly collision frequency and the annual average daily traffic volume (AADT) on both intersecting roads. AADT volumes were used representing the years 1995 to 1999. If the municipality did not have AADT volumes for a particular year at a particular intersection, the municipality provided information necessary for estimating the AADT for that year.

The collision prediction equations were developed using curve fitting formulas available in the GLIM software program. The curves were examined to ensure that they are a reasonable predictor of collision frequency and that the estimates were reasonably accurate.

4.0 EVALUATION STUDY SITES AND DATA

This section describes the forty-eight evaluation study sites and their intersection characteristics, together with the collision and volume data received from the municipalities.

4.1 EVALUATION STUDY SITES AND THEIR INTERSECTION CHARACTERISTICS

The following section presents information regarding the sites included in this evaluation study.

The forty-eight evaluation study sites are located in six different municipalities and represent three different site types (red light camera, stepped-up police enforcement, and local comparison) as shown in **Exhibit 4.1**.

Exhibit 4.1 Site type by municipality

	Stepped-up police enforcement	Red light camera	Local comparison site	Total
City of Hamilton	2	1	2	5
City of Ottawa	2	5	0	7
City of Toronto	4	7	6	17
Region of Halton	3	3	4	10
Region of Peel	5	2	0	7
Region of Waterloo	1	1	0	2
Total	**17**	**19**	**12**	**48**

All of the intersections in this evaluation study have four legs. As well, forty-four of the intersections have two-way traffic on all approaches. Another four intersections had either a one-way to two-way or one-way to one-way traffic control. The intersections were verified to ensure that the amber and all-red phase was consistent with traffic engineering standards in the province of Ontario.

Participating municipalities provided intersection characteristic data, which includes the following parameters:

Signal Timing

- Fixed time or traffic responsive;
- Duration of green time; and
- Cycle time.

Phasing (evaluation study approach)

- Single phase;
- Protected left; and
- Protected/permissive left.

Operations (evaluation study approach)

- Through volume count (vph), through saturation flow (veh/hr green) and the degree of saturation;
- Percent trucks;
- Number of through lanes on the conflicting approach;
- The 85th percentile speed on the approach as well as the posted speed limit; and
- Cycle time of upstream signal.

Intersection geometry (evaluation study approach)

- Number of exclusive left turn lanes;
- Number of shared left/through lanes;
- Number of through lanes;
- Number of shared right/through lanes; and
- Number of exclusive right turn lanes.

Signal visibility (evaluation study approach)

- Size of the primary and secondary lenses;
- Adequacy of sight distance; and
- Backboards.

Further information on intersection characteristics is shown in **Appendix E.**

4.2 COLLISION DATA

Collision data was requested from the six participating municipalities in this evaluation study, in addition to the Cities of London and Windsor. The collision attributes requested were:

- Municipality name;
- Intersection location;
- Direction of travel (Vehicle 1 and Vehicle 2);
- Date;
- Time;
- Classification of collision;
- Impact type;
- Driver action;
- Pedestrian action; and
- Vehicle type.

While for the most part, the municipalities were able to provide the collision data requested, the only fields actually used in this evaluation study were the intersection location (to determine the site type), date, classification of collision and impact type. The remaining attribute data have been set aside for further analysis, should there be any interest expressed by Working Group 1.

For consistency, only reportable collisions classified as either fatal, injury or property damage only were included in the analysis.

Collision data representing the before period (1995-1999) were assembled in the summer of 2001. A majority of the collision data collected at each intersection represents a complete five-year period. A total of 233 years of collision data was collected from among the forty-eight evaluation study sites.

A summary of the number of years of data collected from each site type is shown in **Exhibit 4.2.**

Exhibit 4.2 Before data collected

Site Type	Number of sites	Number of years of data
Red light camera	19	93
Stepped-up police enforcement	17	80
Local comparison	12	60
Total	**48**	**233**

For the after period, a complete two year's worth of collision data was collected from the municipalities, representing the time period November 20, 2000 – November 19, 2002. The following sections provide a description of the collision data collected from the municipalities. Additional tables are shown in **Appendix F.**

4.2.1 Reported collisions (all)

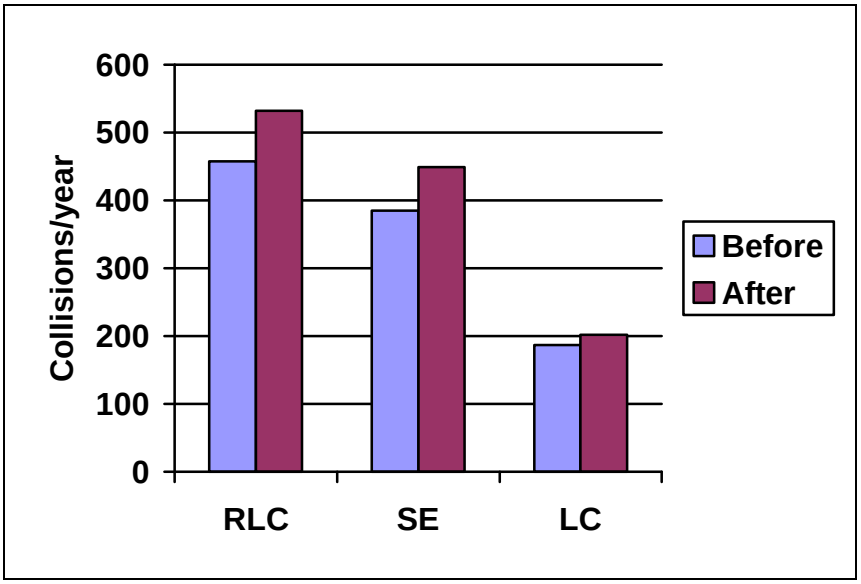
There were 4988 reported collisions at the forty-eight evaluation study sites in the before period. The average reported yearly number of collisions was 1027.6 collisions/year. In the after period, there was a total of 2366 reported collisions. The average reported yearly number of collisions was 1183.0 collisions/year. Compared to the average number of reported collisions occurring in the before period, the average yearly number of reported collisions increased 15.1 per cent in the after period. **Exhibits 4.3** and **4.4** summarize the trends in reported collisions in the before and after period of the evaluation study.

Exhibit 4.3 Before and after data: reported collisions (all)

Site type	Before		After		
	Total	Average[1]	Total	Average[1]	%Change[2]
Red light camera	2241	457.8	1064	532.0	16.2
Stepped-up police enforcement	1813	385.3	898	449.0	16.5
Local comparison	934	186.8	404	202.0	8.1
Total	**4988**	**1027.6**	**2366**	**1183.0**	**15.1**

Notes:
1 The average yearly reported collisions.
2 The percentage change in average yearly reported collisions in the after period compared to the before period.

Exhibit 4.4 Reported collisions (all): before and after yearly averages



4.2.2 Reported fatal and injury collisions

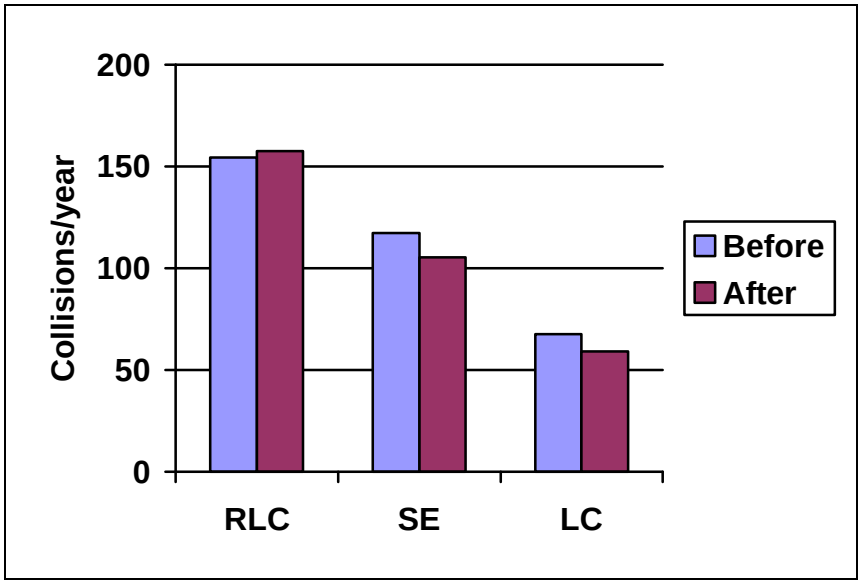
There were 1646 reported fatal and injury collisions at the forty-eight evaluation study sites in the before period. The average reported yearly number of fatal and injury collisions was 339.1 collisions/year. In the after period, there was a total of 644 reported fatal and injury collisions. The average reported yearly number of fatal and injury collisions was 322 collisions/year. Compared to the average number of reported fatal and injury collisions occurring in the before period, the average yearly number of reported fatal and injury collisions decreased 5.0 per cent in the after period. **Exhibits 4.5** and **4.6** summarize the trends in fatal and injury collisions in the before and after period of the evaluation study.

Exhibit 4.5 Before and after data: reported fatal and injury collisions

Site Type	Before		After		
	Total	Average[1]	Total	Average[1]	%Change[2]
Red light camera	756	154.5	315	157.5	2.0
Stepped-up police enforcement	552	117.3	211	105.5	-10.1
Local comparison	338	67.6	118	59.0	-12.7
Total	**1646**	**339.1**	**644**	**322.0**	**-5.0**

Notes:
1 The average yearly reported fatal and injury collisions.
2 The percentage change in average yearly reported fatal and injury collisions in the after period compared to the before period.

Exhibit 4.6 Reported fatal and injury collisions: before and after yearly averages



4.2.3 Reported property damage only collisions

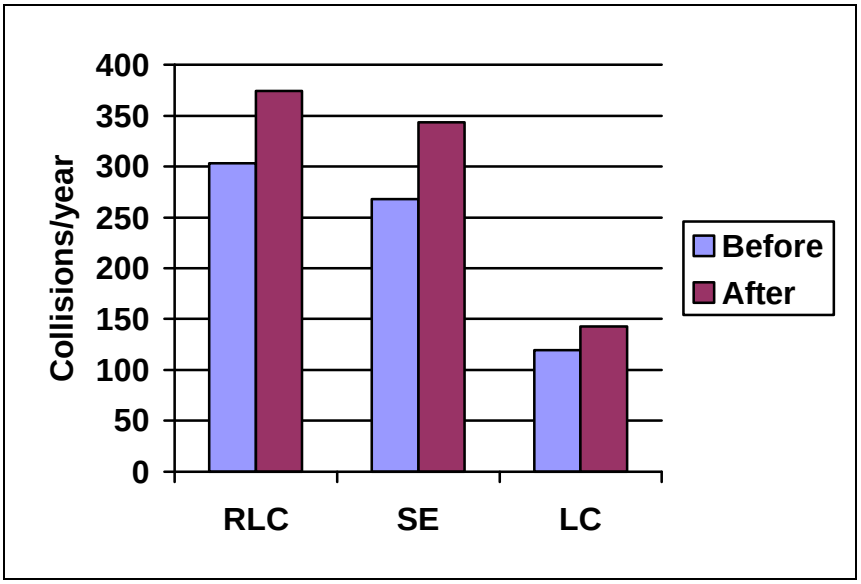
There were 3342 reported property damage only collisions at the forty-eight evaluation study sites in the before period. The average reported yearly number of property damage collisions was 688.5 collisions/year. In the after period, there was a total of 1722 reported property damage only collisions. The average reported yearly number of property damage collisions was 861.0 collisions/year. Compared to the average yearly reported number of property damage only collisions occurring in the before period, the average yearly reported number of property damage only collisions increased 25.1 per cent in the after period. **Exhibits 4.7** and **4.8** summarize the trends in property damage only collisions in the before and after period of the evaluation study.

Exhibit 4.7 Before and after data: reported property damage only collisions

Site type	Before		After		
	Total	Average[1]	Total	Average[1]	%Change[2]
Red light camera	1485	303.4	749	374.5	23.4
Stepped-up police enforcement	1261	268.0	687	343.5	28.2
Local comparison	596	119.2	286	143.0	20.0
Total	**3342**	**688.5**	**1722**	**861.0**	**25.1**

Notes:
1 The average yearly reported property damage only collisions.
2 The percentage change in average yearly reported property damage only collisions in the after period compared to the before period.

Exhibit 4.8 Reported property damage only collisions: before and after yearly averages



4.2.4 Reported angle collisions

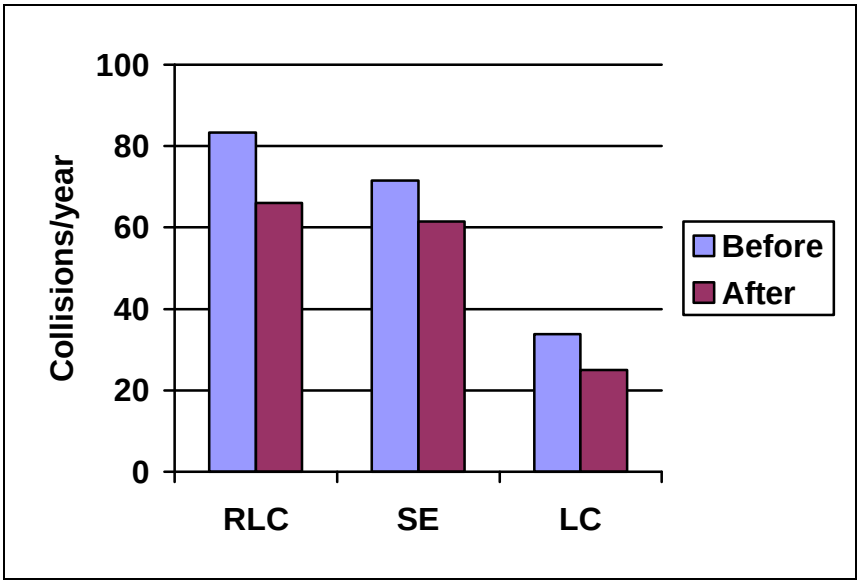
There were 914 reported angle collisions at the forty-eight evaluation study sites in the before period. The average reported yearly number of angle collisions was 188.3 collisions/year. In the after period, there was a total of 305 reported angle collisions. The average reported yearly number of angle collisions was 152.5 collisions/year. Compared to the average yearly reported number of angle collisions occurring in the before period, the average yearly reported number of angle collisions decreased 19.0 per cent in the after period. **Exhibits 4.9** and **4.10** summarize the trends in angle collisions in the before and after period of the evaluation study.

Exhibit 4.9 Before and after data: reported angle collisions

Site type	Before		After		
	Total	Average[1]	Total	Average[1]	%Change[2]
Red light camera	408	83.4	132	66.0	-20.8
Stepped-up police enforcement	337	71.6	123	61.5	-14.1
Local comparison	169	33.8	50	25.0	-26.0
Total	**914**	**188.3**	**305**	**152.5**	**-19.0**

Notes:
1 The average yearly reported angle collisions.
2 The percentage change in average yearly reported angle collisions in the after period compared to the before period.

Exhibit 4.10 Reported angle collisions: before and after yearly averages



4.2.5 Reported rear-end collisions

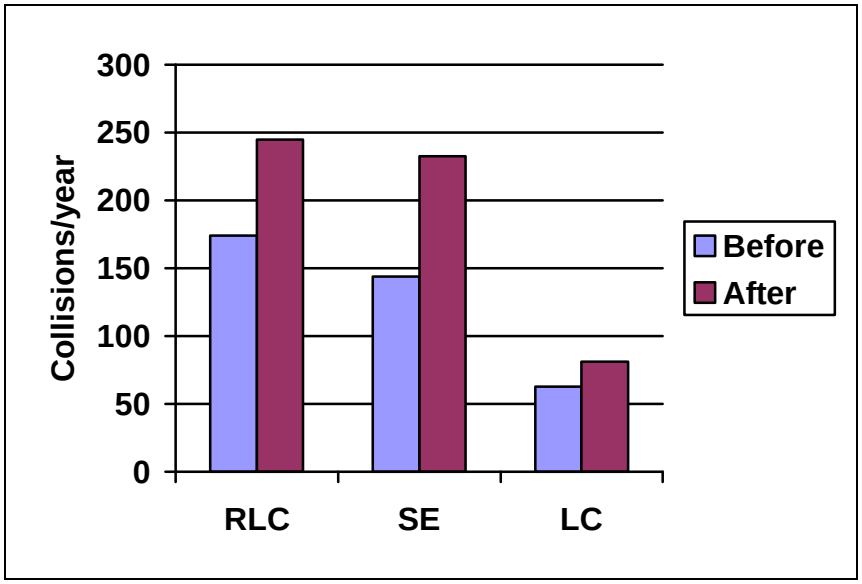
There were 1841 reported rear-end collisions at the 48 evaluation study sites in the before period. The average reported yearly number of rear-end collisions was 379.3 collisions/year. In the after period, there was a total of 1117 reported rear-end collisions. The average reported yearly number of rear-end collisions was 558.5 collisions/year. Compared to the average yearly reported number of rear-end collisions occurring in the before period, the average yearly reported number of rear-end collisions increased 47.3 percent in the after period. **Exhibits 4.11** and **4.12** summarize the trends in rear end collisions in the before and after period of the evaluation study.

Exhibit 4.11 Before and after data: reported rear-end collisions

Site type	Before		After		
	Total	Average[1]	Total	Average[1]	%Change[2]
Red light camera	852	174.1	490	245.0	40.8
Stepped-up police enforcement	676	143.7	465	232.5	61.9
Local comparison	313	62.6	162	81.0	29.4
Total	**1841**	**379.3**	**1117**	**558.5**	**47.3**

Notes:
1 The average yearly reported rear-end collisions.
2 The percentage change in average yearly reported rear-end collisions in the after period compared to the before period.

Exhibit 4.12 Reported rear-end collisions: before and after yearly averages



4.2.6 Collision data collected for use in SPF curves

The collision data requested represented not only the forty-eight evaluation study sites, but also an additional one hundred twenty one sites in the six municipalities. Ten sites were also chosen from the Cities of Windsor and London, outside the evaluation study areas. All of the sites selected are four-leg signalized intersections located in urban or suburban areas. Most of the sites have a two-way to two-way traffic flow. **Exhibit 4.13** summarizes the data collected from these additional sites.

Exhibit 4.13 Summary of additional collision data used for SPF curves

Attribute	Frequency
Number of sites[7]	131
Number of years observed	632
Reported collisions	11 980
Reported fatal and injury collisions	3 788
Reported property damage only collisions	8 192
Reported angle collisions	2 650
Reported angle fatal and injury collisions	991
Reported angle property damage only collisions	1 659
Reported rear-end collisions	3 960
Reported rear-end fatal and injury collisions	1 251
Reported rear-end property damage only collisions	2 709

[7] This includes both the 121 sites located within the evaluation study area and the 10 sites located outside of the evaluation study area as referenced in **Exhibit 3.4**.

4.3 VOLUME DATA

As with the collision data, volume data was requested from each municipality for 179 intersections for the five-year period 1995 to 1999 for use in developing the SPF curves.

The volume data was to be a vehicle count for each approach to the intersection with an accompanying weighting factor to be used for estimating the average annual daily traffic (AADT) volume on all four approaches of the intersections in the evaluation study. Some of the municipalities were able to provide AADT volume while others provided a peak traffic count for a given period of the day with an accompanying weighting factor to convert the count to an estimated AADT volume.

The formula for converting the peak hour count to an AADT volume was:

AADT = WF x PHC

where,

AADT is the average annual daily traffic volume
WF is the weighting factor provided by the municipalities
PHC is the peak hour count (in all cases, eight hours)

Where the municipality did not have a count or a means of estimating the count for a particular year, this was estimated using:

- either volume counts for other years at the same intersection, or
- volume counts for other adjacent intersections in the same municipality (in a few rare cases).

In the winter of 2002 and 2003, volumes for the first two years of the pilot project were requested and received from the participating municipalities. Where the municipality did not have AADT data, it was estimated using the process described above.

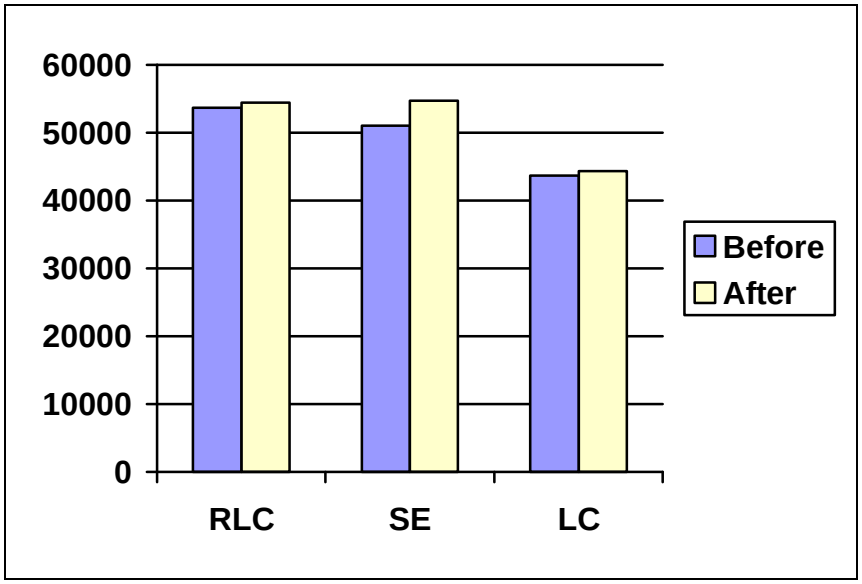
The volume data for the 48 evaluation study sites as collected from the municipalities or trended by the evaluation study team are shown in **Exhibits 4.14** and **4.15**. The red light camera and stepped-up police enforcement sites tend to be higher volume intersections. The sites experienced a slight increase (3.6 per cent) in estimated AADT from the before period to the after period.

Exhibit 4.14 Estimated average annual daily traffic data: before and after

Site type	Before	After	
	Average[1]	Average[1]	%Change[2]
Red light camera	53 744	54 448	1.3
Stepped-up police enforcement	51 094	54 706	7.1
Local comparison	43 655	44 392	1.7
All	**50 186**	**52 026**	**3.6**

Notes:
1 Estimated average annual daily traffic (on all four approaches)
2 The percentage change in estimated AADT in the after period compared to the before period

Exhibit 4.15 Before and after data: estimated AADT volumes



A detailed listing of the data and factors used to estimate the AADT volumes is presented in **Appendix G**.

5.0 EVALUATION OF THE TREATMENTS USING AFTER DATA

SPF curves were developed for fatal and injury, property damage only, fatal and injury angle, property damage only angle, fatal and injury rear-end and property damage only rear-end collisions. The data used to develop the SPF curves is the before data collected from 179 sites during the years 1995-1999. Based on these, it was estimated what the expected number of consequences (i.e. the different collision types) would have been in the first two years of the pilot project had the treatments not been implemented. This estimate is then compared to the actual collision frequency in the first two years of the pilot project with the treatments implemented.

The following comparisons involve both of the treated groups (red light camera and stepped-up police enforcement) together with the local comparison group. The local comparison group is essentially a 'treated' group, in that the twelve sites are in the same municipalities as all of the red light camera and stepped-up police enforcement sites. It is expected that the behaviour of drivers traveling through these intersections has been similarly modified, primarily due to the public education campaign and media coverage.

5.1 USING EB METHOD TO EVALUATE EFFECTIVENESS OF TREATMENTS ON SAFETY IN THE AFTER PERIOD

Using the EB method, estimates of the effectiveness of red light camera (RLC) and stepped-up police enforcement (SE) treatments on safety at the 48 evaluation study intersections was computed. The overall effectiveness of the two treatment measures was estimated for the after period (November 20, 2000 – November 19, 2002). This was done by computing effectiveness estimates using the EB method and comparing the estimated collision count to the observed collision count for treated sites along with the local comparison sites.

The hypothesis for the above comparisons would be:

H_0: Estimated collisions at treated sites (RLC, SE and LC intersections) ***equals***
Observed collisions at treated sites (RLC and SE and LC intersections)

H_1: Estimated collisions at treated sites (RLC and SE and LC intersections) ***does not equal*** Observed collisions at treated sites (RLC and SE and LC intersections)

Where collisions are defined as either:

- Fatal and injury collisions;
- Property damage only collisions;
- Fatal and injury angle collisions;
- Property damage only angle collisions;
- Fatal and injury rear-end collisions; and
- Property damage only rear-end collisions.

5.1.1 Interpretation of results

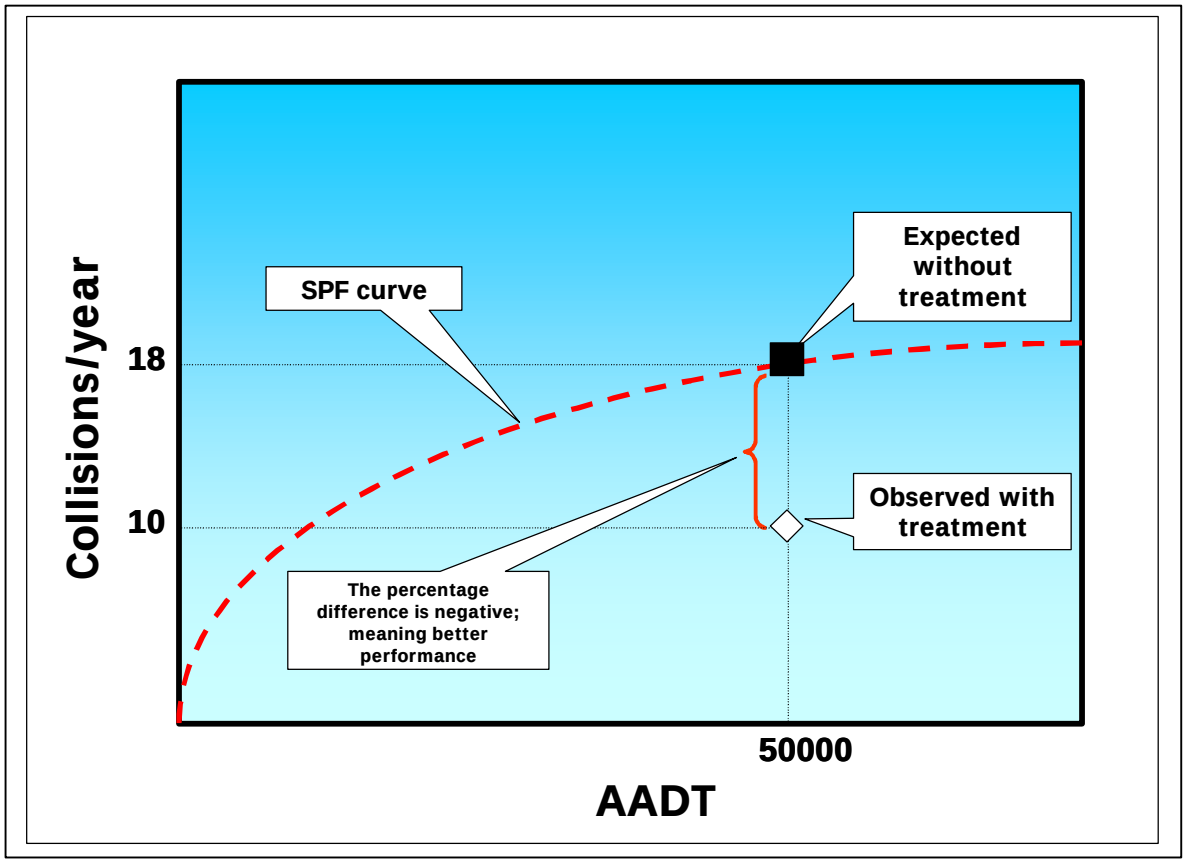
The following information is shown in the following exhibits:

- **Number of sites** – the number of sites included in the EB analysis;
- **Observed with treatment** - the actual number of collisions observed at the sites in the after period of the pilot project during which time the treatments were implemented;
- **Expected without treatment** - the number of collisions that would have been expected to occur if the treatments had not been implemented at each intersection during the after period of the pilot project; and
- **Percentage difference** - the percentage difference between the observed and expected number of collisions in the after period of the pilot project averaged over the sites.[8] A **negative** number indicates that the intersections on average performed **better** than expected, having less collision occurrence than what would have been expected had there been no treatments implemented. A **positive** number indicates the intersections on average performed **worse** than expected, having more collision occurrence than what would have been expected had there been no treatments implemented.

Exhibit 5.1 illustrates how to interpret the results. The dashed curve indicates a SPF curve developed for a group of intersections based on their yearly collision frequency and AADTs. For a given intersection having an AADT of 50,000, the expected yearly number of collisions is 18, based on the SPF curve, as shown by the black square. For the same signalized intersection, the observed yearly number of collisions is 10, as shown by the white diamond. As the difference between the observed and expected yearly number of collisions is **negative**, the signalized intersection is on average performing **better** than expected.

[8] If the observed number of collisions is greater than the expected number of collisions, the percentage difference will be positive and indicates that the intersections on average performed **worse** than expected. If the observed number of collisions is less than the expected number of collisions, the percentage difference will be negative and indicates that the intersections on average performed **better** than expected.

Exhibit 5.1 Interpretation of results



5.1.2 Fatal and injury collisions

Exhibit 5.2 shows the SPF curve developed for the prediction of fatal and injury collisions. The equation developed is:

$$y = a(AADT)^b$$

Where:

y = the expected yearly number of fatal and injury collisions
a = 6.57958E-06
AADT = average annual daily traffic (entering, all four approaches)
b = 1.277789

(Other equation parameters are shown in **Appendix H**.)

Exhibit 5.2 SPF estimate for fatal and injury collisions

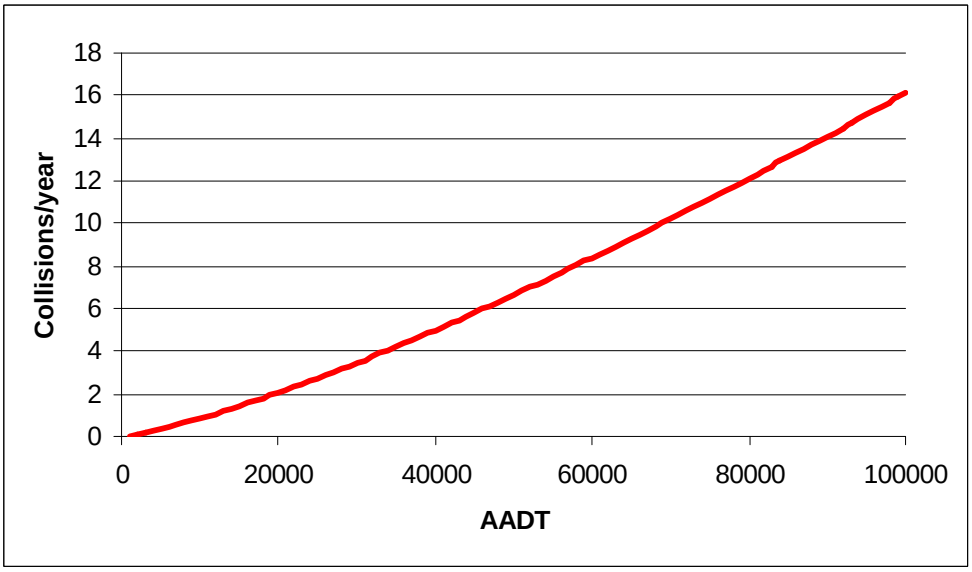


Exhibit 5.3 presents the results of the EB analysis of fatal and injury collisions, showing the number of observed and expected collisions, and the percentage difference, for the first two years of the pilot project. It indicates that the two treatments together with the local comparison sites have contributed to a **6.8 per cent decrease** in fatal and injury collisions.

Exhibit 5.3 Safety effectiveness – fatal and injury collisions

Treatment	Number of sites	Observed with treatment	Expected without treatment	Percentage difference[1]
Red light camera, stepped-up police enforcement and local comparison	48	644	690.87	**-6.8**

Notes:
1 A negative number indicates the sites performed **better** than expected.
A positive number indicates the sites performed **worse** than expected.

5.1.3 Property damage only collisions

Exhibit 5.4 shows the SPF curve developed for the prediction of property damage only collisions. The equation developed is:

$$y = a(AADT)^b$$

Where:

y = the expected yearly number of property damage only collisions
a = 5.03927E-06
AADT = average annual daily traffic (entering, all four approaches)
b = 1.371455
(Other equation parameters are shown in **Appendix H**.)

Exhibit 5.4 SPF estimate for property damage only collisions

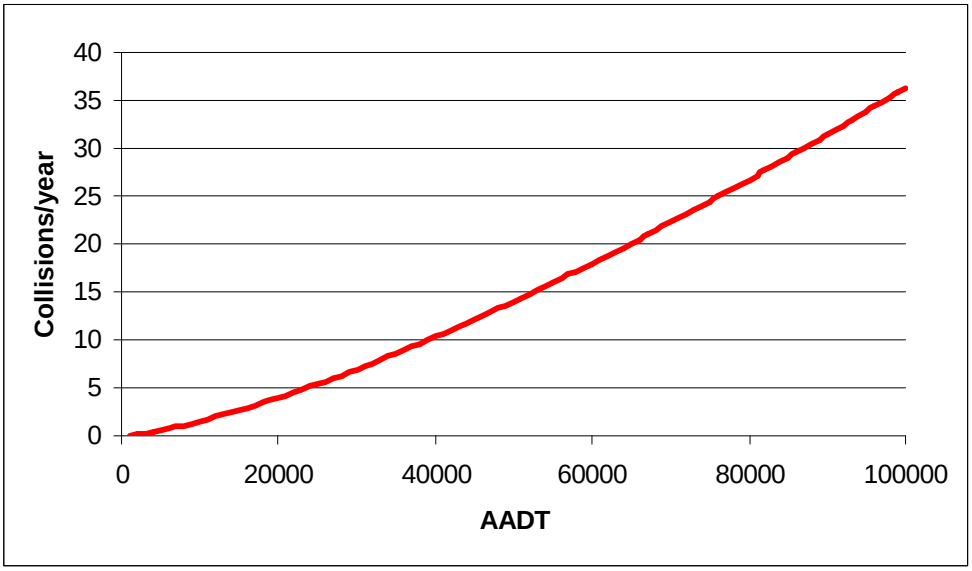


Exhibit 5.5 presents the results of the EB analysis of property damage only collisions, showing the number of observed and expected collisions, and the percentage difference, for the first two years of the pilot project. It indicates that the two treatments together with the local comparison sites have contributed to an **18.5 per cent increase** in property damage only collisions.

Exhibit 5.5 Safety effectiveness – property damage only collisions

Treatment	Number of sites	Observed with treatment	Expected without treatment	Percentage difference[1]
Red light camera, stepped-up police enforcement and local comparison	48	1722	1453.07	**+18.5**
Notes: **1** A negative number indicates the sites performed **better** than expected. A positive number indicates the sites performed **worse** than expected.				

5.1.4 Fatal and injury angle collisions

Exhibit 5.6 shows the SPF curve developed for the prediction of angle collisions resulting in a fatality or injury. The equation developed is:

$$y = a(AADT)^b$$

Where:

y = the expected yearly number of angle collisions resulting in a fatality or an injury
a = 0.0639546
AADT = average annual daily traffic (entering, all four approaches)
b = 0.2979189

(Other equation parameters are shown in **Appendix H**.)

Exhibit 5.6 SPF estimate for fatal and injury angle collisions

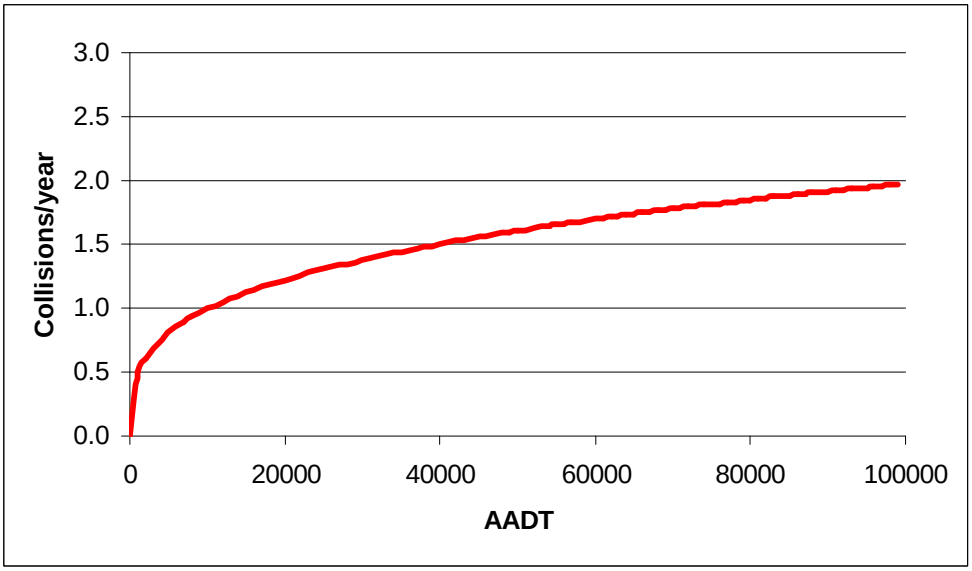


Exhibit 5.7 presents the results of the EB analysis of fatal and injury angle collisions, showing the number of observed and expected collisions, and the percentage difference, for the first two

years of the pilot project. It indicates that the two treatments together with the local comparison sites have contributed to a **25.3 per cent decrease** in fatal and injury angle collisions.

Exhibit 5.7 Safety effectiveness – fatal and injury angle collisions

Treatment	Number of sites	Observed with treatment	Expected without treatment	Percentage difference[1]
Red light camera, stepped-up police enforcement and local comparison	48	108	144.57	**-25.3**

Notes:
1 A negative number indicates the sites performed **better** than expected.
A positive number indicates the sites performed **worse** than expected.

5.1.5 Property damage only angle collisions

Exhibit 5.8 shows the SPF curve developed for the prediction of angle collisions resulting in property damage only. The equation developed is:

$$y = a(AADT)^b$$

Where:
y = the expected yearly number of angle collisions resulting in property damage only
a = 0.0427107
AADT = average annual daily traffic (entering, all four approaches)
b = 0.3831285
(Other equation parameters are shown in **Appendix H**.)

Exhibit 5.8 SPF estimate for property damage only angle collisions

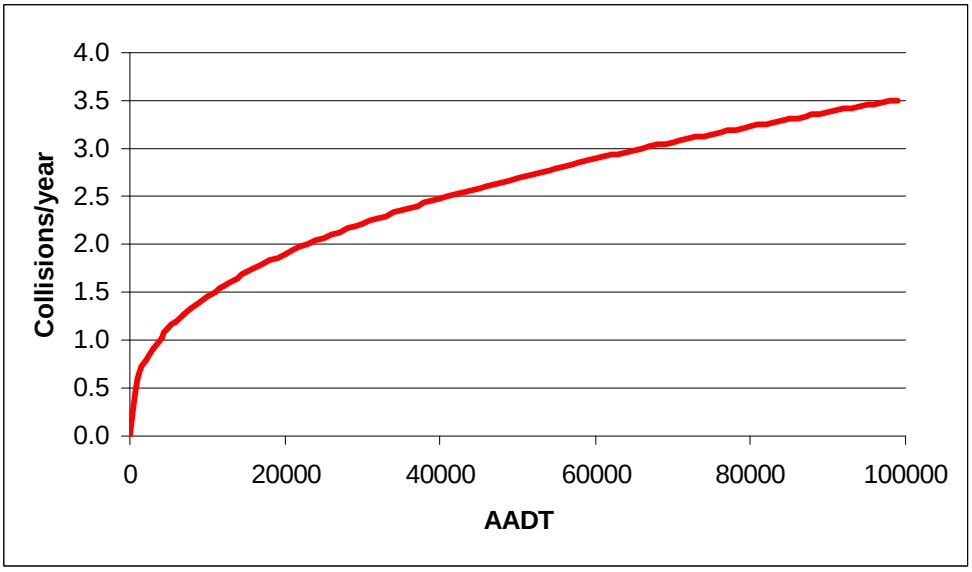


Exhibit 5.9 presents the results of the EB analysis of property damage only angle collisions, showing the number of observed and expected collisions, and the percentage difference, for the first two years of the pilot project. It indicates that the two treatments together with the local comparison sites have contributed to a **17.9 per cent decrease** in property damage only angle collisions.

Exhibit 5.9 Safety effectiveness – property damage only angle collisions

Treatment	Number of sites	Observed with treatment	Expected without treatment	Percentage difference[1]
Red light camera, stepped-up police enforcement and local comparison	48	197	239.91	**-17.9**

Notes:
1 A negative number indicates the sites performed **better** than expected.
A positive number indicates the sites performed **worse** than expected.

5.1.6 Fatal and injury rear-end collisions

Exhibit 5.10 shows the SPF curve developed for the prediction of rear-end collisions resulting in a fatality or an injury. The equation developed is:

$$y = a(AADT)^b$$

Where:

y = the expected yearly number of rear-end collisions resulting in a fatality or an injury
a = 6.301E-10
AADT = average annual daily traffic (entering, all four approaches)
b = 2.025379

(Other equation parameters are shown in **Appendix H**.)

Exhibit 5.10 SPF estimate for fatal and injury rear-end collisions

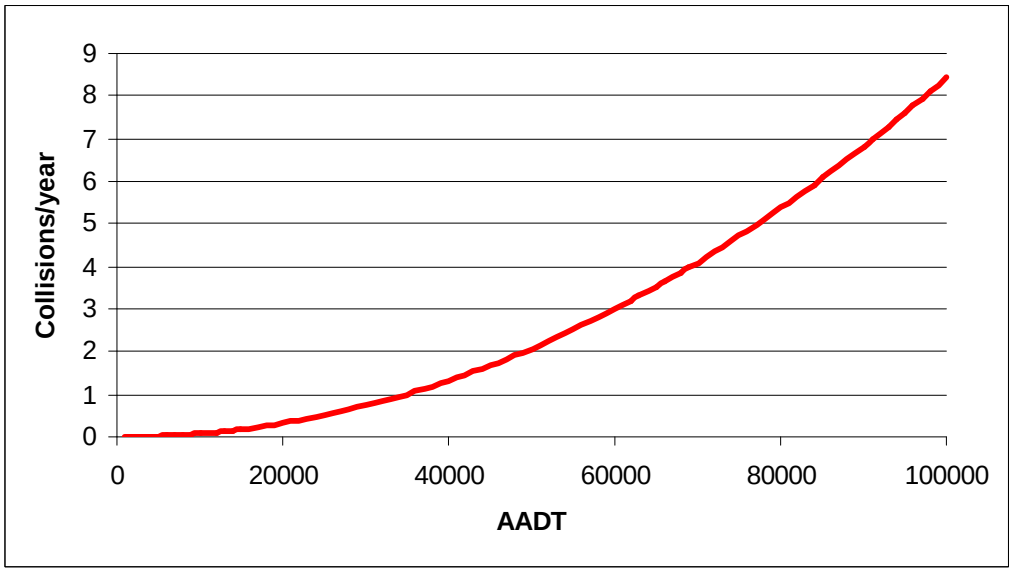


Exhibit 5.11 presents the results of the EB analysis of fatal and injury rear-end collisions, showing the number of observed and expected collisions, and the percentage difference, for the first two years of the pilot project. It indicates that the two treatments together with the local comparison sites have contributed to a **4.9 percent increase** in fatal and injury rear-end collisions.

Exhibit 5.11 Safety effectiveness – fatal and injury rear-end collisions

Treatment	Number of sites	Observed with treatment	Expected without treatment	Percentage difference[1]
Red light camera, stepped-up police enforcement and local comparison	48	246	234.58	**+4.9**

Notes:
1 A negative number indicates the sites performed **better** than expected.
A positive number indicates the sites performed **worse** than expected.

5.1.7 Property damage only rear-end collisions

Exhibit 5.12 shows the SPF curve developed for the prediction of rear-end collisions resulting in property damage only. The equation developed is:

$$y = a(AADT)^b$$

Where:

y = the expected yearly number of rear-end collisions resulting in property damage only
a = 5.643E-09
AADT = average annual daily traffic (entering, all four approaches)
b = 1.898111
(Other equation parameters are shown in **Appendix H**.)

Exhibit 5.12 SPF estimate for property damage only rear-end collisions

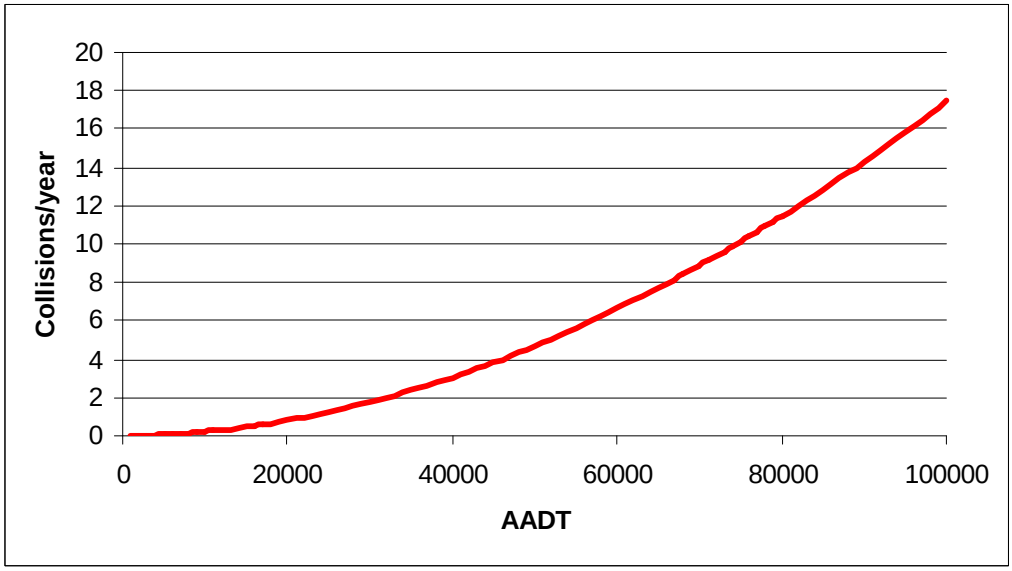


Exhibit 5.13 presents the results of the EB analysis of property damage only rear-end collisions, showing the number of observed and expected collisions, and the percentage difference, for the first two years of the pilot project. It indicates that the two treatments together with the local comparison sites have contributed to a **49.9 per cent increase** in property damage only rear-end collisions.

Exhibit 5.13 Safety effectiveness – property damage only rear-end collisions

Treatment	Number of sites	Observed with treatment	Expected without treatment	Percentage difference[1]
Red light camera, stepped-up police enforcement and local comparison	48	871	580.97	**+49.9**

Notes:
1 A negative number indicates the sites performed **better** than expected.
A positive number indicates the sites performed **worse** than expected.

6.0 INTERPRETATION OF RESULTS

6.1 SAFETY RESULTS

The Empirical Bayes results are shown in **Exhibit 6.1.** The collision profile at the signalized intersections in this evaluation study has changed considerably from that expected with a shift away from fatal and injury collisions towards more minor property damage only collisions. An examination of the percentages associated with the angle collisions provides further insight into why this is occurring. Angle collisions dropped dramatically at the signalized intersections in this evaluation study, particularly among those resulting in a fatality or injury. As angle collisions occur at a signalized intersection when one vehicle is violating a red signal, and these collisions generally involve high speeds, this trend is not surprising. The results indicate that driver behaviour has been modified at the evaluation study sites.

Exhibit 6.1 Safety effectiveness of treatments

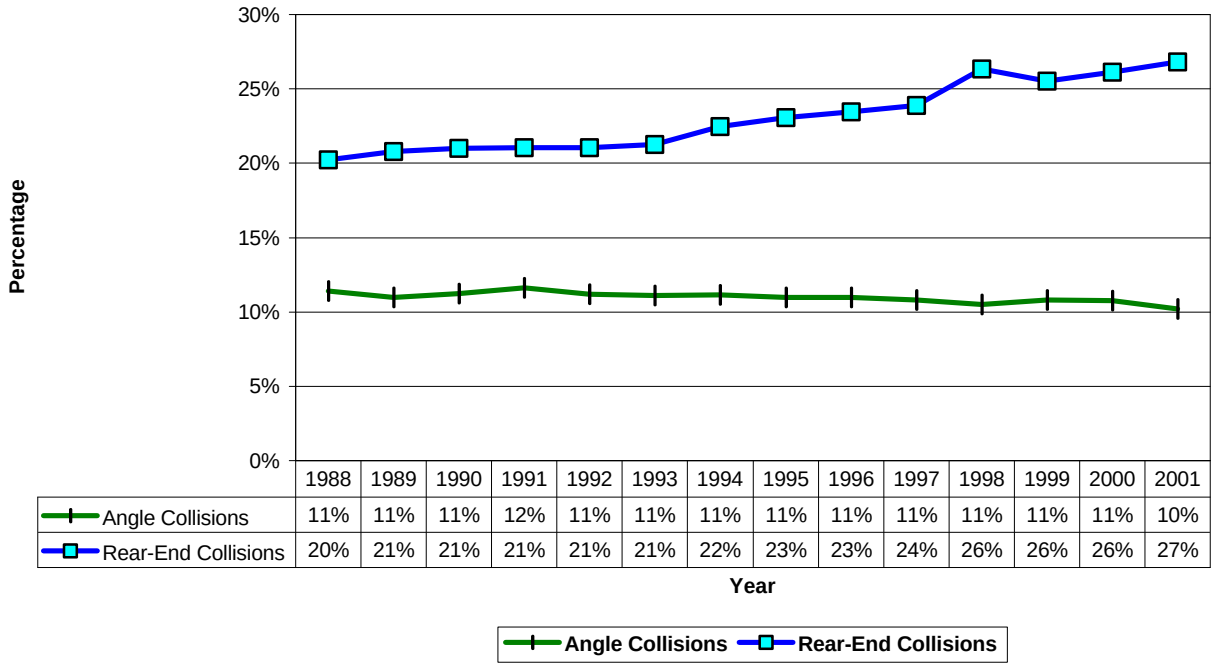
Red light camera, Stepped-up police enforcement and local comparison sites	**Percentage difference between expected and observed collisions (November 20, 2000 – November 19, 2002)**	
	Fatal and injury combined	**Property damage only**
All collision types	-6.8	+18.5
Angle collisions	-25.3	-17.9
Rear-end collisions	+4.9	+49.9

Notes:
1 A negative number indicates the sites performed **better** than expected.
A positive number indicates the sites performed **worse** than expected.

The observed large increase in minor property damage only collisions can be accounted for, in large part, by the 49.9 per cent increase in rear-end property damage only collisions. The increase in rear end collisions at the evaluation study sites may be the result of an increase in motorist compliance with traffic signals. This would be the result when motorists, who are following too closely or driving without due care and attention, collide with the vehicle in front.

General collision trends observed in Ontario provide an additional explanation. A review of initial impact types in Ontario collisions in Ontario Road Safety Annual Reports from 1988 to 2001 shows an increase in rear-end collisions, as shown in **Exhibit 6.2**. In 1988, 20 per cent of all collisions in Ontario were coded as rear-end collisions compared to 27 per cent in 2001. The observed results at the evaluation study sites may be accounted for, in part, by this general trend within the Province of Ontario.

Exhibit 6.2 Percentage of angle and rear-end collisions in Ontario (1988 – 2001)



	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Angle Collisions	11%	11%	11%	12%	11%	11%	11%	11%	11%	11%	11%	11%	11%	10%
Rear-End Collisions	20%	21%	21%	21%	21%	21%	22%	23%	23%	24%	26%	26%	26%	27%

6.2 COMPARISON WITH OTHER FINDINGS

A comparison of the collision results from this evaluation study with the collision results from other studies was undertaken. This comparison was not meant to be an exhaustive literature review, but rather a very quick scan of other findings. NCHRP Synthesis 310 *Impact of Red Light Camera Enforcement on Crash Experience* was the primary reference document used for reviewing these results. The purpose of the scan was to look for similarities and differences in results relating to:

- reported before-after changes in fatal and injury collisions;
- reported before-after changes in property damage only collisions;
- reported before-after changes in angle collisions; and
- reported before-after changes in rear-end collisions.

None of the studies mentioned in the following sections has been examined for their methodology and study design.

6.2.1 Fatal and injury collisions

A review of references to studies undertaken in North America and worldwide shows a consistent overall trend towards reductions in fatal and injury collisions. Reductions are reported at the red light camera sites themselves, as well as in the jurisdictions where the red light cameras were installed. Some of the key studies reporting fatal and injury or injury only results reviewed in NCHRP Synthesis 310 are:

- Retting and Kyrychenko (2002) – Oxnard study reporting a 29 per cent reduction in injury collisions at all signalized intersections within study area;
- Vincant and Tatro (1999) – Mesa, Arizona study reporting a 4 to 5 per cent reduction in injury and fatal collision rates within study area;
- Fleck and Smith (1999) – San Francisco study reporting a 9 per cent reduction in injury collisions city-wide;
- Fox (1995) – Glasgow, Scotland study reporting a 20 to 52 per cent reduction in injury collisions at signalized intersections within study area; and
- Hillier et al (1993) – Australia study reporting a 28 to 33 per cent reduction in injury collisions at red light camera sites.

NCHRP Synthesis 310 reports on the results of a questionnaire that was sent out to various jurisdictions using red light cameras. Some of the respondents had carried out their own evaluation, reporting the results of before-after analyses of collisions. The following jurisdictions reported on injury collisions:

- Baltimore County, Maryland – reporting a 51 per cent reduction in injury collisions;
- Sacramento, California – reporting a 27 per cent reduction in injury collisions;
- San Diego, California – reporting no significant change in injury collisions; and
- Fort Collins, Colorado – reporting no significant change in injury collisions.

Based on the above results, it would appear that the results of the Ontario evaluation study are somewhat modest compared to the results from other studies.

6.2.2 **Property damage only collisions**

Very little research exists that reports the effect of red light cameras on property damage only collisions. Most studies report changes in total collisions and injury collisions. One reference is made in NCHRP Synthesis 310 to a before-after comparison of property damage only collisions at 17 red light camera sites in Baltimore County, Maryland. It reports a 55 per cent reduction in property damage only collisions.

6.2.3 **Angle collisions**

A review of references to studies undertaken in North America and worldwide shows an overall trend towards reductions in angle collisions as well. Reductions are reported at the red light camera sites themselves, as well as in the communities where the red light cameras were installed. Some of the key studies reporting angle collision results reviewed in NCHRP Synthesis 310 are:

- Retting and Kyrychenko (2002) – Oxnard, California study reporting a 32 per cent reduction in all angle collisions and 68 per cent reduction in injury angle collisions; and
- Ng et al (1997) – Singapore study reporting a 17 per cent reduction in angle collision rates.

NCHRP Synthesis 310 reports on the results of a questionnaire that was sent out to various jurisdictions using red light cameras. Some of the respondents had carried out their own evaluation, reporting the results of before-after analyses of collisions at red light camera sites. The following jurisdictions reported on angle collisions:

- Howard County, Maryland – reporting a 42 to 47 per cent reduction in angle collisions;

- Sacramento, California – reporting a 26 per cent reduction in angle collisions; and
- Charlotte, North Carolina – reporting a 37 per cent reduction; 60 per cent reduction on the camera approaches.

Based on the results reported in other studies, the results of the Ontario study appear to be comparable.

6.2.4 **Rear-end collisions**

Based on the results of studies reported in the NCHRP Synthesis 310 report, rear-end collisions may increase at sites where red light cameras are installed. Some of the key studies reporting rear-end collision results reviewed in the report are:

- Retting and Kyrychenko (2002) – Oxnard study reporting a 3 per cent increase in rear-end collisions;
- PB Farradyne, Inc. (2002) – San Diego study reporting a 37 per cent increase in rear-end collisions;
- Ng et al (1997) – Singapore study reporting no change in rear-end collisions;
- Andreassen (1995) – Melbourne, Australia study reporting a twofold increase in rear-end collisions; and
- Hillier et al (1993) – Sydney, Australia study reporting an increase in rear-end collisions in the range of 27 – 62 per cent at sites with red light cameras.

Based on the questionnaire, a number of jurisdictions reported mixed results with regard to changes in rear-end collisions based on a before-after comparison;

- Garden Grove, California – reporting a 1 per cent increase in rear-end collisions;
- Sacramento, California – reporting a 12 per cent decrease in rear-end collisions;
- Charlotte, North Carolina – reporting a 4 per cent increase in rear-end collisions on camera approaches and a 16 per cent increase on all approaches; and
- Howard County, Maryland – reporting a 30 per cent decrease in rear-end collisions.

Based on the results of these studies, an increase in rear-end collisions has been observed in red light camera programs implemented in other jurisdictions. In general, rear-end collisions tend to be less severe than angle collisions.

PART III BENEFIT – COST ANALYSIS

7.0 BENEFIT – COST METHODOLOGY

The assessment of the overall benefits and costs is a crucial factor in determining the effectiveness of the two red light running treatments (red light camera and stepped-up police enforcement). A thorough and detailed analysis of the benefits and costs of the two red light running treatments and the establishment of a benefit/cost ratio for the combined effect of these treatments for a range of parameters is a main deliverable of this evaluation study.

In the benefit-cost analysis, benefits and costs of red light cameras and stepped-up police enforcement are identified and quantified in monetary terms where possible. The focus of the analysis is on social costs and benefits, i.e., the cost and benefits of the project to society as a whole.

The following presents a summary of the benefits and costs anticipated with the treatments.

Reduction in collisions

- Fewer fatalities/injuries;
- Reduced property damage collisions;
- Reduced burden on health care system; and
- Reduced burden on emergency services.

Indirect benefits

- Other offences observed by police officers during stepped-up police enforcement deployments;
- Improved traffic flow due to less collisions occurring;
- Reduced travel times due to less collisions occurring; and
- Driver education as a result of the publicity campaigns.

Costs of red light cameras

- Capital costs;
- Operating costs;
- Maintenance costs; and
- Administrative costs associated with the two treatments.

Recovered costs

- Fine revenue from prepaid fines; and
- Fines imposed.

Court processing costs

- Court time;
- Facility costs; and
- Processing time.

Costs of stepped-up police enforcement

- Direct cost of officers;
- Direct cost of equipment; and
- Indirect (overhead) costs for police administration.

7.1 BENEFITS OF THE TREATMENTS

A benefit is a beneficial outcome or impact for society of a certain activity or occurrence. Benefits may be direct or indirect. Direct benefits are those benefits that can be traced directly to the activity or occurrence, while indirect benefits cannot be traced directly, but are allocated to the activity or occurrence.

The most important direct benefit of the treatments includes the net reduction in fatal and injury collisions and the resultant savings that accrue to society as resources are not expended for healthcare, police and other emergency services in responding to preventable deaths and injuries. The framework established by the Ministry of Transportation, Ontario in its 1994 study, *The Societal Cost of Motor Vehicle Crashes*, is used to establish the cost to society in terms of human consequences such as fatalities and injuries, property damage, time and material expended as a result of a collision. The benefit of a reduction in collisions is the avoidance of these costs. If a collision were not to have occurred, the resources consumed by a collision could be used elsewhere for the benefit of society.

Although revenues generated by fines do not represent a social benefit (they are a social transfer or reallocation from one part of society to another), an accounting of fine revenue generated is also included in the analysis as a recovered cost of carrying out the two treatments.

7.2 COSTS OF THE TREATMENTS

As with any service that is either wholly or partially delivered by people, the primary costs are incurred in paying people to devote time to the performance of a task. Examples would be having police officers attend an enforcement blitz, court staff processing charges, or Provincial Offence Officers viewing a photograph to determine if an offence has occurred. Other costs are associated with items such as the cameras and police equipment.

Costs for the treatments in this evaluation study include:

- Ongoing provincial costs related to the operation of red light cameras and stepped-up police enforcement;
- Municipal costs related to the publicity campaign launched at the beginning of the pilot project and the cost of photographs required for evidence in court;
- Capital costs (red light camera system and Municipal Joint Processing Centre);
- Operating costs (red light camera system and Municipal Joint Processing Centre);
- Recovered and potential recovered costs (fine revenue and fines imposed);
- Court processing costs; and
- Stepped-up police enforcement costs.

Overhead costs would be included in the above costs. We are assuming that these measures are in a sense ongoing, forming part of normal enforcement activities, and therefore must bear an overhead allocation similar to other enforcement activities.

7.3 INFORMATION SOURCES

The data required in the analysis came from the following sources:

Participating municipalities – The municipalities provided data on the initial capital cost of the cameras, and costs related to their installation, maintenance, and operation including processing films. They provided cost data on the site preparatory work done to accommodate the red light cameras. They provided data on the costs associated with their involvement in this evaluation study and any publicity/awareness campaigns. Finally, they also provided collision information used in determining the combined benefit of a reduction in collisions at the intersections;

Municipal Joint Processing Centre – The Centre provided data on the costs associated with reviewing the camera films to determine if an offence has been committed and costs associated with preparing a ticket. This includes all salary and benefit costs for staff, facility costs, material costs, start-up costs for equipment, and any general municipal overhead charges that might apply. The Centre also provided data on the total number of photographs processed, the total number of charges that result, and a listing of ticket numbers for tracking of disposition of the charges;

Ministry of the Attorney General (MAG) – MAG provided data on the disposition of red light running charges, including the proportion of charges that were pre-paid and the cost of court processing;

Participating Police Services – Police services participating in stepped-up police enforcement deployments provided data on direct labour costs such as salaries and benefits of officers, and overhead costs, cost of police equipment, listings of ticket numbers for Part I offences;

Ministry of Transportation, Ontario (MTO) – MTO provided cost information on the social cost of collisions in Ontario. MTO also provided cost data on its involvement in this evaluation study; and

Other sources – Possible other sources of information investigated but ultimately not used were various other industry and published sources which could have potentially provided data on the costs and benefits such as the benefits of broader police enforcement and the impact of reduced collisions on insurance costs.

7.4 METHODOLOGY

All benefits and costs calculated are based on the operation of the two treatments during the first two years of the pilot project (November 20, 2000 – November 19, 2002). This was done to match the results of the Empirical Bayes analysis presented in Part II of this report.

As far as possible, police and court costs were calculated in terms of an hourly basis. The time expended in police enforcement and court processing multiplied by the appropriate rate or charge results in the total cost for these activities. Information on the number of tickets issued was requested from the Municipal Joint Processing Centre and the various police representatives. The

disposition of charges gave an indication of the fines levied, however, not the fines actually paid. Historical data on the percentage of fines levied and paid was used to estimate the actual dollar value of fines collected.

Red light camera supply, installation, maintenance and operating costs were used and tabulated to arrive at a total cost for the supply and operation of the cameras.

A comparison of pre and post-treatment collision data for the red light camera and stepped-up enforcement sites yielded an indication of the collision reduction as a result of the introduction of the treatments. An analysis of the collision reduction and social cost of collisions yielded the savings realized by society as a result of the treatments being in place.

In terms of the actual procedures and methods used to calculate benefits and costs of the treatments**,** further information on the calculation methodology is provided in the following sections.

The benefit-cost analysis limits the calculations to the evaluation study sites. It does not consider the effect on the remainder of the community. Benefits and costs are estimated for the forty-eight sites included in this evaluation study. Benefits and costs incurred at other red light camera and stepped-up enforcement sites are *not* included in this calculation.[9]

For consistency in the presentation of the various calculations, all figures shown are rounded to the nearest dollar.

7.4.1 Accounting for the effect of the OPSEU strike

The Ontario Provincial Employees Union (OPSEU) strike would have had an impact on the calculation of costs since only a limited number of tickets were issued and limited fine revenue (from prepayments and fines imposed) was generated during the strike period. To adjust for this impact, in this evaluation study the costs have been calculated as if the strike had not occurred. Fine revenue (from prepayments and fines imposed) is calculated as if tickets were issued during the strike and the vehicle owner paid the fine in the same proportion as in the period when the strike was not occurring. Fine revenue will be presented as a negative cost as shown in **Section 9.5.**

[9] A second scenario was also undertaken and is detailed in **Appendix I**. This scenario is the hypothetical extension of the evaluation study results to all signalized intersections within the six municipalities and is for illustrative purposes only.

8.0 BENEFIT CALCULATIONS

The benefit calculations involved a calculation of the social cost of collisions (either avoided or incurred). All calculations are based on the first two years of the pilot project, for the forty-eight study sites in the evaluation only.

8.1 CALCULATION OF SOCIAL COST OF COLLISIONS

The social cost of a fatal, injury and property damage only collision is calculated based on Exhibit 2.4 of the 1994 Ministry of Transportation, Ontario document, "*Social Costs of Motor Vehicle Crashes*", using the willingness to pay figures.[10] As the figures presented in this report represent social costs as of 1990, the Consumer Price Index (CPI) was applied to those costs to reflect costs in 2002. The CPI applied was 1.31, based on Statistics Canada data. **Exhibit 8.1** shows the application of the CPI to the 1990 social cost figures.

Exhibit 8.1 Application of CPI to 1990 social cost figures

Collision classification	1990 costs	2002 costs
Property Damage Only	$6,136	$8,038
Injury	$27,112	$35,517
Fatal	$6,311,722	$8,268,421

The calculation of the social cost of collisions is estimated based on the willing-to-pay figures provided by MTO multiplied by the difference between the observed and estimated number of fatal and injury and property damage only collisions presented in the Empirical Bayes analysis in Part II.

The difference between observed and expected fatal and injury and property damage only collisions is shown in **Exhibit 8.2**. Since the number of expected fatal and injury collisions is more than the number of observed fatal and injury collisions, the difference (-46.87) is the number of fatal and injury collisions avoided as a result of the treatment. Since the number of expected property damage only collisions is less than the number of observed property damage only collisions, the difference (268.93) is the number of property damage only collisions incurred as a result of the treatment.

[10] The willingness to pay approach is based on actual human behaviour. For example, it measures the amount of money a person is willing to pay to reduce the risk of death by acquiring optional safety features when purchasing a motor vehicle. This amount is aggregated for the entire population to obtain an estimate of the amount that people would be willing to pay to avoid death and injury.

Exhibit 8.2 Observed and expected number of collisions based on EB analysis

Collision type	Number of sites	Observed with treatment	Expected without treatment	Difference	Percentage difference
Fatal and injury	48	644	690.87	-46.87	-6.8
Property damage only	48	1722	1453.07	268.93	18.5

8.1.1 Calculation of fatal and injury collisions

Fatal and injury before collision data for the study sites in this evaluation (the red light camera, stepped-up enforcement and local comparison sites) was used to calculate the weighting to be applied to the estimated reduction in fatal and injury collisions, as shown in the following calculation.

A total of 1646 fatal and injury collisions occurred among the evaluation study sites in the before period (1995 – 1999) sub-grouped as follows:

- Fatal collisions (9 of 1646, or 0.547%); and
- Injury collisions (1637 of 1646, or 99.453%).

The weighted fatal and injury social cost is:

$8,268,421	(Fatal social cost of collision)	x	0.547%	(Fatal proportion)	+
$35,517	(Injury social cost of collision)	x	99.453%	(Injury proportion)	=
$80,551					

Based on the EB results presented in **Exhibit 8.2**, 46.87 fatal and injury collisions were avoided in the first two years of the pilot project as a result of the treatments.

The benefit from the cost of the fatal and injury collisions avoided is:

46.87	Fatal and injury collisions avoided	x
$80,551	Weighted fatal and injury social cost	=
$3,775,425		

8.1.2 Calculation of property damage only collisions

Based on the EB results presented in **Exhibit 8.2**, 268.93 property damage only collisions were incurred in the first two years of the pilot project as a result of the treatments.

The cost of the property damage only collisions incurred is:

268.93	Property damage only collisions incurred	x
$8,038	Property damage only cost	=
$2,161,659		

8.2 OTHER BENEFITS

Other possible benefits that may be included in the benefit-cost evaluation are a result of the stepped-up police enforcement deployments carried out in Years 1 and 2 of the program. Examples of benefits relating to the stepped-up police enforcement deployments are:

- Other charges laid as shown in **Exhibit 8.3**;
- Lower traffic speeds during deployments;
- Driver 're-education' (not running a red light, wearing a seatbelt, ensuring vehicle is safe to drive etc.) as a result of charges and cautions given to motorists;
- Apprehension of drivers with suspended licences; and
- Apprehension of criminals as a result of motorists being pulled over for questioning.

Exhibit 8.3 Stepped-up police enforcement – other charges laid during deployments at stepped-up police enforcement evaluation study sites (Years 1 and 2)

Charge	Year 1 and 2
Disobey traffic signal – other	47
Illegal turns	48
Not using seatbelt	128
Faulty equipment	56
No insurance	91
Impaired driving	1
Suspended licence	22
No plates/obstructed Plates	83
Other *Highway Traffic Act*/provincial offences	353
Other Federal offences	0
Roadside screenings	4
12-Hour suspension	2
Vehicle impoundment	2
Other Criminal Code	1
Total	**828**

According to **Exhibit 8.3**, a total of 828 additional charges to red light running were given out to motorists during the stepped-up police enforcement deployments. The most prevalent charge specified on the form is failing to wear a seatbelt.

Criminal Code charges occurring as a result of the deployments were one charge of impaired driving and one unspecified Criminal Code charge. Twenty-two motorists had their licence suspended as a result of the deployment and one vehicle was impounded.

While it is possible to quantify direct benefits of the treatments, it is difficult to quantify the secondary or indirect benefits, as identified in this section. The quantification of these benefits is beyond the scope of this evaluation study.

8.3 NET BENEFITS

Exhibit 8.4 summarizes the net benefit of the two treatments based on the forty-eight sites in the evaluation study. The net estimated benefit is approximately **$1.6 million**.

Exhibit 8.4 Summary of estimated net benefits

Item	Benefit
Fatal and Injury Collisions – Benefits	$3,775,425
Property Damage Only Collisions	($2,161,659)
Estimated Net Benefits	**$1,613,766**

9.0 COST CALCULATIONS

The following sections provide a detailed explanation of the cost calculations:

- Provincial one-time costs[11] and ongoing provincial costs related to the operation of red light cameras and stepped-up police enforcement;
- Municipal costs related to the publicity campaign launched at the beginning of the pilot project and the cost of photographs required for evidence in court;
- Capital costs (red light camera system and Municipal Joint Processing Centre);
- Operating costs (red light camera system and Municipal Joint Processing Centre);
- Recovered and potential recovered costs (fine revenue and fines imposed);
- Court processing costs; and
- Stepped-up police enforcement costs.

9.1 PROVINCIAL COSTS

The *Red Light Cameras Pilot Projects Act, 1998* was enacted in December 1998 to permit designated municipalities to operate red light cameras for a two-year period. In early 1999, provincial staff consulted with key municipal, police and road safety stakeholders across the province to determine interest in pilot project participation as well as to identify and address policy and operational issues related to the initiative. Six municipalities agreed to participate in the pilot project and the Intersection Safety Program to Reduce Red Light Running Steering Committee was established.

The provincial costs can be divided into two groups:

- One-time costs (never to be repeated); and
- Ongoing costs (operational) representing the first two years of the pilot project.

9.1.1 One-time costs

Prior to Day 1 of operation of red light cameras, during the preparation phase, the province incurred costs through a number of activities such as:

- Program design and business case;
- Consultation with stakeholders including the Information and Privacy Commissioner;
- Design and development of the Plate Registrant Data Requisition System to provide ownership information;
- Development of the regulations to support the legislation;
- Development of the prosecutorial processes and manuals;
- Training of the Provincial Offences Officers; and
- Procurement of an external consultant to design and manage the pilot evaluation process.

These one-time costs totaled **$1,591,022**, and are not included in the cost calculations[10]. These costs were removed from the calculation to allow for the analysis of the benefits and costs of red light cameras and stepped-up police enforcement once operational (**Section 9.1.2**).

[11] Provincial one-time costs are discussed in this section but are not included in the cost calculations.

9.1.2 On-going costs

Once all the development costs were completed, the following activities represent the day-to-day operations of:

- Plate Registrant Data Requisition system;
- Legal costs related to training of Provincial Offences Officers;
- Court statistical reporting of various dispositions;
- Monitoring and investigation of red light camera issues (e.g. correspondence, briefing material); and
- Financial reporting of provincial expenditures and subsequent invoicing to participating municipalities.

The above costs amounted to **$430,302** in the first two years of the pilot project and are included in the cost calculations.

9.2 MUNICIPAL COSTS

Municipal costs related to publicity campaigns undertaken prior to and during the pilot project amounted to **$190,358** for the first two years of the pilot project.[12]

An additional cost borne by the municipalities is the cost of photographs required for evidence in court. The municipalities are billed directly by the Red Light Camera vendor for this amount. This represents a total of **$15,353** for the sites in this evaluation study alone.

9.3 CAPITAL COSTS

Capital costs include the cost of purchasing the red light cameras, the enclosures, the installation of the equipment and the preparation of the sites, and all start-up costs associated with the Municipal Joint Processing Centre. Capital costs have been prorated to reflect the contribution of the nineteen red light camera sites in this evaluation study.

9.3.1 Red light camera system capital costs

The capital cost of the red light cameras was obtained from the municipalities. The total capital cost for the red light cameras is calculated by adding the costs associated with procuring and installing the cameras (the cost of the camera, the enclosure and their installation) and site preparatory work on a per site basis. The total capital cost per camera site is calculated to be **$77,583**. This figure is annualised over a five-year period ($15,517), which is the expected useful life of the equipment.

To determine the cost attributable to the nineteen red light camera sites in this evaluation study, the five-year annualized cost per site ($15,517) is multiplied by the number of years in the evaluation study and the number of red light camera evaluation study sites as follows:

[12] Publicity costs were prorated to reflect the proportion of evaluation study sites within the pilot project.

$15,517	Five year annualized unit cost per red light camera site	x
2	Two years in evaluation study	x
19	Number of red light camera sites in this evaluation study	=
$589,646		

9.3.2 Municipal Joint Processing Centre capital costs

The Municipal Joint Processing Centre is responsible for the processing of all red light camera photographs taken by the red light cameras. The City of Toronto operates the Municipal Joint Processing Centre, and in exchange for its services, the five other municipalities agreed to pay the City for the processing of photographs taken at the sites based on a cost sharing formula reflective of the operating costs of the Municipal Joint Processing Centre.

The Municipal Joint Processing Centre costs can be calculated from the Centre's financial records, which indicate actual direct labour, materials, and any overhead costs incurred in operating the centre. Capital equipment costs associated with the start-up of the Municipal Joint Processing Centre include the purchase of image processing hardware/software stations, offence notice printers, data card readers and a file server. Based on figures provided by the Municipal Joint Processing Centre, these capital equipment costs are estimated to be **$195,801.** Annualized over five years, the cost amounts to $39,160.

The capital equipment costs are allocated to the evaluation study intersections by prorating these costs on the basis of time that cameras are actually at the evaluation study sites. To determine the capital equipment costs attributed to the evaluation study sites alone, the 5-year annualized cost is multiplied by the ratio of evaluation study site photo sets to all photo sets (0.330) to arrive at $**25,846.**[13]

$39,160	Five year annualized capital equipment costs	x
2	Two years in evaluation study	x
0.330	Ratio of evaluation study site photo sets to all photo sets	=
$25,846		

9.4 OPERATING COSTS

Operating costs include:

- the cost of the operation of the red light camera system; and
- the cost of the operation of the Municipal Joint Processing Centre.

9.4.1 Red Light Camera System operating costs

The operating cost for the red light camera system was provided by the municipalities. Operating costs involve the operation of the red light cameras, including maintenance, loading/unloading film and developing film. The total two-year unit site cost of operating a red

[13] The municipalities provided the evaluation study team with the number of evaluation study site photo sets as well as the number of photo sets from all red light camera sites for the first two years of the pilot project. Using these two numbers, the ratio of evaluation study site photo sets to all photo sets could be calculated.

light camera is **$30,301**. To reflect the total number of red light camera evaluation study sites, this figure is multiplied by nineteen. Based on this, the total operating cost of the red light cameras attributable to the nineteen red light camera evaluation study sites is **$575,719.**

9.4.2 Municipal Joint Processing Centre operating costs

Operating costs associated with the Municipal Joint Processing Centre includes the salaries of a supervisor, clerks and provincial offence officers, supplies (i.e. toner, paper, stationary), postage, office space and photocopies. The cost of operating the Municipal Joint Processing Centre during the first two years of the pilot project was $946,633 based on figures provided by the Municipal Joint Processing Centre.

To calculate the operating cost borne by the evaluation study sites alone, the total operating cost is prorated based on the ratio of red light camera evaluation study site photo sets to all red light camera site photo sets (0.330). Based on this, the operating cost in the first two years of the pilot project is calculated to be $**312,389**.

9.5 CALCULATION OF FINE REVENUE AND FINE DISPOSITIONS IMPOSED

In carrying out a benefit cost study of red light running treatments, one is considering all social costs and benefits attributed to society (the province of Ontario – encompassing all the people, systems, and infrastructure). Using this perspective, fine revenue is a payment from one part of society, i.e. the individual running the red light, to another part of society, the crown (this encompasses both the provincial and municipal governments) which is the symbolic representation of the province. Ontario society does not therefore experience a net benefit from this payment because there is no net cost savings or increase in wealth, but rather it is a redistribution of wealth within the 'society' from individuals to the state. In other words, it is a social transfer of wealth.

From the perspective of the six municipalities, fine revenue is a cost recovery since they would use any fines received to offset the cost of the red light camera equipment. For the purposes of this evaluation study, fine revenue is assessed and included in the benefit – cost calculations as a recovered cost.

Although the term 'fine revenue' is commonly used, it should be noted that the amounts indicated in this section, reflect both monies actually received as a result of the payment of the fine[14] without 'going to court' as well as fine dispositions or sentences imposed by the courts should the person be found guilty.[15] The actual monies may not be received until years after the disposition

[14] When a person is sentenced by a judicial officer in court, the sentence is usually a fine, which may be less or the same as the set fine. In addition to the fine, there are various court costs that may be applicable as well as the amount of the victim fine surcharge which is based on the exact amount of the fine imposed in court. As a result, a person who attends at trial, for example, may have a total fine amount imposed that is in excess of the original $190 total payable indicated on the ticket. These variable total amounts impact the average court fine disposition amount.

[15] The relationship between fines imposed and fines actually received or paid as a result of a court disposition is fluid in terms of both times and quantum. For example, a person who is convicted and fined after being found guilty at trial is usually given one to three months to pay the fine, court costs and the applicable victim fine surcharge. The person might pay all or some of the total amount on time, after the

and, at any time, may not be paid in full. The exception is when persons receiving a ticket decide to pay the out-of-court payment amount or total payable without invoking the court process. Such payments are referred to as 'prepaids'.

From any fine payment, municipalities must remit to the province the applicable victim fine surcharge and any adjudication costs, for example. These remittances obviously impact the net amount of any actual or potential fine revenue. Pursuant to the POA transfer agreement, fines imposed as a result of the municipality or of a related board or agency being convicted must be remitted to the province. Finally, it should be noted that the revenue received as a result of dispositions is not credited to the corresponding municipal office or department responsible for the red light pilot project participation. Other costs, such as court processing costs, are discussed in **Section 9.6**.

Prepaid fines and fine dispositions result from charges laid for failing to stop at a red light where the offence was detected through the use of a red light camera system and from the stepped-up police enforcement deployment.[16] The out-of-court payment amount for both is $190. The net amount is a $155 set fine (which includes $5 court costs) plus an applicable victim fine surcharge. The victim fine surcharge is a surcharge established by the province to compensate victims of crimes and is not returned to municipalities, so this amount is not available for cost recovery. Consequently, all fine amounts mentioned in this section are net of the victim fine surcharge.

Only tickets issued for charges laid at the nineteen red light camera intersections and seventeen stepped-up police enforcement intersections in this evaluation study are included in the fine revenue calculation.

Fine revenue would have been received and fines imposed in court as a result of charges laid by the police during the stepped-up police enforcement deployments taking place during the first two years of the pilot project. The evaluation study team requested the police services to complete a form summarizing stepped-up police enforcement police efforts at the seventeen stepped-up police enforcement intersections selected for this evaluation study. The charges laid by the police at these sites, specific to stepped-up enforcement activity, would be charges laid under the *Highway Traffic Act*, either by issuing the driver an Offence Notice (ticket – Part I of the *Provincial Offences Act*) or by summonsing the driver to appear in court (Part III of the *Provincial Offences Act*). While some criminal charges were laid, these are not included in any calculation of fines as there is no out of court payment option for criminal charges and the disposition history is not known.

In the following calculations, tickets resulting from both the red light camera systems and stepped-up police enforcement are presented together.

fine goes into default or after the unpaid fine is enforced through plate denial (licence suspension in the case of police laid charges).

[16] Other charges were laid as a result of the stepped-up police enforcement deployments, consisting of both provincial and criminal offences. While the charges and locations have been documented, the disposition of them has not been tracked and is, therefore, not included in this report. It is assumed that the disposition of charges resulting from stepped-up police enforcement is the same as with red light camera dispositions.

9.5.1 Estimated fine revenue and fine disposition imposed

Based on data provided to the consultant team from the Municipal Joint Processing Centre and the police representatives, a total of 13,992 tickets were issued in the first two years of the pilot project.

In the first two years of the pilot project, 54 per cent of tickets issued resulted in a prepayment of the $190 total out-of-court payment amount. The remaining 46 per cent resulted in a disposition – a dismissal or a conviction. The disposition would have been determined by a judicial officer and could have occurred as a result of the failure of the person to respond initially or to appear at trial or when the person appeared to enter a plea of guilty, for example. Of the 46 per cent of the matters not resulting in a prepayment, 80 per cent resulted in a fine being imposed by the court (fine disposition). The average ticket value of all prepayment and fine dispositions is $136.30 (not including the victim surcharge).

Based on this information, the prepayment amount generated from tickets associated with the 19 red light camera and 17 stepped-up police enforcement intersections is estimated[17] at:

$136.30	Average ticket value	x
7,556	Prepaid (54 per cent of 13,992)	=
$1,029,883		

Fine dispositions are calculated by multiplying the average ticket value by the percentage of fine dispositions that result in an imposed fine. Fine dispositions imposed are calculated then as:

$136.30	Average ticket value	x
5,149	Fine dispositions (80 per cent of (46 per cent of 13,992))	=
$701,809		

Therefore, it is estimated that net fine revenue (based on prepayments) and fine dispositions amount to **$1,731,692** for the evaluation study sites alone.

9.6 COURT PROCESSING COSTS

Tickets issued for failing to stop at red lights are processed and disposed of by the courts. Court processing costs are the estimated costs of processing tickets and any subsequent trial. These costs range from the charging process to prosecution, to the ultimate disposition in court to fine enforcement. Court processing costs have been categorized into:

- Pre-disposition administrative processing of the ticket;
- Trials by the court; and
- Post-disposition administrative processing of the court disposition.

The general approach adopted for developing the costs for these categories was to break each category down into its component business processes, and then to estimate the time required to complete each individual business process. The staff cost per unit time and facilities cost per unit

[17] The actual amount of prepaid fines and fines imposed is not available for the sites in the evaluation.

time were then applied to the estimated time required to complete the business processes. The cost for each court processing cost category is the sum of the costs for each component business process. In developing the estimated costs for these categories the administrative staff costs included the salary/wages of the person who typically performs the process, including benefits and applied overhead. Also, the facilities costs include the cost of leases, facility operating costs and taxes.

During the evaluation study period the responsibility for the administration and most of the prosecution of charges laid under the *Highway Traffic Act* was in the process of being transferred from the province to municipalities. As the transfer of these responsibilities was not fully completed at the outset of the evaluation study period, information provided by the Ministry of the Attorney General, reflective of estimated pre-transfer costs to the Ministry, was used. It is assumed that these costs approximate those incurred by individual municipalities post-transfer. It is acknowledged that the costs might be higher or lower depending on specific circumstances or locations. Certain assumptions have been made in calculating the estimated costs, which are detailed in subsequent subsections.

9.6.1 Pre-disposition administrative processing costs

These costs pertain to the costs associated with filing Part I and Part III offences by the court office or when the information is sworn to and summonses served on the defendant. In either case, court administration staff is required to update the Integrated Court Offences Network (ICON) by entering information pertaining to the charge into the system. As the proceeding goes through the related court process, the ICON system is updated throughout this process. In addition to entering information into ICON, associated paper documents need to be processed and filed by the court office.

The estimated processing cost per charge is the sum of the average time to complete each step in the process multiplied by the cost of the staff person performing the task. The estimated facility cost is the unit facility cost (determined from budgets of actual data) multiplied by the average time required to do the pre-disposition administrative processing.

The MAG estimated that the time required to enter the charge on ICON, as well as process the associated paper documents, was 7.5 minutes per charge. By applying staff and facility costs to this time, the total pre-disposition administrative processing cost by the court office is estimated at **$14.53 per offence**.

9.6.2 Trial costs

These costs pertain to the cost of court proceedings when a charge proceeds to the trial stage for Part I and Part III offences. The MAG has provided the processing steps and the average time required to complete proceedings depending on the type of court disposition. These costs include the cost of adjudication at $160 per hour and prosecution at $90 per hour based on *Provincial Offences Act* transfer agreements with the municipalities, and the cost of a court clerk/monitor. The cost of photographs for the disclosure of evidence at trial is not included, however, because this cost is captured elsewhere in the analysis because municipalities pay for this directly, not the court.

It should also be noted that trial costs as well as the cost of prosecution varies from matter to matter depending on the length and the complexity of the individual proceeding, whether the person charged is represented by a lawyer or agent and other factors. ICON does not specifically indicate when a matter was resolved through a plea or other disposition with the involvement of the prosecutor nor is it a prosecutorial database. Requests for disclosure and the like are not recorded or tracked on the ICON system. While many disposition types are indicated on ICON, the prosecutorial information essential to a cost calculation is not available. It cannot be stated or assumed with any degree of accuracy what amount of time was spent or total or partial actions taken for any of these matters with regard to prosecution costs.

For the purposes of estimating trial costs, typical trial durations were provided by MAG. The associated staff and adjudication costs, as well as facilities costs, were applied to these durations to arrive at a cost per disposition. MAG was also able to provide data on the number of dispositions from ICON for charges over the duration of the evaluation study period. The numbers of each type of disposition with staff, adjudication and facility costs applied, resulted in a cost for each type of court disposition. It is noted that staff costs varied depending on the type of disposition because the presence of a prosecutor was not always required for some types of dispositions. **Exhibit 9.1** presents the cost of each type of disposition along with the percentage each disposition represented of the total number of offences. The average cost of a disposition is calculated to be **$17.07 per offence**. The cost of processing a pre-paid ticket is calculated to be **$16.90 per offence**.

Exhibit 9.1 – Costs by disposition

Disposition	Proportion of total offences	Trial cost per offence
Failure to appear	23%	$36.33
Walk-in-guilty	7%	$28.83
Withdrawal/adjournment	9%	$7.27
Guilty plea	5%	$36.33
Reopenings	1%	$34.60
Not guilty plea/found guilty	2%	$145.34
Trial cost (aggregate of all dispositions)[18]	**46%**	**$17.07**
Pre-paid[19]	**54%**	**$16.90**

9.6.3 Post-disposition processing costs

These costs pertain to processing done by the court office after the trial. When a disposition is entered by the courts, the defendant is advised verbally and through a Notice of Fine and Due Date of the amount of the penalty or fine plus the applicable court costs and victim fine surcharge. Most fines are payable within fifteen days of imposition unless the judicial official in court has granted the person additional time to pay. The fine goes into default if it is not paid fifteen days after it is due. If the fine remains unpaid, there is a direction issued for plate denial and the Ministry of Transportation, Ontario will not renew the vehicle plate or issue new plates to the person until the amounts are paid. No specific measurement of the court office activities was

[18] The trial cost per offence for each disposition type is calculated based on the estimated amount of time required to process that disposition type and the overall proportion of occurrence of that particular disposition type.
[19] This is the total cost for processing pre-paid offences by the court office.

available at time of writing so the assumption was made that the time estimated for the filing and processing of the charge is the same as the time expended on the issuance of notices of fine and due date and the issuance of any plate denial directions to the Registrar of Motor Vehicles. Therefore, a cost of **$14.53 per offence** is used for post-disposition processing.

9.6.4 Calculating total court processing costs

Only tickets originating from evaluation study sites (nineteen red light camera or seventeen stepped-up police enforcement sites) are included in the calculation. Overall court costs are then calculated as shown in **Exhibit 9.2**.

Exhibit 9.2 – Court processing costs

Court processing cost category	Cost
Pre-disposition processing costs	$93,515
Trial costs	$237,559
Post-disposition processing costs	$93,515
TOTAL	**$424,589**

9.7 STEPPED-UP POLICE ENFORCEMENT COSTS

Each of the six police services was asked for information as it applied to the stepped-up police enforcement deployments carried out in the first two years of the pilot project. Specific information asked for included police officer, equipment, court and overhead costs. Each of these is explained below:

- **Police Officer Costs** – The cost of staffing stepped-up police enforcement deployments is calculated by multiplying the total deployment time and officer payroll cost and summing this officer cost for each police officer deployed at evaluation study sites.
- **Police Equipment Costs** – The cost of equipment used in deployments (cruisers, motorcycles primarily), is calculated by multiplying the total deployment time and equipment cost and summing this equipment cost for each piece of equipment deployed at evaluation study sites.
- **Police Court Costs** – These are the costs associated with police officers attending trials to testify.
- **Police Overhead Costs** – These are the costs associated with administering the stepped-up police enforcement deployments.

Based on data provided by the police services, the total estimated cost of stepped-up police enforcement carried out at the seventeen evaluation study intersections is **$194,295** for the two years of the pilot project.

9.8 NET COSTS

Exhibit 9.3 summarizes net costs calculated in **Section 9**. Recovered fine revenue (through prepayments and convictions) and estimated recovered fine dispositions are presented as negative costs and are subtracted from all other estimated costs as they are a recovered cost.

The estimated net costs attributed to the nineteen red light camera and seventeen stepped-up police enforcement sites in this evaluation study are approximately **$1.03 million**.

Exhibit 9.3 Calculation of estimated net costs

Item	Cost
Ongoing provincial costs	$430,302
Municipal costs	$205,711
Red light camera system capital costs	$589,646
Municipal Joint Processing Centre capital costs	$25,846
Red Light Camera System operating costs	$575,719
Municipal Joint Processing Centre operating costs	$312,389
Fine revenue	($1,029,883)
Fine dispositions imposed	($701,809)
Court processing costs	$424,589
Stepped-up police enforcement costs	$194,295
Estimated net costs	**$1,026,805**

10.0 RESULTS OF BENEFIT – COST ANALYSIS

The total calculated benefits in **Section 8** and calculated costs in **Section 9** are summarized in **Exhibit 10.1.** The benefit-to-cost ratio is **1.57.** Based on these findings, the Red Light Camera Enforcement Pilot Project has been shown to be economically viable, given that the social cost of collisions avoided exceeds the amount invested in the treatments at the forty-eight evaluation study sites. The EB analysis shows that an estimated forty-seven fatal and injury collisions were avoided as a result of the treatments, valued at $3,775,425.[20] Based on this, the pilot project has been shown to be a valid safety program for the province of Ontario, having achieved the objective of reducing fatal and injury collisions.

Exhibit 10.1 Estimated net benefits and costs (November 20, 2000 – November 19, 2002)

Estimated net benefits and costs[1]	
Total net benefits[20]	$1,613,766
Total net costs	$1,026,805
Benefit-to-cost ratio	**1.57**
Notes: [1]The benefits and costs were calculated based on only the forty-eight study sites included in this evaluation.	

[20] The $3,775,425 in fatal and injury collisions avoided is offset by a gain in property damage only collisions of $2,161,659, yielding a total net benefit of $1,613,766 as shown in **Exhibit 10.1**.

11.0 CONCLUDING REMARKS ON THIS EVALUATION STUDY

The following section provides some concluding remarks on this evaluation study. The Evaluation of the Red Light Camera Enforcement Pilot Project represents the most ambitious evaluation study of red light running treatments undertaken to date. Several components of this evaluation study are particularly noteworthy:

- **It examined the combined effect of two red light running treatments** - This evaluation study is unique in that it involved an examination of *two red light running treatments*, namely red light camera systems and stepped-up police enforcement.[21] Most evaluations traditionally examine just one treatment alone;
- **The SPF curves developed will be of significant value to the research community –** The Safety Performance Function Curves developed for this evaluation study, represented 179 signalized intersections in urban and suburban areas scattered throughout eight different municipalities in Ontario and involved 865 years worth of collision and trended volume data. Due to their size and accuracy, they will be of significant value to the research community; and
- **The benefit-cost analysis was very comprehensive -** The benefit-cost analysis represents one of the most detailed examinations of a safety treatment ever undertaken, involving calculation of the social cost of collisions avoided, the cost of the red light camera system, the cost of Municipal Joint Processing Centre, fine revenue from prepaid tickets and fine dispositions imposed, court processing costs, provincial and municipal administration costs and stepped-up police enforcement costs.

One limitation to this evaluation study should be noted also. This evaluation study cannot make any claim to the effectiveness of the red light cameras on their own. As this evaluation study involved an evaluation of the effectiveness of two treatments, as well as a publicity campaign, it is impossible to isolate the effect of the red light cameras from the stepped-up police enforcement deployments and the publicity campaign. All the results presented in this evaluation study represent the combined effect of the treatments.

11.1 FUTURE RESEARCH

This evaluation study indicated that rear-end (and property damage only) collisions increased as a result of the two treatments. While the increase is primarily attributed to minor property damage type collisions, it still is a cause for concern and represented the only negative outcome of this evaluation study. It was speculated that this might be occurring to drivers braking suddenly as they approach evaluation study intersections, being struck from behind by other motorists following too closely. It was also observed that an increase in rear end collisions is a province-wide trend, partially accounting for the increase observed at the evaluation study sites.

[21] A publicity campaign directed against red light running was also occurring, starting in September 2000 and continuing into the pilot project.

To that end, further research could be undertaken into the behaviour of drivers in municipalities where red light cameras are operating. Questions worth following up on are:

- Are drivers exhibiting a combination of sudden braking and following too close behaviours on the approaches to signalized intersection in the six municipalities, leading to a higher probability of rear-end collisions occurring?
- Is the increase in rear-end collisions a temporary problem that will go away as drivers become used to the new treatments?

Another question that could be of interest to the research community is the evaluation of the spillover effect of red light cameras together with stepped-up police enforcement. This evaluation study could not isolate the effect of the treatments on the surrounding signalized intersections in the same communities, although there is some indication that there is an effect.[22]

Questions worth asking are:

- How can the 'spillover' effect be measured?
- How many red light cameras and stepped-up police enforcement deployments are required to sustain a reduction across an entire community?
- Would more red light cameras/stepped-up police enforcement deployments achieve a greater benefit in terms of collision reductions?

11.2 CONCLUSIONS AND RECOMMENDATIONS

Based on the results presented in this report, the Red Light Camera Enforcement Pilot Project has been shown to be an effective tool in reducing fatal and injury collisions, thereby preventing injuries and saving lives. For these reasons, it is the opinion of the evaluation study team that the

[22] NCHRP Synthesis 310 makes reference to the spillover effect. A spillover effect is an observed decrease in collisions at neighbouring signalized intersections that is attributed to a group of red light cameras. Very little research has been undertaken into the spillover effect.
In **Appendix I**, a scenario is presented for illustration purposes only in which 15% of the safety effectiveness of the treatments is applied across the six municipalities, making the assumption that the effectiveness of the treatments at the 48 signalized intersections in this evaluation study would apply, at a reduced level, to the other signalized intersections in the six municipalities.

pilot project has been worthwhile and would continue to be of benefit to any participating municipality.

It is recommended that collisions continue to be monitored and examined on a yearly basis to validate that the trend continues as presented in the evaluation study results.

APPENDICES

Appendix A – Stepped-up police enforcement data form

Stepped-up Red Light Running Enforcement Data Sheet (to be completed for each deployment)						
Intersection Location:		Number of Officers Deployed: (including Supervisor)		Supervisory Officer:(Name/Rank):		
Study Approach/Direction:						
Deployment Date (yy/mm/dd):						
Start Time of Deployment:						
Finish Time of Deployment:						
Study Approach				**Other Approach**		
# Cruiser-Hours				# Cruiser-Hours		
# Motorcycle-Hours				# Motorcycle-Hours		
# Unmarked-Vehicle Hours				# Unmarked-Vehicle Hours		
# Roadside Screening Devices				# Roadside Screening Devices		
# Radar Unit-Hours				# Radar Unit-Hours		
	CHARGES – STUDY APPROACH			**CHARGES – OTHER APPROACH**		
	Total #	# Driver Not Owner	Total #	# Driver Not Owner	Total #	# Driver Not Owner
Disobey Red Light – Through (144.18)						
Disobey Red Light – Turning (144.18)						
Disobey Signal – Other						
Turns						
Seat Belts						
Equipment						
Insurance						
Impaired Driving						
Suspended Licence						
No Plates/Obstructed Plates						
Other HTA/Provincial Offences						
Other Federal Offences						
Roadside Screenings						
12-Hour Suspensions						
Vehicle Impoundments						
Other Criminal Code (specify Section)						
GRAND TOTAL – CHARGES						
	CAUTIONS - STUDY APPROACH			**CAUTIONS – OTHER APPROACH**		
	Total #	# Driver Not Owner	Total #	# Driver Not Owner	Total #	# Driver Not Owner
Disobey Red Light – Through (144.18)						
Disobey Red Light – Turning (144.18)						
Disobey Signal – Other						
Turns						
Seat Belts						
Equipment						
Insurance						
No Plates/Obstructed Plates						
Other HTA						
GRAND TOTAL – CAUTIONS						
COMMENTS:						
NOTE: PLEASE INCLUDE A LISTING OF ALL CERTIFICATE OF OFFENCE NUMBERS RESULTING FROM THIS DEPLOYMENT ON THE TRACKING OF DISPOSITION OF CHARGES FORM						

Appendix B – List of sites in this evaluation study

There were one hundred seventeen sites originally selected for the pilot project. Of these:

- Forty-eight sites were selected for this evaluation study, consisting of nineteen red light camera, seventeen stepped-up police enforcement and twelve local comparison sites as shown in **Exhibit B-1**;
- Fifty-nine sites were included in the pilot project but not in this evaluation study, selected for either a red light camera or stepped-up police enforcement treatment; and
- Ten sites were originally included in this evaluation study, being sites in the Cities of London and Windsor as shown in **Exhibit B-2**. These evaluation study sites, referred to as distant comparison sites were only used in the field analysis of red light running and posted speed limit violation data.

Exhibit B-1 Evaluation study sites

Municipality	Intersection	Approach	Treatment	Traffic Control
City of Toronto	Albion Rd @ Finch Ave. W.	Westbound	Stepped-Up Police Enforcement	Two way - Two way
City of Toronto	Dixon Road @ Martingrove Road	Westbound	Red Light Camera	Two way - Two way
City of Toronto	Don Mills Road @ Finch Avenue East	Northbound	Red Light Camera	Two way - Two way
City of Toronto	Don Mills Road @ The Donway North	Northbound	Local comparison Site	Two way - Two way
City of Toronto	Dupont Street @ Landsdowne Avenue	Westbound	Local comparison Site	Two way - Two way
City of Toronto	Eglinton Avenue @ Don Mills Road	Westbound	Red Light Camera	Two way - Two way
City of Toronto	Eglinton Avenue @ Kennedy Road	Eastbound	Local comparison Site	Two way - Two way
City of Toronto	Eglinton Avenue @ Pharmacy Avenue	Westbound	Red Light Camera	Two way - Two way
City of Toronto	Eglinton Ave. E. @ Laird Dr.	Westbound	Stepped-Up Police Enforcement	Two way - Two way
City of Toronto	Eglinton Ave. W. @ Jane St.	Eastbound	Stepped-Up Police Enforcement	Two way - Two way
City of Toronto	Eglinton Avenue West @ Martingrove Road	Eastbound	Red Light Camera	Two way - Two way
City of Toronto	Finch Avenue @ Kipling Avenue	Eastbound	Red Light Camera	Two way - Two way
City of Toronto	Jane Street @ Trethewey Drive	Southbound	Local comparison Site	Two way - Two way
City of Toronto	McCowan Rd. @ Lawrence Ave. E.	Southbound	Stepped-Up Police Enforcement	Two way - Two way
City of Toronto	Midland Avenue @ Finch Avenue East	Southbound	Local comparison Site	Two way - Two way
City of Toronto	Neilson Road @ Sheppard Avenue East	Northbound	Local comparison Site	Two way - Two way
City of Toronto	Victoria Park at Lawrence Avenue East	Northbound	Red Light Camera	Two way - Two way
Region of Halton	Fairview Street @ Brant Street	Westbound	Stepped-Up Police Enforcement	Two way - Two way
Region of Halton	Fairview Street @ Walker's Line	Southbound	Local comparison Site	Two way - Two way
Region of Halton	Dorval Drive @ North Service Road	Southbound	Red Light Camera	Two way - Two way
Region of Halton	Dorval Drive @ Upper Middle Road	Eastbound	Stepped-Up Police Enforcement	Two way - Two way
City of Hamilton	Mohawk Road @ West 5th Street	Eastbound	Stepped-Up Police Enforcement	Two way - Two way
City of Hamilton	Queensdale @ Upper Sherman	Southbound	Red Light Camera	Two way - Two way
City of Hamilton	Wilson @ Wellington	Eastbound	Stepped-Up Police Enforcement	One way - One way
Region of Peel	Airport Road @ Queen Street	Westbound	Stepped-Up Police Enforcement	Two way - Two way
Region of Peel	Derry Road @ Hurontario Street	Westbound	Red Light Camera	Two way - Two way
Region of Peel	Dixie Road @ Dundas Street	Eastbound	Red Light Camera	Two way - Two way
Region of Peel	Dixie Road @ Eglinton Avenue	Southbound	Stepped-Up Police Enforcement	Two way - Two way
Region of Peel	Erin Mills Parkway @ Dundas Street	Northbound	Stepped-Up Police Enforcement	Two way - Two way
Region of Peel	Steeles Avenue @ Hurontario Street	Southbound	Stepped-Up Police Enforcement	Two way - Two way
City of Ottawa	Albert Street @ Kent Street	Northbound	Red Light Camera	One way - One way
City of Ottawa	Bronson Avenue @ Carling Avenue/Glebe Street	Southbound	Red Light Camera	Two way - One way
City of Ottawa	RR 12 (Fallowfield) @ RR 13 (Greenbank)	Westbound	Stepped-Up Police Enforcement	Two way - Two way
City of Ottawa	RR 17 (Merivale) @ RR 51 (Meadowlands)	Northbound	Red Light Camera	Two way - Two way
City of Ottawa	RR 34 (St. Joseph) @ RR 55 (Jeanne d'Arc)	Eastbound	Red Light Camera	Two way - Two way
City of Ottawa	RR 36 (Hazeldean/Robertson) & RR 49 (Eagleson)	Southbound	Red Light Camera	Two way - Two way
City of Ottawa	RR 36 (Robertson) @ RR 59 (Moodie)	Eastbound	Stepped-Up Police Enforcement	Two way - Two way
Region of Halton	Upper Middle Road @ Walker's Line	Eastbound	Red Light Camera	Two way - Two way
Region of Halton	Guelph Line @ Upper Middle Road	Southbound	Local comparison Site	Two way - Two way
Region of Halton	RR 5 (Dundas Street) @ Trafalgar Road	Eastbound	Red Light Camera	Two way - Two way
Region of Halton	RR 5 (Dundas Street) @ Brant St/ Cedar Springs Rd	Eastbound	Local comparison Site	Two way - Two way
Region of Halton	RR 5 (Dundas Street) @ Guelph Line	Eastbound	Stepped-Up Police Enforcement	Two way - Two way
Region of Halton	Upper Middle Road @ 8th Line	Eastbound	Local comparison Site	Two way - Two way

Municipality	Intersection	Approach	Treatment	Traffic Control
Region of Peel	Erin Mills Parkway @ Eglinton Avenue	Southbound	Stepped-Up Police Enforcement	Two way - Two way
City of Hamilton	Cannon Street @ Wellington Street	Westbound	Local comparison Site	One way - One way
City of Hamilton	Fennell Avenue @ Wellington Street	Westbound	Local comparison Site	Two way - Two way
Region of Waterloo	Homer Watson Blvd @ Ottawa Street	Eastbound	Red Light Camera	Two way - Two way
Region of Waterloo	Homer Watson Blvd @ Manitou Dr/Doon Village Rd	Northbound	Stepped-Up Police Enforcement	Two way - Two way

Exhibit B-2 Distant comparison sites

Municipality	Intersection	Approach	Treatment	Traffic Control
City of London	Wharncliffe Road @ Baseline Road	Northbound	Distant Comparison Site	Two way - Two way
City of London	Wonderland Road @ Viscount Road	Southbound	Distant Comparison Site	Two way - Two way
City of London	Wharncliffe Road @ Southdale Road	Southbound	Distant Comparison Site	Two way - Two way
City of London	Commissioners Road @ Pond Mills Road	Westbound	Distant Comparison Site	Two way - Two way
City of London	Southdale Road @ Ernest Avenue / Nixon Road	Westbound	Distant Comparison Site	Two way - Two way
City of London	Wellington Road @ Commissioners Road	Northbound	Distant Comparison Site	Two way - Two way
City of Windsor	Lauzon @ Tecumseh	Southbound	Distant Comparison Site	Two way - Two way
City of Windsor	Howard @ Tecumseh	Southbound	Distant Comparison Site	Two way - Two way
City of Windsor	Dougal @ Cabana	Westbound	Distant Comparison Site	Two way – Two way
City of Windsor	Tecumseh @ Walker	Southbound	Distant Comparison Site	Two way - Two way

Appendix C - Red light running and posted speed limit violation data

C.1 Evaluation criteria

In evaluating the safety effectiveness of the two treatments, Working Group 1 originally chose to examine three different evaluation criteria:

- Collision history;
- Red light running violations; and
- Posted speed limit violations.

A reduction in red light running and posted speed limit violations was viewed as being a *secondary* expected outcome of this evaluation study. The two criteria were seen as an indicator of aggressive driving. Red light running violations have often been used as a basis for evaluating red light camera initiatives elsewhere in North America. The measurement of posted speed limit violations was an additional behaviour of interest to the Working Group 1, of which it was hoped could provide some further insight into the behaviour of drivers as they approach traffic signals at the study sites in this evaluation (including the distant comparison sites). This section presents the red light running violation and posted speed limit violation data, the results of the analysis of the data using the RROR and C-G method and an interpretation of the results.

Data was collected for three time periods, before (prior to the beginning of the pilot project), interim (in the first year of the pilot project) and final (in the second year of the pilot project).

C.2 Red light running violation data

Red light running violation (RLRV) data was collected among the fifty-eight sites during the following time periods: fall 1999, spring 2000 and fall 2000 prior to the beginning of the pilot project. The aforementioned represent the before period. During the pilot project itself, RLRV data was collected in the fall of 2001 (for the interim period) and the fall of 2002 (for the final period). The methodology used to collect the RLRV data is described below.

Data collection methodology

The field observation of RLRVs occurred during the periods 07:30-12:00 (with a half hour break from 9:30-10:00), and 13:00-17:00 (half hour break from 15:00-15:30) on a weekday when schools were in operation. The observers recorded red light violations for the selected approach only. A violation is considered to occur in cases of right turning traffic when the vehicle proceeds through the intersection greater than 0.1 seconds following the start of the red display and the vehicle is travelling 15 km/h or more. The site observers cannot be as accurate as the red light cameras in this regard, but they attempt to follow these guidelines as precisely as possible. In cases of through or left turning traffic, a violation is considered to occur when the vehicle is behind the stop bar at the start of the red display, and proceeded with the movement anyway. The observers used a standard form to record the violations. The observer counted red light violations for straight through, right turn and left turn movements. The observer positioned himself or herself such that they could observe both the signal indication and the stop line for all lanes on the evaluation study approach.

For each violation on the evaluation study approach, the observer recorded:

- the time of violation (hour and minute);
- the travel lane;
- the movement (i.e. straight through, left or right);
- vehicle type (i.e. car, truck or bus);
- whether the violation occurred during the all red, a stale red (i.e. conflicting green), or just prior to the start of green (i.e. green jumper);
- whether the vehicle had an "out of province" licence plate; and
- any additional comments the observer felt were relevant (i.e. vehicle accelerated through red light, or inattentive driver).

Violations collected during the before period involved using a training video to define when a violation occurred. This video was created in order to calibrate among the different members of the observation team what a violation entailed. This same video was used during the interim data and final data collection to refresh the memory of the observation team. In addition, random audits were performed to ensure that the observer was collecting data according to the above recording guidelines. Eight site visits were undertaken to four of the municipalities. The following was verified at the time of the data collection:

- The observer was at the correct location and monitoring the right approach; and
- The observer was using the correct form and procedure.

In addition to the red light running violation counts, the observers counted all vehicles passing through the approach. This allowed the risk exposure to be determined, as required in the RROR method.

Data Collected

The distribution of RLRV data among the four site types along with the accompanying vehicle counts is presented in **Exhibits C-1** through **C-3.** RLRVs occur in approximately 1 in 1000 drivers according the base data observed in the before period.

The number of RLRVs decreased at the treated sites by approximately fifty percent from the before period to the final period. However, this decrease was outpaced by the decrease in RLRVs at the distant comparison sites over the same period. Overall, the general trend observed is a drop in the number of observed RLRVs across all site groups, partially attributable to a lower volume of vehicles.

In the interim period, the number of RLRVs was counted twice at the distant comparison sites due to the dramatic change from the before to the interim period (202 to 88). At that time, the change in RLRVs was thought to have been an anomaly, as those sites should have been unaffected by any safety intervention. The recount, carried out in the late fall of 2001, was somewhat higher (129) but still far from the original distant comparison total (202). The final count (52) appears to further confirm that the original before count must have been uncharacteristic of conditions occurring at the sites.

Exhibit C-1 Distribution of RLRV data among the four site types

Site type	Red light running violations			Number of sites
	Before (1999-2000)	Interim (Fall 2001)	Final (Fall 2002)	
Red light camera	428	226	194	19
Stepped-up police enforcement	182	132[1]	91	16
Local comparison	168	168	115	12
Distant comparison	202	88 (129)[2]	52	10

Notes:
1 Violation data was not collected at one stepped-up police enforcement site due to road construction occurring during the interim period. For comparative purposes, violations in the before and final period have also been removed.
2 Violation data was collected twice in the interim period for the ten distant comparison sites.

Exhibit C-2 Distribution of RLRV data among the four site types

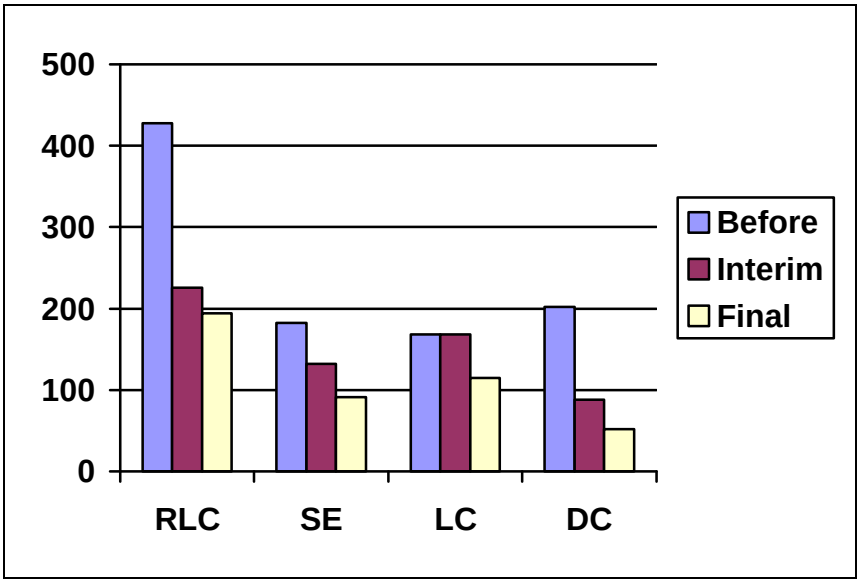


Exhibit C-3 Distribution of vehicle counts among the four site types

Site type	Vehicle counts			Number of sites
	Before (1999–2000)	Interim (Fall 2001)	Final (Fall 2002)	
Red light camera	155 828	153 293	155 610	19
Stepped-up police enforcement	146 439	113 573[1]	104 596	16
Local comparison	100 695	83 708	87 067	12
Distant comparison	82 220	61 594 (64 629)[2]	64 228	10

Note:
1 Vehicle count data was not collected at one stepped-up police enforcement site due to road construction for the interim period. For comparative purposes, vehicle counts in the before and final period have also been removed.
2 Vehicle count data was collected twice in the interim period for the ten distant comparison sites.

C.3 Posted speed violation data

As with the RLRV data, posted speed limit violation (PSLV) data was collected among the fifty-eight sites during the following time periods: fall 1999, spring 2000 and fall 2000 prior to the beginning of the pilot project. The aforementioned time period represents the before period. During the pilot project itself, PSLV data was collected in the fall of 2001 (interim period) and the fall of 2002 (final period). The methodology used to collect the PSLV data is described below.

Data collection methodology

Speed data was collected for 24 hours on the evaluation study approach using Nu-Metrics Hi-Star counters during the before, interim and final period on a weekday when schools were in operation. The counters were placed upstream on the evaluation study approach, within the 'decision zone'. For the purposes of this evaluation study, the decision zone is based on the posted speed limit and is defined as a zone between 4 and 5 seconds of travel upstream of the stop bar that a vehicle would be in if travellig at the posted speed limit. For example, the decision zone for an approach with a 50 km/h posted speed limit is between 55 and 69 metres upstream from the stop bar.

The speed data is aggregated into 5 km/h speed bins, ranging from under 40 km/h to over 100 km/h. Data is reported in 15-minute increments. For each 15-minute increment, the total number of vehicles recorded traveling at a particular speed bin is reported. Therefore, in addition to the manual traffic volume counts collected during the observation of red light running violations, the evaluation study team also has automatic traffic volume counts.

Those vehicles traveling above the posted speed limit on the approach in question were counted as a 'posted speed limit violation'. Using the speed data collected, the total number of posted speed violations was determined for each evaluation study approach.

Data collected

The distribution of PSLV data among the four site types along with the accompanying vehicle counts is presented in **Exhibits C-4** through **C-6.**

In contrast to the RLRV data, the number of PSLVs remained approximately the same in the interim period as in the before period, with the exception of an increase among the red light camera sites. At first glance, it is seen that the number of posted speed violations occurring among the evaluation study sites was quite high. Roughly one in four of all drivers passing through on the study approach were driving above the posted speed limit. PSLVs increased among all site groups by approximately fifty percent in the final period as compared to the before period. The overall vehicle count remained relatively stable through the three observation periods.

Exhibit C-4 Distribution of PSLV data among the four site types

Site type	Posted speed limit violations			Number of sites
	Before (1999-2000)	Interim (Fall 2001)	Final (Fall 2002)	
Red light camera	43 088	53 341	69 904	19
Stepped-up police enforcement	53 123	50 028	63 913	17
Local comparison	40 440	43 511	67 904	12
Distant comparison	24 184	17 389	31 004	10

Exhibit C-5 Distribution of PSLV data among the four site types

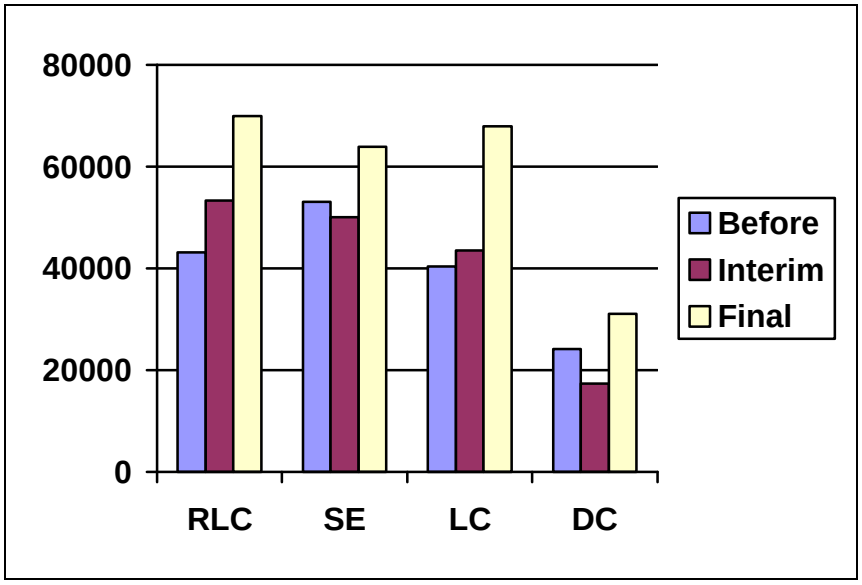


Exhibit C-6 Distribution of vehicle counts among the four site types

Site type	Vehicle counts			Number of sites
	Before (1999–2000)	Interim (Fall 2001)	Final (Fall 2002)	
Red light camera	252 880	271 310	276 703	19
Stepped-up police enforcement	219 188	232 748	243 372	17
Local comparison	148 600	211 629	187 635	12
Distant comparison	105 105	99 430	110 844	10

C.4 Methodology

The two methods used to evaluate the effectiveness of the two treatments at reducing the risk of red light running and posted speed limit violations were the Relative Risk Odds Ratio method and the Comparison Group method. Each of these methods is briefly described in the following sections.

Relative Risk Odds Ratio method

The Relative Risk Odds Ratio (RROR) method is a proven statistical modeling method. This method uses 'consequence' data (e.g., collisions, violations, number of motorists travelling above the speed limit) and 'exposure (to risk)' data (e.g., vehicles entering intersections, traffic volume, AADT) for the treated and untreated (comparison) intersections. These are required for both the 'before' and 'after' (interim and final) periods as primary data inputs into the model.

The data is merged in a log odds-ratio mathematical relationship that compares:

> "the change in safety that took place in the 'after' (interim/final) period compared to the 'before' period for the treated group *relative to* the change in safety that took place in the 'after' period compared to the 'before' period for the untreated (comparison) group".

In essence, the resultant relative risk odds-ratio performance measure indicator provides a measure of the differential (if any) in road travel risks being experienced by the treated group and the untreated (comparison) group in the 'after' (interim and final) period relative to the 'before' period.

Further information on the RROR Method is presented in the 1998 Transport Canada publication by Stewart (TP 13238).

Comparison Group (C-G) method

The Comparison Group (C-G) method is also a valid statistical analysis method, but it is less robust and less accurate than RROR method because it does not generally account for differences in exposure (to risk) in the 'before' and 'after' periods. The C-G method uses 'consequence data' (e.g., RLRVs) for the treatment and control (untreated) groups from the 'before' and 'after' periods as the primary data inputs to estimate the treatment effectiveness. The C-G method hinges on the belief that the ratio of the expected number of consequences 'before' and 'after' treatment implementation would be the same for the treatment and control groups had the

treatment not been implemented. The key to its validity is that the treated and control sites are very similar in traits and characteristics in both the 'before' and 'after' periods of treatment implementation, especially their exposure (to risk). For further details concerning the methodology, refer to Hauer (1997).

Analysis of interim data

After the first year of the pilot project, the RROR and C-G method were used to evaluate the effectiveness of the treatments using red light running and posted speed limit gathered in the interim period as the evaluation criteria. The purpose of carrying out the evaluation of interim data was to provide a preliminary indication of the effectiveness of the treatments. The RROR and C-G method were used as they involve a relatively simple, straightforward method of evaluating treatments using before-after data and treated and comparison groups. The two methods were used to evaluate the effectiveness of the treatments at reducing the risk of violations (red light running and posted speed limit).

Using the RROR and C-G method, estimates of the effectiveness of red light camera (RLC) and stepped-up police enforcement (SE) treatment on aggressive driving at intersections were computed. The overall effectiveness of the two treatment measures was estimated for the interim year (first year after treatment implementation) and final year (second year after treatment implementation). This was done by computing effectiveness estimates using the RROR and C-G methods and comparing:

- Treated sites (RLC + SE intersections) to 'local comparison' sites;
- Treated sites (RLC + SE intersections) to 'distant comparison' sites; and
- Treated sites (RLC + SE intersections) to ('local comparison' + 'distant comparison') sites

Using the RROR and C-G method, estimates of the effectiveness of red light camera (RLC) and stepped-up police enforcement (SE) treatment on aggressive driving (as defined as red light running and posted speed limit violations) at intersections were computed. The overall effectiveness of the two treatment measures were estimated for the interim year (first year after treatment implementation) and final year (second year after treatment implementation). This will be done by computing effectiveness estimates using the RROR and C-G methods and comparing:

- Treated sites (RLC + SE intersections) to 'local comparison' sites;
- Treated sites (RLC + SE intersections) to 'distant comparison' sites; and
- Treated sites (RLC + SE intersections) to ('local comparison' + 'distant comparison') sites

The hypothesis for the above comparisons would be:

H_0: Violations at treated sites (RLC and SE) ***equals*** Violations at untreated sites (local comparison and/or distant comparison).

H_1: Violations at treated sites (RLC and SE) ***does not equal*** Violations at untreated sites (local comparison and/or distant comparison).

Where violations are defined as either:

- Red light running violations; or

- Posted speed limit violations

In addition to the above comparisons, the local comparison sites were grouped together with the red light camera and stepped-up police enforcement sites to ascertain how the entire community (treated and untreated sites) had been affected by the red light camera and stepped-up police enforcement treatments. Using the same methodology described above, a comparison was undertaken of:

- Treated sites (RLC + SE intersections) plus 'local comparison' sites to 'distant comparison' sites

The hypothesis for the above comparison would be:

H_0: Violations at treated sites (RLC and SE) plus 'local comparison' sites ***equals*** Violations at untreated sites (distant comparison).

H_1: Violations at treated sites (RLC and SE) plus 'local comparison' sites ***does not equal*** Violations at untreated sites (distant comparison).

Where violations are defined as either:

- Red light running violations; or
- Posted speed limit violations.

C.5 Interpretation of the results

Primary outputs from the RROR and C-G method are the percentage effectiveness estimator and the lower and upper 95% confidence limits. The percentage effectiveness estimator indicates whether or not the treated group is associated with a higher or lower risk (or likelihood) of violations relative to the control group. The lower and upper 95% confidence limits provide a measure of the degree of confidence in the results being estimated.

Results indicating **positive effectiveness,** where the percentage effectiveness estimator and lower and upper 95% confidence intervals are all positive should be interpreted as follows:

- The treated sites are definitely associated with a lower risk (or likelihood) of the violations occurring at the treated sites relative to the control sites;
- There is 95% confidence that this lower risk (or likelihood) is between the lower and upper 95% confidence limits (both being positive); and
- The results are statistically significant at the 95% level of statistical confidence.

Results indicating **negative effectiveness,** where the percentage effectiveness estimator and lower and upper 95% confidence intervals are all negative should be interpreted as follows:

- The treated sites are definitely associated with a higher risk (or likelihood) of the violations occurring at the treated sites relative to the control sites;
- There is 95% confidence that this higher risk (or likelihood) is between the lower and upper 95% confidence limits (both being negative); and
- The results are statistically significant at the 95% level of statistical confidence.

Results that are **inconclusive,** where the percentage effectiveness estimator is either positive or negative, but the upper and lower 95% confidence limits are neither both negative or both positive, should be interpreted as follows:

- The results are not statistically significant at the 95% level of statistical confidence; the effectiveness is inconclusive at the 95% level of statistical confidence.

The results of the analysis are shown in the following section. The percentage effectiveness estimator (EE) will be shown along with the 95% confidence limits (95% C.L).

C.6 Results

Exhibit C-7 shows the results of the RROR and C-G analysis of red light running and posted speed limit violations using the before and interim field data. Based on the results of the analyses done, the treated sites show **positive effectiveness** at reducing the risk of red light running violations at the treated sites as compared to the local comparison sites, distant comparison sites and local and distant comparison sites combined. When the local comparison sites are included with the treated sites, together they show **negative effectiveness** at reducing the risk of red light running violations as compared to the distant comparison sites.

Results of the RROR and C-G analysis on posted speed limit violations overall show **negative effectiveness** at reducing the risk of a posted speed limit violations at the treated sites as compared to either the local comparison sites, the distant comparison sites and both the local and distant sites combined. When the local comparison sites are included with the treated sites, together they show **negative effectiveness** at reducing the risk of posted speed limit violations as compared to the distant comparison sites.

Exhibit C-7 Results of RROR and C-G analysis of violations (before to interim): selected comparisons

Comparison	Method	Evaluation criteria	Results[1]	Lower[2]	EE[3]	Upper[4]
RLC + SE vs. LC	RROR	Red light running violations	✓	44.0	44.7	45.4
	C-G		✓	23.9	40.7	57.5
	RROR	Posted speed limit violations	✖	-34.7	-33.2	-31.7
	C-G		?	-6.7	0.7	8.7
RLC + SE vs. DC	RROR	Red light running violations	✓	3.8	5.0	6.2
	C-G		N/A[5]			
	RROR	Posted speed limit violations	✖	-34.4	-32.4	-30.4
	C-G		✖	-57.7	-35.5	-13.4
RLC + SE vs. LC + DC	RROR	Red light running violations	✓	25.7	26.7	27.8
	C-G		N/A[5]			
	RROR	Posted speed limit violations	✖	-32.2	-30.9	-29.6
	C-G		✖	-21.8	-13.4	-5.0
RLC + SE + LC vs. DC	RROR	Red light running violations	✖	-12.5	-11.1	-9.6
	C-G		N/A[5]			
	RROR	Posted speed limit violations	✖	-24.2	-22.6	-21.1
	C-G		✖	-59.7	-48.7	-37.7

Notes:
1 Results showing a checkmark indicate positive effectiveness, showing a X indicate negative effectiveness and showing a question mark indicate inconclusive results.
2 Lower 95% confidence limits.
3 Effectiveness estimator.s
4 Upper 95% confidence limits.
5 Comparison Group analysis was not carried out due to differing sample periods in the before-interim data (London and Windsor RLRV data was collected twice in the interim period)

Final period results

Red light running and posted speed violation data were collected in the final period (Year 2) of the pilot project. **Exhibit C-8** shows the results of the RROR and C-G analysis of red light running and posted speed limit violations using the before and final field data.

Based on the results of the analysis done, treated groups show **positive effectiveness** at reducing the risk of red light running and posted speed limit violations as compared to the local comparison groups, but **negative effectiveness** as compared to the distant comparison groups.

The treated groups also show **positive effectiveness** at reducing the risk of posted speed limit violations as compared to the local and distant comparison groups combined.

The treated groups, with the addition of the local comparisons, overall show **negative effectiveness** at reducing the risk of red light running and posted speed limit violations as compared to the distant comparison group.

Exhibit C-8 Results of RROR and C-G analysis of violations (before to final): selected comparisons

Comparison	Method	Evaluation criteria	Results[1]	Lower[2]	EE[3]	Upper[4]
RLC + SE vs. LC	RROR	Red light running violations	✓	41.9	42.7	43.4
	C-G		✓	15.1	26.3	37.5
	RROR	Posted speed limit violations	✓	4.3	5.5	6.7
	C-G		✓	11.5	17.6	23.7
RLC + SE vs. DC	RROR	Red light running violations	✖	-67.3	-64.9	-62.6
	C-G		✖	-125.7	-94.0	-62.3
	RROR	Posted speed limit violations	✖	-4.7	-3.3	-2.0
	C-G		?	-15.9	-7.9	0.1
RLC + SE vs. LC + DC	RROR	Red light running violations	?	-1.0	0.4	1.7
	C-G		?	-26.7	-12.1	2.5
	RROR	Posted speed limit violations	✓	2.2	3.4	4.7
	C-G		✓	2.9	9.6	16.3
RLC + SE + LC vs. DC	RROR	Red light running violations	✖	-83.6	-81.0	-78.4
	C-G		✖	-142.2	-109.2	-76.1
	RROR	Posted speed limit violations	✖	-7.5	-6.2	-4.8
	C-G		?	-8.1	-0.7	6.8

Notes
1 Results showing a checkmark indicate positive effectiveness, showing a X indicate negative effectiveness and showing a question mark indicate inconclusive results.
2 Lower 95% confidence limits.
3 Effectiveness estimator.
4 Upper 95% confidence limits.

C.7 Conclusions

This Appendix presents a statistical analysis of two different types of evaluation criteria used to determine the effectiveness of reducing aggressive driving behaviour at signalized intersections, namely red light running and posted speed limit violations. **Exhibit C-9** shows the results of the RROR analysis only. According of the analysis undertaken**,** there was a wide variation in the results between the interim and final period as compared to the before period. The only result that appears to remain consistent is the RROR red light running violation results for the treated sites as compared to the local comparison sites.

Exhibit C-9 Summary of aggressive driving results: RROR effectiveness estimators found in interim and final analysis

Comparison	RRLVs	PSLVs
RLC + SE vs. LC	+44.7 (Interim) +42.7 (Final)	-33.2 (Interim) +5.5 (Final)
RLC + SE vs. DC	+5.0 (Interim) -64.9 (Final)	-32.4 (Interim) -3.3 (Final)
RLC + SE vs. LC + DC	+26.7 (Interim) + 0.4 (Final)	-30.9 (Interim) +3.4 (Final)
RLC + SE + LC vs. DC	-11.1 (Interim) -81.0 (Final)	-22.6 (Interim) -6.2 (Final)

When the idea of using red light running violation and posted speed limit violation data was first proposed by Working Group 1, it had been hoped that the data collected would provide some insight in the aggressive driving behaviour of motorists passing through the intersections, and possibly be an indicator of safety. Intuitively, it had been expected that aggressive driving, particularly red light running violations would decrease at the treated sites and remain the same at the control sites. Unfortunately, these results largely suggest that aggressive driving has worsened at the treated intersections as they contradict the EB results of the safety analysis. One main explanation is provided regarding the results:

- **There were other influencing factors at work at the evaluation study sites –** It would appear that there were other factors that were influencing the incidence of aggressive driving (RLRVs and PSLVs) at the evaluation study sites during the various observation periods. These factors appear to have overshadowed the effect of the treatment. A prime example of this is red light running violations at the distant comparison sites. The RLRV count was 202 in the before period, 88 and 129 in the interim period and 52 in the final period. As noted in earlier in this report, no safety intervention was to occur at the distant comparison sites, yet the total number of violations in the final period decreased almost 75%. The only possible explanation is that other intervening factors were present that overshadowed any effect the two treatments may have had.

For this reason, the results of the analysis of aggressive driving using the red light running and posted speed limit violation data were discarded by Working Group 1 as being flawed and will not be used as a basis for drawing any conclusions regarding the effectiveness of the treatments.

Appendix D - EB method

The EB method is the result of many years of research and testing of the method, see Hauer (1997). The merits of the EB approach are three. It helps to deal with the regression-to-the-mean (RTM) bias. Secondly, the EB estimates tend to be more precise than estimates from other methods. Lastly, the EB approach permits the estimation of the entire time series of expected incident occurrences. The EB approach involves two pieces of information being used to estimate the safety of a certain entity

i) the collision history of the entity,
ii) what is known about the safety of other entities with similar traits.

Therefore, the main difference between most conventional approaches and the EB approach is quite clear. Conventional approaches generally use only the collision history of an entity for estimating its safety, while knowledge of the safety of entities with similar traits is not utilized.

As mentioned above there are two pieces of information to be considered for measuring the safety (and changes thereof) of an entity. These two pieces of information must be joined into one estimate.

Hauer (1997) has demonstrated that the best estimate of the expected value of incident occurrence for a certain entity is given by:

$E(\kappa|K) = \alpha E(\kappa) + (1-\alpha)K$

where,

κ is the expected number of incidents of some kind and pertaining to a given period,

K is the actual number of incidents that occurred in the 'before' period,

$E(\kappa)$ is the mean of the reference population with similar traits as the entity,

α is a weighting factor that is a function of mean and variance of the κ's in the reference population, and is given by:

$\alpha = 1 / [\ 1 + (Var(\kappa) / E(\kappa)\ )\ ]$

The $Var(\kappa)$ and $E(\kappa)$ can be derived through two methods -- the method of sample moments or through multivariate regression modeling techniques. The most appropriate method to use depends upon the size of the reference population available.

With the ability to estimate $Var(\kappa)$ and the $E(\kappa)$ for the reference population, and $E(\kappa|K)$ and $Var(\kappa|K)$ for each entity (in this case, an intersection) of the treatment group it is possible to examine other relevant questions of interest. These include:

- What is the estimate of the expected frequency of incidents (e.g., collisions) for each treated intersection and how does its estimate compare to what is considered 'normal'? In other words, it is imperative to know how many incidents of a specified type should be

expected to occur at an average intersection with similar traits as the treated intersection. This is an important application of the E-B method -- if 'what is normal' is not known, then how is it possible to deduce 'what is deviant'? As discussed above, two statistical analytical methods (i.e., the 'Method of Sample Moments' and 'Multivariate Statistical Regression Models') can be used for deriving these estimates. These estimates provide the answer to 'what is considered *normal* for intersections of this type'.

- What is the *expected number of incidents* (e.g., collisions) that would have been expected to occur at each specific treated intersection in the after period, had treatment not been implemented? In other words, what is the estimate of each treated intersections safety before any treatment is applied to it? Here again, the 'method of sample moments' and 'multivariate statistical regression models' provide a sound statistical basis for estimating the Var(κ). Using the results of E(κ) and Var(κ) it is now possible to estimate the safety (i.e., expected number of incidents) of each treated intersection had the intersection not been treated.

- Is each intersection that was in the treated group a 'deviant' intersection? In other words, prior to treatment what is the probability that the safety of each of the treated intersections was significantly higher than the reference population group of similar type and characteristics -- i.e., the 'normal' estimator?

- Is the treatment effective in improving the safety of the intersections? In other words, are significant reductions in target incidents (e.g., collisions) expected due to the implementation of the treatment? Through the use of the EB method and procedures it is possible to estimate the true effects of treatments on the safety levels of entities (e.g., intersections).

As can be deduced by now the EB Method offers a variety of uses and applications for estimating the safety, and changers thereof, of travel on the roads. The benefits of the EB method of safety estimation are primarily to account for the regression-to-the-mean problem in observational before-after studies, thereby estimating the 'true' effects of treatments. As described above, however, its usefulness is much broader. It provides a scientifically proven method for devising the most precise estimates of the safety of individual entities whenever such information is required. Some of these types of applications might include 'Network Screening' for identifying and prioritizing deviant entities for potential treatment to improve the level of safety for road users.

Appendix E – Selected intersection characteristics

Municipality	Street 1	Street 2	App	F or T	Green	Cycle	Single	Pro_Left	Per_left	LOS	Truck	Speed	Excl_LT	Thru	R_Lens	A_Lens	G_Lens	LED
Halton	Brant	Fairview St.	WB	T	33	100	YES	NO	NO	A	3	60	1	2	300	300	300	NO
Halton	Walkers Line	Fairview St.	SB	T	39	110	YES	NO	NO	A	2	50	1	2	300	300	300	NO
Halton	Dorval	North Service Road	SB	T	25	120	NO	YES	YES	B	2	60	1	1	300	300	300	YES
Halton	Upper Middle	Dorval	EB	T	25	120	NO	YES	YES	A	6	60	1	1	300	300	300	YES
Halton	Upper Middle	Walkers Line	EB	T	45	95	YES	NO	NO	A	7	60	1	2	300	300	300	NO
Halton	Upper Middle	Guelph Line	SB	T	34	90	YES	NO	NO	A	5	50	1	2	300	300	300	NO
Halton	Dundas	Trafalgar	EB	T	55	120	NO	YES	YES		0	80	1	2	300	200	200	NO
Halton	Dundas	Brant	EB	T	21	62	YES	NO	NO	A	3	80	1	2	300	200	200	NO
Halton	Dundas	Guelph	EB	T	30	73	YES	NO	NO	A	3	60	1	2	300	200	200	NO
Halton	Upper Middle Road	Eighth Line	WB	F	50	120	NO	YES	YES		0	60	1	1	300	300	300	YES
Hamilton	West 5th	Mohawk	EB	F	28	80	YES	NO	NO	B	3	50	1	1	300	200	200	NO
Hamilton	Upper Sherman	Queensdale	SB	F	42	80	YES	NO	NO	A	3	50	0	0	300	200	200	NO
Hamilton	Wellington	Wilson	EB	F	36	70	YES	NO	NO	A	5	50	0	3	300	200	200	NO
Hamilton	Cannon	Wellington	WB	F	36	70	YES	NO	YES	A	38	50	0	3	300	200	200	NO
Hamilton	Fennel	Upper Wellingtom	WB	F	31	80	YES	NO	YES	C	10	50	1	1	300	200	200	NO
London	Wharncliffe	Baseline	NB	T	39	110	NO	YES	YES	C	3	50	1	2	300	200	200	NO
London	Viscount	Wonderland	SB	T	41	120	NO	YES	YES	C	3	60	1	2	300	200	200	NO
London	Southdale	Wharncliffe	SB	T	52	110	NO	YES	YES	A	3	70	1	2	300	200	200	NO
London	Pond Mills	Commissioners	WB	T	58	100	NO	YES	YES	A	5	60	1	2	300	200	200	NO
London	Southdale	Ernest/Nixon	WB	T	42	100	NO	YES	YES	A	3	60	1	1	300	200	200	NO
London	Commissioners	Wellington	NB	T	30	130	NO	YES	YES	C	4	50	1	3	300	200	200	NO
Ottawa	Kent	Albert	NB	F	21	55	YES	NO	YES	A	3	50	0	3	300	200	200	NO
Ottawa	Carling	Bronson	SB	F	27	70	NO	NO	YES	C	3	50	0	1	300	200	200	NO
Ottawa	RR13 Greenbank	RR12 Fallowfield	WB	T	25	60	NO	YES	YES	A	3	60	1	2	300	200	200	NO
Ottawa	RR17 Merivale	RR51 Meadowlands	NB	T	37	100	NO	YES	YES	C	3	60	1	2	300	200	200	NO
Ottawa	RR34 St. Joseph	RR55 Jeanne d'Arc	EB	T	33	90	YES	NO	YES	A	0		1	2	300	200	200	NO
Ottawa	RR36 Hazeldean/Robertson	RR49 Eagleson	SB	T	28	110	NO	YES	NO	A	5	60	1	3	300	200	200	NO
Ottawa	RR36 Robertson	RR59 Moodie	EB	T	29	120	NO	YES	NO	D	1	60	1	2	300	200	200	NO
Peel	Queen	Airport Rd.	WB	T	45	125	YES	NO	NO	A	11	80	1	3	300	200	200	NO
Peel	Hurontario	Derry	WB	T	47	100	YES	NO	NO	A	9	70	1	3	300	200	200	NO

Municipality	Street 1	Street 2	App	F or T	Green	Cycle	Single	Pro_Left	Per_left	LOS	Truck	Speed	Excl_LT	Thru	R_Lens	A_Lens	G_Lens	LED
Peel	Dundas	Dixie	EB	T	39	115	YES	NO	NO	A	5		1	3	300	200	200	NO
Peel	Eglinton	Dixie	SB	T	48	115	YES	NO	NO	A	9	70	1	3	300	200	200	NO
Peel	Erin Mills Pkwy	Dundas	NB	T	39	110	YES	NO	NO	A	7	70	1	3	300	200	200	NO
Peel	Steeles	Hurontario	SB	T	35	171	YES	NO	NO	B	2		1	3	300	200	200	NO
Peel	Erin Mills	Eglinton	SB	T	35	171	YES	NO	YES	B	2	70	1	3	300	200	200	NO
Toronto	Finch	Albion	WB	F	37	80	YES	NO	YES	A	5	60	1	2	300	200	200	NO
Toronto	Dixon	Martingrove	WB	F	32	90	NO	YES	YES	A	6	60	1	2	300	200	200	NO
Toronto	Don Mills	Finch	NB	T	38	104	NO	YES	YES	A	3	60	1	2	300	200	200	NO
Toronto	Don Mills	The Donway	NB	T	39	96	YES	NO	YES	A	4	60	1	2	300	200	200	NO
Toronto	Dupont	Lansdowne	WB	F	26	60	YES	NO	YES	A	5	50	0	0	300	200	200	NO
Toronto	Don Mills	Eglinton	WB	T	31	112	NO	YES	YES	B	7	60	1	3	300	300	300	NO
Toronto	Eglinton	Kennedy	EB	T	37	104	NO	YES	YES	B	4	60	1	3	300	200	200	NO
Toronto	Eglinton	Pharmacy	WB	T	46	104	NO	YES	YES	B	6	60	1	3	300	200	200	NO
Toronto	Eglinton	Laird	WB	F	40	80	NO	YES	YES	A	4	50	0	0	300	200	200	NO
Toronto	Eglinton	Jane	EB	F	32	80	NO	YES	YES	A	3	60	1	2	300	200	200	NO
Toronto	Eglinton	Martingrove	EB	F	45	90	NO	YES	YES	B	5	60	1	2	300	200	200	NO
Toronto	Finch	Kipling	EB	F	28	80	YES	NO	YES	A	7	60	1	2	300	200	200	NO
Toronto	Jane	Trethewey	SB	F	34	70	NO	YES	YES	A	5	50	1	1	300	200	200	NO
Toronto	McCowan	Lawrence	SB	F	33	90	YES	NO	YES	A	4	60	1	1	300	200	200	NO
Toronto	Finch	Midland	SB	F	33	80	NO	YES	YES	A	4	60	1	2	300	200	200	NO
Toronto	Sheppard	Neilson	NB	F	36	80	YES	NO	YES	A	5	50	1	2	300	200	200	NO
Toronto	Lawrence	Victoria Park	NB	F	29	90	NO	YES	YES	A	5	60	1	1	300	200	200	NO
Waterloo	Homer Watson	Ottawa	EB															
Waterloo	Homer Watson	Manitou	NB															
Windsor	Tecumseh	Lauzon	SB	F	32	106	NO	YES	NO	A	3	50	1	2	300	300	300	YES
Windsor	Tecumseh	Howard	SB	F	28	106	NO	YES	NO	A	4	50	1	1	300	300	300	YES
Windsor	Cabana	Dougall	WB	F	29	106	NO	YES	NO	A	4	60	1	2	300	300	300	YES
Windsor	Tecumseh	Walker	SB	F	26	106	NO	YES	NO	C	8	50	1	1	300	300	300	YES

Notes:
F or T – Fixed Time or Traffic Responsive, Green – Green time in seconds, Cycle – Cycle time in seconds, Single – Single Phase, Pro_Left – Protected Left, Per_Left – Permissive Left, LOS – Level of Service, Truck – Truck Volume Percentage, Speed – Posted Speed Limit, ExcLT – Number of exclusive left turn lane, Thru – Number of through lanes, R_Lens – Size of primary red lens in mm, A_Lens – Size of primary amber lens in mm, G_Lens – Size of green lens in mm, LED – Primary lens is LED type

Appendix F – Collision data

Reported collisions: before (average), interim and final

Municipality	Intersection	Treatment	Before	Interim	Final
City of Hamilton	Cannon Street @ Wellington Street	Local Comparison Site	4.2	5	3
City of Hamilton	Fennell Avenue @ Wellington Street	Local Comparison Site	5.8	5	7
City of Hamilton	Mohawk Road @ West 5th Street	Stepped-Up Police Enforcement	8.0	4	10
City of Hamilton	Queensdale @ Upper Sherman	Red Light Camera	4.2	4	2
City of Hamilton	Wilson @ Wellington	Stepped-Up Police Enforcement	7.8	4	4
City of Ottawa	Albert Street @ Kent Street	Red Light Camera	15.4	8	14
City of Ottawa	Bronson Avenue @ Carling Avenue/Glebe Street	Red Light Camera	18.0	19	22
City of Ottawa	RR 12 (Fallowfield) @ RR 13 (Greenbank)	Stepped-Up Police Enforcement	17.4	16	15
City of Ottawa	RR 17 (Merivale) @ RR 51 (Meadowlands)	Red Light Camera	17.2	22	14
City of Ottawa	RR 34 (St. Joseph) @ RR 55 (Jeanne d'Arc)	Red Light Camera	12.0	8	8
City of Ottawa	RR 36 (Hazeldean/Robertson) & RR 49 (Eagleson)	Red Light Camera	24.0	20	16
City of Ottawa	RR 36 (Robertson) @ RR 59 (Moodie)	Stepped-Up Police Enforcement	19.0	13	17
City of Toronto	Albion Rd @ Finch Ave. W.	Stepped-Up Police Enforcement	27.8	27	28
City of Toronto	Dixon Road @ Martingrove Road	Red Light Camera	34.6	33	29
City of Toronto	Don Mills Road @ Finch Avenue East	Red Light Camera	34.2	43	27
City of Toronto	Don Mills Road @ The Donway North	Local Comparison Site	14.4	9	9
City of Toronto	Dupont Street @ Landsdowne Avenue	Local Comparison Site	24.0	28	22
City of Toronto	Eglinton Ave. E. @ Laird Dr.	Stepped-Up Police Enforcement	16.2	22	12
City of Toronto	Eglinton Ave. W. @ Jane St.	Stepped-Up Police Enforcement	20.6	27	23
City of Toronto	Eglinton Avenue @ Don Mills Road	Red Light Camera	41.4	61	38
City of Toronto	Eglinton Avenue @ Kennedy Road	Local Comparison Site	37.2	34	41
City of Toronto	Eglinton Avenue @ Pharmacy Avenue	Red Light Camera	29.0	35	38
City of Toronto	Eglinton Avenue West @ Martingrove Road	Red Light Camera	26.0	46	30
City of Toronto	Finch Avenue @ Kipling Avenue	Red Light Camera	31.0	41	32
City of Toronto	Jane Street @ Trethewey Drive	Local Comparison Site	12.0	9	17
City of Toronto	McCowan Rd. @ Lawrence Ave. E.	Stepped-Up Police Enforcement	42.2	50	46
City of Toronto	Midland Avenue @ Finch Avenue East	Local comparison Site	32.8	22	31
City of Toronto	Neilson Road @ Sheppard Avenue East	Local comparison Site	19.8	20	15
City of Toronto	Victoria Park at Lawrence Avenue East	Red Light Camera	44.2	51	43
Region of Halton	Dorval Drive @ North Service Road	Red Light Camera	13.0	27	26
Region of Halton	Dorval Drive @ Upper Middle Road	Stepped-Up Police Enforcement	16.7	34	31
Region of Halton	Fairview Street @ Brant Street	Stepped-Up Police Enforcement	26.6	22	36
Region of Halton	Fairview Street @ Walker's Line	Local Comparison Site	15.0	11	23
Region of Halton	Guelph Line @ Upper Middle Road	Local Comparison Site	12.0	21	19
Region of Halton	RR 5 (Dundas Street) @ Brant Street/ Cedar Springs Road	Local Comparison Site	3.8	9	18
Region of Halton	RR 5 (Dundas Street) @ Guelph Line	Stepped-Up Police Enforcement	9.0	12	11
Region of Halton	RR 5 (Dundas Street) @ Trafalgar Road	Red Light Camera	14.2	35	25
Region of Halton	Upper Middle Road @ 8th Line	Local Comparison Site	5.8	16	10
Region of Halton	Upper Middle Road @ Walker's Line	Red Light Camera	17.6	21	23
Region of Peel	Airport Road @ Queen Street	Stepped-Up Police Enforcement	14.0	17	26
Region of Peel	Derry Road @ Hurontario Street	Red Light Camera	26.2	23	43

Municipality	Intersection	Treatment	Before	Interim	Final
Region of Peel	Dixie Road @ Dundas Street	Red Light Camera	30.0	59	44
Region of Peel	Dixie Road @ Eglinton Avenue	Stepped-Up Police Enforcement	28.4	39	33
Region of Peel	Erin Mills Parkway @ Dundas Street	Stepped-Up Police Enforcement	25.0	69	47
Region of Peel	Erin Mills Parkway @ Eglinton Avenue	Stepped-Up Police Enforcement	25.8	53	43
Region of Peel	Steeles Avenue @ Hurontario Street	Stepped-Up Police Enforcement	61.0	50	37
Region of Waterloo	Homer Watson Boulevard @ Manitou Drive/Doon Village Road	Stepped-Up Police Enforcement	12.2	11	9
Region of Waterloo	Homer Watson Boulevard @ Ottawa Street	Red Light Camera	21.2	15	19
Total			1017.9	1421	1360

Reported fatal and injury collisions: before (average), interim and final

Municipality	Intersection	Treatment	Before	Interim	Final
City of Hamilton	Cannon Street @ Wellington Street	Local Comparison Site	2.4	3	0
City of Hamilton	Fennell Avenue @ Wellington Street	Local Comparison Site	3.6	3	4
City of Hamilton	Mohawk Road @ West 5th Street	Stepped-Up Police Enforcement	4.4	0	7
City of Hamilton	Queensdale @ Upper Sherman	Red Light Camera	2.4	3	2
City of Hamilton	Wilson @ Wellington	Stepped-Up Police Enforcement	4.0	3	3
City of Ottawa	Albert Street @ Kent Street	Red Light Camera	5.0	4	5
City of Ottawa	Bronson Avenue @ Carling Avenue/Glebe Street	Red Light Camera	4.6	4	2
City of Ottawa	RR 12 (Fallowfield) @ RR 13 (Greenbank)	Stepped-Up Police Enforcement	5.8	5	8
City of Ottawa	RR 17 (Merivale) @ RR 51 (Meadowlands)	Red Light Camera	4.8	9	6
City of Ottawa	RR 34 (St. Joseph) @ RR 55 (Jeanne d'Arc)	Red Light Camera	3.4	1	3
City of Ottawa	RR 36 (Hazeldean/Robertson) & RR 49 (Eagleson)	Red Light Camera	5.0	2	9
City of Ottawa	RR 36 (Robertson) @ RR 59 (Moodie)	Stepped-Up Police Enforcement	5.2	3	6
City of Toronto	Albion Rd @ Finch Ave. W.	Stepped-Up Police Enforcement	14.4	8	13
City of Toronto	Dixon Road @ Martingrove Road	Red Light Camera	13.2	16	14
City of Toronto	Don Mills Road @ Finch Avenue East	Red Light Camera	16.0	14	12
City of Toronto	Don Mills Road @ The Donway North	Local Comparison Site	6.0	3	3
City of Toronto	Dupont Street @ Landsdowne Avenue	Local Comparison Site	7.4	3	7
City of Toronto	Eglinton Ave. E. @ Laird Dr.	Stepped-Up Police Enforcement	5.8	6	3
City of Toronto	Eglinton Ave. W. @ Jane St.	Stepped-Up Police Enforcement	7.4	10	17
City of Toronto	Eglinton Avenue @ Don Mills Road	Red Light Camera	16.0	21	13
City of Toronto	Eglinton Avenue @ Kennedy Road	Local Comparison Site	15.0	13	11
City of Toronto	Eglinton Avenue @ Pharmacy Avenue	Red Light Camera	12.8	11	11
City of Toronto	Eglinton Avenue West @ Martingrove Road	Red Light Camera	9.0	13	12
City of Toronto	Finch Avenue @ Kipling Avenue	Red Light Camera	13.2	20	10
City of Toronto	Jane Street @ Trethewey Drive	Local Comparison Site	4.0	3	4
City of Toronto	McCowan Rd. @ Lawrence Ave. E.	Stepped-Up Police Enforcement	16.0	22	12
City of Toronto	Midland Avenue @ Finch Avenue East	Local Comparison Site	11.0	8	13
City of Toronto	Neilson Road @ Sheppard Avenue East	Local Comparison Site	8.4	7	6
City of Toronto	Victoria Park at Lawrence Avenue East	Red Light Camera	17.4	18	20
Region of Halton	Dorval Drive @ North Service Road	Red Light Camera	4.0	4	7
Region of Halton	Dorval Drive @ Upper Middle Road	Stepped-Up Police Enforcement	4.0	8	7
Region of Halton	Fairview Street @ Brant Street	Stepped-Up Police Enforcement	5.0	3	5
Region of Halton	Fairview Street @ Walker's Line	Local Comparison Site	3.4	2	3
Region of Halton	Guelph Line @ Upper Middle Road	Local Comparison Site	4.0	3	4
Region of Halton	RR 5 (Dundas Street) @ Brant Street/ Cedar Springs Road	Local Comparison Site	0.8	5	8
Region of Halton	RR 5 (Dundas Street) @ Guelph Line	Stepped-Up Police Enforcement	3.8	6	3
Region of Halton	RR 5 (Dundas Street) @ Trafalgar Road	Red Light Camera	3.0	4	7
Region of Halton	Upper Middle Road @ 8th Line	Local Comparison Site	1.6	1	1
Region of Halton	Upper Middle Road @ Walker's Line	Red Light Camera	4.0	5	4
Region of Peel	Airport Road @ Queen Street	Stepped-Up Police Enforcement	2.3	4	5
Region of Peel	Derry Road @ Hurontario Street	Red Light Camera	6.6	3	7
Region of Peel	Dixie Road @ Dundas Street	Red Light Camera	5.2	6	3

Municipality	Intersection	Treatment	Before	Interim	Final
Region of Peel	Dixie Road @ Eglinton Avenue	Stepped-Up Police Enforcement	5.4	5	2
Region of Peel	Erin Mills Parkway @ Dundas Street	Stepped-Up Police Enforcement	4.8	6	4
Region of Peel	Erin Mills Parkway @ Eglinton Avenue	Stepped-Up Police Enforcement	5.4	4	4
Region of Peel	Steeles Avenue @ Hurontario Street	Stepped-Up Police Enforcement	16.4	7	5
Region of Waterloo	Homer Watson Boulevard @ Manitou Drive/Doon Village Road	Stepped-Up Police Enforcement	2.8	2	5
Region of Waterloo	Homer Watson Boulevard @ Ottawa Street	Red Light Camera	7.2	4	6
Total			**389.3**	**364.0**	**383.0**

Appendix G – Trending of volume data

Not all of the municipalities were able to provide the evaluation study team with volumes for each years in the before period (1995-1999) or the interim and final period. If the municipality did not have volume information for a given year, different methods were used to estimate the volume using the years available. In the first example in **Exhibit G-1**, AADT volume data was provided for the shaded years 1996 and 1998 and trended linearly for the other years. In the second example, the volume information was provided for four years as shown in **Exhibit G-2**. In this example, the average of the four years (1996 – 1999) was used to estimate the volume in the missing year (1995). If some cases, volume information was only available for one year. In the third example, volume data is only available for 1996, as shown in **Exhibit G-3.** If this was the case, it was assumed that the volume stayed constant at that level for the remaining years**.**

Exhibit G-1 Estimating volume using two years (Method 1)

Year	North approach	South approach	East approach	West approach
1995	4975	4975	2005	2005
1996	**5000**	**5000**	**2000**	**2000**
1997	5025	5025	1995	1995
1998	**5050**	**5050**	**1990**	**1990**
1999	5075	5075	1985	1985

Exhibit G-2 Estimating volume using multiple years (Method 2)

Year	North approach	South approach	East approach	West approach
1995	5000	4900	2100	1995
1996	**5000**	**5000**	**2000**	**2000**
1997	**4900**	**4800**	**2100**	**1990**
1998	**5100**	**4900**	**2200**	**1990**
1999	**5000**	**4900**	**2100**	**2000**

Exhibit G-3 Estimating volume using one year (Method 3)

Year	North approach	South approach	East approach	West approach
1995	5013	5015	2154	2194
1996	**5013**	**5015**	**2154**	**2194**
1997	5013	5015	2154	2194
1998	5013	5015	2154	2194
1999	5013	5015	2154	2194

Appendix H – SPF equation parameters

SPF model for fatal and injury collisions combined

Model Form SPF = $a*(AADT)^b$

- "a" and "b" are estimated from GLIM software (a = 6.57958E-06 and b = 1.277789)
- AADT Range From 8853 to 98746

	estimate	s.e.
log(a)	-11.93154	0.6414424
b	1.277789	0.05959579

SPF model for property damage only collisions

Model Form SPF = $a*(AADT)^b$

- "a" and "b" are estimated from GLIM software(a = 5.03927E-06 and b = 1.371455)
- AADT Range From 8853 to 98746

	estimate	s.e.
log(a)	-12.19825	0.5388965
b	1.371455	0.05016859

SPF Model for angle, fatal and injury collisions

Model Form SPF = $a*(AADT)^b$

- "a" and "b" are estimated from GLIM software (a = 0.0639546 and b = 0.2979189)
- AADT Range From 8853 to 98746

	estimate	s.e.
log(a)	-2.749582	0.9347607
b	0.2979189	0.08736029

SPF Model for angle, property damage only collisions

Model Form SPF = $a*(AADT)^b$

- "a" and "b" are estimated from GLIM software (a = 0.0427107 and b = 0.3831285)
- AADT Range From 8853 to 98746

	estimate	s.e.
log(a)	-3.153305	0.8472006
b	0.3831285	0.07919040

SPF Model for rear-end, fatal and injury collisions

Model Form SPF = $a*(AADT)^b$

- "a" and "b" are to be estimated from GLIM software (a = 6.301E-10 and b = 2.025379)
- AADT Range From 8853 to 98746

	estimate	s.e.
log(a)	-21.18511	1.062527
b	2.025379	0.09783909

SPF Model for rear-end, property damage only collisions

Model Form SPF = $a*(AADT)^b$

- "a" and "b" are to be estimated from GLIM software (a = 5.643E-09 and b = 1.898111)
- AADT Range From 8853 to 98746

	estimate	s.e.
log(a)	-18.99282	0.7941384
b	1.898111	0.07340544

Appendix I – Estimating the benefits and costs of the treatments on all signalized intersections

The effect of the treatments on all signalized intersections within the six municipalities is being estimated for the two years of the pilot project, for illustration purposes. The estimates are a hypothetical extension of a portion of the safety benefits to all signalized intersections in the six municipalities.

For consistency in the presentation of the various calculations, all figures shown are rounded to the nearest dollar. Due to the rounding, calculations presented are approximations. For more background information on each of the costs and benefits discussed in this section, refer to **Sections 8** and **9** of the report.

I.1 Benefit calculations

Assumptions in the calculation of benefits

As a detailed measure an analysis of the actual effectiveness at these other signalized intersections is beyond the scope of this evaluation study, the study team was requested to apply 15% of the safety benefit (measured through the evaluation study) to all other untreated signalized intersections in the six participating municipalities. Although the application of 15% of the safety benefit was not based on a formal analysis, the municipalities requested that this figure be used for illustrative purposes only, recognizing that the resulting calculation cannot be considered as statistically significant and as such it should be referenced with caution.

The six municipalities provided fatal, injury and property damage totals for all their signalized intersections for the years 1998 – 1999. Using this information multiplied by the EB estimators presented in Part II provided a basis for estimating:

- the number of fatal and injury collisions *avoided* among the signalized intersections in the six municipalities; and
- the number of property damage only collisions *incurred* among the signalized intersections in the six municipalities.

Calculation of fatal and injury collisions

The weighted social cost of a fatal and injury collision was calculated as follows, using the pre-treatment signalized intersection data provided by the six municipalities. The proportion of fatal to injury collisions at signalized intersections across the six municipalities in the years 1998-1999 is roughly the same as the proportion of fatal to injury collisions among the forty-eight evaluation study sites during the first two years of the pilot project. In 1998-1999, an estimated 19,619 fatal and injury collisions occurred, subgrouped as follows:

- Estimated fatal collisions (99 of 19,619, or 0.505%); and
- Estimated injury collisions (19,520 of 19,619, or 99.495%).

The weighted fatal and injury social cost is then:

$8,268,421	(Fatal social cost of collision)	x	0.495%	(Fatal proportion)	+
$35,517	(Injury social cost of collision)	x	99.505%	(Injury proportion)	=
$77,093					

The estimated number of fatal and injury collisions occurring in the six municipalities in 1998-1999 was 19,619. Assuming that the treatments only affected 15% of the signalized intersections, the total number of affected collisions is reduced to 2,943. To calculate the number of fatal and injury collisions that would have been avoided during the first two years of the pilot project among the signalized intersections across the six municipalities, the percentage decrease in casualty collisions calculated as part of the Empirical Bayes analysis (6.8%) is multiplied by the estimated number of affected fatal and injury collisions at signalized intersections in the six municipalities (2,943) to arrive at the value of 200 fatal and injury collisions avoided.

The cost of the fatal and injury collisions avoided is:

200	Fatal and injury collisions avoided	x
$77,093	Weighted fatal and injury social cost	=
$15,418,600		

Calculation of property damage only collisions

The estimated number of property damage only collisions occurring in the six municipalities in 1998-1999 was 37,281. Assuming that the treatments only affected 15% of the signalized intersections, the total number of affected collisions is reduced to 5,592. To calculate the number of property damage only collisions that would have been avoided during the first two years of the pilot project among the signalized intersections across the six municipalities, the percentage increase in property damage only collisions calculated as part of the EB analysis (18.5%) is multiplied by the estimated number of affected property damage only collisions at signalized intersections in the six municipalities (5,592) to arrive at the value of 1035 incurred.

The cost of the property damage only collisions incurred is:

1035	Property damage only collisions incurred	x
$8,038	Property damage only collision social cost	=
$8,319,330		

I.2 Cost calculations

The following sections provide a detailed explanation of the following cost calculations:

- Ongoing provincial costs related to the operation of red light cameras and stepped-up police enforcement;
- Municipal costs related to the publicity campaign launched at the beginning of the pilot project and the cost of photographs required for evidence in court;
- Capital costs (red light camera system and Municipal Joint Processing Centre);
- Operating costs (red light camera system and Municipal Joint Processing Centre);
- Recovered and potential recovered costs (fine revenue and fines imposed);
- Court processing costs; and
- Stepped-up police enforcement costs.

Ongoing provincial costs

Ongoing provincial costs related to the operation of red light cameras and stepped-up police enforcement amounted to **$430,302** for the first two years of the pilot project.

Municipal costs

Municipal costs related to the publicity campaign and the cost of photographs required for evidence in court. The municipalities are billed directly by the Red Light Camera vendor for this amount. This represents a total of **$440,815** for all pilot project sites.

Red light camera system capital costs

To determine the cost attributable to all of the red light camera sites in the entire pilot project, the five-year annualized cost per camera ($15,517) is multiplied by the number of years in the evaluation study and the number of red light camera sites (68 in all):

$15,517	Five year annualized unit cost per red light camera site	x
2	Two years in evaluation study	x
68	Number of red light camera evaluation sites	=
$2,110,312		

Municipal Joint Processing Centre capital costs

The capital equipment costs attributed to the entire pilot project (all red light camera sites) is simply the 5-year annualized capital equipment figure presented in **Section 9.3** ($39,160) multiplied by two years (**$78,320**).

Red Light Camera system operating costs

The operating cost for the red light camera system was provided by the municipalities. Operating costs involve the operation of the red light cameras, including maintenance, loading/unloading film and developing film. The total operating cost of the red light cameras attributable to the red light camera sites is **$2,060,508.**

Municipal Joint Processing Centre operating costs

The total operating cost associated with the Municipal Joint Processing Centre (as borne by all sites in the pilot project) is simply the $**946,633** figure presented in **Section 9.4.2**.

Calculation of fine revenue and fine dispositions imposed

Based on data provided to the consultant team from the Municipal Joint Processing Centre and the stepped-up police enforcement forms, in total, for the nineteen red light camera and the seventeen stepped-up police enforcement intersections included in the evaluation, 47,208 tickets were issued. Based on this information, the prepayment amount generated from tickets associated with the sixty-eight red light camera and twenty-seven stepped-up police enforcement intersections in the pilot project is estimated[23] at:

$136.30	Average ticket value	x
25,492	Prepaid (54 per cent of 47,208)	=
$3,474,560		

Fine dispositions imposed are calculated as:

$136.30	Average ticket value	x
17,373	Fine dispositions (80 per cent of (46 per cent of 47,208))	=
$2,367,940		

Therefore, it is estimated that net fine revenue (based on prepayments) and fine dispositions that are anticipated to be collected will amount to **$5,842,500** for the entire pilot project.

Court processing costs

All tickets originating from all pilot project sites (95 red light camera or stepped-up police enforcement sites) are included in the calculation. Overall court costs are then calculated as **$1,432,574** as shown in Exhibit I-1.

Exhibit I-1 – Court processing costs

Court processing cost category	Cost
Pre-disposition processing costs	$315,533
Trial costs	$801,507
Post-disposition processing costs	$315,533
TOTAL	**$1,432,574**

For the above, the costs of each category are rounded off to the nearest dollar, consequently there is a slight discrepancy between the total shown and the sum of the figures presented.

[23] The actual amount of prepaid fines and fines imposed is not available for the sites in the evaluation.

Stepped-up police enforcement

As there are a total of twenty-seven stepped-up police enforcement sites in the entire pilot project, the total estimated cost for the two years of the pilot project is **$308,586** (by prorating 27/17 to reflect the additional contribution of the ten non-study sites).

I.3 Net benefits and costs

The calculations in this appendix are illustrative of the benefits of the treatments had they affected collisions at 15% of the signalized intersections in the six municipalities in the same manner as the findings of this evaluation study. Costs are estimated for all 95 red light camera and stepped-up police enforcement sites in the six municipalities. **Exhibits I-2** and **I-3** show the estimated benefits and costs as presented in **Appendix I**.

Exhibit I-2 Estimated net benefits

Item	Benefit
Fatal and injury collisions – collisions avoided[1]	$15,418,600
Property damage only collisions – collisions incurred[1]	($8,319,330)
Estimated net benefits	**$7,099,270**
Notes: 1 Assuming only 15% of the signalized intersections in the six municipalities were affected in the same way as the 48 evaluation study sites.	

Exhibit I-3 Estimated net costs

Item	Cost
Ongoing provincial costs	$430,302
Municipal costs	$440,815
Red light camera system capital costs	$2,110,312
Municipal Joint Processing Centre capital costs	$78,320
Red Light Camera System operating costs	$2,060,508
Municipal Joint Processing Centre operating costs	$946,633
Fine revenue	($3,474,560)
Fine dispositions imposed	($2,367,940)
Court processing costs	$1,432,574
Stepped-up police enforcement costs	$308,586
Estimated net costs	**$1,965,551**

I.4 Results of benefit-cost analysis

Based on the estimated net benefits and costs presented in this appendix, the benefit-to-cost ratio is calculated to be 3.61 as shown in **Exhibit 1-4.**

Exhibit I-4 Estimated net benefits and costs (November 20, 2000 – November 19, 2002)

Estimated net benefits and costs[1]	
Total net benefits	$7.10 million
Total net costs	$1.97 million
Benefit-to-cost ratio	**3.61**

Notes:

[1]The total net benefits are illustrative of the benefits of the treatments had they affected collisions at 15% of the signalized intersections in the six municipalities in the same manner as the findings of this evaluation study. Costs are estimated for all 95 red light camera and stepped-up police enforcement sites in the six municipalities.