SafeLight Raleigh Camera Analysis
Observational Before-After Study

Prepared for
Xerox State & Local Solutions, Inc. and the City of Raleigh

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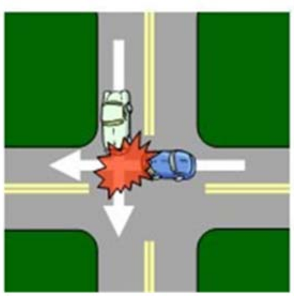
EXECUTIVE SUMMARY

Xerox State and Local Solutions, Inc. (formerly ACS) contracted with AECOM for an independent analysis of the SafeLight Raleigh red-light camera program which started back in 2003. This project was in part to fulfill the *Extension for Red Light Camera Contract* on the September 20, 2011 Public Works Consent Agenda for the City of Raleigh; specifically it stated, "… ACS will relocate one camera and conduct a 3rd party analysis of the program …." The City of Raleigh's Transportation Operations Division (the City), which manages the SafeLight Raleigh program, scoped the study for analysis methodology. To maintain independence, the City's role was that of a data compiler. The focus of study was determining if there is a relationship between crash levels and red-light camera operation at an intersection. Specifically, did angle crashes decrease from before the treatment (camera installation) to after? Implicit in the question is whether the treatment itself, and not other factors, can be found to effect crash levels. Hence, other factors that may trend with crash frequencies or bias them must be accounted for so the treatment effect is isolated and becomes visible. To this end, Safety Performance Functions that incorporate intersection traits and traffic volumes to estimate and predict crash levels assist with the former and Empircal Bayes methods assist with the latter.

A total of twenty-nine intersections were studied, sixteen of which were in the SafeLight Raleigh program, and the remaining intersections served as comparisons. Cameras were installed in three sets, one in 2003, one in 2004, and one in 2009. Crash data were compiled by the City from the statewide crash database, Traffic Engineering Accident Analysis System (TEAAS), for all Type 30 crashes that occurred at the study intersections for at least three years before and three years after camera installation (for treatment sites and paired comparison sites). These data were supplemented by intersection characteristics, signal operations, and traffic volumes by both the City and AECOM. For a follow-on analysis that is discussed in the Addendum, the City performed data compilation of Type 21 rear end crashes at the study intersections.

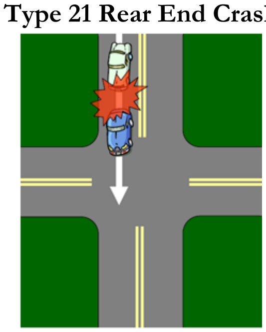
There are many types of crashes that can occur at an intersection – sideswipes, rear-ends, head-on collisions, hitting an object, running off the road, and more. Angle crashes are often the target of red-light camera programs since they occur in an intersection because one or more vehicles have violated the temporally-assigned right-of-way as designated by the intersection's traffic signal; serious injury and death may result from such impacts (high severity potential). The original study dataset (as described in the main report) was comprised solely of Type 30 angle accident records as defined by the North Carolina Department of Motor Vehicles. Type 30 crashes involve two vehicles from opposing directions of travel impacting one another at approximately right-angles to each other; typically, these are called angle accidents, broadsides, and T-bones (see image at left). Rear-ends (see image at right) are the other common crash type examined when assessing such programs because avoiding running a red light and earning a citation can involve drivers depressing their brakes fast and hard, then being impacted by one or more following vehicles; impacts usually cause property damage only (low severity potential). Hence, research has often shown an inversely proportional relationship between angle and rear-end crashes at red-light camera locations, in other words, a tradeoff. Of direct interest in this regard are the findings of Cunningham and Hummer (2010), as part of a study for the City of Raleigh's SafeLight cameras, that rear-end crashes in Raleigh (data through July 2007) did not significantly change after cameras were installed. In light of their results and the knowledge that angle collisions are typically the more severe crash type, the focus on Type 30 angle crashes for the main report seems reasonable as the strongest indicator

Type 30 Angle Crash



Source: Federal Highway Administration

Type 21 Rear End Crash



Source: Federal Highway Administration

of changing safety levels. The addendum is focused on the Type 21 rear end crash (as defined by the North Carolina Department of Motor Vehicles) to augment the previously conducted angle crash analysis described in the main report and further aid the City in determining if the red light camera system is providing an overall benefit at the treated intersections. Typically, there is an inverse relationship between the occurrence of angle and rear end crashes at red light camera locations. Therefore, this rear end crash analysis has been conducted to see if that relation holds true for Raleigh and if so, what the ratio of the two crash types is before and after treatment.

To assess the safety impact (or safety effectiveness) of the SafeLight Raleigh program, what is called an *observational before-after study* was conducted. Simply put, crashes occur over time at an intersection, some crashes are "observed" (official accident reports are filed, thereby recording events), observed crashes are then grouped into those that occurred before a treatment (such as a red-light camera installation) and those that occurred after a treatment, finally results are compared to determine how crash levels have changed from before to after a treatment and how such results may be directly related to the treatment itself (as opposed to being related to other variables, such as the after period having significantly more bad weather). Within the format of observational before-after studies, a variety of analysis methods can be applied depending on the needs of an organization, budget constraints, available data, and analyst experience. For this study, multiple observational before-after analyses – from simplistic "naïve" methods[1] to complex multivariate methods – were conducted to enable Xerox State and Local Solutions, Inc. (Xerox) and the City to see how results vary with the types and amounts of data incorporated and the methods applied, thereby gaining comfort in the conclusions reached and gaining an understanding of the need to go beyond naïve observational before-after analyses. The multivariate methods are based on Hauer (2002) and drawn from the *Highway Safety Manual* (HSM), 2010 edition – a federal-level guideline for transportation engineering practitioners. Presented below are the results of the naïve analyses for each crash type analyzed.

Overall Safety Effectiveness as a Percent Change in Crash Frequency Across All Treatment Sites

Methodology Applied	Change in Crashes Average crashes +/- stdev(Average crashes)	Percent Change SafeEff +/- SE(SafeEff)
<u>Type 30 Angle Crashes</u>		
Naïve Before-After	108 +/- 19.03	46.2 % +/- 5.9 %
Naïve with Traffic Factor Before-After	105 +/- 19.44	45.4 % +/- 6.1 %
Comparison-Group Study, Naïve Style	100 +/- 215.97	70.6 % +/- 14.7 %
Comparison-Group Study, Naïve Style, Pooled Sites	178 +/- 63.40	60.0 % +/- 8.6 %
<u>Type 21 Rear End Crashes</u>		
Naïve Before-After	-80 +/- 19.90	-49.7 % +/- 15.3 %
Naïve with Traffic Factor Before-After	-82 +/- 20.07	-51.8 % +/- 15.8 %
Comparison-Group Study, Naïve Style	-88 +/- 163.94	27.4 % +/- 36.2 %
Comparison-Group Study, Naïve Style, Pooled Sites	-56 +/- 38.38	-25.8 % +/- 24.7 %

SafeEff = Safety Effectiveness; stdev(average crashes) = standard deviation of the average number of crashes; SE(SafeEff) = standard error of SafeEff.

Applying two methods that are more complex, with refinements that each adds more local knowledge, results are summarized in the following table for each crash type.

[1] Paraphrasing Hauer (2002), a naïve observational before-after method is one that compares accident counts from before a treatment to accident counts after a treatment. The count of before crashes is used to predict what would have been the expected crash count in the after period <u>had the treatment not been applied</u>. Implicit is the typically unrealistic assumption that nothing else has changed over time (but adding the treatment). And that the available counts are a reasonable proxy for the actual distribution of crashes.

Comparing Overall Safety Effectiveness of Angle and Rear End Crashes Across All Treatment Sites

Methodology Applied	Percent Change in **Type 30 Angles** SafeEff +/- SE(SafeEff), (Approx. Sig.)	Percent Change in **Type 21 Rear Ends** SafeEff +/- SE(SafeEff), (Approx. Sig.)
HSM 1: Empirical Bayes Before/After Safety Evaluation		
Base Case	48.06 % +/- 5.58 %, (8.61)	-33.63 % +/- 12.87 %, (2.61)
Refinement 1	45.94 % +/- 5.85 %, (7.86)	-41.25 % +/- 13.82 %, (2.98)
Refinement 2	55.03 % +/- 4.73 %, (11.64)	-10.21 % +/- 10.08 %, (1.01)
Refinement 3	59.34 % +/- 4.21 %, (14.08)	3.21 % +/- 8.58 %, (0.37)
Refinement 4	59.17 % +/- 4.23 %, (13.98)	3.99 % +/- 8.49 %, (0.47)
HSM 2: Before/After Comparison-Group Safety Evaluation		
Base Case	52.85 % +/- 5.71 %, (9.26)	-31.96 % +/- 15.17 %, (2.11)
Refinement 1	51.69 % +/- 5.85 %, (8.83)	-31.49 % +/- 15.33 %, (2.05)
Refinement 2	51.71 % +/- 5.85 %, (8.83)	-31.52 % +/- 15.33 %, (2.06)
Refinement 3	51.78 % +/- 5.85 %, (8.85)	-31.58 % +/- 15.35 %, (2.06)
Refinement 4	51.78 % +/- 5.85 %, (8.85)	-31.58 % +/- 15.35 %, (2.06)

SafeEff = Safety Effectiveness; SE(SafeEff) = standard error of SafeEff; Approx. Sig. = approximate significance (greater than 2.0 means significant at least at the 95% confidence level)

Overall, the results and our analysis suggest that the SafeLight Raleigh red-light camera program is having a positive impact by, on average, a 52 percent reduction in Type 30 angle crashes at this group of treated intersections. Based on the multiple analyses, the smallest percent change in angle crash frequency was approximately a 39 percent reduction and the largest percent change was approximately 85 percent; these widely varying results were found via the naïve approaches. The methods that incorporate more information about the intersections and crashes (HSM 1 & HSM 2) show a tighter spread of safety effectiveness (approximately 40% to 64%) both in terms of the mean values and their standard errors. In detail, most treated intersections had improved safety; however, the analysis suggests a few locations did not benefit with respect to Type 30 crash types. Therefore, the program may further be improved after assessing what those few intersections had in common with one another and how they differed from the majority of the treated intersections.

For the Type 21 rear end crashes, the opposite results were obtained – the results suggest that the SafeLight Raleigh red-light camera program is having a negative impact by, on average, a 32 percent increase in Type 21 rear end crashes at this group of treated intersections. Based on the multiple analyses, the smallest percent change in rear end crash frequency was approximately a 64 percent reduction and the largest percent change was approximately a 68 percent increase; these widely varying results were found with the naïve approaches – and as discussed in the Addendum's Results section, the naïve style comparison-group study is quite different from the other analyses because the mean and variance of the odds ratio are much higher than normal. The methods that incorporate more information about the intersections and crashes (HSM 1 & HSM 2) show a tighter spread of safety effectiveness both in terms of the means (-41 to +4%) and their standard errors (9 to 15%). In general, most treated intersections were less safe with respect to Type 21 rear end crashes.

Red-light camera research typically shows an inverse relationship between angle and rear end crashes, in other words, as angle crashes decrease rear end crashes often increase – although the proportionate changes may vary. Typically, the former are more severe and the latter more often property damage only. Investigating the proportionality between the two crash types at the SafeLight Raleigh program locations in this study is now possible with the completion of the addendum. Comparing results of the two crash types, the City of Raleigh does indeed display the typical inverse relationship between angle and rear end crashes. Specifically, Type 30 angle crashes are expected to <u>reduce by approximately 52 percent</u> (or by 122 from 235 to 113) at intersections treated with red light cameras while Type 21 rear end crashes are expected to <u>increase by approximately 32 percent</u> (or by 51 from 158 to 209) at intersections treated with red light cameras as compared to the untreated comparison intersections in this study. Therefore, there is a net improvement in safety, when focusing on the number of angle and rear end crashes at the intersections treated with red light cameras as part of the SafeLight Raleigh program based on the sites and time periods studied; additional variables to consider are the severity of crashes and property damage costs incurred.

Although the results are encouraging, potential limitations of this study should of course be mentioned.

- Short "before and after" time periods that lessen the ability to identify patterns and trends. Although, the HSM methods yielded results that were strongly statistically significant with confidence levels above 95 percent.
- A small number of comparison intersections, with some sites possibly exhibiting spillover effects.
- Some intersections were at or near interchanges which is not recommended by the Highway Safety Manual for inclusion in the more complex analysis methods.

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ABBREVIATIONS

AADT	average annual daily traffic (vehicles per day on a road section)
avg	average
C-G	Comparison-Group study
DOT	Department of Transportation
EB	Empirical Bayes method
FHWA	Federal Highway Administration
FI	crash with a fatality or injury
hrs	hours
HSM	Highway Safety Manual, 2010 Edition
mph	speed, miles per hour
NC	North Carolina
NCDOT	North Carolina Department of Transportation
PDO	crash with property damage only
RLC	red-light camera
RLR	red-light running
RTM	regression-to-the-mean
stdev	standard deviation
TEAAS	Traffic Engineering Accident Analysis System
USDOT	United States Department of Transportation
var	variance
vol	volume
yr	year

MATHEMATICAL NOTATION

For consistency, the notation in this report follows the notation used in Hauer, 2002 and HSM, 2010.

Aft#Yr	number of crashes in the after period for the #'ed year after camera install. For example, Aft2Yr is the number of crashes in the year that is 2 years after camera install.
Bef#Yr	number of crashes in the before period for the #'ed year before camera install. For example, Bef3Yr is the number of crashes in the year that is 3 years prior to the camera install.
R_SiteType	0/1 variable designating whether an intersection is a member of the treatment group or the comparison group. 0 = comparison group, 1 = treatment group.

From Hauer, 2002:

j	
K	observed crashes in before period for the treatment group
L	observed crashes in the after period for the treatment group
M	observed crashes in before period for the comparison group
N	observed crashes in after period for the comparison group
$\varkappa$	kappa, expected number of crashes occurring on a group of entities during a specified time period

π pi, prediction, what would have been the safety of a treated entity (or group of entities) in the after period had the treatment not been applied
λ lambda, estimate, safety of a treated entity (or group of entities) in the after period
δ delta, the reduction in the expected frequency of target crashes per unit of time
θ theta, index of effectiveness

r_d ratio of durations
r_{tf} ratio of traffic factors

$\tau =$ **dependent variable**, expected accident frequency for intersection τ
$d, F_1, F_2, \ldots =$ **covariates** for road length and traffic flows on approaches 1, 2, … ,
$\alpha, \beta, \gamma =$ **parameters** to be determined via method of **maximum likelihood**

From HSM, 2010:

$N_{observed,B,i}$ Crashes OBSERVED in the BEFORE condition at intersection i
$N_{observed,A,i}$ Crashes OBSERVED in the AFTER condition at intersection i
$N_{predicted,B,i}$ Crashes PREDICTED in the BEFORE condition at intersection i
$N_{predicted,A,i}$ Crashes PREDICTED in the AFTER condition at intersection i
$N_{expected,B,i}$ Crashes EXPECTED in the BEFORE condition at intersection i
$N_{expected,A,i}$ Crashes EXPECTED in the AFTER condition at intersection i
CMF Crash Modification Factor
CMF_1,i CMF for Intersection Left-Turn Lanes (HSM Table 12-24)
CMF_2,i CMF for Intersection Left-Turn Signal Phasing (HSM Table 12-25)
CMF_3,i CMF for Intersection Right-Turn Lanes (HSM Table 12-26)
CMF_4,i CMF for Right-Turn-on-Red (HSM Equation 12-35)
CMF_5,i CMF for Lighting (HSM Equation 12-36, Table 12-27)
CMF_6,i CMF for Red-Light Cameras (HSM Equations 12-37, 12-38, and 12-39)
Ci Calibration Factor
SPF Safety Performance Function (N or N' notation)
a, b, c SPF coefficients
k overdispersion parameter
N_{bimv} predicted number of multiple-vehicle crashes for intersection per year for base conditions;
N_{bisv} predicted number of single-vehicle crashes for intersection per year for base conditions.
$N_{bimv\text{-}3SG}$, $N_{bimv\text{-}4SG}$ baseline total multi-vehicle intersection-related crashes per year for intersections of types 3SG and 4SG, respectively
$N'_{bimv(FI)\text{-}3SG}$, $N'_{bimv(FI)\text{-}4SG}$ baseline "FI" multi-vehicle intersection-related crashes per year for intersections of types 3SG and 4SG, respectively
$N'_{bimv(PDO)\text{-}3SG}$, $N'_{bimv(PDO)\text{-}4SG}$ baseline "PDO" multi-vehicle intersection-related crashes per year for intersections of types 3SG and 4SG, respectively
$AADT_{maj}$ average daily traffic volume (veh/day) for major road (both directions of travel combined)
$AADT_{min}$ average daily traffic volume (veh/day) for minor road (both directions of travel combined)
p_ra proportion of crashes that are multiple-vehicle, right-angle collisions
p_re proportion of crashes that are multiple-vehicle, rear-end collisions
$p_{ramv(FI)}$ proportion of crashes that are multiple-vehicle, right-angle collisions (fatalities & injuries only)
$p_{ramv(PDO)}$ proportion of crashes that are multiple-vehicle, right-angle collisions (property damage only)
$p_{remv(FI)}$ proportion of crashes that are multiple-vehicle, rear-end collisions (fatalities & injuries only)
$p_{remv(PDO)}$ proportion of crashes that are multiple-vehicle, rear-end collisions (property damage only)
ri adjustment factor in EB method

Adj_{ijb}, Adj_{ija}	adjustment factors in C-G method to account for differences in traffic volumes and number of years between treatment intersection i and comparison intersection j, in the before (b) or after (a) condition
OR'	odds ratio
OR	adjusted odds ratio
R_i	log odds ratio in C-G method for treatment site i
SafeEff	safety effectiveness
w_i	weight in C-G method for treatment site i

Common Functions:

ABS{x} = absolute value of x
E{x} = expected value (mean) of x
SE{x} = standard error of x
SQRT{x} = square root of x
VAR{x} = variance of x
σ{x} = standard deviation of x
v{x} = coefficient of variation of x

1 INTRODUCTION & OBJECTIVES

ACS State and Local Solutions (ACS) contracted with AECOM for an independent analysis of the SafeLight Raleigh red-light camera program which started back in 2003.[2] SafeLight Raleigh was part of a statewide initiative – the State Legislature passed Senate Bill 243 allowing certain cities and towns, including those in Wake County, to install red light photo enforcement systems.[3] The goal of the SafeLight Raleigh program is to reduce angle collisions at intersections where the problem continues after other safety-measures may have proven less effective.

Throughout the US and other countries, Red Light Running (RLR) has been an issue of careful study so crashes can be reduced and safe intersections operated. Several studies have been conducted around the world for an assessment of crash experience due to Red-Light Camera (RLC) implementation. Enforcement had long been in the hands of law enforcement agencies such as police departments, but starting in the late 1990's RLCs became the norm in the US. Triggered by the onset of red for an approach, these cameras take pictures of vehicle license plates and the agency (city/town/county) then sends a ticket and/or a fine to the owner of the offending vehicle. At one point in North Carolina (NC), RLCs were installed in several Cities/Towns including, Charlotte, Cary, Greensboro, Fayetteville, High Point, Raleigh, Indian Point, Monroe, Wilmington and others. Recently, RLC's have been the subject of controversy, such as the Town of Cary, NC system which is currently shut down.

Three elements make up the SafeLight Raleigh program – site selection, camera operation, and violation review. The City contracts out camera operations to a vendor for a flat fee that is not tied to the number of violations, but rather to time in operation. A two-level review of a potential violation is conducted prior to issuing a formal citation. The vendor is the first violations reviewer, followed by the City of Raleigh's Transportation Operations Division. A typical citation is for $50, with all revenues first used to cover program costs, then going to the Wake County Public School System.

The focus of this study is the Type 30 angle accident (see picture and description in the Executive Summary) as defined by the North Carolina Department of Motor Vehicles. Specifically, did this crash type decrease from before the treatment (camera installation) to after? Implicit in the question is whether the treatment itself, and not other factors, can be found to effect Type 30 crash levels. Follow-on questions include, are the RLCs continuing to be effective? And, should one or more cameras be relocated? To support this study, detailed crash and intersection data were collected, then analyzed within the observational before-after study framework. Following this introduction, details of site selection, data collection, and analysis methods applied are covered in the Methodology section. Next, results of each analysis are presented. Details of various steps are provided in appendices as noted in the text.

[2] This action is to fulfill a requirement of the *Extension for Red Light Camera Contract* on the City of Raleigh's Public Works Consent Agenda of September 20, 2011. This stated the following: "It is recommended that the City of Raleigh approve the option for extending the Safelight program contract to October, 2013 as amended. The contract amendment for this is included in the agenda packet and has been reviewed by the City Attorney's office. In October, 2008 the City of Raleigh entered into a new contract with ACS Xerox for the Safelight program. The original contract was for a three-year term with two one-year extensions. Staff is recommending that Council approve the two one-year extensions due to continued positive safety benefits. In addition ACS will relocate one camera and conduct a 3rd party analysis of the program at no additional charge to the City with this contract extension. Should State legislation prohibit the use of red light cameras in North Carolina, the existing contract will be voided."

[3] Source: City of Raleigh's SafeLight website

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2 METHODOLOGY

The AECOM Team conducted the SafeLight Raleigh Red Light Camera analysis by applying the methods of Ezra Hauer (2002), the *Highway Safety Manual* (2010), and recent research as noted throughout this report and listed in the references. Moreover, this study builds off of the local knowledge accumulated by Cunningham and Hummer (2004, 2010); similar to those studies are the use of multiple before-after analysis methods. Two software packages were used: Microsoft Office Excel for spreadsheeting and basic calculations, and IBM's SPSS for statistical analysis and modeling. This section is divided into four parts: intersection selection, data collection, observed crash histories, and descriptions of applied analysis methods.

2.1 Intersection Selection

The City of Raleigh and AECOM independently, then together, reviewed intersections for study inclusion. Most treatment intersections were included with a handful of sites left out because of data gaps. Comparison intersections were chosen based on their geometries and traffic operations to pair with the treatment intersections with an attempt to avoid halo effects[4] in the data set.

Sixteen intersections with camera installations were selected as the treatment group.[5] And sixteen intersections without cameras (during the relevant time periods) were chosen for the comparison group. Note, it is desirable to have at least twice as many comparison sites as treatment sites; however, data collection time and project budget constrained the analysis to sixteen comparison intersections. Moreover, three intersections were used twice – intersections 3, 9, and 22, one was initially used as a comparison intersection, then later as a treatment site (intersection 3); two served as comparison sites in two different time periods (intersections 9 and 22). To distinguish when an intersection was used for a second time, possibly in a different capacity but always in a different time period, the second use was numbered as 103, 109, and 122, respectively.

Intersections included in this analysis are listed in Table 1. The predominant characteristics of the intersections are:

- All of the intersections are signalized
- The intersections are urban and suburban in nature with several in downtown Raleigh
- There are both 3- and 4-legged intersections which have between 2 and 4 approaches
- The majority of intersection approaches allow Right-Turn-On-Red
- Every intersection has an all-red phase

Site maps plus aerial images for all intersections are provided in appendices A and B, for treatment and comparison sites, respectively.

[4] Halo or spillover effects are when the behavior changes anticipated at a treated site are visible at nearby sites that have not been treated – in other words, a single treated site may cause a general deterrence of the undesirable behavior in the community. This effect is important to consider both during study design (choosing comparison intersections that are indeed unaffected by a treatment) and during analysis (effects of a treatment program may be underestimated if nearby untreated sites are not examined). For an example of the first point, the intersection of Louisburg and New Hope was removed from consideration because of its close proximity to the Capital and Buffalo intersection. This was less possible to do for the downtown locations, but every attempt was made.

[5] Locations for the SafeLight Raleigh program are chosen for treatment based on high numbers of angle crashes and a minimum AADT to cover operating capture; therefore, regression-to-the-mean is expected to be an analysis issue.

Table 1: Study Intersections

Intersection Number	Approach 1	Approach 2	Approach 3	Approach 4
Treatment Intersections				
1	Dawson	Morgan		
2	Dawson	South		
3	McDowell	Morgan		
4	Six Forks	Six Forks	Rowan	Rowan
5	Six Forks	Six Forks	Dartmouth	Dartmouth
6	New Hope Church	New Hope Church	Brentwood	Brentwood
7	Capital	Capital	Highwoods	
8	Capital	Capital	Millbrook	New Hope
9	Capital	Capital	New Hope Church	Buffaloe
10	West	West	Peace	Peace
11	Friendly	Dixie	Hillsborough	Hillsborough
12	Wilmington	Wilmington	Chapanoke	Chapanoke
13	Rock Quarry	Rock Quarry	Cross Link	Proctor
14	Tarboro	Tarboro	New Bern	
15	I440 Inner	New Bern		
16	I440 Outer	New Bern		
Comparison Intersections				
17	Person	Edenton		
18	Cox	Woodburn	Hillsborough	Hillsborough
19	Blount	Peace	Peace	
20	St. Marys	St. Marys	Peace	Peace
21	Old Wake Forest	Old Wake Forest	Millbrook	Millbrook
22	I440 Outer	Poole	Poole	
23	Wilmington	Edenton		
24	Raleigh	Raleigh	Poole	Poole
25	Blount	MLK	MLK	
26	Wilmington	Morgan		
27	Edwards Mill	Edwards Mill	Duraleigh	Duraleigh
28	Rock Quarry	Rock Quarry	MLK	MLK
29	Dixie	Dixie	Wade	Wade

Treatment intersection approaches with red-light cameras are shown in bold.

Once the study intersections were selected, it was necessary to determine the time periods of analysis so crash and traffic volume data could be assembled for the required years. Moreover, the comparison intersections had to be grouped into the three time periods defined by the 2003, 2004, and 2009 camera install dates. These data are shown in Table 2 with B_{start} standing for Before period start year and A_{end} standing for After period end year, and so forth.

Table 2: Intersection Pairings, based on discussions with City and internal AECOM

Treatment #	Comparison #	B_{start}	B_{end}	Camera Install Date, A_{start}	A_{end}
4	3	7/15/2000	7/14/2003	7/15/2003	7/14/2006
2	17	8/11/2000	8/10/2003	8/11/2003	8/10/2006
7	22	9/1/2000	8/31/2003	9/1/2003	8/31/2006
11	18	9/1/2000	8/31/2003	9/1/2003	8/31/2006
13	19	9/1/2000	8/31/2003	9/1/2003	8/31/2006
1	23	9/15/2000	9/14/2003	9/15/2003	9/14/2006
14	25	6/24/2001	6/23/2004	6/24/2004	6/24/2007
6	21	6/25/2001	6/24/2004	6/25/2004	6/25/2007
10	20	6/25/2001	6/24/2004	6/25/2004	6/25/2007
5	24	10/1/2001	9/30/2004	10/1/2004	10/1/2007
8	9	10/1/2001	9/30/2004	10/1/2004	10/1/2007
103	26	3/4/2006	3/3/2009	3/4/2009	3/3/2012
109	28	3/4/2006	3/3/2009	3/4/2009	3/3/2012
12	27	3/4/2006	3/3/2009	3/4/2009	3/3/2012
15	29	3/4/2006	3/3/2009	3/4/2009	3/3/2012
16	122	3/4/2006	3/3/2009	3/4/2009	3/3/2012

Note: Since cameras were installed at various times, each color represents a different, approximate six-year span of time (3 years before, 3 years after). The different time spans become important in the calculations when adjustments are made because only other intersections from the same time period should be used for the calculations to be valid.

With the study locations set, the data collection process began.

2.2 Data Collection

Three types of data were collected to form the basis of this analysis: crash data from the TEAAS database, violation data from the cameras, and intersection data. Data were collected from the City, the North Carolina Department of Transportation (NCDOT), and Google maps. These data were gathered to enable the team to track changes in potentially confounding variables that can affect crash rates.

A template was designed for data collection purposes. In that regard, 2008 VDOT Highway Operations Section provided Red Light Running Camera (Photo Enforcement) Engineering Safety Analysis Guidelines-Virginia Department of Transportation. This document, revised in 2009 provided a useful template for collecting the necessary data at each intersection for a before-after study. A template similar to this was developed for the City of Raleigh in the form of an Excel workbook; Appendix C includes a full listing of the variables. Data included:

- Conduct data collection in the field at the instrumented and controlled intersections.
- Crash records (years of records, number of crashes, type, distance from center of intersection)[6]
- speed (of vehicle)
- time of day
- day of the week

[6] A more in-depth study could consider vehicle safety features, driver characteristics, vehicle mix, road improvements, adjacent intersection features, etc. as independent variables when modeling crash frequencies.

- day, month, year
- pavement condition at time of crash (dry/wet/icy)
- Traffic flow rate (AADTs on approaches, TMCs during peak hours to gain a sense of turning percentages and estimate AADTs when necessary)
- Speed limits
- Weather (precipitation, daylight/brightness)
- Intersection characteristics
- geometry
- signage (especially restrictions such as no right turn on red)
- lane assignments
- signal configuration & timing (yellow duration, all-red duration, left-turn phasing type)
- presence of RLCs on each approach

As mentioned earlier, a total of twenty-nine intersections were selected for the study, sixteen of which were in the SafeLight Raleigh program, and the remaining intersections served as comparisons. Note, three intersections were used twice, one was initially used as a comparison intersection, then later as a treatment site; two served as comparison sites in two different time periods. Cameras were installed in three sets, one in 2003, one in 2004, and one in 2009. Crash data were compiled by the City from the statewide crash database, Traffic Engineering Accident Analysis System (TEAAS), for all Type 30 crashes that occurred at the study intersections for at least three years before and three years after camera installation (for treatment sites and their paired comparison sites). These data were supplemented by intersection characteristics, signal operations, and traffic volumes by both the City and AECOM.

2.3 Observed Crash Histories

As a starting point to the analysis, the intersection dataset was merged with the crash dataset so that each crash record was on a table row, now augmented with the appropriate intersection information (i.e. a one-to-many join). Dates of crashes were then binned by number of years before or after camera install. For example, year 2006 is Bef3Yr for intersection 12 whereas year 2006 is Aft2Yr for intersection 5. Crashes by bin were then plotted for each intersection in Figure 1 (treatment sites) and Figure 2 (comparison sites). The intersection number (IntNum) is on the x-axis and the crash frequency (crashes per year) are on the y-axis with one bar for each year of data. The legend assigned colors to the binned years; for instance, "-4" is four years before camera install while "+2" is two years after install.

At first glance, it appears that most treatment intersections show reductions in crashes after cameras have been installed. Likewise, it seems comparison intersections exhibit more unpredictable behavior from year-to-year. But a note of caution must be heeded. Crashes are rare events, so time trends should be quite long to dampen near-term fluctuations for the big picture to be visible. What this means for this study is that observed crash frequencies can greatly vary from year-to-year, hence they may not be a reliable indicator of increased or decreased safety for observational before-after studies. Thus, naïve analysis methods should not be relied upon for drawing conclusions but may serve as useful starting points. Moreover, the general rarity of crashes points to a need for estimating the expected number of crashes in the before and after periods for each site. Then analysis can proceed. In the next section, a brief description of each analysis method is offered.

Figure 1: All Before–After Crash Data for the Selected Intersections: Treatment Sites

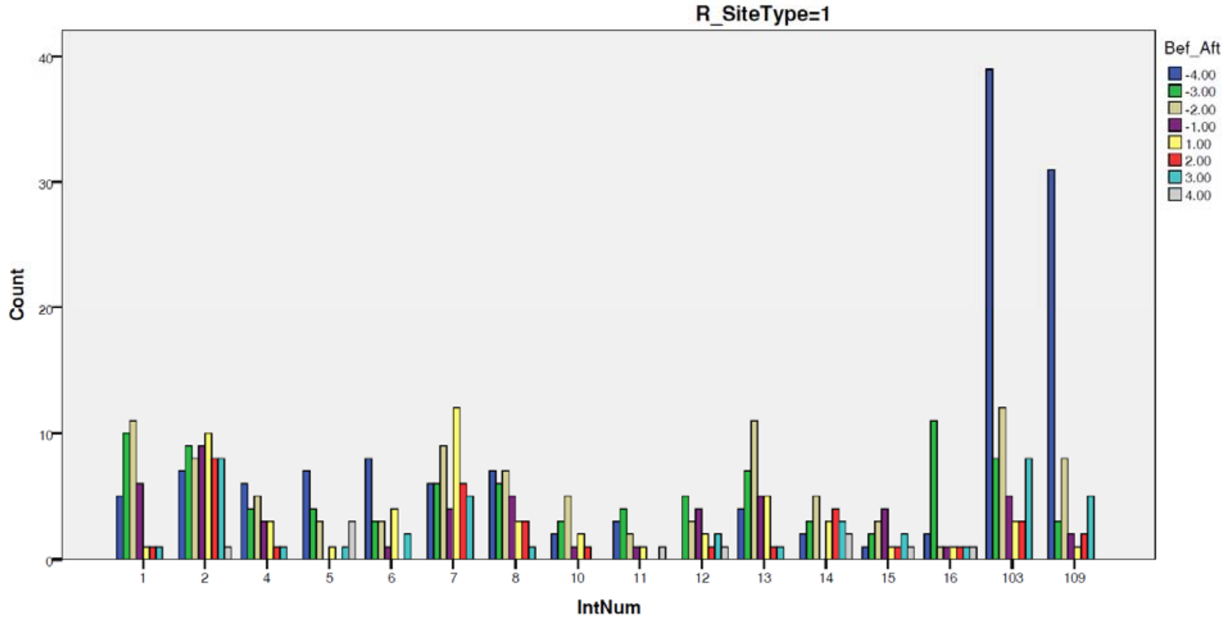
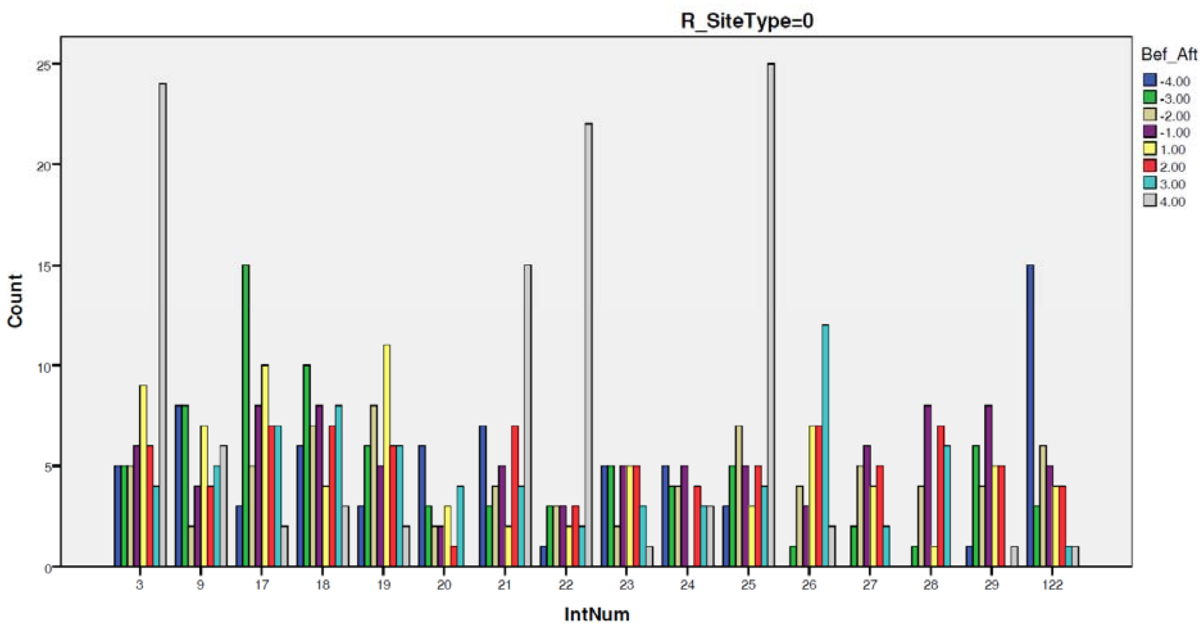


Figure 2: All Before–After Crash Data for the Selected Intersections: Comparison Sites



Note: these data are revisited and further explored in the naïve comparison group study.

2.4 Applied Analysis Methods

The goal of this study is to examine angle crash frequencies at intersections treated with red light cameras to determine if crash frequencies decreased after the treatment was instituted. The methods employed in this study come from two primary sources, *Observational Before-After Studies in Road Safety* (the seminal textbook by Hauer, 2002) and the *Highway Safety Manual* (2010) (HSM). Four distinct methods were applied (some with more than one variation) and results compared:

- Naïve Study (Naïve),
- Naïve Comparison-Group Study (Naïve C-G),
- Empirical Bayes Before-After Safety Evaluation (HSM 1), and
- Before-After Comparison-Group Safety Evaluation (HSM 2).

The first two are directly drawn from Hauer (chapters 7 and 9) and illustrate what is often performed by novice analysts or those with limited data; these are described first followed by a brief discussion. The last two are more complex statistical methods from chapter 9 of the HSM that are loosely based on Hauer (chapter 11). Lastly, the role of Safety Performance Functions (SPFs) in crash estimation is touched upon.

2.4.1 Naïve Study

The Naïve Study is based upon the assumption that the number of observed crashes at a location, K, is a good estimate of the expected value (mean) of the crash probability distribution function, $E\{\kappa\}$. Therefore, to measure the change in crash frequency from before a treatment was instituted to afterwards, the analyst would simply calculate the difference, normalized by the number of years (or other measure of time) in the before and after periods. From this, the percent change can be calculated.

As per Hauer's notation, delta and theta with their variances are the key results.

rd	= ratio of durations
lambda	= Sum(L), with L being the crashes in the after period
pi	= Sum(K), with K being the crashes in the before period
var{lambda}	= lambda, since crashes are assumed to be Poisson distributed
var{pi}	= rd^2 * Sum(K)
delta	= pi – lambda = the change in crash frequency
theta	= (lambda/pi)/(1+[var{pi}/pi^2]) = the index of effectiveness, a percent change measure
var{delta}	= var{lambda}+var{pi}
var{theta}	= theta^2 * ([var{lambda}/lambda^2]+[var{pi}/pi^2])/[(1+[var{pi}/pi^2])^2]

The assumption that $E\{\kappa\} = K$ is reasonable when there is a large pool of data over an extended time period, such as recording the results of a coin toss every second for a day. This assumption crumbles when there is a small dataset for a short time period because patterns are not yet evident, such as tossing a coin only ten times and you have a run of seven heads in a row, leading you to expect heads 70 percent of the time when in reality it is 50 percent. Another shortcoming of this method is that only crash data is considered. Thus, potentially useful information (other variables) that may also be impacting crash levels are embedded. One step toward removing the impact of other factors (so the treatment effect can be further isolated) is to run the Naïve Study with Traffic Factors which removes one of the largest variables from play.[7] A host of known factors affect crash levels, of which some are measurable (such as intersection geometry, traffic volumes, weather conditions) and others are less quantifiable (such as the mechanical condition of every vehicle, driver ability, driver mood/behavior). One factor that is known to correlate with crash levels is traffic volume; however, the relation is often not a linear one so a nonlinear relationship must be estimated as best as possible with the available data. By knowing an approximate relationship between traffic volumes and crash levels, we can estimate crash levels at similar intersections by applying the equation. In other words, if we know traffic volumes increased over the past few years in a region, then we would expect crash frequencies to also have increased in some fashion (such as because more people are on the road and interacting), but this does not mean an intersection is necessarily more dangerous.

2.4.2 Naïve Comparison-Group Study

Another method that tries to isolate the treatment effect on crash frequencies is to use a second group of intersections that have not been treated as a comparison group.[8] In the world of lab experiments, the corollary would be a control group with all the exact same characteristics as the treatment group and only the one variable of interest is perturbed. Outside of lab experiments where all conditions can be controlled and measured, it is difficult to find entities that are exact matches; hence, we use comparison groups. The hope is that the intersections in each group are reasonably similar and therefore would exhibit similar behavior if a treatment were applied. So the performance of the comparison group in the years after the treatment group was treated (cameras installed) is basically a proxy for the treatment group intersections had they not been treated. The main assumption present in the Naïve Study is again present here, that of the observed crashes being representative of the expected value of the crash probability distribution function. A second assumption is that the two groups of entities exhibit similar behavior on the variable of interest before treatment is applied. To be clear, it may seem a wise choice to have all intersections in the comparison group be 3-legged if this is the case in the treatment group, but for the Naïve C-G approach it is not directly relevant. What is directly relevant is that the C-G entities have the same (or similar) crash histories as the treatment group entities.

2.4.3 Why the "Naïve" Methods Should Be Used Cautiously

Evaluation of RLC programs has often been with the use of simple statistics, such as how many crashes occurred in the year prior to the RLC program and how many occurred in the year after it. Based on such analyses, many RLC programs may look highly successful. However, applying a detailed statistical analysis often may reveal that such programs are not or are only somewhat successful in reducing crashes. Based on detailed statistical analysis performed throughout the US, the key points to take away are that the following flaws are common and should be avoided for a strong analysis to study the effectiveness of the RLCs:

- Studies often do not apply an experimental design with a randomized control group or a comparison group. The former is preferred, but much harder to obtain since intersections are quite dissimilar when examined across a host of variables. Hazard: overestimation of safety impact.
- Several studies only examine the RLC intersections applying a simple before-and-after analysis and not looking at comparison groups (intersections with similar characteristics but without RLCs). This disregards other reasons crashes may have decreased (such as with design improvements). Hazard: over- or underestimated safety effects.
- RLC programs often install RLCs at intersections with high crash rates, in other words, creating a biased sample of treatment intersections. This can cause regression-to-the-mean (RTM) errors in the analysis which is when the natural tendency of crash reduction over time (say by drivers gaining

[7] This method is denoted the "Causal Factor Method" in Cunningham and Hummer (2004, 2010).
[8] This method is denoted the "Comparison Group Method" in Cunningham and Hummer (2004, 2010).

experience) at an untreated intersection is not accounted for by the analysis. Hazard: overestimation of safety improvements.

- Studies that do not examine the crash experiences of intersections nearby the RLC locations fail to account for spillover or halo effects. In other words, if a driver knows that there are RLCs at some intersections along Dawson Street in Raleigh, then they are more likely to avoid running red lights at all intersections along Dawson Street. Hazard: underestimation of program-wide RLC benefit.
- Crashes are rare. Given this knowledge, it behooves analysts to be cognizant of the sample size of their studies. However, often sample sizes are too small for RLC studies because there are not enough years of data or intersections with RLCs. Hazard: statistical significance is not reached and over- or underestimation of safety impacts may result.
- Analysts calculating simple statistics will not always test for the statistical significance of their results; hence, it is unclear whether the resultant change in crashes and/or violations could have occurred because of chance or indeed occurred because of the RLC installation. Hazard: unsubstantiated claims of safety impacts.

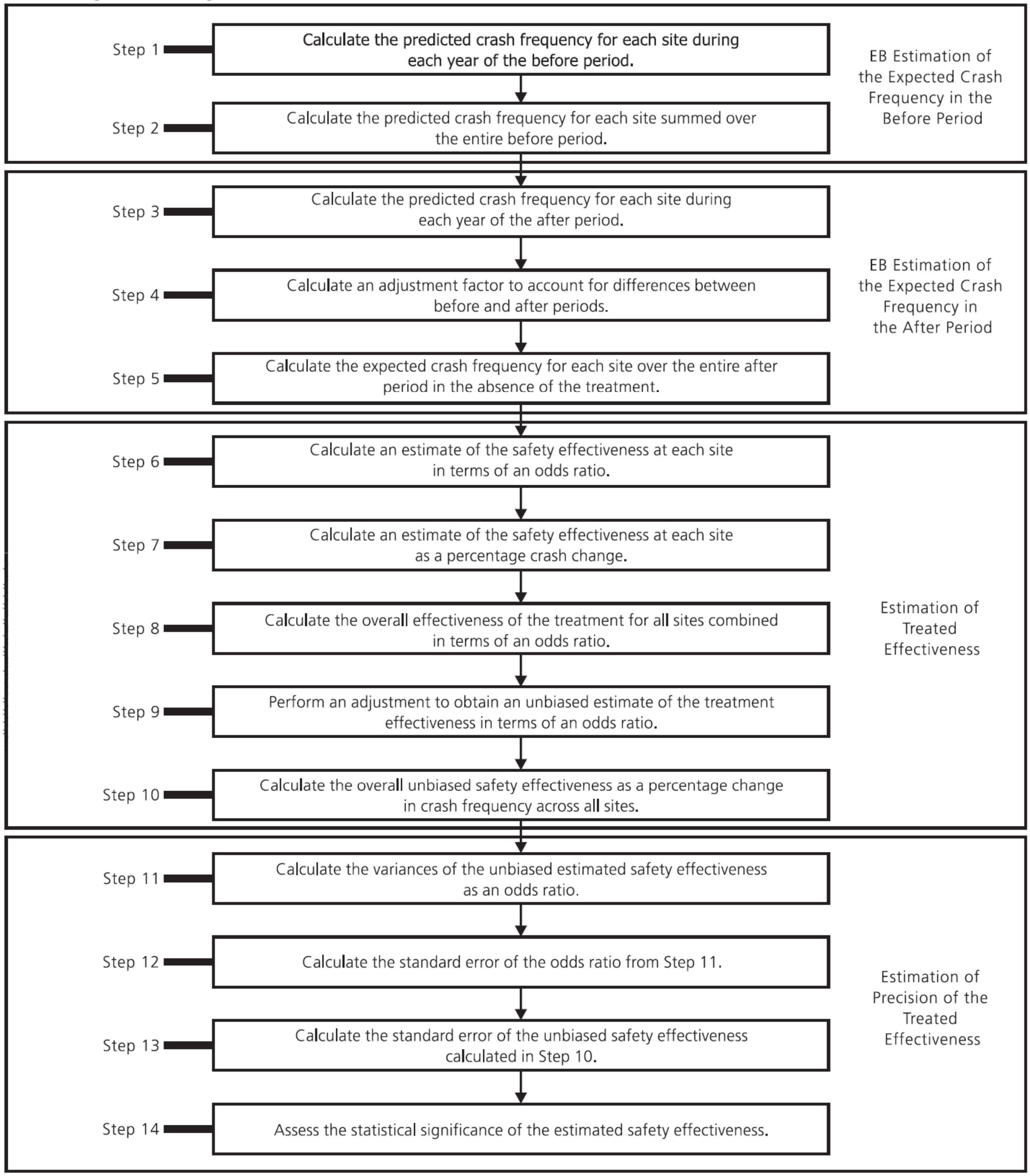
Although rough estimates of safety effectiveness can be measured by the naïve methods, these can be improved with more rigorous methods that accomplish two things. One, they can incorporate available information about the intersections that had previously been ignored, enabling creation of models that more accurately estimate and predict crash levels and isolate treatment effects. Two, they can incorporate more details about the crashes themselves (percent at night, percent that are fatal, percent that are single vehicle or multi-vehicle, and so forth). The modeling portion is dealt with in this study by using Safety Performance Functions (SPFs), discussed later in this section since they are used for both of the Highway Safety Manual methods. Moreover, statistical estimation methods that handle thorny issues such as regression-to-the-mean (selection bias) can be applied. These methods are discussed in the next two subsections.

2.4.4 Empirical Bayes Before-After Safety Evaluation (HSM 1)

Before-After crash studies must be carefully conducted via rigorous statistical methods to avoid the risk of inadequately addressing issues of regression-to-the-mean (RTM), spillover effects, and confounding variables. It is vitally important that a rigorous analysis be conducted that can be a strong foundation from which to base conclusions and recommendations upon. Therefore, Hauer's Empirical Bayes Approach with Multivariate Models of Accident Counts is the recommended approach. A variation of this method has been developed in the Highway Safety Manual (2010) and is called the Empirical Bayes Before-After Safety Evaluation, noted here as HSM 1. The steps of the procedure are as shown in the following figure reproduced from the HSM.

Figure 3: Overview of the Empirical Bayes Before-After Safety Evaluation

Source: Figure 9-2, Highway Safety Manual (2010)

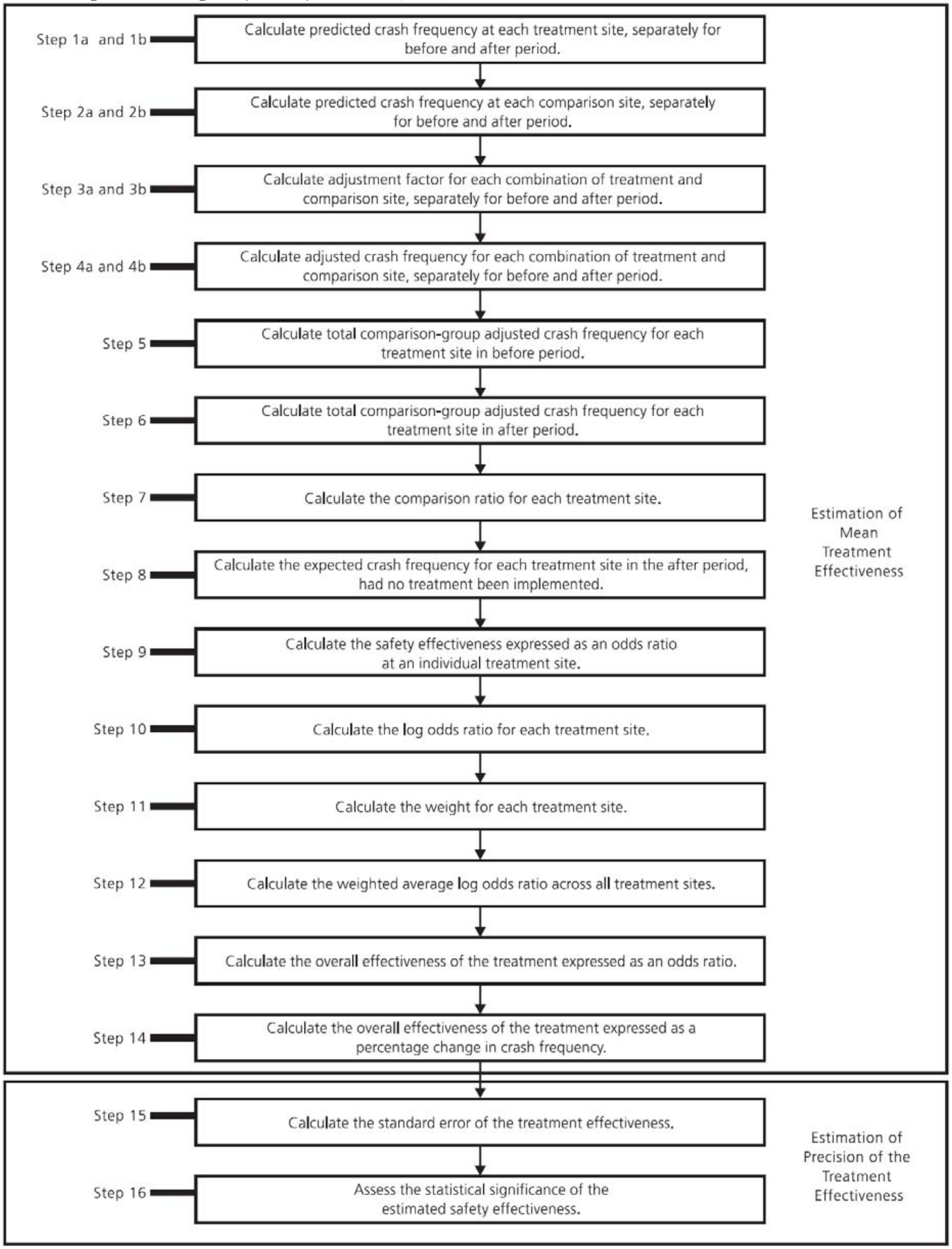


2.4.5 Before-After Comparison-Group Safety Evaluation (HSM 2)

A variation of this method has been developed in the Highway Safety Manual (2010) and is called the Before-After Comparison-Group Safety Evaluation, noted here as HSM 2. The steps of the procedure are as shown in the following figure reproduced from the HSM.

Figure 4: Overview of the Before-After Comparison-Group Safety Evaluation

Source: Figure 9-3, Highway Safety Manual (2010)



Similar to the Naïve C-G method, a comparison group is used to hopefully improve the analyses. However, in this case it is actually being used to generate imaginary reference groups for each treatment intersection. Basically, this means intersection trait and crash history information from a group of untreated intersections enable creation of imaginary reference groups, one per treatment intersection, with all members in the reference group having the same characteristics as the treatment intersection. Therefore, more robust estimates of the expected number of crashes with and without the treatment in the after condition can be estimated.

2.4.6 Safety Performance Functions

Empirical data from several regions and cities across the United States were compiled and analyzed through several research projects (such as NCHRP 17-25 and FHWA-HRT-05-048 on a national level and several other studies such as ICT-R27-20 in Illinois and Srinivasan et al. in North Carolina). One outcome of most of these projects was creation of Safety Performance Functions (SPFs) that relate intersection traits to crash types, severities, and levels. The primary variables are the Average Annual Daily Traffic (AADT) for the major and minor approaches to the intersection of interest. The following key formulae from the HSM were applied in this study:

Safety performance functions for 3-legged (3SG) and 4-legged (4SG) signalized intersections:

$N_{bimv\text{-}3SG} = \exp[-12.13+1.11Ln(AADT_{maj})+0.26Ln(AADT_{min})]$ (HSM Eqn. 3.54)
$N_{bimv\text{-}4SG} = \exp[-10.99+1.07Ln(AADT_{maj})+0.23Ln(AADT_{min})]$ (HSM Eqn. 3.56)

Safety performance functions for "FI" crashes:

$N'_{bimv(FI)\text{-}3SG} = \exp[-11.58+1.02Ln(AADT_{maj})+0.17Ln(AADT_{min})]$ (HSM Eqn. 3.58)
$N'_{bimv(FI)\text{-}4SG} = \exp[-13.14+1.18Ln(AADT_{maj})+0.22Ln(AADT_{min})]$ (HSM Eqn. 3.60)

Safety performance functions for "PDO" crashes:

$N'_{bimv(PDO)\text{-}3SG} = \exp[-13.24+1.14Ln(AADT_{maj})+0.30Ln(AADT_{min})]$ (HSM Eqn. 3.62)
$N'_{bimv(PDO)\text{-}4SG} = \exp[-11.02+1.02Ln(AADT_{maj})+0.24Ln(AADT_{min})]$ (HSM Eqn. 3.64)

The expected number of crashes at an intersection is then adjusted based on further data being available. This is done through a series of multipliers called Crash Modification Factors (CMFs); default values are 1.0. For example,

$$N_{expected,treatment\ intersection\ i,before} = N_{bimv\text{-}3SG} * (CMF_{1,i}*CMF_{2,i}*\ldots*CMF_{6,i}) * C_i$$

The CMFs applied in this study were the following:

CMF_1,i CMF for Intersection Left-Turn Lanes (HSM Table 12-24)
CMF_2,i CMF for Intersection Left-Turn Signal Phasing (HSM Table 12-25)
CMF_3,i CMF for Intersection Right-Turn Lanes (HSM Table 12-26)
CMF_4,i CMF for Right-Turn-on-Red (HSM Equation 12-35)
CMF_5,i CMF for Lighting (HSM Equation 12-36, Table 12-27)

Finally, the expected number of crashes can be calibrated if local data are available. Again, this is done through a multiplier, C_i, as seen at the end of the above equation. Fortunately, North Carolina has been active in this area of safety research and the Highway Safety Research Center of the University of North

Carolina has developed calibration factors for the state as a whole and for the three regions of the state, see Srinivasan et al. (2008). The calibration factors for the state and the Piedmont region were each tested.

For both of the HSM methods applied, five cases of SPFs were calculated with varying values of the CMFs and calibration factor so the effect (or lack thereof) of each new piece of information could be seen. Specifically, the following were run:

- BASE CASE: All CMFs = 1.00 and the Ci = 1.00
- Refinement 1: BASE + All CMFs calculated from available data; Ci = 1.00
- Refinement 2: BASE + All CMFs calculated from available data; Ci set based on the statewide numbers
- Refinement 3: BASE + All CMFs calculated from available data; Ci set based on the Piedmont numbers
- Refinement 4: BASE + All CMFs calculated from available data but CMF5 tailored to the available Raleigh Data; Ci set based on the Piedmont numbers

With the analysis methods now described, results are presented in the following section.

3 RESULTS & ANALYSIS

The analysis methods described in the previous section were each applied to the dataset. For the naïve studies, only crashes and traffic volumes were included in computations as needed – generally, these are the quick and dirty methods applied when limited data and resources are available. Input data, calculations, and results are shown in the main body of the report for these methods. For the studies that apply the Empirical Bayes methods as well as Safety Performance Functions, key input data, sample calculations, and results are shown in the main body, but full details are relegated to the appendices (G and H), especially since multiple refinements were made to the crash estimates and predictions for both of these methods.

3.1 Naïve Before-After Analysis

Treatment Intersections (R_sitetype = 1)

IntNum, j	Crashes 3yrBef	3yrAft
1	27	3
2	26	26
4	12	5
5	7	2
6	7	6
7	19	23
8	18	7
10	9	3
11	7	1
12	12	5
13	23	7
14	8	10
15	9	4
16	13	3
103	25	14
109	13	8
Totals	235	127
	K	L

rd	1	= ratio of durations
lambda	127	= Sum(L)
pi	235	= Sum(K)
var{lambda}	127	= lambda
var{pi}	235	= rd^2 * Sum(K)
delta	108	= pi - lambda
theta	0.538136	= (lambda/pi)/(1+[var{pi}/pi^2])
var{delta}	362	= var{lambda}+var{pi}
var{theta}	0.003483	= theta^2 * ([var{lambda}/lambda^2]+[var{pi}/pi^2])/[(1+[var{pi}/pi^2])^2]
stdev{lambda}	11.26943	= sqrt[var{lambda}]
stdev{pi}	15.32971	
stdev{delta}	19.0263	
stdev{theta}	0.059015	

NAÏVE BEFORE-AFTER RESULTS

Change in Crashes:	108	REDUCTION - SAFER
	19.03	+/- std deviation
Percent Change:	46.2%	REDUCTION - SAFER
	5.9%	+/- std deviation

3.2 Naïve Before-After Analysis with Traffic Flow Factors

Treatment Intersections (R_sitetype = 1)

	Crashes		Traffic Factor						
IntNum, j	3yrBef	3yrAft	r_tf_naive	AADTb	AADTa	v{AADTb}	v{AADTa}	var{r_tf_naive}	Q
1	27	3	0.928	33,275	30,875	0.0517	0.0519	0.0046	26.618
2	26	26	1.020	25,600	26,100	0.0525	0.0524	0.0057	30.895
4	12	5	1.000	47,515	49,955	0.0509	0.0508	0.0052	12.745
5	7	2	0.962	43,992	42,300	0.0511	0.0512	0.0048	6.709
6	7	6	1.020	25,350	25,850	0.0525	0.0525	0.0057	7.560
7	19	23	1.014	79,810	80,810	0.0501	0.0501	0.0052	21.418
8	18	7	0.966	67,000	64,750	0.0503	0.0504	0.0047	18.345
10	9	3	0.976	25,255	25,130	0.0526	0.0526	0.0053	8.998
11	7	1	0.956	29,825	28,525	0.0520	0.0522	0.0050	6.646
12	12	5	0.996	61,243	62,308	0.0505	0.0504	0.0050	12.621
13	23	7	1.041	30,250	31,500	0.0520	0.0519	0.0058	28.035
14	8	10	0.976	21,175	20,675	0.0532	0.0533	0.0054	7.972
15	9	4	0.979	130,500	127,750	0.0496	0.0496	0.0047	9.006
16	13	3	0.949	136,500	129,500	0.0495	0.0496	0.0044	12.447
103	25	14	0.999	25,275	25,250	0.0525	0.0526	0.0055	28.396
109	13	8	0.944	82,548	77,448	0.0500	0.0501	0.0045	12.341
Totals	235	127							
	K	L							

Note: var{r_tf_naive} = r_tf_naive^2*(v{AADTb}^2 + v{AADTa}^2)
Q = rd^2 * ([r_tf_naive^2]*K+K^2*var{r_tf_naive})

rd	1	= ratio of durations
lambda	127	= Sum(L)
pi_traf	232	= Sum(r_tf_naive*K)
var{lambda}	127	= lambda
var{pi_traf}	250.752	= Sum[rd^2 * ([r_tf_naive^2]*K+K^2*var{r_tf_naive})], over all intersections j
delta	105	= pi - lambda
theta	0.545625	= (lambda/pi)/(1+[var{pi}/pi^2])
var{delta}	378	= var{lambda}+var{pi}
var{theta}	0.0037	= theta^2 * ([var{lambda}/lambda^2]+[var{pi}/pi^2])/[(1+[var{pi}/pi^2])^2]
stdev{lambda}	11.26943	= sqrt[var{lambda}]
stdev{pi}	15.83515	
stdev{delta}	19.43584	
stdev{theta}	0.06083	
Count_Days	2	NCDOT's Coverage Count Program collects data for AADTs based on 48-hour counts ever two years. (Odd years for the City of Raleigh locations.)

% v{AADT}	= percent coefficient of variation of AADT = 100*v{AADT} = 100*ratio of stdev{AADT} to expected value{AADT} = 1+(7.7/[count_days])+(1650/[AADT^0.82]), Source: V

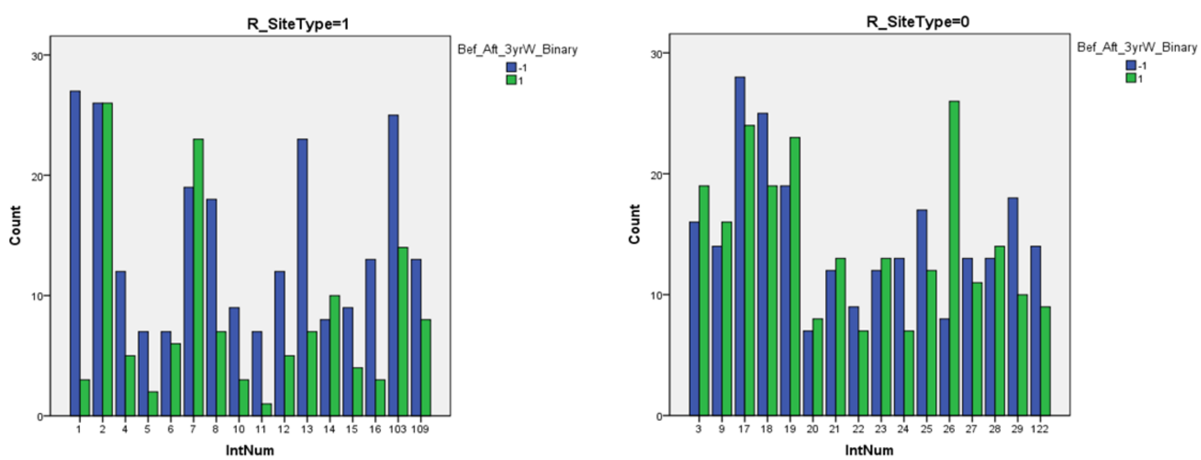
Change in Crashes:	105	REDUCTION - SAFER
	19.44	+/- std deviation
Percent Change:	45.4%	REDUCTION - SAFER
	6.1%	+/- std deviation

3.3 Naïve Comparison Group Analysis

Table 3: Crash Histories for 3-year Periods Before and After RLC Treatment

Treatment Intersections			Comparison Intersections		
	Crashes			Crashes	
IntNum, j	3yrBef	3yrAft	IntNum, j	3yrBef	3yrAft
1	27	3	3	16	19
2	26	26	9	14	16
4	12	5	17	28	24
5	7	2	18	25	19
6	7	6	19	19	23
7	19	23	20	7	8
8	18	7	21	12	13
10	9	3	22	9	7
11	7	1	23	12	13
12	12	5	24	13	7
13	23	7	25	17	12
14	8	10	26	8	26
15	9	4	27	13	11
16	13	3	28	13	14
103	25	14	29	18	10
109	13	8	122	14	9
Totals	235	127	Totals	238	231
	K	L		M	N

Figure 5: Data for 3 Years Before (BLUE) and 3 Years After (GREEN) Install Dates of Red Light Cameras



o3_2	0.807	= sample odds ratio Bef3 vs. Bef2 = (KN)/(LM)/(1+1/L+1/M)
o2_1	2.175	= sample odds ratio Bef2 vs. Bef1 = (KN)/(LM)/(1+1/L+1/M)
m{o}	1.491	= mean of sample odds ratio
s^2{o}	0.937	= sample variance of odds ratio
var{omega}	0.889	= s^2{o} - [1/K+1/L+1/M+1/N] if>0, else 0.
rd	1	= ratio of durations

lambda	127	= Sum(L)
rT = rC	0.967	= (N/M)/(1+1/M) = comparison ratio (rC) or treatment ratio (rT)
pi	227	= rT * Sum(K)
var{lambda}	127	= lambda
var{rT}/rT^2	0.897	= 1/M+1/N+var{omega}
var{pi}	46517	= pi^2 * [1/K + var{rT}/rT^2]
delta	100	= pi - lambda
theta	0.2940273	= (lambda/pi)/(1+[var{pi}/pi^2])
var{delta}	46644	= var{lambda}+var{pi}
var{theta}	0.0217435	= theta^2 * ([var{lambda}/lambda^2]+[var{pi}/pi^2])/[(1+[var{pi}/pi^2])^2]
stdev{lambda}	11.269428	= sqrt[var{lambda}]
stdev{pi}	215.67741	
stdev{delta}	215.97163	
stdev{theta}	0.1474566	

Change in Crashes:	100	REDUCTION - SAFER
	215.97	+/- std deviation
Percent Change:	70.6%	REDUCTION - SAFER
	14.7%	+/- std deviation

Conclusion: For this mix of intersections, the naïve comparison group method proves to be a poor performer, yielding an extremely high standard deviation in the change in crashes. This is primarily due to the comparison group not being similar enough to the treatment group (based on the sample odds ratios for angle crashes) which solely relies on comparing the crash rates in the 3 years before the treatment is in place.[9]

[9] Cunningham and Hummer (2010) suggest that the sample odds ratio be calculated for the total crashes (including angle crashes) and for crashes they associate with red-light running (specifically, angle, rear-end, left-turn same roadway, left-turn different roadway). Since these data were not available for this study, we relied upon angle crashes for the sample odds ratios which may change the outcome of this indicator variable.

3.4 Naïve Comparison Group Analysis with Pooled Sites

DATA

	Treatment Intersections Crashes			Comparison Intersections Crashes	
IntNum	3yrBef	3yrAft	IntNum	3yrBef	3yrAft
j	K	L	j	M	N
1	27	3	23	12	13
2	26	26	17	28	24
4	12	5	3	16	19
5	7	2	24	13	7
6	7	6	21	12	13
7	19	23	22	9	7
8	18	7	9	14	16
10	9	3	20	7	8
11	7	1	18	25	19
12	12	5	27	13	11
13	23	7	19	19	23
14	8	10	25	17	12
15	9	4	29	18	10
16	13	3	122	14	9
103	25	14	26	8	26
109	13	8	28	13	14
Totals	235	127	Totals	238	231
	K	L		M	N

INDIVIDUAL SITES

var{ω}	λ(j)	rC(j)	π(j)	var{λ(j)}	var{π(j)}
0.648	3	1.174	31.69	3	532.80
0.648	26	0.888	23.08	26	82.21
0.648	5	1.262	15.14	5	91.34
2.712	2	0.580	4.06	2	14.21
	6	1.174	8.22	6	31.71
0.648	23	0.864	16.42	23	94.38
2.712	7	1.224	22.04	7	161.45
2.712	3	1.306	11.76	3	98.43
0.648	1	0.790	5.53	1	37.82
0	5	0.911	10.93	5	53.95
0.648	7	1.274	29.31	7	242.60
2.712	10	0.747	5.98	10	13.13
0	4	0.586	5.28	4	14.39
0	3	0.689	8.95	3	47.53
0	14	3.656	91.41	14	2296.74
0	8	1.160	15.08	8	79.62
	sum{λ}		sum{π}	var{λ}	var{π}
	127		305	127	3892

POOLED SITES

delta	178	= pi - lambda
theta	0.3998	= (lambda/pi)/(1+[var{pi}/pi^2])
var{delta}	4019	= var{lambda}+var{pi}
var{theta}	0.0073	= theta^2 * ([var{lambda}/lambda^2]+[var{pi}/pi^2])/[(1+[var{pi}/pi^2])^2]
stdev{lambda}	11.27	= sqrt[var{lambda}]
stdev{pi}	62.39	
stdev{delta}	63.40	
stdev{theta}	0.086	

Change in Crashes:	178	REDUCTION - SAFER
	63.40	+/- std deviation
Percent Change:	60.0%	REDUCTION - SAFER
	8.6%	+/- std deviation

Table 4: Summary Results of Naïve Methods

	Change in Crashes Change +/- Std Dev(Change)	Percent Change SafeEff +/- Std Err(SafeEff)
Naïve Before-After Results	108 +/- 19.03	46.2 % +/- 5.9 %
Naïve with Traffic Factor Before-After Results	105 +/- 19.44	45.4 % +/- 6.1 %
C-G Study, Naïve Style	100 +/- 215.97	70.6 % +/- 14.7 %
C-G Study, Naïve Style, Pooled Sites	178 +/- 63.4	60 % +/- 8.6 %

3.5 Empirical Bayes Before-After Safety Evaluation

Shown below are the key calculations and results for the BASE CASE analysis. The same process is used for the four refinements.

		BefAllYrs				AftAllYrs					
IntNum	Formula Applied	Nbimv-nSG	Npred,bi	wi,B	Nexpected,B	Naimv-nSG	Npred,ai	ri	Nexpected,A	omega_i	SafeEff_i
1	4SG	21.41	21.41	0.11	26.40	18.93	18.93	0.88	23.35	0.13	87.15
2	4SG	14.86	14.86	0.15	24.36	15.22	15.22	1.02	24.94	1.04	-4.24
4	4SG	32.94	32.94	0.07	13.51	34.32	34.32	1.04	14.08	0.36	64.48
5	4SG	27.34	27.34	0.09	8.74	25.27	25.27	0.92	8.08	0.25	75.25
6	4SG	15.01	15.01	0.15	8.17	14.86	14.86	0.99	8.09	0.74	25.81
7	3SG	42.57	42.57	0.07	20.57	44.17	44.17	1.04	21.34	1.08	-7.79
8	4SG	50.09	50.09	0.05	19.56	44.54	44.54	0.89	17.40	0.40	59.76
10	4SG	15.14	15.14	0.14	9.89	14.60	14.60	0.96	9.53	0.31	68.53
11	4SG	18.36	18.36	0.12	8.39	16.89	16.89	0.92	7.72	0.13	87.05
12	4SG	40.31	40.31	0.06	13.69	44.85	44.85	1.11	15.24	0.33	67.19
13	4SG	17.64	17.64	0.13	22.32	17.44	17.44	0.99	22.07	0.32	68.28
14	4SG	9.23	9.23	0.22	8.27	8.78	8.78	0.95	7.87	1.27	-27.09
15	3SG	78.95	78.95	0.04	11.59	76.31	76.31	0.97	11.20	0.36	64.28
16	3SG	81.34	81.34	0.04	15.45	77.42	77.42	0.95	14.71	0.20	79.61
103	4SG	14.32	14.32	0.15	23.38	14.28	14.28	1.00	23.32	0.60	39.97
109	4SG	64.75	64.75	0.04	14.97	63.69	63.69	0.98	14.73	0.54	45.68

omega' = sum($N_{observed,A}$)all sites / sum($N_{expected,A}$)all sites

Var(Nexpected,A,all) = sum[(ri^2)*$N_{expected,B}$ * (1-$w_{i,B}$)] over all sites

omega = omega' / {1+[var($N_{expected,A,all}$)] / [$N_{expected,A,all}$]^2}

Safety Effectiveness = 100*(1 - omega)

var(omega) = {omega'^2 *
[(1/$N_{observed,A}$) + (var{sum[$N_{expected,A}$]over all sites}/(sum[$N_{expected,A}$]over all sites)^2)] /
[1 + (var{sum[$N_{expected,A}$] over all sites} / (sum[$N_{expected,A}$]over all sites)^2)]

SE(omega)	= sqrt[var(omega)]
SE(Safety Effectiveness)	=100 * SE(omega)
Performance Measure	= ABS[Safety Effectiveness / SE(Safety Effectiveness)]
PM < 1.7	Treatment Effect NOT significant at the (approx.) 90% confidence interval
PM >= 1.7	Treatment Effect IS significant at the (approx.) 90% confidence interval
PM >= 2.0	Treatment Effect IS significant at the (approx.) 95% confidence interval

STEP 8 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT (ODDS RATIO omega') FOR ALL SITES COMBINED

R_SiteType		omega'
0	All Ints	1.04
1	All Ints	0.52

STEP 9 ADJUST ODDS RATIO TO OBTAIN UNBIASED ESTIMATE OF TREATMENT EFFECTIVENESS

R_SiteType		Var(Nexpected,A,all)	omega
0	All Ints	181.90	1.04
1	All Ints	215.40	0.52

STEP 10 CALCULATE OVERALL UNBIASED SAFETY EFFECTIVENESS AS A PERCENT CHANGE IN CRASH FREQUENCY ACROSS ALL SITES

R_SiteType		Safety Effectiveness
0	All Ints	-3.59
1	All Ints	48.06

ESTIMATION OF PRECISION OF TREATMENT EFFECTIVENESS

STEP 11 CALCULATE VARIANCE OF UNBIASED ESTIMATED SAFETY EFFECTIVENESS AS AN ODDS RATIO

R_SiteType		$N_{observed,A,all\ sites}$	$N_{expected,A,all\ sites}$	var(omega)
0	All Ints	231	222.17	0.00863
1	All Ints	127	243.65	0.00311

STEP 12 CALCULATE STANDARD ERROR OF THE STEP 11 ODDS RATIO

R_SiteType		SE(omega)
0	All Ints	0.09
1	All Ints	0.06

STEP 13 CALCULATE STANDARD ERROR OF THE STEP 10 UNBIASED SAFETY EFFECTIVENESS

R_SiteType		SE(Safety Effectiveness)
0	All Ints	9.29
1	All Ints	5.58

STEP 14 ASSESS STATISTICAL SIGNIFICANCE OF ESTIMATED SAFETY EFFECTIVENESS

R_SiteType		Performance Measure
0	All Ints	0.39
1	All Ints	8.61

3.6 Before-After Comparison-Group Safety Evaluation

Shown below are the key calculations and results for the BASE CASE analysis. The same process is used for the four refinements.

$N_{exptd,CB}$ — $N_{obsvd,Cbj}$	$N_{pred,Tbi}$ / Y_{BT} / Tint Num / CInt Num	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
16	3	21.62	15.00	33.26	42.97	18.53	17.81										
28	17	78.57	54.54	120.88	156.21	67.37	64.74										
25	18	37.14	25.78	57.14	73.83	31.84	30.60										
19	19	50.64	35.15	77.90	100.67	43.41	41.72										
9	22	2.41	1.67	3.71	4.79	2.07	1.99										
12	23	37.37	25.94	57.50	74.30	32.04	30.79										
14	9							5.36	2.94	9.82	2.97	1.81					
7	20							22.34	12.26	40.92	12.37	7.54					
12	21							15.02	8.25	27.52	8.32	5.07					
13	24							29.98	16.46	54.93	16.61	10.12					
17	25							23.00	12.63	42.14	12.74	7.77					
8	26												55.22	108.15	111.43	19.61	88.70
13	27												21.13	41.38	42.64	7.50	33.94
13	28												31.68	62.05	63.93	11.25	50.89
18	29												33.47	65.55	67.54	11.89	53.76
14	122												5.30	10.39	10.70	1.88	8.52
	$N_{exptd,CB,total}$	**227.75**	**158.09**	**350.39**	**452.77**	**195.27**	**187.66**	**95.71**	**52.55**	**175.34**	**53.01**	**32.31**	**146.79**	**287.52**	**296.24**	**52.14**	**235.80**

Adj_{ijb} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during BEFORE period (b)

$= (N_{pred,Tbi} / N_{pred,Cbj})*(Y_{BT} / Y_{BC})$

$N_{exptd,CA}$ — $N_{obsvd,Caj}$	Y_{AC}	$N_{pred,Tai}$ / Y_{AT} / Tint Num / CInt Num	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
19	3	3	24.35	19.57	44.15	56.81	21.73	22.44										
24	3	17	63.52	51.05	115.14	148.16	56.66	58.51										
19	3	18	30.45	24.47	55.20	71.03	27.16	28.05										
23	3	19	63.85	51.32	115.75	148.95	56.96	58.82										
7	3	22	1.30	1.04	2.36	3.03	1.16	1.20										
13	3	23	39.22	31.52	71.09	91.49	34.99	36.13										
16	3	9							5.88	3.46	10.37	3.40	2.05					
8	3	20							25.32	14.90	44.64	14.63	8.80					
13	3	21							19.42	11.42	34.23	11.22	6.75					
7	3	24							15.83	9.31	27.91	9.15	5.51					
12	3	25							15.83	9.31	27.90	9.14	5.50					
26	3	26												203.72	346.62	351.65	64.86	289.29
11	3	27												20.68	35.19	35.70	6.58	29.37
14	3	28												37.16	63.22	64.14	11.83	52.77
10	3	29												22.00	37.44	37.98	7.01	31.24
9	3	122												3.81	6.48	6.57	1.21	5.40
		$N_{exptd,CA,total}$	**222.69**	**178.99**	**403.69**	**519.48**	**198.66**	**205.14**	**82.28**	**48.40**	**145.06**	**47.54**	**28.61**	**287.36**	**488.94**	**496.04**	**91.49**	**408.07**

Adj_{ija} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during AFTER period (a)

$= (N_{pred,Tai} / N_{pred,Caj})*(Y_{AT} / Y_{AC})$

$r_{i,C} = N_{exptd,C,A,total} / N_{exptd,C,B,total}$

$N_{exptd,TA} = \text{sum}(N_{obsvd,T,B} * r_{iC})$ over all sites

$$omega_i = \text{sum}(N_{observed,T,A} / N_{expected,T,A}) \text{ over all sites}$$
$$= (N_{observed,T,A,total} / N_{observed,T,B,total}) * (N_{expected,C,B,total} / N_{expected,C,A,total})$$

$$R_{i(SE)}^2 = (1/N_{observed,T,A,total}) + (1/ N_{observed,T,B,total}) + (1/N_{expected,C,B,total}) + (1/N_{expected,C,A,total})$$

$$w_i = 1/R_{i(SE)}^2$$

TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	**103**	**109**
$N_{exptd,CA,total}$	222.69	178.99	403.69	519.48	198.66	205.14	82.28	48.40	145.06	47.54	28.61	287.36	488.94	496.04	91.49	408.07
$N_{exptd,CB,total}$	227.75	158.09	350.39	452.77	195.27	187.66	95.71	52.55	175.34	53.01	32.31	146.79	287.52	296.24	52.14	235.80
$r_{i,C}$	0.9778	1.1322	1.1521	1.1473	1.0174	1.0932	0.8597	0.9211	0.8273	0.8969	0.8855	1.9576	1.7005	1.6745	1.7549	1.7305
$N_{observedTB}$	27	26	12	19	7	23	7	7	18	9	8	12	9	13	25	13
$N_{exptd,TA}$	26.40	29.44	13.83	21.80	7.12	25.14	6.02	6.45	14.89	8.07	7.08	23.49	15.30	21.77	43.87	22.50
$N_{observedTA}$	3	26	5	23	1	7	2	6	7	3	10	5	4	3	14	8
$omega_i$	0.114	0.883	0.362	1.055	0.140	0.278	0.332	0.931	0.470	0.372	1.412	0.213	0.261	0.138	0.319	0.356
R_i	-2.175	-0.124	-1.017	0.0536	-1.963	-1.279	-1.102	-0.072	-0.755	-0.99	0.3448	-1.547	-1.342	-1.982	-1.142	-1.034
$R_{i(SE)}^2$	0.3793	0.0888	0.2887	0.1002	1.153	0.1965	0.6655	0.3492	0.211	0.4843	0.2909	0.2936	0.3666	0.4156	0.1415	0.2086
w_i	2.637	11.257	3.464	9.976	0.867	5.088	1.503	2.864	4.739	2.065	3.438	3.406	2.728	2.406	7.065	4.794
w_iR_i	-5.734	-1.397	-3.523	0.5349	-1.703	-6.506	-1.655	-0.206	-3.577	-2.044	1.1852	-5.269	-3.66	-4.768	-8.07	-4.956

STEP 12 CALCULATE WEIGHTED AVERAGE LOG ODDS RATIO ACROSS ALL TREATMENT SITES

$\text{sum}(w_i*R_i)$ -51.349
$\text{sum}(w_i)$ 68.294
-0.752 = R =sum(wi*Ri)/sum(wi)

STEP 13 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT EXPRESSED AS AN ODDS RATIO

0.47 = OR = exp(R)

STEP 14 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT EXPRESSED AS A PERCENTAGE CHANGE IN CRASH FREQUENCY

52.85 = Safety Effectiveness = 100 * (1 - R)

52.85%	= Safety Effectiveness

ESTIMATION OF PRECISION OF TREATMENT EFFECTIVENESS

STEP 15 CALCULATE STANDARD ERROR OF TREATMENT EFFECTIVENESS

5.71	= SE(Safety Effectiveness)

= 100 * OR / sqrt(sum(wi))

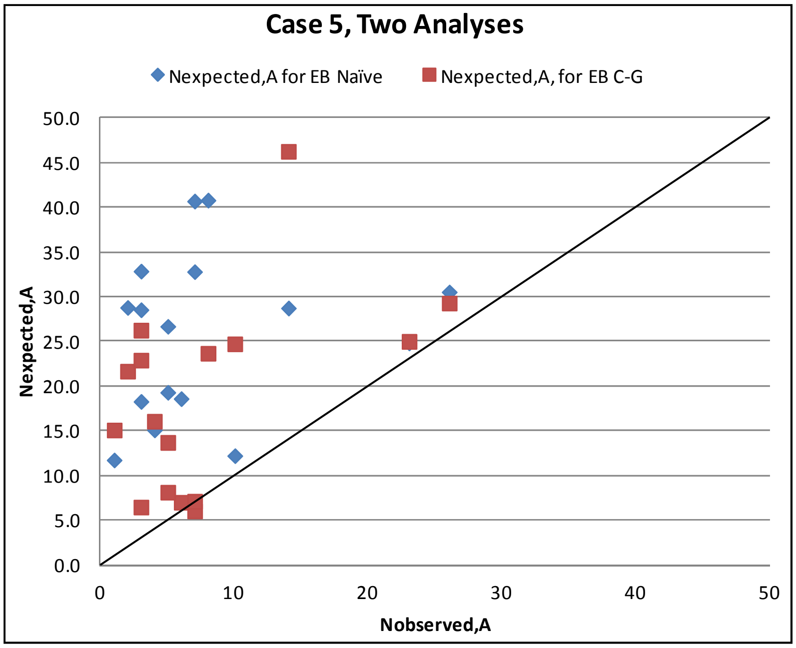
STEP 16 ASSESS STATISTICAL SIGNIFICANCE OF ESTIMATED SAFETY EFFECTIVENESS

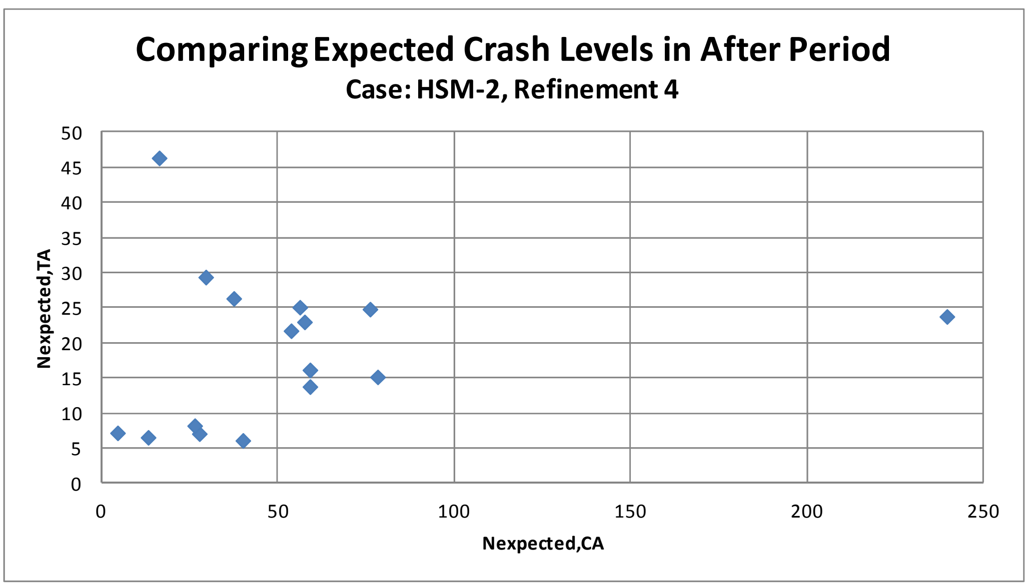
9.26	= Performance Measure

= ABS[Safety Effectiveness / SE(Safety Effectiveness)]

PM < 1.7 Treatment Effect NOT significant at the (approx.) 90% confidence interval
PM >= 1.7 Treatment Effect IS significant at the (approx.) 90% confidence interval
PM >= 2.0 Treatment Effect IS significant at the (approx.) 95% confidence interval

Figure 6: Comparing the Expected to Observed Number of Crashes after Treatment





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4 SUMMARY & CONCLUSIONS

The City of Raleigh instituted a red-light running prevention campaign in 2003 by installing cameras triggered by red light violators at intersections with a high number of crashes that did not respond strongly to other safety measures. With several years of before and after crash data now available, the City wanted a system assessment by an independent analyst. Therefore AECOM was selected by the City and hired by the red-light camera vendor, ACS, to conduct an observational before-after study using Empirical Bayes methods.

Multiple observational before/after analyses – from simplistic "naïve" methods to complex multivariate methods – were conducted to enable the City to see how results vary with the types of data incorporated and the methods applied, thereby gaining comfort in the conclusions reached.

Table 5: Overall Safety Effectiveness as a Percent Change in Crash Frequency Across All Sites

Methodology Applied	Percent Change SafeEff +/- SE(SafeEff), (Approx. Sig.)
Naïve Before-After	46.2 % +/- 5.9 %
Naïve with Traffic Factor Before-After	45.4 % +/- 6.1 %
C-G Study, Naïve Style	70.6 % +/- 14.7 %
C-G Study, Naïve Style, Pooled Sites	60.0 % +/- 8.6 %
HSM 1: Empirical Bayes Before/After Safety Evaluation	
Base Case	48.06 % +/- 5.58 %, (8.61)
Refinement 1	45.94 % +/- 5.85 %, (7.86)
Refinement 2	55.03 % +/- 4.73 %, (11.64)
Refinement 3	59.34 % +/- 4.21 %, (14.08)
Refinement 4	59.17 % +/- 4.23 %, (13.98)
HSM 2: Before/After Comparison-Group Safety Evaluation	
Base Case	52.85 % +/- 5.71 %, (9.26)
Refinement 1	51.69 % +/- 5.85 %, (8.83)
Refinement 2	51.71 % +/- 5.85 %, (8.83)
Refinement 3	51.78 % +/- 5.85 %, (8.85)
Refinement 4	51.78 % +/- 5.85 %, (8.85)

SafeEff = Safety Effectiveness, SE(SafeEff) = standard error of SafeEff, Approx. Sig. = approximate significance.

BASE CASE: All CMF, Ci = 1.00
Refinement 1: BASE + All CMF; Ci = 1.00
Refinement 2: BASE + All CMF + Ci_forNC
Refinement 3: BASE + All CMF + Ci_forPiedmont
Refinement 4: BASE + All CMF (CMF5 with Raleigh Data) + Ci_forPiedmont

Overall, the results suggest that the SafeLight Raleigh red-light camera program is having a positive impact by, on average, a 52 percent reduction in Type 30 angle crashes at this group of treated intersections. Based on the multiple analyses, the smallest percent change in crash frequency was approximately a 39 percent reduction (method: naïve with traffic factor) and the largest percent change was approximately 85 percent (method: naïve comparison-group); these widely varying results were found with the naïve approaches. The methods that incorporate more information about the intersections and crashes (HSM 1 & HSM 2) show a tighter spread of safety effectiveness both in terms of the means (48 to 59%) and their standard errors (4 to 6%).

In detail, most treated intersections had improved safety; however, the analysis suggests a few locations did not benefit with respect to Type 30 crash types. Therefore, the program may further be improved after assessing what those few intersections had in common with one another and how they differed from the majority of the treated intersections.

Although the results are quite promising, potential limitations of this study should of course be mentioned.

- Short before and after time periods that lessen the ability to identify patterns and trends. Although, the HSM methods yielded results that were strongly statistically significant with confidence levels above 95 percent.
- A small number of comparison intersections, with some sites possibly exhibiting spillover effects.
- Some intersections were at or near interchanges which is not recommended by the HSM.

Finally note, only Type 30 angle crashes were investigated herein. Red-light camera research typically shows an inverse relationship between angle and rear-end crashes, in other words, as angle crashes decrease rear-end crashes often increase in some proportion. Typically, the former are more severe and the latter more often property damage only, but the City may want to investigate the proportionality between the two crash types at SafeLight Raleigh program locations as the program moves forward.

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[obtained on 6/2/2011]

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http://www.sciencedirect.com/science/article/pii/S0001457598000591
Notes: abstract only.

Transportation Research Board (2010). *Highway Safety Manual*. Washington, DC.

http://www.thenewspaper.com/rlc/docs/2007/gvnc-cancel.pdf
Notes: 2007 article on termination of red light contract in NC town because money was not going to correct agency.

2008 report for Orange Cty, FL on an RLR pilot project.
http://www.orangecountyfl.net/Portals/0/Resources/Internet/DEPARTMENTS/Public_Works/Docs_2009/RLRFinalReport112508.pdf
Notes: No statistical analysis conducted. Report not saved.

2009 news release & report on crash reductions in Lafayette, LA
http://www.lafayettela.gov/upload/images/traffic/pdf/safelight_safespeed_newsrelease.pdf
http://www.lafayettela.gov/upload/images/traffic/pdf/safelight_safespeed_statusreport.pdf

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6 APPENDICES

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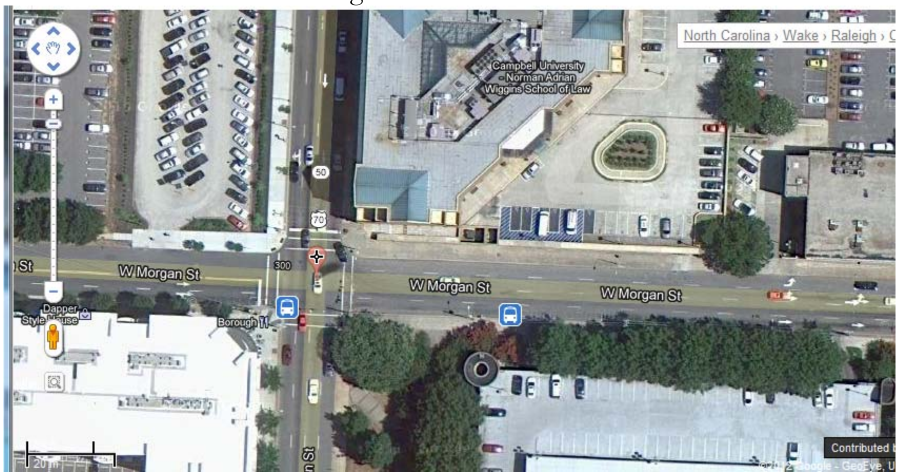
APPENDIX A. TREATMENT INTERSECTIONS

Intersection 1: Dawson & Morgan



Intersection 2: Dawson & South

Intersection 3 & 103: McDowell & Morgan

Intersection 4: Rowan & Six Forks

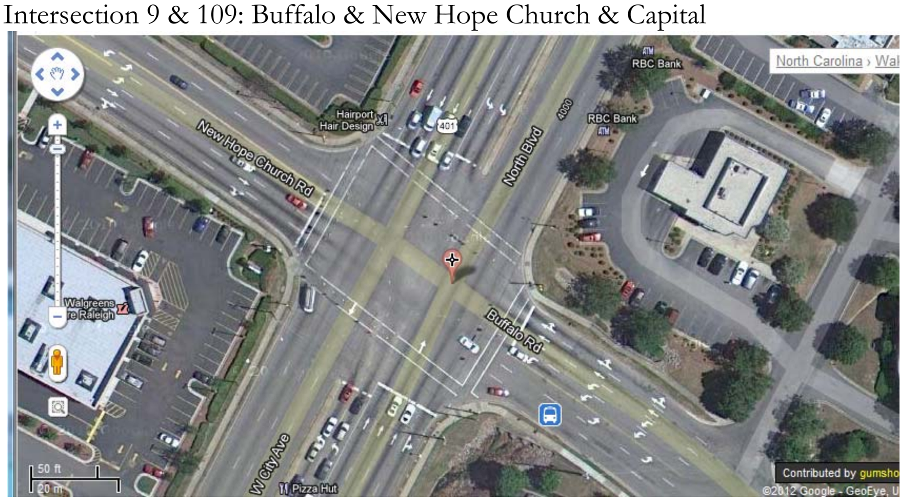
Intersection 5: Dartmouth & Six Forks

Intersection 6: Brentwood & New Hope Church

Intersection 7: Capital & Highwoods

Intersection 8: Capital & Millbrook & New Hope

Intersection 9 & 109: Buffalo & New Hope Church & Capital

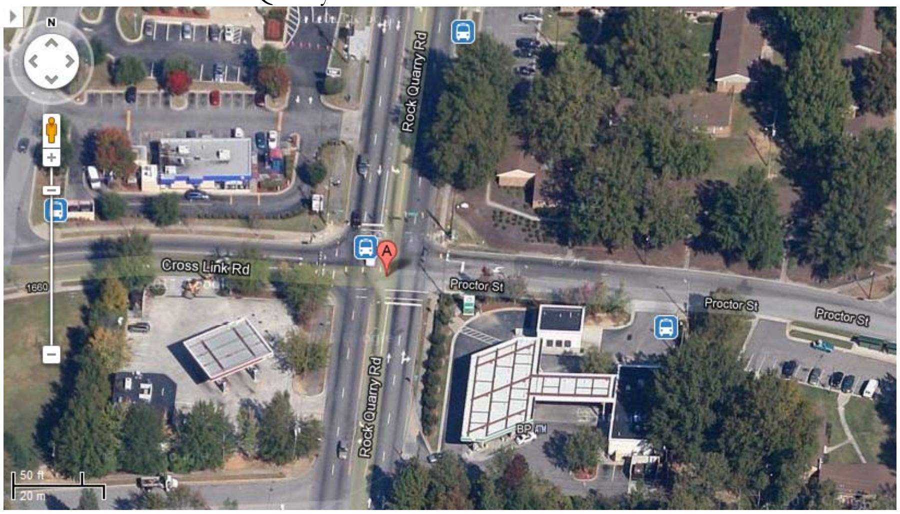


Intersection 10: Peace & West

Intersection 11: Dixie & Friendly & Hillsborough

Intersection 12: Chapanoke & Wilmington

Intersection 13: Rock Quarry & Cross Link & Proctor



Intersection 14: New Bern & Tarboro

Intersection 15: I-440 Inner & New Bern

Intersection 16: I-440 Outer & New Bern

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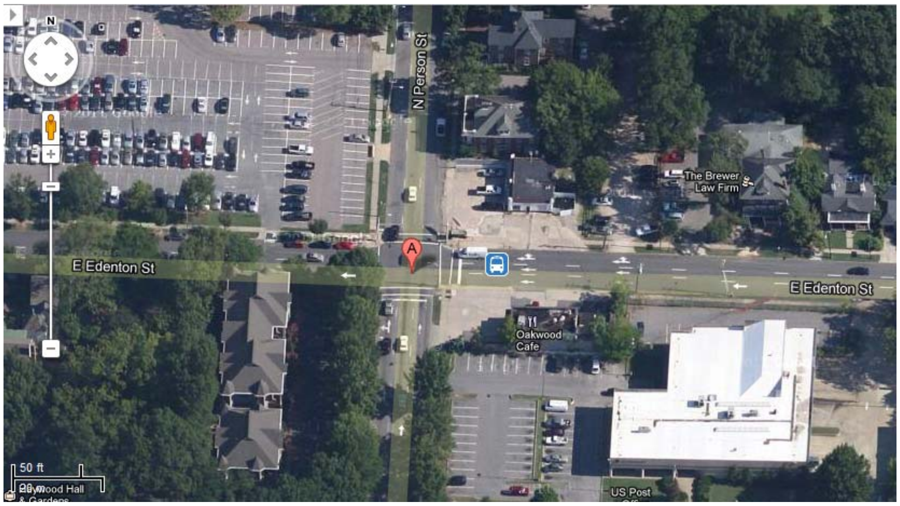
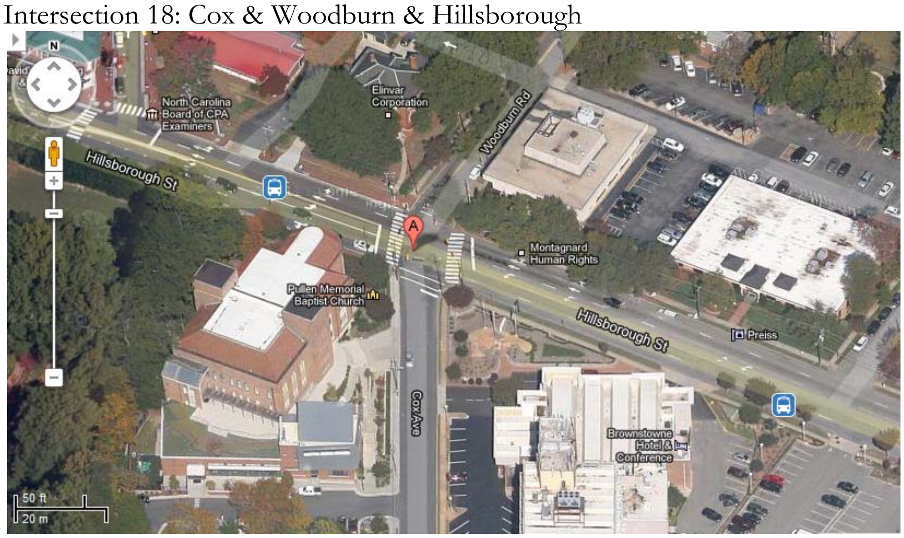
APPENDIX B. COMPARISON INTERSECTIONS

Intersection 17: Person & Edenton

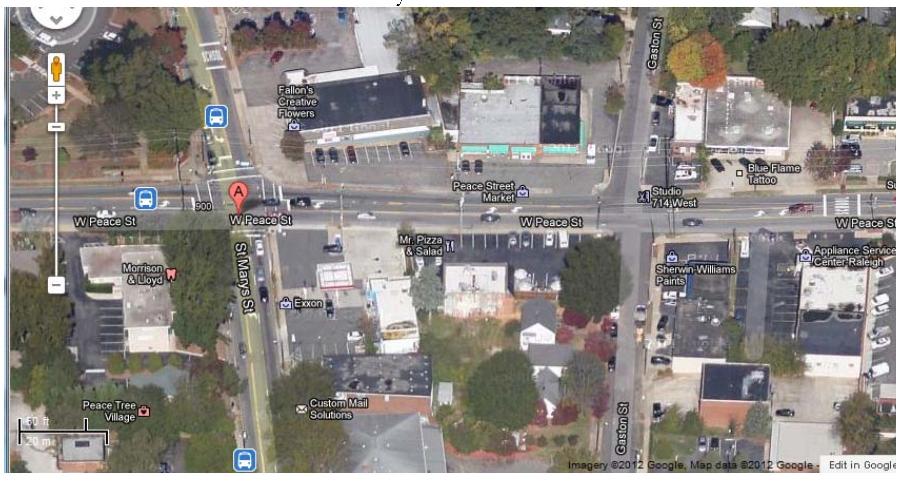


Intersection 18: Cox & Woodburn & Hillsborough



Intersection 19: Blount & Peace

Intersection 20: Peace & Saint Marys



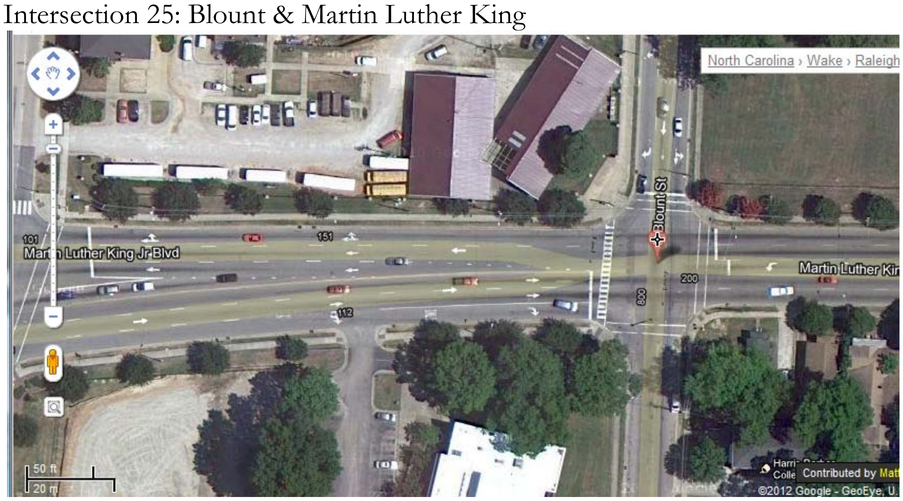
Intersection 21: Millbrook & Old Wake Forest

Intersection 22 & 122: I-440 Outer & Poole

Intersection 23: Edenton & Wilmington

Intersection 24: Poole & Raleigh

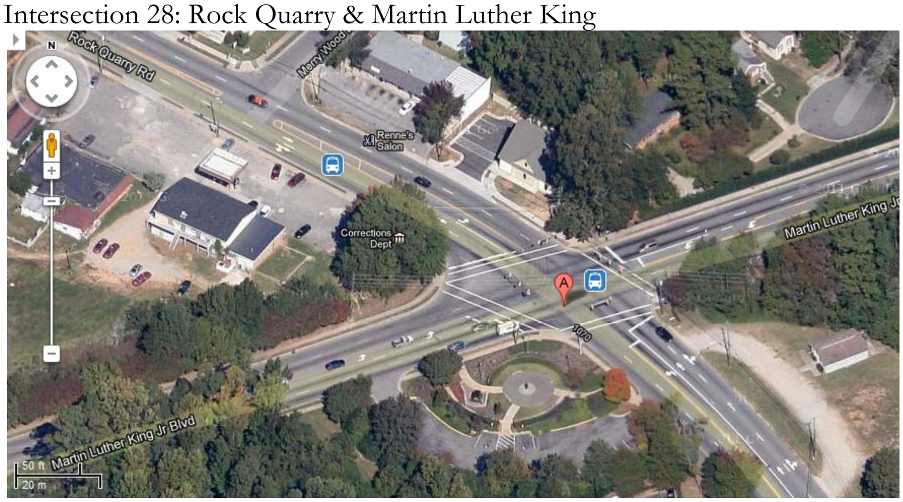
Intersection 25: Blount & Martin Luther King



Intersection 26: Morgan & Wilmington

Intersection 27: Duraleigh & Edward Mills

Intersection 28: Rock Quarry & Martin Luther King



Intersection 29: Dixie & Wade

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APPENDIX C. DATA COLLECTION VARIABLES

VARIABLE	DESCRIPTION	POSSIBLE VALUES
SigNum	Signal ID Number	
Filename_Image	Aerial Image Filename	Naming convention: FI-xxxxx (FI = image, xxxxx = signal ID number)
Filename_SigPlan	Signal Plan Filename	Naming convention: FS-xxxxx (FS = signal plan, xxxxx = signal ID number)
Filename_Crash	Crash Report Filename	Use naming convention of TEAAS or Raleigh Police Dept. -- be consistent
Lat	Latitude of Intersection Center	
Lon	Longitude of Intersection Center	
Approaches	Number of Approaches	1 to 4
Name_A1	Name of Approach 1	Use naming convention of Raleigh Police Dept.
Name_A2	Name of Approach 2	Use naming convention of Raleigh Police Dept.
Name_A3	Name of Approach 3	Use naming convention of Raleigh Police Dept.
Name_A4	Name of Approach 4	Use naming convention of Raleigh Police Dept.
Dir_A1	Direction of Travel of Approach 1	NB, SB, EB, WB
Dir_A2	Direction of Travel of Approach 2	NB, SB, EB, WB
Dir_A3	Direction of Travel of Approach 3	NB, SB, EB, WB
Dir_A4	Direction of Travel of Approach 4	NB, SB, EB, WB
G_Ang_A1toA2	Geometry - angle between centerlines of approaches 1 and 2	Default should be 90 degrees. Range should be approx. 20 deg. To 180 deg.
G_Ang_A2toA3	Geometry - angle between centerlines of approaches 2 and 3	Default should be 90 degrees. Range should be approx. 20 deg. To 180 deg.
G_Ang_A3toA4	Geometry - angle between centerlines of approaches 3 and 4	Default should be 90 degrees. Range should be approx. 20 deg. To 180 deg.
G_Ang_A4toA1	Geometry - angle between centerlines of approaches 4 and 1	Default should be 90 degrees. Range should be approx. 20 deg. To 180 deg.
G_NumLns_A1	Geometry - number of lanes for approach 1	1 to 6
G_NumLns_A2	Geometry - number of lanes for approach 2	1 to 6
G_NumLns_A3	Geometry - number of lanes for approach 3	1 to 6
G_NumLns_A4	Geometry - number of lanes for approach 4	1 to 6
G_Grade_A1	Geometry - percent grade on approach 1	+ = uphill towards intersection, - = downhill towards intersection
G_Grade_A2	Geometry - percent grade on approach 2	+ = uphill towards intersection, - = downhill towards intersection
G_Grade_A3	Geometry - percent grade on approach 3	+ = uphill towards intersection, - = downhill towards intersection
G_Grade_A4	Geometry - percent grade on approach 4	+ = uphill towards intersection, - = downhill towards intersection
G_Speed_A1	Geometry - speed limit on approach 1 (mph)	20 to 55 mph in 5 mph increments
G_Speed_A2	Geometry - speed limit on approach 2 (mph)	20 to 55 mph in 5 mph increments
G_Speed_A3	Geometry - speed limit on approach 3 (mph)	20 to 55 mph in 5 mph increments
G_Speed_A4	Geometry - speed limit on approach 4 (mph)	20 to 55 mph in 5 mph increments
G_ISD_A1	Geometry - intersection sight distance for approach 1 (ft)	
G_ISD_A2	Geometry - intersection sight distance for approach 2 (ft)	
G_ISD_A3	Geometry - intersection sight distance for approach 3 (ft)	
G_ISD_A4	Geometry - intersection sight distance for approach 4 (ft)	
G_Width_A1	Geometry - width of approach 1 (curb-to-curb in ft)	
G_Width_A2	Geometry - width of approach 2 (curb-to-curb in ft)	
G_Width_A3	Geometry - width of approach 3 (curb-to-curb in ft)	
G_Width_A4	Geometry - width of approach 4 (curb-to-curb in ft)	

VARIABLE	DESCRIPTION	POSSIBLE VALUES
M_LaneAssign_A1L1	Markings - lane assignment approach 1, lane 1	U, L, T, R, Pkg (lane 1 = adjacent to centerline if two-way or left-hand side if one-way)
M_LaneAssign_A1L2	Markings - lane assignment approach 1, lane 2	U, L, T, R, Pkg (lane 2 = lane to right of lane 1)
M_LaneAssign_A1L3	Markings - lane assignment approach 1, lane 3	U, L, T, R, Pkg
M_LaneAssign_A1L4	Markings - lane assignment approach 1, lane 4	U, L, T, R, Pkg
M_LaneAssign_A1L5	Markings - lane assignment approach 1, lane 5	U, L, T, R, Pkg
M_LaneAssign_A1L6	Markings - lane assignment approach 1, lane 6	U, L, T, R, Pkg
M_LaneAssign_A2L1	Markings - lane assignment approach 2, lane 1	U, L, T, R, Pkg (lane 1 = adjacent to centerline if two-way or left-hand side if one-way)
M_LaneAssign_A2L2	Markings - lane assignment approach 2, lane 2	U, L, T, R, Pkg (lane 2 = lane to right of lane 1)
M_LaneAssign_A2L3	Markings - lane assignment approach 2, lane 3	U, L, T, R, Pkg
M_LaneAssign_A2L4	Markings - lane assignment approach 2, lane 4	U, L, T, R, Pkg
M_LaneAssign_A2L5	Markings - lane assignment approach 2, lane 5	U, L, T, R, Pkg
M_LaneAssign_A2L6	Markings - lane assignment approach 2, lane 6	U, L, T, R, Pkg
M_LaneAssign_A3L1	Markings - lane assignment approach 3, lane 1	U, L, T, R, Pkg (lane 1 = adjacent to centerline if two-way or left-hand side if one-way)
M_LaneAssign_A3L2	Markings - lane assignment approach 3, lane 2	U, L, T, R, Pkg (lane 2 = lane to right of lane 1)
M_LaneAssign_A3L3	Markings - lane assignment approach 3, lane 3	U, L, T, R, Pkg
M_LaneAssign_A3L4	Markings - lane assignment approach 3, lane 4	U, L, T, R, Pkg
M_LaneAssign_A3L5	Markings - lane assignment approach 3, lane 5	U, L, T, R, Pkg
M_LaneAssign_A3L6	Markings - lane assignment approach 3, lane 6	U, L, T, R, Pkg
M_LaneAssign_A4L1	Markings - lane assignment approach 4, lane 1	U, L, T, R, Pkg (lane 1 = adjacent to centerline if two-way or left-hand side if one-way)
M_LaneAssign_A4L2	Markings - lane assignment approach 4, lane 2	U, L, T, R, Pkg (lane 2 = lane to right of lane 1)
M_LaneAssign_A4L3	Markings - lane assignment approach 4, lane 3	U, L, T, R, Pkg
M_LaneAssign_A4L4	Markings - lane assignment approach 4, lane 4	U, L, T, R, Pkg
M_LaneAssign_A4L5	Markings - lane assignment approach 4, lane 5	U, L, T, R, Pkg
M_LaneAssign_A4L6	Markings - lane assignment approach 4, lane 6	U, L, T, R, Pkg
M_StopbarCond_A1	Markings - condition of the stopbar on approach 1	Good/clearly visible = 1, Bad = 0
M_StopbarCond_A2	Markings - condition of the stopbar on approach 2	Good/clearly visible = 1, Bad = 0
M_StopbarCond_A3	Markings - condition of the stopbar on approach 3	Good/clearly visible = 1, Bad = 0
M_StopbarCond_A4	Markings - condition of the stopbar on approach 4	Good/clearly visible = 1, Bad = 0
M_LaneLineCond_A1	Markings - condition of lane lines on approach 1	Good/clearly visible = 1, Bad = 0
M_LaneLineCond_A2	Markings - condition of lane lines on approach 2	Good/clearly visible = 1, Bad = 0
M_LaneLineCond_A3	Markings - condition of lane lines on approach 3	Good/clearly visible = 1, Bad = 0
M_LaneLineCond_A4	Markings - condition of lane lines on approach 4	Good/clearly visible = 1, Bad = 0
M_XWalkCond_A1	Markings - condition of crosswalk on approach 1	Good/clearly visible = 1, Bad = 0, No crosswalk = 2
M_XWalkCond_A2	Markings - condition of crosswalk on approach 2	Good/clearly visible = 1, Bad = 0, No crosswalk = 2
M_XWalkCond_A3	Markings - condition of crosswalk on approach 3	Good/clearly visible = 1, Bad = 0, No crosswalk = 2
M_XWalkCond_A4	Markings - condition of crosswalk on approach 4	Good/clearly visible = 1, Bad = 0, No crosswalk = 2

VARIABLE	DESCRIPTION	POSSIBLE VALUES
S_SignalAhead_A1	Signage - presence of "Signal Ahead" sign on approach 1	Yes = 1, No = 0
S_SignalAhead_A2	Signage - presence of "Signal Ahead" sign on approach 2	Yes = 1, No = 0
S_SignalAhead_A3	Signage - presence of "Signal Ahead" sign on approach 3	Yes = 1, No = 0
S_SignalAhead_A4	Signage - presence of "Signal Ahead" sign on approach 4	Yes = 1, No = 0
S_OtherWSigns_A1	Signage - presence of other warning signs on approach 1	Yes = 1, No = 0 (if yes, add an explanation in a comment)
S_OtherWSigns_A2	Signage - presence of other warning signs on approach 2	Yes = 1, No = 0 (if yes, add an explanation in a comment)
S_OtherWSigns_A3	Signage - presence of other warning signs on approach 3	Yes = 1, No = 0 (if yes, add an explanation in a comment)
S_OtherWSigns_A4	Signage - presence of other warning signs on approach 4	Yes = 1, No = 0 (if yes, add an explanation in a comment)
S_SpeedPost_A1	Signage - is speed limit posted on approach 1?	Yes = 1, No = 0
S_SpeedPost_A2	Signage - is speed limit posted on approach 2?	Yes = 1, No = 0
S_SpeedPost_A3	Signage - is speed limit posted on approach 3?	Yes = 1, No = 0
S_SpeedPost_A4	Signage - is speed limit posted on approach 4?	Yes = 1, No = 0
SH_LSize_A1	Signal Hardware - lens size on approach 1	8 inches = 8, 12 inches = 12
SH_LSize_A2	Signal Hardware - lens size on approach 2	8 inches = 8, 12 inches = 12
SH_LSize_A3	Signal Hardware - lens size on approach 3	8 inches = 8, 12 inches = 12
SH_LSize_A4	Signal Hardware - lens size on approach 4	8 inches = 8, 12 inches = 12
SH_LType_A1	Signal Hardware - lens type on approach 1	Bulb = 1, LED = 2
SH_LType_A2	Signal Hardware - lens type on approach 2	Bulb = 1, LED = 2
SH_LType_A3	Signal Hardware - lens type on approach 3	Bulb = 1, LED = 2
SH_LType_A4	Signal Hardware - lens type on approach 4	Bulb = 1, LED = 2
SH_BackPlate_A1	Signal Hardware - back plate on approach 1	Yes = 1, No = 0
SH_BackPlate_A2	Signal Hardware - back plate on approach 2	Yes = 1, No = 0
SH_BackPlate_A3	Signal Hardware - back plate on approach 3	Yes = 1, No = 0
SH_BackPlate_A4	Signal Hardware - back plate on approach 4	Yes = 1, No = 0
SH_ChangeDate_A1	Signal Hardware - date signal head was changed out on approach 1	mm/dd/yyyy
SH_ChangeDate_A2	Signal Hardware - date signal head was changed out on approach 2	mm/dd/yyyy
SH_ChangeDate_A3	Signal Hardware - date signal head was changed out on approach 3	mm/dd/yyyy
SH_ChangeDate_A4	Signal Hardware - date signal head was changed out on approach 4	mm/dd/yyyy
R_SiteType	Red Light Camera - site type	comparison (no camera) = 0, treatment (camera) = 1, dummy (camera, violations not being issued) = 2
R_InstallYear	Red Light Camera - year of installation	yyyy - 1998 to 2011
R_InstallMonth	Red Light Camera - month of installation	mm - 01 to 12
R_InstallDay	Red Light Camera - month of installation	dd - 01 to 31
R_ApprANum	Red Light Camera - approach number for A direction	1 to 4
R_ApprBNum	Red Light Camera - approach number for B direction	1 to 4
R_RedOffset_ApprA	Red Light Camera - offset in seconds from start of red in direction A	time at which camera begins to take pictures of violators, show in seconds, x.xx
R_RedOffset_ApprB	Red Light Camera - offset in seconds from start of red in direction B	time at which camera begins to take pictures of violators, show in seconds, x.xx

VARIABLE	DESCRIPTION	POSSIBLE VALUES
P_Cond_A1	Pavement - condition of approach 1 (ruts, potholes, cracking, etc.)	Good = 2, Fair = 1, Poor = 0 (explain using a comment)
P_Cond_A2	Pavement - condition of approach 2 (ruts, potholes, cracking, etc.)	Good = 2, Fair = 1, Poor = 0 (explain using a comment)
P_Cond_A3	Pavement - condition of approach 3 (ruts, potholes, cracking, etc.)	Good = 2, Fair = 1, Poor = 0 (explain using a comment)
P_Cond_A4	Pavement - condition of approach 4 (ruts, potholes, cracking, etc.)	Good = 2, Fair = 1, Poor = 0 (explain using a comment)
P_xxx	Pavement -- may not need further variables except to note construction projects	
ST_A1	Signal Timing - approach 1	Pretimed = 0, Semi = 1, Fully = 2
ST_A2	Signal Timing - approach 2	Pretimed = 0, Semi = 1, Fully = 2
ST_A3	Signal Timing - approach 3	Pretimed = 0, Semi = 1, Fully = 2
ST_A4	Signal Timing - approach 4	Pretimed = 0, Semi = 1, Fully = 2
ST_Coord	Signal Timing - coordinated?	Uncoordinated/Free = 0, Coordinated = 1
ST_Cycle	Signal Timing - cycle length	seconds
ST_Yel1StartDate	Signal Timing - yellow interval 1, date initiated	mm/dd/yyyy
ST_Yel2StartDate	Signal Timing - yellow interval 2, date initiated	mm/dd/yyyy
ST_Yel3StartDate	Signal Timing - yellow interval 3, date initiated	mm/dd/yyyy
ST_Yel1_A1	Signal Timing - yellow interval 1 in seconds, approach 1	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_Yel1_A2	Signal Timing - yellow interval 1 in seconds, approach 2	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_Yel1_A3	Signal Timing - yellow interval 1 in seconds, approach 3	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_Yel1_A4	Signal Timing - yellow interval 1 in seconds, approach 4	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_Yel2_A1	Signal Timing - yellow interval 2 in seconds, approach 1	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_Yel2_A2	Signal Timing - yellow interval 2 in seconds, approach 2	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_Yel2_A3	Signal Timing - yellow interval 2 in seconds, approach 3	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_Yel2_A4	Signal Timing - yellow interval 2 in seconds, approach 4	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_Yel3_A1	Signal Timing - yellow interval 3 in seconds, approach 1	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_Yel3_A2	Signal Timing - yellow interval 3 in seconds, approach 2	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_Yel3_A3	Signal Timing - yellow interval 3 in seconds, approach 3	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_Yel3_A4	Signal Timing - yellow interval 3 in seconds, approach 4	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_AR_A1	Signal Timing - all red interval in seconds, approach 1	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_AR_A2	Signal Timing - all red interval in seconds, approach 2	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_AR_A3	Signal Timing - all red interval in seconds, approach 3	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_AR_A4	Signal Timing - all red interval in seconds, approach 4	x.x seconds (e.g. 3.2 = three and two-tenths of a second)
ST_Lprot	Signal Timing - number of approaches with protected left phasing	
ST_Lprotperm	Signal Timing - number of approaches with protected/permitted left phasing	
ST_RTORprohib	Signal Timing - number of approaches that prohibit right turn on red	

VARIABLE	DESCRIPTION	POSSIBLE VALUES
T_year1	Traffic - year first set of traffic data collected	yyyy - 1998 to 2011
T_year2	Traffic - year second set of traffic data collected	yyyy - 1998 to 2011
T_year3	Traffic - year third set of traffic data collected	yyyy - 1998 to 2011
T_year4	Traffic - year fourth set of traffic data collected	yyyy - 1998 to 2011
T_year5	Traffic - year fifth set of traffic data collected	yyyy - 1998 to 2011
T_year6	Traffic - year sixth set of traffic data collected	yyyy - 1998 to 2011
T_year7	Traffic - year seventh set of traffic data collected	yyyy - 1998 to 2011
T_year8	Traffic - year eighth set of traffic data collected	yyyy - 1998 to 2011
T_year9	Traffic - year ninth set of traffic data collected	yyyy - 1998 to 2011
T_year10	Traffic - year tenth set of traffic data collected	yyyy - 1998 to 2011
T_month1	Traffic - month first set of traffic data collected	mm - 01 to 12
T_month2	Traffic - month second set of traffic data collected	mm - 01 to 12
T_month3	Traffic - month third set of traffic data collected	mm - 01 to 12
T_month4	Traffic - month fourth set of traffic data collected	mm - 01 to 12
T_month5	Traffic - month fifth set of traffic data collected	mm - 01 to 12
T_month6	Traffic - month sixth set of traffic data collected	mm - 01 to 12
T_month7	Traffic - month seventh set of traffic data collected	mm - 01 to 12
T_month8	Traffic - month eighth set of traffic data collected	mm - 01 to 12
T_month9	Traffic - month ninth set of traffic data collected	mm - 01 to 12
T_month10	Traffic - month tenth set of traffic data collected	mm - 01 to 12
T_TMC_ampkStart_Y1	Traffic - AM peak hour start time for year 1	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_ampkStart_Y2	Traffic - AM peak hour start time for year 2	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_ampkStart_Y3	Traffic - AM peak hour start time for year 3	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_ampkStart_Y4	Traffic - AM peak hour start time for year 4	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_ampkStart_Y5	Traffic - AM peak hour start time for year 5	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_ampkStart_Y6	Traffic - AM peak hour start time for year 6	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_ampkStart_Y7	Traffic - AM peak hour start time for year 7	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_ampkStart_Y8	Traffic - AM peak hour start time for year 8	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_ampkStart_Y9	Traffic - AM peak hour start time for year 9	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_ampkStart_Y10	Traffic - AM peak hour start time for year 10	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_pmpkStart_Y1	Traffic - PM peak hour start time for year 1	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_pmpkStart_Y2	Traffic - PM peak hour start time for year 2	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_pmpkStart_Y3	Traffic - PM peak hour start time for year 3	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_pmpkStart_Y4	Traffic - PM peak hour start time for year 4	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_pmpkStart_Y5	Traffic - PM peak hour start time for year 5	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_pmpkStart_Y6	Traffic - PM peak hour start time for year 6	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_pmpkStart_Y7	Traffic - PM peak hour start time for year 7	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_pmpkStart_Y8	Traffic - PM peak hour start time for year 8	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_pmpkStart_Y9	Traffic - PM peak hour start time for year 9	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)
T_TMC_pmpkStart_Y10	Traffic - PM peak hour start time for year 10	24-hr clock (choose peak hour for entire intersection, not different peak hours per approach)

VARIABLE	DESCRIPTION	POSSIBLE VALUES
T_ampkTotal_Y1A1	Traffic - AM peak hour total traffic for year 1, approach 1	
T_ampkTotTrk_Y1A1	Traffic - AM peak hour total truck traffic for year 1, approach 1	
T_ampkTotPed_Y1A1	Traffic - AM peak hour total ped traffic for year 1, approach 1	
T_ampkL_Y1A1	Traffic - AM peak hour left-turn traffic for year 1, approach 1	
T_ampkT_Y1A1	Traffic - AM peak hour through traffic for year 1, approach 1	
T_ampkR_Y1A1	Traffic - AM peak hour right-turn traffic for year 1, approach 1	
T_ampkTotal_Y1A1	Traffic - PM peak hour total traffic for year 1, approach 1	
T_ampkTotTrk_Y1A1	Traffic - PM peak hour total truck traffic for year 1, approach 1	
T_ampkTotPed_Y1A1	Traffic - PM peak hour total ped traffic for year 1, approach 1	
T_ampkL_Y1A1	Traffic - PM peak hour left-turn traffic for year 1, approach 1	
T_ampkT_Y1A1	Traffic - PM peak hour through traffic for year 1, approach 1	
T_ampkR_Y1A1	Traffic - PM peak hour right-turn traffic for year 1, approach 1	
T_ADT1	Traffic - average daily traffic for year 1 on approach 1	
T_PHF1	Traffic - peak hour factor for year 1 on approach 1 (calculated)	
T_PeakHr_A1	Traffic - peak hour traffic from TMC for year 1 on approach 1	
T_ampkTotal_Y1A2	Traffic - AM peak hour total traffic for year 1, approach 2	
T_ampkTotTrk_Y1A2	Traffic - AM peak hour total truck traffic for year 1, approach 2	
T_ampkTotPed_Y1A2	Traffic - AM peak hour total ped traffic for year 1, approach 2	
T_ampkL_Y1A2	Traffic - AM peak hour left-turn traffic for year 1, approach 2	
T_ampkT_Y1A2	Traffic - AM peak hour through traffic for year 1, approach 2	
T_ampkR_Y1A2	Traffic - AM peak hour right-turn traffic for year 1, approach 2	
T_ampkTotal_Y1A2	Traffic - PM peak hour total traffic for year 1, approach 2	
T_ampkTotTrk_Y1A2	Traffic - PM peak hour total truck traffic for year 1, approach 2	
T_ampkTotPed_Y1A2	Traffic - PM peak hour total ped traffic for year 1, approach 2	
T_ampkL_Y1A2	Traffic - PM peak hour left-turn traffic for year 1, approach 2	
T_ampkT_Y1A2	Traffic - PM peak hour through traffic for year 1, approach 2	
T_ampkR_Y1A2	Traffic - PM peak hour right-turn traffic for year 1, approach 2	
T_ADT1	Traffic - average daily traffic for year 1 on approach 2	
T_PHF1	Traffic - peak hour factor for year 1 on approach 2 (calculated)	
T_PeakHr_A1	Traffic - peak hour traffic from TMC for year 1 on approach 2	

VARIABLE	DESCRIPTION	POSSIBLE VALUES
T_ampkTotal_Y1A3	Traffic - AM peak hour total traffic for year 1, approach 3	
T_ampkTotTrk_Y1A3	Traffic - AM peak hour total truck traffic for year 1, approach 3	
T_ampkTotPed_Y1A3	Traffic - AM peak hour total ped traffic for year 1, approach 3	
T_ampkL_Y1A3	Traffic - AM peak hour left-turn traffic for year 1, approach 3	
T_ampkT_Y1A3	Traffic - AM peak hour through traffic for year 1, approach 3	
T_ampkR_Y1A3	Traffic - AM peak hour right-turn traffic for year 1, approach 3	
T_ampkTotal_Y1A3	Traffic - PM peak hour total traffic for year 1, approach 3	
T_ampkTotTrk_Y1A3	Traffic - PM peak hour total truck traffic for year 1, approach 3	
T_ampkTotPed_Y1A3	Traffic - PM peak hour total ped traffic for year 1, approach 3	
T_ampkL_Y1A3	Traffic - PM peak hour left-turn traffic for year 1, approach 3	
T_ampkT_Y1A3	Traffic - PM peak hour through traffic for year 1, approach 3	
T_ampkR_Y1A3	Traffic - PM peak hour right-turn traffic for year 1, approach 3	
T_ADT1	Traffic - average daily traffic for year 1 on approach 3	
T_PHF1	Traffic - peak hour factor for year 1 on approach 3 (calculated)	
T_PeakHr_A1	Traffic - peak hour traffic from TMC for year 1 on approach 3	
T_ampkTotal_Y1A4	Traffic - AM peak hour total traffic for year 1, approach 4	
T_ampkTotTrk_Y1A4	Traffic - AM peak hour total truck traffic for year 1, approach 4	
T_ampkTotPed_Y1A4	Traffic - AM peak hour total ped traffic for year 1, approach 4	
T_ampkL_Y1A4	Traffic - AM peak hour left-turn traffic for year 1, approach 4	
T_ampkT_Y1A4	Traffic - AM peak hour through traffic for year 1, approach 4	
T_ampkR_Y1A4	Traffic - AM peak hour right-turn traffic for year 1, approach 4	
T_ampkTotal_Y1A4	Traffic - PM peak hour total traffic for year 1, approach 4	
T_ampkTotTrk_Y1A4	Traffic - PM peak hour total truck traffic for year 1, approach 4	
T_ampkTotPed_Y1A4	Traffic - PM peak hour total ped traffic for year 1, approach 4	
T_ampkL_Y1A4	Traffic - PM peak hour left-turn traffic for year 1, approach 4	
T_ampkT_Y1A4	Traffic - PM peak hour through traffic for year 1, approach 4	
T_ampkR_Y1A4	Traffic - PM peak hour right-turn traffic for year 1, approach 4	
T_ADT1	Traffic - average daily traffic for year 1 on approach 4	
T_PHF1	Traffic - peak hour factor for year 1 on approach 4 (calculated)	
T_PeakHr_A1	Traffic - peak hour traffic from TMC for year 1 on approach 4	

VARIABLE	DESCRIPTION	POSSIBLE VALUES
T_ampkTotal_Y2A1	Traffic - AM peak hour total traffic for year 2, approach 1	
T_ampkTotTrk_Y2A1	Traffic - AM peak hour total truck traffic for year 2, approach 1	
T_ampkTotPed_Y2A1	Traffic - AM peak hour total ped traffic for year 2, approach 1	
T_ampkL_Y2A1	Traffic - AM peak hour left-turn traffic for year 2, approach 1	
T_ampkT_Y2A1	Traffic - AM peak hour through traffic for year 2, approach 1	
T_ampkR_Y2A1	Traffic - AM peak hour right-turn traffic for year 2, approach 1	
T_ampkTotal_Y2A1	Traffic - PM peak hour total traffic for year 2, approach 1	
T_ampkTotTrk_Y2A1	Traffic - PM peak hour total truck traffic for year 2, approach 1	
T_ampkTotPed_Y2A1	Traffic - PM peak hour total ped traffic for year 2, approach 1	
T_ampkL_Y2A1	Traffic - PM peak hour left-turn traffic for year 2, approach 1	
T_ampkT_Y2A1	Traffic - PM peak hour through traffic for year 2, approach 1	
T_ampkR_Y2A1	Traffic - PM peak hour right-turn traffic for year 2, approach 1	
T_ADT1	Traffic - average daily traffic for year 2 on approach 1	
T_PHF1	Traffic - peak hour factor for year 2 on approach 1 (calculated)	
T_PeakHr_A1	Traffic - peak hour traffic from TMC for year 2 on approach 1	
T_ampkTotal_Y2A2	Traffic - AM peak hour total traffic for year 2, approach 2	
T_ampkTotTrk_Y2A2	Traffic - AM peak hour total truck traffic for year 2, approach 2	
T_ampkTotPed_Y2A2	Traffic - AM peak hour total ped traffic for year 2, approach 2	
T_ampkL_Y2A2	Traffic - AM peak hour left-turn traffic for year 2, approach 2	
T_ampkT_Y2A2	Traffic - AM peak hour through traffic for year 2, approach 2	
T_ampkR_Y2A2	Traffic - AM peak hour right-turn traffic for year 2, approach 2	
T_ampkTotal_Y2A2	Traffic - PM peak hour total traffic for year 2, approach 2	
T_ampkTotTrk_Y2A2	Traffic - PM peak hour total truck traffic for year 2, approach 2	
T_ampkTotPed_Y2A2	Traffic - PM peak hour total ped traffic for year 2, approach 2	
T_ampkL_Y2A2	Traffic - PM peak hour left-turn traffic for year 2, approach 2	
T_ampkT_Y2A2	Traffic - PM peak hour through traffic for year 2, approach 2	
T_ampkR_Y2A2	Traffic - PM peak hour right-turn traffic for year 2, approach 2	
T_ADT1	Traffic - average daily traffic for year 2 on approach 2	
T_PHF1	Traffic - peak hour factor for year 2 on approach 2 (calculated)	
T_PeakHr_A1	Traffic - peak hour traffic from TMC for year 2 on approach 2	

VARIABLE	DESCRIPTION	POSSIBLE VALUES
T_ampkTotal_Y2A3	Traffic - AM peak hour total traffic for year 2, approach 3	
T_ampkTotTrk_Y2A3	Traffic - AM peak hour total truck traffic for year 2, approach 3	
T_ampkTotPed_Y2A3	Traffic - AM peak hour total ped traffic for year 2, approach 3	
T_ampkL_Y2A3	Traffic - AM peak hour left-turn traffic for year 2, approach 3	
T_ampkT_Y2A3	Traffic - AM peak hour through traffic for year 2, approach 3	
T_ampkR_Y2A3	Traffic - AM peak hour right-turn traffic for year 2, approach 3	
T_ampkTotal_Y2A3	Traffic - PM peak hour total traffic for year 2, approach 3	
T_ampkTotTrk_Y2A3	Traffic - PM peak hour total truck traffic for year 2, approach 3	
T_ampkTotPed_Y2A3	Traffic - PM peak hour total ped traffic for year 2, approach 3	
T_ampkL_Y2A3	Traffic - PM peak hour left-turn traffic for year 2, approach 3	
T_ampkT_Y2A3	Traffic - PM peak hour through traffic for year 2, approach 3	
T_ampkR_Y2A3	Traffic - PM peak hour right-turn traffic for year 2, approach 3	
T_ADT1	Traffic - average daily traffic for year 2 on approach 3	
T_PHF1	Traffic - peak hour factor for year 2 on approach 3 (calculated)	
T_PeakHr_A1	Traffic - peak hour traffic from TMC for year 2 on approach 3	
T_ampkTotal_Y2A4	Traffic - AM peak hour total traffic for year 2, approach 4	
T_ampkTotTrk_Y2A4	Traffic - AM peak hour total truck traffic for year 2, approach 4	
T_ampkTotPed_Y2A4	Traffic - AM peak hour total ped traffic for year 2, approach 4	
T_ampkL_Y2A4	Traffic - AM peak hour left-turn traffic for year 2, approach 4	
T_ampkT_Y2A4	Traffic - AM peak hour through traffic for year 2, approach 4	
T_ampkR_Y2A4	Traffic - AM peak hour right-turn traffic for year 2, approach 4	
T_ampkTotal_Y2A4	Traffic - PM peak hour total traffic for year 2, approach 4	
T_ampkTotTrk_Y2A4	Traffic - PM peak hour total truck traffic for year 2, approach 4	
T_ampkTotPed_Y2A4	Traffic - PM peak hour total ped traffic for year 2, approach 4	
T_ampkL_Y2A4	Traffic - PM peak hour left-turn traffic for year 2, approach 4	
T_ampkT_Y2A4	Traffic - PM peak hour through traffic for year 2, approach 4	
T_ampkR_Y2A4	Traffic - PM peak hour right-turn traffic for year 2, approach 4	
T_ADT1	Traffic - average daily traffic for year 2 on approach 4	
T_PHF1	Traffic - peak hour factor for year 2 on approach 4 (calculated)	
T_PeakHr_A1	Traffic - peak hour traffic from TMC for year 2 on approach 4	

VARIABLE	DESCRIPTION	POSSIBLE VALUES
T_ampkTotal_Y3A1	Traffic - AM peak hour total traffic for year 3, approach 1	
T_ampkTotTrk_Y3A1	Traffic - AM peak hour total truck traffic for year 3, approach 1	
T_ampkTotPed_Y3A1	Traffic - AM peak hour total ped traffic for year 3, approach 1	
T_ampkL_Y3A1	Traffic - AM peak hour left-turn traffic for year 3, approach 1	
T_ampkT_Y3A1	Traffic - AM peak hour through traffic for year 3, approach 1	
T_ampkR_Y3A1	Traffic - AM peak hour right-turn traffic for year 3, approach 1	
T_ampkTotal_Y3A1	Traffic - PM peak hour total traffic for year 3, approach 1	
T_ampkTotTrk_Y3A1	Traffic - PM peak hour total truck traffic for year 3, approach 1	
T_ampkTotPed_Y3A1	Traffic - PM peak hour total ped traffic for year 3, approach 1	
T_ampkL_Y3A1	Traffic - PM peak hour left-turn traffic for year 3, approach 1	
T_ampkT_Y3A1	Traffic - PM peak hour through traffic for year 3, approach 1	
T_ampkR_Y3A1	Traffic - PM peak hour right-turn traffic for year 3, approach 1	
T_ADT1	Traffic - average daily traffic for year 3 on approach 1	
T_PHF1	Traffic - peak hour factor for year 3 on approach 1 (calculated)	
T_PeakHr_A1	Traffic - peak hour traffic from TMC for year 3 on approach 1	
T_ampkTotal_Y3A2	Traffic - AM peak hour total traffic for year 3, approach 2	
T_ampkTotTrk_Y3A2	Traffic - AM peak hour total truck traffic for year 3, approach 2	
T_ampkTotPed_Y3A2	Traffic - AM peak hour total ped traffic for year 3, approach 2	
T_ampkL_Y3A2	Traffic - AM peak hour left-turn traffic for year 3, approach 2	
T_ampkT_Y3A2	Traffic - AM peak hour through traffic for year 3, approach 2	
T_ampkR_Y3A2	Traffic - AM peak hour right-turn traffic for year 3, approach 2	
T_ampkTotal_Y3A2	Traffic - PM peak hour total traffic for year 3, approach 2	
T_ampkTotTrk_Y3A2	Traffic - PM peak hour total truck traffic for year 3, approach 2	
T_ampkTotPed_Y3A2	Traffic - PM peak hour total ped traffic for year 3, approach 2	
T_ampkL_Y3A2	Traffic - PM peak hour left-turn traffic for year 3, approach 2	
T_ampkT_Y3A2	Traffic - PM peak hour through traffic for year 3, approach 2	
T_ampkR_Y3A2	Traffic - PM peak hour right-turn traffic for year 3, approach 2	
T_ADT1	Traffic - average daily traffic for year 3 on approach 2	
T_PHF1	Traffic - peak hour factor for year 3 on approach 2 (calculated)	
T_PeakHr_A1	Traffic - peak hour traffic from TMC for year 3 on approach 2	

VARIABLE	DESCRIPTION	POSSIBLE VALUES
T_ampkTotal_Y3A3	Traffic - AM peak hour total traffic for year 3, approach 3	
T_ampkTotTrk_Y3A3	Traffic - AM peak hour total truck traffic for year 3, approach 3	
T_ampkTotPed_Y3A3	Traffic - AM peak hour total ped traffic for year 3, approach 3	
T_ampkL_Y3A3	Traffic - AM peak hour left-turn traffic for year 3, approach 3	
T_ampkT_Y3A3	Traffic - AM peak hour through traffic for year 3, approach 3	
T_ampkR_Y3A3	Traffic - AM peak hour right-turn traffic for year 3, approach 3	
T_ampkTotal_Y3A3	Traffic - PM peak hour total traffic for year 3, approach 3	
T_ampkTotTrk_Y3A3	Traffic - PM peak hour total truck traffic for year 3, approach 3	
T_ampkTotPed_Y3A3	Traffic - PM peak hour total ped traffic for year 3, approach 3	
T_ampkL_Y3A3	Traffic - PM peak hour left-turn traffic for year 3, approach 3	
T_ampkT_Y3A3	Traffic - PM peak hour through traffic for year 3, approach 3	
T_ampkR_Y3A3	Traffic - PM peak hour right-turn traffic for year 3, approach 3	
T_ADT1	Traffic - average daily traffic for year 3 on approach 3	
T_PHF1	Traffic - peak hour factor for year 3 on approach 3 (calculated)	
T_PeakHr_A1	Traffic - peak hour traffic from TMC for year 3 on approach 3	
T_ampkTotal_Y3A4	Traffic - AM peak hour total traffic for year 3, approach 4	
T_ampkTotTrk_Y3A4	Traffic - AM peak hour total truck traffic for year 3, approach 4	
T_ampkTotPed_Y3A4	Traffic - AM peak hour total ped traffic for year 3, approach 4	
T_ampkL_Y3A4	Traffic - AM peak hour left-turn traffic for year 3, approach 4	
T_ampkT_Y3A4	Traffic - AM peak hour through traffic for year 3, approach 4	
T_ampkR_Y3A4	Traffic - AM peak hour right-turn traffic for year 3, approach 4	
T_ampkTotal_Y3A4	Traffic - PM peak hour total traffic for year 3, approach 4	
T_ampkTotTrk_Y3A4	Traffic - PM peak hour total truck traffic for year 3, approach 4	
T_ampkTotPed_Y3A4	Traffic - PM peak hour total ped traffic for year 3, approach 4	
T_ampkL_Y3A4	Traffic - PM peak hour left-turn traffic for year 3, approach 4	
T_ampkT_Y3A4	Traffic - PM peak hour through traffic for year 3, approach 4	
T_ampkR_Y3A4	Traffic - PM peak hour right-turn traffic for year 3, approach 4	
T_ADT1	Traffic - average daily traffic for year 3 on approach 4	
T_PHF1	Traffic - peak hour factor for year 3 on approach 4 (calculated)	
T_PeakHr_A1	Traffic - peak hour traffic from TMC for year 3 on approach 4	

VARIABLE	DESCRIPTION	POSSIBLE VALUES
T_yr_count		
T_yr12diff		
T_yr23diff		
T_yr12growth		
T_yr23growth		
T_yr13growth		
T_avgYrGrowth	Traffic - PM peak hour total traffic for year 1, approach 1	
T_ampkTotTrk_Y1A1	Traffic - PM peak hour total truck traffic for year 1, approach 1	
T_ampkTotPed_Y1A1	Traffic - PM peak hour total ped traffic for year 1, approach 1	
T_ampkL_Y1A1	Traffic - PM peak hour left-turn traffic for year 1, approach 1	
T_ampkT_Y1A1	Traffic - PM peak hour through traffic for year 1, approach 1	
T_ampkR_Y1A1	Traffic - PM peak hour right-turn traffic for year 1, approach 1	

Note: these variable definitions and possible values follow those used on the North Carolina Crash Report Form DMV-349

ITEM NUMBER	VARIABLE	DESCRIPTION	POSSIBLE VALUES
0.1	NumOfUnits		
0.21	Year		Note: make sure we record what lane each driver w
0.22	Month		
0.23	Day		
0.24	Hour_24HrClock		
0.25	Minute		
0.26	DayOfWeek	formula: Sunday = 1. Note: must keep cells formatted as "general", otherwise it won't work because th	
0.3	Loc_RoadOnName		
0.4	Loc_FeetFromInt		
0.5	Loc_RoadAtFrom		
0.6	Loc_RoadAtFromName		
0.7	Loc_TravelDirection		
0.8	Loc_RoadTowardName		
3	RoadSurfaceCond		
4	WeatherCond		
5	WeatherCond2		
6	WeatherContribute		
7	AmbientLight		
8	ContribCircumNon-motor1		
9	ContribCircumNon-motor2		
10	CRASHLEVEL_FirstHarmEv		
11	CRASHLEVEL_MostHarmEv		
12	ContribCircumRoad1		
13	ContribCircumRoad2		
14	ContribCircumDriver1a		
15	ContribCircumDriver1b		
16	ContribCircumDriver1c		
17	ContribCircumDriver2a		
18	ContribCircumDriver2b		

Note: these variable definitions and possible values follow those used on the North Carolina Crash Report Form DMV-349

ITEM NUMBER	VARIABLE	DESCRIPTION	POSSIBLE VALUES
19	ContribCircumDriver2c		
32.1	InjuryStatusUnit1		
32.2	InjuryStatusUnit2		
33	Rel2Road		
34.1	VisionObstrUnit1		
34.2	VisionObstrUnit2		
35.1	PhysCondUnit1		
35.2	PhysCondUnit2		
37.1	AlcoDrugSuspectUnit1		
37.2	AlcoDrugSuspectUnit1		
39.1	AlcoDrugResultUnit1		
39.2	AlcoDrugResultUnit1		
41.1	VehStyleUnit1		
41.2	VehStyleUnit1		
43.11	TAD_Unit1Area1		
43.12	TAD_Unit1Area2		
43.13	TAD_Unit1Area3		
43.21	TAD_Unit2Area1		
43.22	TAD_Unit2Area2		
43.23	TAD_Unit2Area3		
43.111	TAD_Unit1Area1Deform		
43.121	TAD_Unit1Area2Deform		
43.131	TAD_Unit1Area3Deform		
43.211	TAD_Unit2Area1Deform		
43.221	TAD_Unit2Area2Deform		
43.231	TAD_Unit2Area3Deform		
48.11	PtOfInitialContact_Unit1Area1		
48.12	PtOfInitialContact_Unit1Area2		
48.13	PtOfInitialContact_Unit1Area3		
48.21	PtOfInitialContact_Unit2Area1		

Note: these variable definitions and possible values follow those used on the North Carolina Crash Report Form DMV-349

ITEM NUMBER	VARIABLE	DESCRIPTION	POSSIBLE VALUES
48.22	PtOfInitialContact_Unit2Area2		
48.23	PtOfInitialContact_Unit2Area3		
49.1	VehAction_Unit1		
49.2	VehAction_Unit2		
50.1	Non-motorAction_Unit1		
50.2	Non-motorAction_Unit2		
51.1	Non-motorLocPrior_Unit1		
51.2	Non-motorLocPrior_Unit2		
52.1	CrashSeqEv1_Unit1		
52.2	CrashSeqEv1_Unit2		
53.1	CrashSeqEv2_Unit1		
53.2	CrashSeqEv2_Unit2		
54.1	CrashSeqEv3_Unit1		
54.2	CrashSeqEv3_Unit2		
55.1	CrashSeqEv4_Unit1		
55.2	CrashSeqEv4_Unit2		
56.1	MostHarmEv_Unit1		
56.2	MostHarmEv_Unit2		
57.1	DistDirRoadToObj_Unit1		
57.2	DistDirRoadToObj_Unit2		
58.1	VehUnderOver_Unit1		
58.2	VehUnderOver_Unit2		
59.11	VehDefect1_Unit1		
59.12	VehDefect1_Unit2	must = 0 or be filtered out	
59.21	VehDefect2_Unit1	must = 3	
59.22	VehDefect2_Unit2	must = 1	
60.1	SpeedLimit_Unit1	must = 5	
60.2	SpeedLimit_Unit2	must = 2	
61.1	SpeedOrig_Unit1		
61.2	SpeedOrig_Unit2		

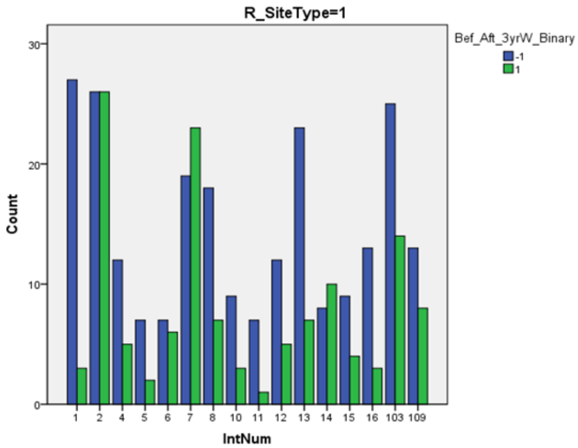
Note: these variable definitions and possible values follow those used on the North Carolina Crash Report Form DMV-349

ITEM NUMBER	VARIABLE	DESCRIPTION	POSSIBLE VALUES
62.1	SpeedImpact_Unit1		
62.2	SpeedImpact_Unit2		
69	RoadFeature		
70	RoadChar		
71	RoadClass		
72	RoadSurfaceType		
73	RoadConfig		
74	AccessControl		
75	NumLanes		
65	EmerVehUse		
76	TrafControlType		
77	TrafControlOper		
78	WorkZone		
79	WorkActiv		

APPENDIX D. CRASH DATA

Observed Crash Data

Figure 7: Data for 3 Years Before (BLUE) and 3 Years After (GREEN) Install Dates of Red Light Cameras



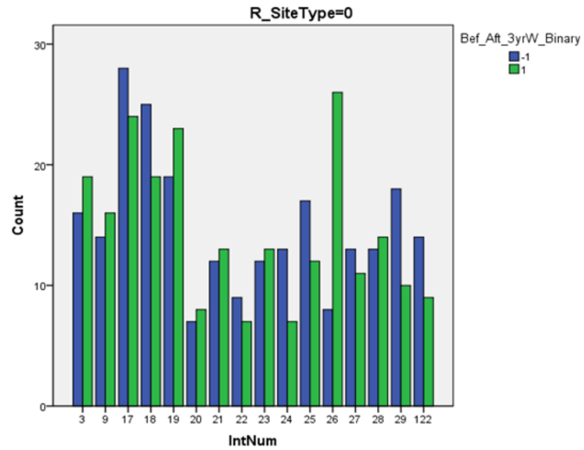


Table D.6: Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
IntNum * Bef_Aft_3yrW_Binary * R_SiteType	831	.7	315	.3	1146	1.0

Table D.7: Chi-Square Tests

R_SiteType		Value	df	Asymp. Sig. (2-sided)
0	Pearson Chi-Square	17.9613481848071[a]	15	.265
	Likelihood Ratio	18.540	15	.235
	Linear-by-Linear Association	1.196	1	.274
	N of Valid Cases	469		
1	Pearson Chi-Square	32.427338808436[b]	15	.006
	Likelihood Ratio	34.192	15	.003
	Linear-by-Linear Association	.038	1	.846
	N of Valid Cases	362		
Total	Pearson Chi-Square	65.1571261014673[c]	31	.000
	Likelihood Ratio	69.588	31	.000
	Linear-by-Linear Association	.173	1	.677
	N of Valid Cases	831		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.39.
b. 5 cells (15.6%) have expected count less than 5. The minimum expected count is 2.81.
c. 3 cells (4.7%) have expected count less than 5. The minimum expected count is 3.45.

Table D.8: Symmetric Measures

R_SiteType			Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
0	Nominal by Nominal	Phi	.196			.265
		Cramer's V	.196			.265
		Contingency Coefficient	.192			.265
	Interval by Interval	Pearson's R	-.051	.045	-1.094	.275
	Ordinal by Ordinal	Spearman Correlation	-.026	.046	-.553	.581
	N of Valid Cases		469			
1	Nominal by Nominal	Phi	.299			.006
		Cramer's V	.299			.006
		Contingency Coefficient	.287			.006
	Interval by Interval	Pearson's R	.010	.053	.194	.847
	Ordinal by Ordinal	Spearman Correlation	-.008	.052	-.151	.880
	N of Valid Cases		362			
Total	Nominal by Nominal	Phi	.280			.000
		Cramer's V	.280			.000
		Contingency Coefficient	.270			.000
	Interval by Interval	Pearson's R	-.014	.034	-.416	.678
	Ordinal by Ordinal	Spearman Correlation	.053	.035	1.524	.128
	N of Valid Cases		831			

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.
c. Based on normal approximation.

Table D.9: Directional Measures

R_SiteType				Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
0	Nominal by Nominal	Lambda	Symmetric	.051	.028	1.809	.070
			IntNum Dependent	.005	.017	.283	.777
			Bef_Aft_3yrW_Binary Dependent	.134	.061	2.040	.041
		Goodman and Kruskal tau	IntNum Dependent	.003	.001		.194
			Bef_Aft_3yrW_Binary Dependent	.038	.016		.267
		Uncertainty Coefficient	Symmetric	.012	.005	2.221	.235
			IntNum Dependent	.007	.003	2.221	.235
			Bef_Aft_3yrW_Binary Dependent	.029	.013	2.221	.235
1	Nominal by Nominal	Lambda	Symmetric	.016	.024	.659	.510
			IntNum Dependent	.003	.023	.137	.891
			Bef_Aft_3yrW_Binary Dependent	.047	.060	.775	.438
		Goodman and Kruskal tau	IntNum Dependent	.008	.003		.000
			Bef_Aft_3yrW_Binary Dependent	.090	.028		.006
		Uncertainty Coefficient	Symmetric	.029	.009	3.093	.003
			IntNum Dependent	.018	.006	3.093	.003
			Bef_Aft_3yrW_Binary Dependent	.073	.023	3.093	.003
Total	Nominal by Nominal	Lambda	Symmetric	.034	.016	2.099	.036
			IntNum Dependent	.003	.009	.272	.785
			Bef_Aft_3yrW_Binary Dependent	.103	.045	2.168	.030
		Goodman and Kruskal tau	IntNum Dependent	.003	.001		.000
			Bef_Aft_3yrW_Binary Dependent	.078	.016		.000
		Uncertainty Coefficient	Symmetric	.021	.005	4.452	.000
			IntNum Dependent	.012	.003	4.452	.000
			Bef_Aft_3yrW_Binary Dependent	.061	.014	4.452	.000

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.
c. Based on chi-square approximation
d. Likelihood ratio chi-square probability.

The significance value of the Pearson Chi-Square test for untreated intersections is 0.265. This is greater than 0.10 so we can conclude there is evidence of a relationship between intersection and crash levels before/after.

The significance value of the Pearson Chi-Square test for intersections that were treated is 0.006. Since this value is less than 0.05, we can conclude that the relationship observed in the crosstabulation is real and not due to chance. To assess the strength of the relationship, turn to the table of symmetric measures. These measures are based on the chi-square statistic.

Phi is a ratio: chi-square statistic / weighted total number of observations. It is an optimistic measure. Cramer's V is a rescaling of phi so that its maximum possible value is always 1. As the number of rows and columns increases, Cramer's V becomes more conservative with respect to phi. The contingency coefficient takes values between 0 and sqrt[(k-1)/k], where k=the number of rows or columns, whichever is smaller. It becomes more conservative with respect to phi as the associations between the variables become stronger.

Looking at the significance values of these three measures (0.006) indicates that there is a statistically significant relationship. However, the values for these measures range from 0.299 to 0.287 which are all below 0.300, so the relationship is not by chance, however, it is not necessarily strong.

Next, to develop a clear sense of the associations, see the table of directional measures. Such measures quantify the reduction in the error of predicting the row variable value when you know the column variable value or vice versa. The measures differ in how "error" is defined. Lamda defines error as the misclassification of cases, and cases are classified according to the modal (most frequent) category.

Tau defines error as the misclassification of a case, and cases are classified into category j with probability equal to the observed frequency of category j.The uncertainty coefficient defines error as the entropy, or P(category j)*ln[P(category j)] summed over the categories of the variable. The uncertainty coefficient is also known as Theil's U.

For intersections that were treated, the Goodman and Kruskal's tau value of 0.008 with Intersection as the dependent means that there is a 0.8% reduction in misclassification. The other measures report similarly small values (except possibly Lamda for Bef_Aft at 0.134 or 13.4%), indicating the association between intersection and number of before-after crashes is ... almost solely due to the _good/poor__ performance at intersection ___.

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APPENDIX E. RED-LIGHT RUNNING VIOLATION DATA

IntNum	CameraCode			ApproachNum	
1	602	702		1	
2	101	102	202	1	
3	2101			1	
4	301	302	402	1	
5	1801	1802		1	2
6	1403			1	
7	1001	1101	1201	1	
8	1704			4	
9	2401			1	
10	1303			3	
11	503			3	
12	2001			2	
13	901	902		1	2
14	1501	1503	1603	3	
15	2201			2	
16	2301			2	

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APPENDIX F. ANNUAL AVERAGE DAILY TRAFFIC, 1998-2012

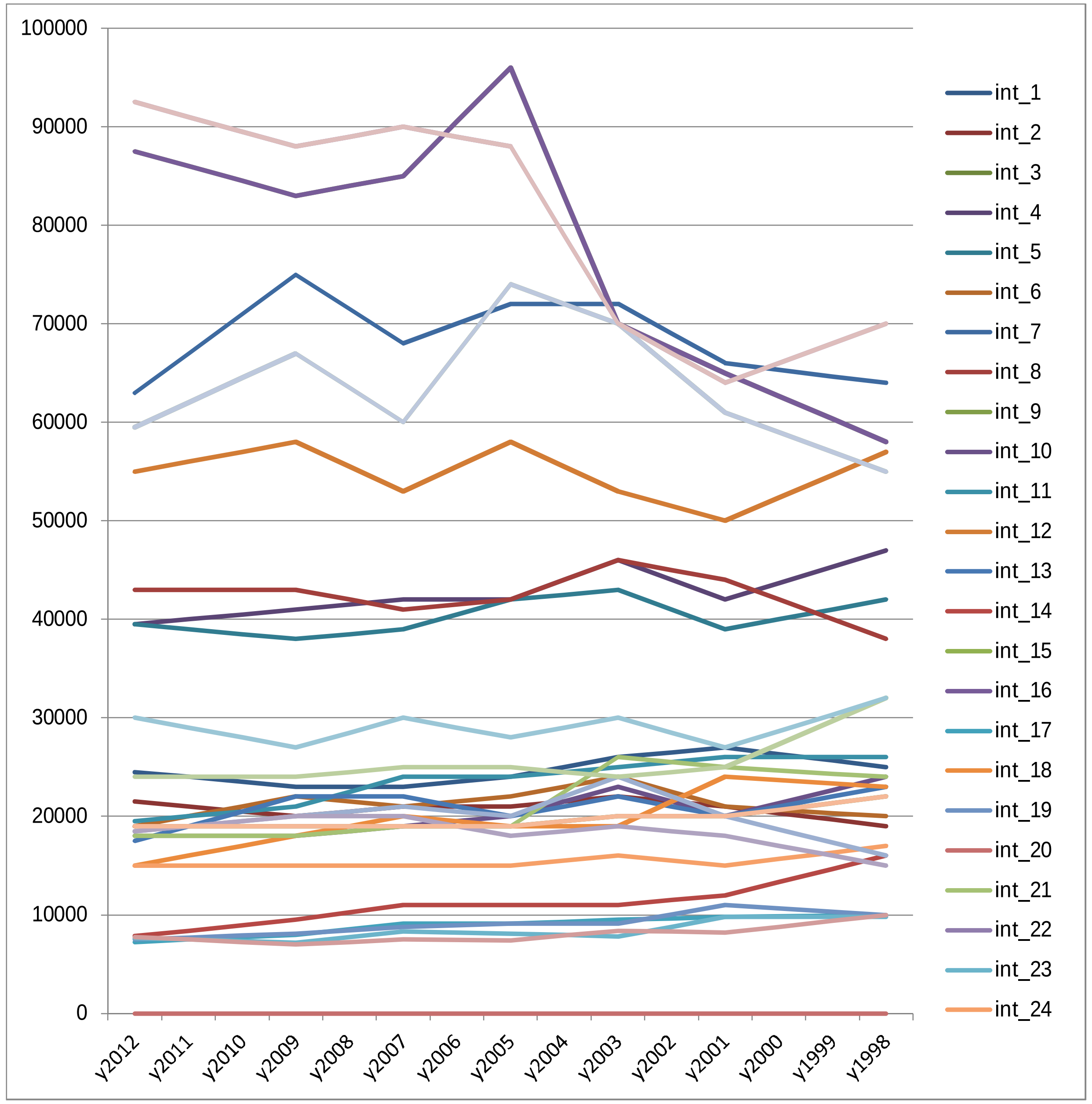
Source: NCDOT Traffic Volume Sheets for 1998, 2001, 2003, 2005, 2007, 2009, and 2011

INTERSECTION AADT DATA (in black): from NCDOT for 1998 to 2011
ASSUMPTION (in blue): Straight-line averaging for intermediate years' AADTs.

Note on AADTs: they are based on 48-hour counts through the Coverage Count Program,
http://www.ncdot.gov/doh/preconstruct/tpb/traffic_survey/

				AADT_Major														
			IntNum	y2012	y2011	y2010	y2009	y2008	y2007	y2006	y2005	y2004	y2003	y2002	y2001	y2000	y1999	y1998
Dawson	Morgan		int_1	24500	24000	23500	23000	23000	23000	23500	24000	25000	26000	26500	27000	26333	25667	25000
Dawson	South		int_2	21500	21000	20500	20000	20500	21000	21000	21000	21500	22000	21500	21000	20333	19667	19000
McDowell	Morgan		int_3	19000	19000	19000	19000	19000	19000	19000	19000	19500	20000	20000	20000	20667	21333	22000
Six Forks	Six Forks	Rowan	int_4	39500	40000	40500	41000	41500	42000	42000	42000	44000	46000	44000	42000	43667	45333	47000
Six Forks	Six Forks	Dartmouth	int_5	39500	39000	38500	38000	38500	39000	40500	42000	42500	43000	41000	39000	40000	41000	42000
New Hope Chu	New Hope Chu	Brentwood	int_6	19000	20000	21000	22000	21500	21000	21500	22000	23000	24000	22500	21000	20667	20333	20000
Capital	Capital	Highwoods	int_7	63000	67000	71000	75000	71500	68000	70000	72000	72000	72000	69000	66000	65333	64667	64000
Capital	Capital	Millbrook	int_8	43000	43000	43000	43000	42000	41000	41500	42000	44000	46000	45000	44000	42000	40000	38000
Capital	Capital	New Hope Chu	int_9	59500	62000	64500	67000	63500	60000	67000	74000	72000	70000	65500	61000	59000	57000	55000
West	West	Peace	int_10	18000	18000	18000	18000	18500	19000	19500	20000	21500	23000	21500	20000	21333	22667	24000
Friendly	Dixie	Hillsborough	int_11	19500	20000	20500	21000	22500	24000	24000	24000	24500	25000	25500	26000	26000	26000	26000
Wilmington	Wilmington	Chapanoke	int_12	55000	56000	57000	58000	55500	53000	55500	58000	55500	53000	51500	50000	52333	54667	57000
Rock Quarry	Rock Quarry	Cross Link	int_13	17500	19000	20500	22000	22000	22000	21000	20000	21000	22000	21000	20000	21000	22000	23000
Tarboro	Tarboro	New Bern	int_14	7850	8400	8950	9500	10250	11000	11000	11000	11000	11000	11500	12000	13333	14667	16000
I440 Inner	New Bern		int_15	87500	86000	84500	83000	84000	85000	90500	96000	83000	70000	67500	65000	62667	60333	58000
I440 Outer	New Bern		int_16	87500	86000	84500	83000	84000	85000	90500	96000	83000	70000	67500	65000	62667	60333	58000
Person	Edenton		int_17	7250	7500	7750	8000	8550	9100	9100	9100	9300	9500	9650	9800	9867	9933	10000
Cox	Woodburn	Hillsborough	int_18	15000	16000	17000	18000	19000	20000	19500	19000	19000	19000	21500	24000	23667	23333	23000
Blount	Peace	Peace	int_19	7500	7700	7900	8100	8450	8800	8950	9100	9100	9100	10050	11000	10667	10333	10000
St. Marys	St. Marys	Peace	int_20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Old Wake Fore	Old Wake Fore	Millbrook	int_21	18000	18000	18000	18000	18500	19000	19000	19000	22500	26000	25500	25000	24667	24333	24000
I440 Outer	Poole	Poole	int_22	92500	91000	89500	88000	89000	90000	89000	88000	79000	70000	67000	64000	66000	68000	70000
Wilmington	Edenton		int_23	7650	7500	7350	7200	7750	8300	8200	8100	7950	7800	8800	9800	9800	9800	9800
Raleigh	Raleigh	Poole	int_24	15000	15000	15000	15000	15000	15000	15000	15000	15500	16000	15500	15000	15667	16333	17000
Blount	MLK	MLK	int_25	18500	19000	19500	20000	20500	21000	20500	20000	22000	24000	22000	20000	18667	17333	16000
Wilmington	Morgan		int_26	7750	7500	7250	7000	7250	7500	7450	7400	7900	8400	8300	8200	8800	9400	10000
Edwards Mill	Edwards Mill	Duraleigh	int_27	24000	24000	24000	24000	24500	25000	25000	25000	24500	24000	24500	25000	27333	29667	32000
Rock Quarry	Rock Quarry	MLK	int_28	18500	19000	19500	20000	20000	20000	19000	18000	18500	19000	18500	18000	17000	16000	15000
Dixie	Dixie	Wade	int_29	30000	29000	28000	27000	28500	30000	29000	28000	29000	30000	28500	27000	28667	30333	32000
McDowell	Morgan		int_103	19000	19000	19000	19000	19000	19000	19000	19000	19500	20000	20000	20000	20667	21333	22000
Capital	Capital	New Hope Chu	int_109	59500	62000	64500	67000	63500	60000	67000	74000	72000	70000	65500	61000	59000	57000	55000
I440 Outer	Poole	Poole	int_122	92500	91000	89500	88000	89000	90000	89000	88000	79000	70000	67000	64000	66000	68000	70000

			IntNum	AADT_Minor y2012	y2011	y2010	y2009	y2008	y2007	y2006	y2005	y2004	y2003	y2002	y2001	y2000	y1999	y1998
Dawson	Morgan		int_1	6400	6300	6200	6100	6150	6200	6450	6700	7550	8400	7700	7000	7000	7000	7000
Dawson	South		int_2	3000	3700	4400	5100	5050	5000	5050	5100	4700	4300	4150	4000	4167	4333	4500
McDowell	Morgan		int_3	6400	6300	6200	6100	6150	6200	6450	6700	7550	8400	7700	7000	7000	7000	7000
Six Forks	Six Forks	Rowan	int_4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Six Forks	Six Forks	Dartmouth	int_5	1500	1600	1700	1800	2100	2400	2200	2000	2250	2500	2983	3467	4111	4756	5400
New Hope Chu	New Hope Chu	Brentwood	int_6	3650	3600	3550	3500	3750	4000	3700	3400	3700	4000	3500	3000	3667	4333	5000
Capital	Capital	Highwoods	int_7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Capital	Capital	Millbrook	int_8	20500	21000	21500	22000	22500	23000	23000	23000	26000	29000	24000	19000	19000	19000	19000
Capital	Capital	New Hope Chu	int_9	0	0	0	0	0	0	0	0	0	0	0	0	4000	8000	12000
West	West	Peace	int_10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Friendly	Dixie	Hillsborough	int_11	3200	3400	3600	3800	4000	4200	4150	4100	4350	4600	4700	4800	4767	4733	4700
Wilmington	Wilmington	Chapanoke	int_12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Quarry	Rock Quarry	Cross Link	int_13	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	9750	9500	9267	9033	8800
Tarboro	Tarboro	New Bern	int_14	8600	9400	10200	11000	10500	10000	9750	9500	9350	9200	9600	10000	10000	10000	10000
I440 Inner	New Bern		int_15	41000	42000	43000	44000	44500	45000	43500	42000	41000	40000	40500	41000	40000	39000	38000
I440 Outer	New Bern		int_16	40500	43000	45500	48000	48500	49000	51500	54000	60000	66000	65000	64000	63667	63333	63000
Person	Edenton		int_17	8150	8200	8250	8300	8600	8900	9050	9200	9100	9000	9500	10000	10333	10667	11000
Cox	Woodburn	Hillsborough	int_18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blount	Peace	Peace	int_19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Marys	St. Marys	Peace	int_20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Old Wake Fore	Old Wake Fore	Millbrook	int_21	10450	10000	9550	9100	9550	10000	9850	9700	9850	10000	10000	10000	9800	9600	9400
I440 Outer	Poole	Poole	int_22	30000	29000	28000	27000	28000	29000	29000	29000	30500	32000	31500	31000	29333	27667	26000
Wilmington	Edenton		int_23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Raleigh	Raleigh	Poole	int_24	5400	5500	5600	5700	6150	6600	6400	6200	6550	6900	6850	6800	6933	7067	7200
Blount	MLK	MLK	int_25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wilmington	Morgan		int_26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Edwards Mill	Edwards Mill	Duraleigh	int_27	22500	21000	19500	18000	19000	20000	20000	20000	18000	16000	13500	11000	11667	12333	13000
Rock Quarry	Rock Quarry	MLK	int_28	14500	13000	11500	10000	10000	10000	10000	10000	11000	12000	11000	10000	10667	11333	12000
Dixie	Dixie	Wade	int_29	4600	4700	4800	4900	5050	5200	5300	5400	5700	6000	5950	5900	6067	6233	6400
McDowell	Morgan		int_103	6400	6300	6200	6100	6150	6200	6450	6700	7550	8400	7700	7000	7000	7000	7000
Capital	Capital	New Hope Chu	int_109	0	0	0	0	0	0	0	0	0	0	0	0	4000	8000	12000
I440 Outer	Poole	Poole	int_122	30000	29000	28000	27000	28000	29000	29000	29000	30500	32000	31500	31000	29333	27667	26000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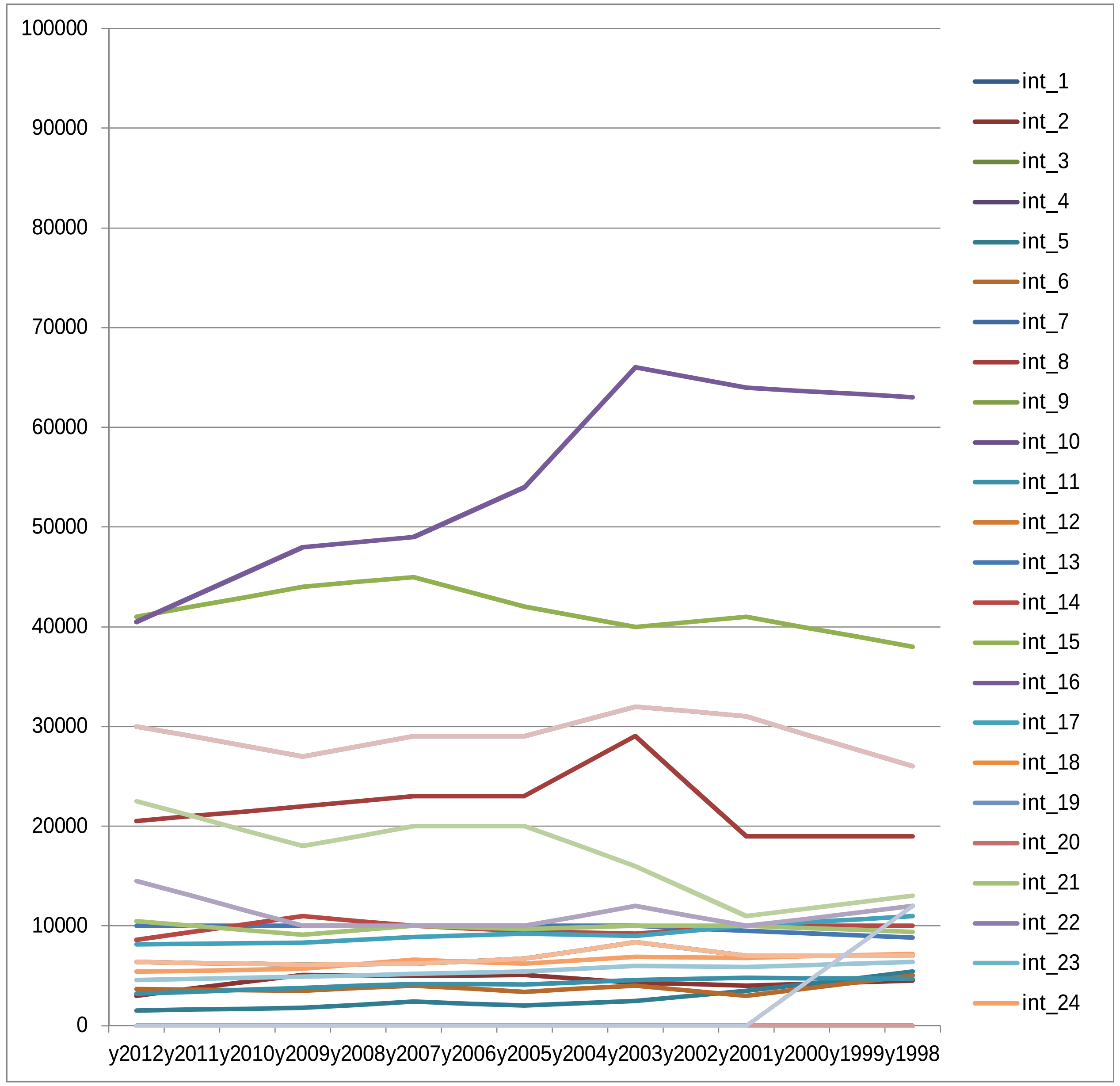
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AADT Estimates from PM Peak Hour Counts - assuming k = 0.10.
AADT_Major

IntNum	T_year1	T_year2	T_year3	y1998	y1999	y2000	y2001	y2002	y2003	y2004	y2005	y2006	y2007	y2008	y2009	y2010	y2011	y2012
20	2001	2005	0				11800				10600							

AADT Estimates from PM Peak Hour Counts - assuming k = 0.10.

	AADT_Minor																					
IntNum	T_year1	T_year2	T_year3	L1	L2	L3	L4	y1998	y1999	y2000	y2001	y2002	y2003	y2004	y2005	y2006	y2007	y2008	y2009	y2010	y2011	y2012
4	2001	2004	2006								5210			3820		10090						
7	2004	0	0											10810								
10	2001	2004	2005								4480			4530	5230							
12	2006	2008	2012													4250		4020				6880
18	2002	2004	0									3810		2610								
19	2002	2004	2005									9860		9670	7050							
20	2001	2005	0								6880				7170							
23	2002	0	0									9260										
25	2002	2007	2011									14120					14720				13010	
26	2009	2011	0																10210		10380	
109	2002	2008	2010									16740						16050		13580		

FINAL NUMBERS FOR ALL SITES

	AADT_Major														
IntNum	y1998	y1999	y2000	y2001	y2002	y2003	y2004	y2005	y2006	y2007	y2008	y2009	y2010	y2011	y2012
int_1	25000	25667	26333	27000	26500	26000	25000	24000	23500	23000	23000	23000	23500	24000	24500
int_2	19000	19667	20333	21000	21500	22000	21500	21000	21000	21000	20500	20000	20500	21000	21500
int_3	22000	21333	20667	20000	20000	20000	19500	19000	19000	19000	19000	19000	19000	19000	19000
int_4	47000	45333	43667	42000	44000	46000	44000	42000	42000	42000	41500	41000	40500	40000	39500
int_5	42000	41000	40000	39000	41000	43000	42500	42000	40500	39000	38500	38000	38500	39000	39500
int_6	20000	20333	20667	21000	22500	24000	23000	22000	21500	21000	21500	22000	21000	20000	19000
int_7	64000	64667	65333	66000	69000	72000	72000	72000	70000	68000	71500	75000	71000	67000	63000
int_8	38000	40000	42000	44000	45000	46000	44000	42000	41500	41000	42000	43000	43000	43000	43000
int_9	55000	57000	59000	61000	65500	70000	72000	74000	67000	60000	63500	67000	64500	62000	59500
int_10	24000	22667	21333	20000	21500	23000	21500	20000	19500	19000	18500	18000	18000	18000	18000
int_11	26000	26000	26000	26000	25500	25000	24500	24000	24000	24000	22500	21000	20500	20000	19500
int_12	57000	54667	52333	50000	51500	53000	55500	58000	55500	53000	55500	58000	57000	56000	55000
int_13	23000	22000	21000	20000	21000	22000	21000	20000	21000	22000	22000	22000	20500	19000	17500
int_14	16000	14667	13333	12000	11500	11000	11000	11000	11000	11000	10250	9500	8950	8400	7850
int_15	58000	60333	62667	65000	67500	70000	83000	96000	90500	85000	84000	83000	84500	86000	87500
int_16	58000	60333	62667	65000	67500	70000	83000	96000	90500	85000	84000	83000	84500	86000	87500
int_17	10000	9933	9867	9800	9650	9500	9300	9100	9100	9100	8550	8000	7750	7500	7250
int_18	23000	23333	23667	24000	21500	19000	19000	19000	19500	20000	19000	18000	17000	16000	15000
int_19	10000	10333	10667	11000	10050	9100	9100	9100	8950	8800	8450	8100	7900	7700	7500
int_20	11800	11800	11800	11800	11500	11200	10900	10600	10600	10600	10600	10600	10600	10600	10600
int_21	24000	24333	24667	25000	25500	26000	22500	19000	19000	19000	18500	18000	18000	18000	18000
int_22	70000	68000	66000	64000	67000	70000	79000	88000	89000	90000	89000	88000	89500	91000	92500
int_23	9800	9800	9800	9800	8800	7800	7950	8100	8200	8300	7750	7200	7350	7500	7650
int_24	17000	16333	15667	15000	15500	16000	15500	15000	15000	15000	15000	15000	15000	15000	15000
int_25	16000	17333	18667	20000	22000	24000	22000	20000	20500	21000	20500	20000	19500	19000	18500
int_26	10000	9400	8800	8200	8300	8400	7900	7400	7450	7500	7250	7000	7250	7500	7750
int_27	32000	29667	27333	25000	24500	24000	24500	25000	25000	25000	24500	24000	24000	24000	24000
int_28	15000	16000	17000	18000	18500	19000	18500	18000	19000	20000	20000	20000	19500	19000	18500
int_29	32000	30333	28667	27000	28500	30000	29000	28000	29000	30000	28500	27000	28000	29000	30000
int_103	22000	21333	20667	20000	20000	20000	19500	19000	19000	19000	19000	19000	19000	19000	19000
int_109	55000	57000	59000	61000	65500	70000	72000	74000	67000	60000	63500	67000	64500	62000	59500
int_122	70000	68000	66000	64000	67000	70000	79000	88000	89000	90000	89000	88000	89500	91000	92500

IntNum	AADT_Minor y1998	y1999	y2000	y2001	y2002	y2003	y2004	y2005	y2006	y2007	y2008	y2009	y2010	y2011	y2012
int_1	7000	7000	7000	7000	7700	8400	7550	6700	6450	6200	6150	6100	6200	6300	6400
int_2	4500	4333	4167	4000	4150	4300	4700	5100	5050	5000	5050	5100	4400	3700	3000
int_3	7000	7000	7000	7000	7700	8400	7550	6700	6450	6200	6150	6100	6200	6300	6400
int_4	5210	5210	5210	5210	4747	4283	3820	6955	10090	10090	10090	10090	10090	10090	10090
int_5	5400	4756	4111	3467	2983	2500	2250	2000	2200	2400	2100	1800	1700	1600	1500
int_6	5000	4333	3667	3000	3500	4000	3700	3400	3700	4000	3750	3500	3550	3600	3650
int_7	10810	10810	10810	10810	10810	10810	10810	10810	10810	10810	10810	10810	10810	10810	10810
int_8	19000	19000	19000	19000	24000	29000	26000	23000	23000	23000	22500	22000	21500	21000	20500
int_9	12000	13185	14370	15555	16740	16625	16510	16395	16280	16165	16050	14815	13580	13580	13580
int_10	4480	4480	4480	4480	4497	4513	4530	5230	5230	5230	5230	5230	5230	5230	5230
int_11	4700	4733	4767	4800	4700	4600	4350	4100	4150	4200	4000	3800	3600	3400	3200
int_12	4250	4250	4250	4250	4250	4250	4250	4250	4250	4135	4020	4735	5450	6165	6880
int_13	8800	9033	9267	9500	9750	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
int_14	10000	10000	10000	10000	9600	9200	9350	9500	9750	10000	10500	11000	10200	9400	8600
int_15	38000	39000	40000	41000	40500	40000	41000	42000	43500	45000	44500	44000	43000	42000	41000
int_16	63000	63333	63667	64000	65000	66000	60000	54000	51500	49000	48500	48000	45500	43000	40500
int_17	11000	10667	10333	10000	9500	9000	9100	9200	9050	8900	8600	8300	8250	8200	8150
int_18	3810	3810	3810	3810	3810	3210	2610	2610	2610	2610	2610	2610	2610	2610	2610
int_19	9860	9860	9860	9860	9860	9765	9670	7050	7050	7050	7050	7050	7050	7050	7050
int_20	6880	6880	6880	6880	6953	7025	7098	7170	7170	7170	7170	7170	7170	7170	7170
int_21	9400	9600	9800	10000	10000	10000	9850	9700	9850	10000	9550	9100	9550	10000	10450
int_22	26000	27667	29333	31000	31500	32000	30500	29000	29000	29000	28000	27000	28000	29000	30000
int_23	9260	9260	9260	9260	9260	9260	9260	9260	9260	9260	9260	9260	9260	9260	9260
int_24	7200	7067	6933	6800	6850	6900	6550	6200	6400	6600	6150	5700	5600	5500	5400
int_25	14120	14120	14120	14120	14120	14240	14360	14480	14600	14720	14293	13865	13438	13010	13010
int_26	10210	10210	10210	10210	10210	10210	10210	10210	10210	10210	10210	10210	10295	10380	10380
int_27	13000	12333	11667	11000	13500	16000	18000	20000	20000	20000	19000	18000	19500	21000	22500
int_28	12000	11333	10667	10000	11000	12000	11000	10000	10000	10000	10000	10000	11500	13000	14500
int_29	6400	6233	6067	5900	5950	6000	5700	5400	5300	5200	5050	4900	4800	4700	4600
int_103	7000	7000	7000	7000	7700	8400	7550	6700	6450	6200	6150	6100	6200	6300	6400
int_109	12000	13185	14370	15555	16740	16625	16510	16395	16280	16165	16050	14815	13580	13580	13580
int_122	26000	27667	29333	31000	31500	32000	30500	29000	29000	29000	28000	27000	28000	29000	30000

For AADT calculations:

IntNum	Date_Bef3yr	Date_BefStart	Date_AfterStart	Date_Aft3yr	Bef3yr	Bef	Aft	Aft3yr
1	9/14/2000	9/14/2003	9/15/2003	9/14/2006	2001	2004	2004	2007
2	8/10/2000	8/10/2003	8/11/2003	8/10/2006	2001	2004	2004	2007
3	7/14/2000	7/14/2003	7/15/2003	7/14/2006	2001	2004	2004	2007
4	7/14/2000	7/14/2003	7/15/2003	7/14/2006	2001	2004	2004	2007
5	10/1/2001	9/30/2004	10/1/2004	10/1/2007	2002	2005	2005	2008
6	6/25/2001	6/24/2004	6/25/2004	6/25/2007	2001	2004	2004	2007
7	8/31/2000	8/31/2003	9/1/2003	8/31/2006	2001	2004	2004	2007
8	10/1/2001	9/30/2004	10/1/2004	10/1/2007	2002	2005	2005	2008
9	10/1/2001	9/30/2004	10/1/2004	10/1/2007	2002	2005	2005	2008
10	6/25/2001	6/24/2004	6/25/2004	6/25/2007	2001	2004	2004	2007
11	8/31/2000	8/31/2003	9/1/2003	8/31/2006	2001	2004	2004	2007
12	3/4/2006	3/3/2009	3/4/2009	3/3/2012	2006	2009	2009	2012
13	8/31/2000	8/31/2003	9/1/2003	8/31/2006	2001	2004	2004	2007
14	6/24/2001	6/23/2004	6/24/2004	6/24/2007	2001	2004	2004	2007
15	3/4/2006	3/3/2009	3/4/2009	3/3/2012	2006	2009	2009	2012
16	3/4/2006	3/3/2009	3/4/2009	3/3/2012	2006	2009	2009	2012
17	8/10/2000	8/10/2003	8/11/2003	8/10/2006	2001	2004	2004	2007
18	8/31/2000	8/31/2003	9/1/2003	8/31/2006	2001	2004	2004	2007
19	8/31/2000	8/31/2003	9/1/2003	8/31/2006	2001	2004	2004	2007
20	6/25/2001	6/24/2004	6/25/2004	6/25/2007	2001	2004	2004	2007
21	6/25/2001	6/24/2004	6/25/2004	6/25/2007	2001	2004	2004	2007
22	8/31/2000	8/31/2003	9/1/2003	8/31/2006	2001	2004	2004	2007
23	9/14/2000	9/14/2003	9/15/2003	9/14/2006	2001	2004	2004	2007
24	10/1/2001	9/30/2004	10/1/2004	10/1/2007	2002	2005	2005	2008
25	6/24/2001	6/23/2004	6/24/2004	6/24/2007	2001	2004	2004	2007
26	3/4/2006	3/3/2009	3/4/2009	3/3/2012	2006	2009	2009	2012
27	3/4/2006	3/3/2009	3/4/2009	3/3/2012	2006	2009	2009	2012
28	3/4/2006	3/3/2009	3/4/2009	3/3/2012	2006	2009	2009	2012
29	3/4/2006	3/3/2009	3/4/2009	3/3/2012	2006	2009	2009	2012
103	3/4/2006	3/3/2009	3/4/2009	3/3/2012	2006	2009	2009	2012
109	3/4/2006	3/3/2009	3/4/2009	3/3/2012	2006	2009	2009	2012
122	3/4/2006	3/3/2009	3/4/2009	3/3/2012	2006	2009	2009	2012

						naïve traffic ratio = AADTafter/AADTbefore								
Major				Time Pd Averages					Minor					
AADT_B3	AADT_B0	AADT_A0	AADT_A3	AADT_B	AADT_A	r_tf	diff	r_tf	AADT_B3	AADT_B0	AADT_A0	AADT_A3	AADT_B	AADT_A
27000	25000	25000	23000	26000	24000	0.923	-0.022	0.945	7000	7550	7550	6200	7275	6875
21000	21500	21500	21000	21250	21250	1.000	-0.115	1.115	4000	4700	4700	5000	4350	4850
20000	19500	19500	19000	19750	19250	0.975	0.030	0.945	7000	7550	7550	6200	7275	6875
42000	44000	44000	42000	43000	43000	1.000	-0.540	1.540	5210	3820	3820	10090	4515	6955
41000	42000	42000	38500	41500	40250	0.970	0.147	0.823	2983	2000	2000	2100	2492	2050
21000	23000	23000	21000	22000	22000	1.000	-0.149	1.149	3000	3700	3700	4000	3350	3850
66000	72000	72000	68000	69000	70000	1.014	0.014	1.000	10810	10810	10810	10810	10810	10810
45000	42000	42000	42000	43500	42000	0.966	-0.003	0.968	24000	23000	23000	22500	23500	22750
65500	74000	74000	63500	69750	68750	0.986	0.006	0.979	16740	16395	16395	16050	16567.5	16222.5
20000	21500	21500	19000	20750	20250	0.976	-0.107	1.083	4480	4530	4530	5230	4505	4880
26000	24500	24500	24000	25250	24250	0.960	0.026	0.934	4800	4350	4350	4200	4575	4275
55500	58000	58000	55000	56750	56500	0.996	-0.297	1.293	4250	4735	4735	6880	4492.5	5807.5
20000	21000	21000	22000	20500	21500	1.049	0.023	1.026	9500	10000	10000	10000	9750	10000
12000	11000	11000	11000	11500	11000	0.957	-0.043	1.000	10000	9350	9350	10000	9675	9675
90500	83000	83000	87500	86750	85250	0.983	0.011	0.971	43500	44000	44000	41000	43750	42500
90500	83000	83000	87500	86750	85250	0.983	0.093	0.889	51500	48000	48000	40500	49750	44250
9800	9300	9300	9100	9550	9200	0.963	0.021	0.942	10000	9100	9100	8900	9550	9000
24000	19000	19000	20000	21500	19500	0.907	0.094	0.813	3810	2610	2610	2610	3210	2610
11000	9100	9100	8800	10050	8950	0.891	0.034	0.856	9860	9670	9670	7050	9765	8360
11800	10900	10900	10600	11350	10750	0.947	-0.074	1.021	6880	7097.5	7097.5	7170	6988.75	7133.75
25000	22500	22500	19000	23750	20750	0.874	-0.126	1.000	10000	9850	9850	10000	9925	9925
64000	79000	79000	90000	71500	84500	1.182	0.214	0.967	31000	30500	30500	29000	30750	29750
9800	7950	7950	8300	8875	8125	0.915	-0.085	1.000	9260	9260	9260	9260	9260	9260
15500	15000	15000	15000	15250	15000	0.984	0.037	0.946	6850	6200	6200	6150	6525	6175
20000	22000	22000	21000	21000	21500	1.024	0.003	1.021	14120	14360	14360	14720	14240	14540
7450	7000	7000	7750	7225	7375	1.021	0.012	1.008	10210	10210	10210	10380	10210	10295
25000	24000	24000	24000	24500	24000	0.980	-0.086	1.066	20000	18000	18000	22500	19000	20250
19000	20000	20000	18500	19500	19250	0.987	-0.238	1.225	10000	10000	10000	14500	10000	12250
29000	27000	27000	30000	28000	28500	1.018	0.086	0.931	5300	4900	4900	4600	5100	4750
19000	19000	19000	19000	19000	19000	1.000	0.004	0.996	6450	6100	6100	6400	6275	6250
67000	67000	67000	59500	67000	63250	0.944	0.031	0.913	16280	14815	14815	13580	15547.5	14197.5
89000	88000	88000	92500	88500	90250	1.020	0.002	1.018	29000	27000	27000	30000	28000	28500

AADT Numbers for EB Analysis on Sheet 8a and CG Analysis on Sheet 9a:

Summed Major + Min ENTERED INTO SPSS DATASET AS

IntNum	AADT_B	AADT_A	r_tf
1	33275	30875	0.928
2	25600	26100	1.020
3	27025	26125	0.967
4	47515	49955	1.051
5	43992	42300	0.962
6	25350	25850	1.020
7	79810	80810	1.013
8	67000	64750	0.966
9	86317.5	84972.5	0.984
10	25255	25130	0.995
11	29825	28525	0.956
12	61242.5	62307.5	1.017
13	30250	31500	1.041
14	21175	20675	0.976
15	130500	127750	0.979
16	136500	129500	0.949
17	19100	18200	0.953
18	24710	22110	0.895
19	19815	17310	0.874
20	18338.75	17883.75	1.000
21	33675	30675	0.911
22	102250	114250	1.117
23	18135	17385	0.959
24	21775	21175	0.972
25	35240	36040	1.023
26	17435	17670	1.013
27	43500	44250	1.017
28	29500	31500	1.068
29	33100	33250	1.005
103	25275	25250	0.999
109	82547.5	77447.5	0.938
122	116500	118750	1.019

Major

IntNum	AADT_B3	AADT_B2	AADT_B1	AADT_A1	AADT_A2	AADT_A3
1	27000	26500	26000	25000	24000	23500
2	21000	21500	22000	21500	21000	21000
3	20000	20000	20000	19500	19000	19000
4	42000	44000	46000	44000	42000	42000
5	41000	43000	42500	42000	40500	39000
6	21000	22500	24000	23000	22000	21500
7	66000	69000	72000	72000	72000	70000
8	45000	46000	44000	42000	41500	41000
9	65500	70000	72000	74000	67000	60000
10	20000	21500	23000	21500	20000	19500
11	26000	25500	25000	24500	24000	24000
12	55500	53000	55500	58000	57000	56000
13	20000	21000	22000	21000	20000	21000
14	12000	11500	11000	11000	11000	11000
15	90500	85000	84000	83000	84500	86000
16	90500	85000	84000	83000	84500	86000
17	9800	9650	9500	9300	9100	9100
18	24000	21500	19000	19000	19000	19500
19	11000	10050	9100	9100	9100	8950
20	11800	11500	11200	10900	10600	10600
21	25000	25500	26000	22500	19000	19000
22	64000	67000	70000	79000	88000	89000
23	9800	8800	7800	7950	8100	8200
24	15500	16000	15500	15000	15000	15000
25	20000	22000	24000	22000	20000	20500
26	7450	7500	7250	7000	7250	7500
27	25000	25000	24500	24000	24000	24000
28	19000	20000	20000	20000	19500	19000
29	29000	30000	28500	27000	28000	29000
103	19000	19000	19000	19000	19000	19000
109	67000	60000	63500	67000	64500	62000
122	89000	90000	89000	88000	89500	91000

Minor

AADT_B3	AADT_B2	AADT_B1	AADT_A1	AADT_A2	AADT_A3
7000	7700	8400	7550	6700	6450
4000	4150	4300	4700	5100	5050
7000	7700	8400	7550	6700	6450
5210	4746.667	4283.333	3820	6955	10090
2983.333	2500	2250	2000	2200	2400
3000	3500	4000	3700	3400	3700
10810	10810	10810	10810	10810	10810
24000	29000	26000	23000	23000	23000
16740	16625	16510	16395	16280	16165
4480	4496.667	4513.333	4530	5230	5230
4800	4700	4600	4350	4100	4150
4250	4135	4020	4735	5450	6165
9500	9750	10000	10000	10000	10000
10000	9600	9200	9350	9500	9750
43500	45000	44500	44000	43000	42000
51500	49000	48500	48000	45500	43000
10000	9500	9000	9100	9200	9050
3810	3810	3210	2610	2610	2610
9860	9860	9765	9670	7050	7050
6880	6952.5	7025	7097.5	7170	7170
10000	10000	10000	9850	9700	9850
31000	31500	32000	30500	29000	29000
9260	9260	9260	9260	9260	9260
6850	6900	6550	6200	6400	6600
14120	14120	14240	14360	14480	14600
10210	10210	10210	10210	10295	10380
20000	20000	19000	18000	19500	21000
10000	10000	10000	10000	11500	13000
5300	5200	5050	4900	4800	4700
6450	6200	6150	6100	6200	6300
16280	16165	16050	14815	13580	13580
29000	29000	28000	27000	28000	29000

AECOM

JOB TITLE SAFELIGHT RLR
JOB NO. PM PK → AADT #s
CALCULATION NO.
ORIGINATOR AD
DATE 9/14/2012
REVIEWER
DATE
SCALE
SHEET NO. ONE OF

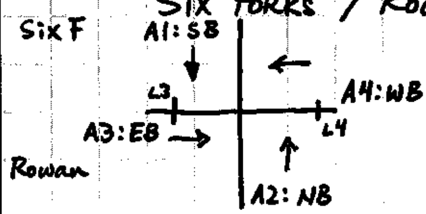
THE FOLLOWING INTERSECTIONS WERE MISSING AADT COUNTS FOR ONE OR MORE ROADS: 4, 7, 10, 12, 18, 19, 20, 23, 25, 26, 109

SOLUTION: ESTIMATE ADTs FROM PM PEAK HOUR TMCs THAT WERE SUPPLIED FOR 1 TO 3 YEARS PER INTERSECTION.

ASSUMPTION: PM PK HR = 0.10 ADT , 0.10 = K FACTOR.
→ COULD COMPARE TO MAJOR LEG AADT IF AVAILABLE

$$\therefore ADT = \frac{PM\ PK\ HR}{0.10}$$ → MVMTS ON LEG

4/ NEED MINOR RD ADT → ROWAN
SIX FORKS / ROWAN



MINORS

L3 = EB Appr + WB Dep

$$= (L+T+R)_{A3} + R_{A1} + T_{A4} + L_{A2}$$

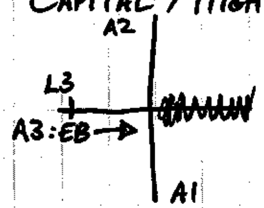
L4 = WB Appr + EB Dep

$$= (L+T+R)_{A4} + R_{A2} + T_{A3} + L_{A1}$$

MAX (L3, L4) = MINOR LEG TO USE

$$ADT_{MINOR\ 4} = \frac{MAX(L3, L4)}{0.10}$$

7/ NEED MINOR RD ADT → HIGHWOODS
CAPITAL / HIGHWOODS



$$L3 = (L+T+R)_{A3} + R_{A2} + L_{A1}$$

$$ADT_{MINOR\ 7} = \frac{L3}{0.10}$$

Grid: 4x4 = 1"

AECOM

JOB TITLE SAFE LIGHT RLR

JOB NO. PM PK → AADT #'s

CALCULATION NO.

ORIGINATOR AD

DATE 9/14/2012

REVIEWER

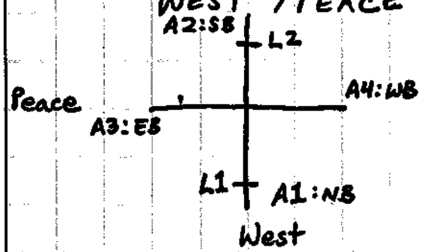
DATE

SCALE

SHEET NO. 2 OF

10/ NEED MINOR RD ADT → WEST ST.

WEST / PEACE



$$L1 = (L+T+R)_{A1} + R_{A3} + T_{A2} + L_{A4}$$

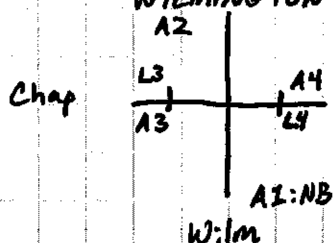
$$L2 = (L+T+R)_{A2} + R_{A4} + T_{A1} + L_{A3}$$

$$Max(L1, L2)$$

$$ADT_{MINOR_{10}} = \frac{Max(L1, L2)}{0.10}$$

12/ NEED MINOR RD ADT → CHAPANOKE

WILMINGTON / CHAPANOKE



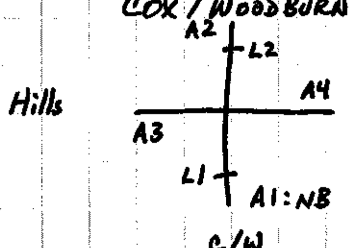
$$L3 = (L+T+R)_{A3} + R_{A2} + T_{A4} + L_{A1}$$

$$L4 = (L+T+R)_{A4} + R_{A1} + T_{A3} + L_{A2}$$

$$ADT_{MINOR_{12}} = \frac{Max(L3, L4)}{0.10}$$

18/ NEED MINOR RD ADT → COX / WOODBURN

COX / WOODBURN / HILLSBOROUGH



$$L1 = (L+T+R)_{A1} + R_{A3} + T_{A2} + L_{A4}$$

$$L2 = (L+T+R)_{A2} + R_{A4} + T_{A1} + L_{A3}$$

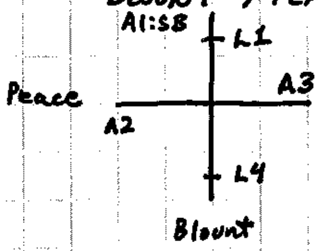
$$ADT_{MINOR_{18}} = \frac{Max(L1, L2)}{0.10}$$

Grid: 4x4 = 1"

AECOM

JOB TITLE: SAFE LIGHT RLR
JOB NO.: PM Pk → AADT #'s
CALCULATION NO.:
ORIGINATOR: AD
DATE: 9/14/2012
REVIEWER:
DATE:
SCALE:
SHEET NO.: 3 OF

19/ NEED MINOR RD ADT → Blount
BLOUNT / PEACE (3 approaches)

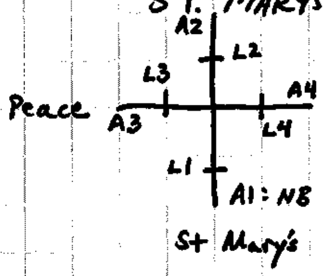


$$L1 = (L + T + R)_{A1}$$

$$L4 = R_{A2} + T_{A1} + L_{A3}$$

$$ADT_{MINOR\ 19} = \frac{MAX(L1, L4)}{0.10}$$

20/ NEED MAJOR & MINOR RD ADTs — MAJOR = PEACE, MINOR = ST MARY'S
ST. MARY'S / PEACE



$$L3 = (L + T + R)_{A3} + R_{A2} + T_{A4} + L_{A1}$$

$$L4 = (L + T + R)_{A4} + R_{A1} + T_{A3} + L_{A2}$$

$$ADT_{MAJOR\ 20} = \frac{MAX(L3, L4)}{0.10}$$

$$L1 = (L + T + R)_{A1} + R_{A3} + T_{A2} + L_{A4}$$

$$L2 = (L + T + R)_{A2} + R_{A4} + T_{A1} + L_{A3}$$

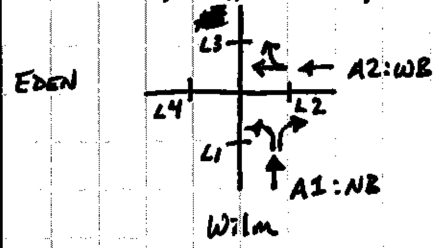
$$ADT_{MINOR\ 20} = \frac{MAX(L1, L2)}{0.10}$$

Grid: 4x4 = 1"

AECOM

JOB TITLE: SAFELIGHT RLR
JOB NO.: PM PK → AADT#s
CALCULATION NO.:
ORIGINATOR: AD
DATE: 9/14/2012
REVIEWER:
DATE:
SCALE:
SHEET NO. 4 OF

23/ Need Minor Rd ADT → Check Both Wilmington / Edenton (2 approaches, 4 legs)



$L1 = (L+R)_{A1} + \cancel{L_{A2}}$ No left here.

$L2 = (T+R)_{A2} + R_{A1}$

$L3 = \cancel{T_{A1}} + R_{A2}$ No thru here.

$L4 = T_{A2} + L_{A1}$

$$ADT_a = \frac{Max(L1, L3)}{0.10}$$

$$ADT_b = \frac{Max(L2, L4)}{0.10}$$

$$ADT_{MAJOR} = Max(ADT_a, ADT_b)$$

$$ADT_{MINOR} = Min(ADT_a, ADT_b)$$

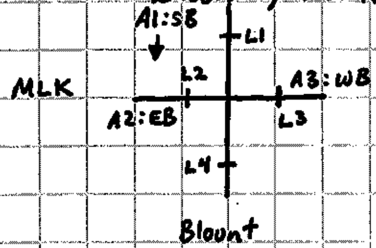
Grid: 4x4 = 1"

AECOM

JOB TITLE SAFE LIGHT RLR
JOB NO. PM Pk → AADT #s
ORIGINATOR AD
REVIEWER
SCALE

CALCULATION NO.
DATE 9/14/2012
DATE
SHEET NO. 5 OF

25/ NEED MINOR RD ADT → Check Both
Blount / MLK (3 approaches)



$L1 = (L+T+R)_{A1}$

$L4 = R_{A2} + T_{A1} + L_{A3}$

$L2 = (T+R)_{A2} + R_{A1}$

$L3 = (L+T)_{A3} + L_{A1}$

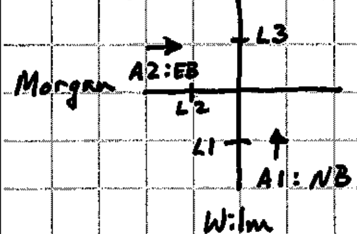
$ADT_a = \frac{MAX(L1, L4)}{0.10}$ } MAJOR

⟹ $ADT_b = \frac{MAX(L2, L3)}{0.10}$ } MINOR

$ADT_{MAJOR} = MAX(ADT_a, ADT_b)$

$ADT_{MINOR} = MIN(ADT_a, ADT_b)$

26/ NEED MINOR RD ADT → Wilmington
WILMINGTON / MORGAN (2 approaches, 4 legs)



$L1 = (T+R)_{A1}$

$L3 = T_{A1} + L_{A2}$

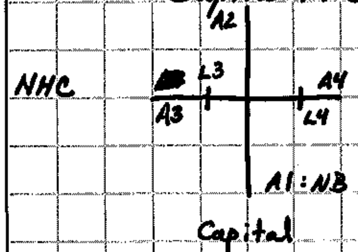
$ADT_{MINOR_{26}} = \frac{MAX(L1, L3)}{0.10}$

Grid: 4x4 = 1"

AECOM

JOB TITLE	SAFE LIGHT RLR		
JOB NO.	PM PK → AADT#s	CALCULATION NO.	
ORIGINATOR	AD	DATE	9/14/2012
REVIEWER		DATE	
SCALE		SHEET NO.	6 OF

109 / NEED MINOR RD ADT → New Hope Church / Buffaloe
Capital / New Hope Church / Buffaloe



$$L3 = (L+T+R)_{A3} + R_{A2} + T_{A4} + L_{A1}$$

$$L4 = (L+T+R)_{A4} + R_{A1} + T_{A3} + L_{A2}$$

$$ADT_{MINOR\ 109} = \frac{MAX(L3, L4)}{0.10}$$

IF TIME ALLOWS, THE K FACTOR CAN BE CHECKED BASED ON THE KNOWN AADTs AT VARIOUS INTERSECTIONS.

Grid: 4x4 = 1"

APPENDIX G. COMPUTATIONS: EMPIRICAL BAYES BEFORE-AFTER SAFETY EVALUATION

EMPIRICAL BAYES BEFORE-AFTER OBSERVATIONAL STUDY

Following the Highway Safety Manual Procedure in Chapter 9, see Figure 9-2.

INPUT DATA FOR BEFORE-AFTER ANALYSIS

STEP 0a OUTPUT FROM SPSS, OBSERVED CRASH FREQUENCY BY SITE BY YEAR BEFORE AND AFTER TREATMENT (crosstabulations)

STEP 0b PULL DATA FROM OTHER SHEETS (such as intersection and traffic volume data)

EB ESTIMATION IN BEFORE PERIOD

STEP 1 CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR BEFORE TREATMENT

STEP 2 CALCULATE EXPECTED CRASH FREQUENCY BY SITE FOR ENTIRE BEFORE PERIOD

EB ESTIMATION IN AFTER PERIOD

STEP 3 CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR AFTER TREATMENT

STEP 4 CALCULATE AN ADJUSTMENT FACTOR FOR DIFFERENCES BETWEEN BEFORE & AFTER PERIODS

STEP 5 CALCULATE EXPECTED CRASH FREQUENCY BY SITE FOR ENTIRE AFTER PERIOD IN ABSENCE OF TREATMENT

ESTIMATION OF TREATED EFFECTIVENESS

STEP 6 ESTIMATE SAFETY EFFECTIVENESS AT EACH SITE VIA ODDS RATIO

STEP 7 ESTIMATE SAFETY EFFECTIVENESS AT EACH SITE AS A PERCENTAGE CRASH CHANGE

STEP 8 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT (ODDS RATIO) FOR ALL SITES COMBINED

STEP 9 ADJUST ODDS RATIO TO OBTAIN UNBIASED ESTIMATE OF TREATMENT EFFECTIVENESS

STEP 10 CALCULATE OVERALL UNBIASED SAFETY EFFECTIVENESS AS A PERCENT CHANGE IN CRASH FREQUENCY ACROSS ALL SITES

ESTIMATION OF PRECISION OF TREATED EFFECTIVENESS

STEP 11 CALCULATE VARIANCE OF UNBIASED ESTIMATED SAFETY EFFECTIVENESS AS AN ODDS RATIO

STEP 12 CALCULATE STANDARD ERROR OF THE STEP 11 ODDS RATIO

STEP 13 CALCULATE STANDARD ERROR OF THE STEP 10 UNBIASED SAFETY EFFECTIVENESS

STEP 14 ASSESS STATISTICAL SIGNIFICANCE OF ESTIMATED SAFETY EFFECTIVENESS

INPUT DATA FOR BEFORE-AFTER ANALYSIS

STEP 0a OUTPUT FROM SPSS, OBSERVED CRASH FREQUENCY BY SITE BY YEAR BEFORE AND AFTER TREATMENT (crosstabulations)

IntNum * Bef3 * R_SiteType Crosstabulation

Count

			Bef3		
R_SiteType			-3	0	Total
0	IntNum	3	5	59	64
		9	8	36	44
		17	15	42	57
		18	10	43	53
		19	6	41	47
		20	3	18	21
		21	3	44	47
		22	3	36	39
		23	5	26	31
		24	4	24	28
		25	5	52	57
		26	1	35	36
		27	2	22	24
		28	1	26	27
		29	6	24	30
		122	3	36	39
	Total		80	564	644
1	IntNum	1	10	25	35
		2	9	51	60
		4	4	19	23
		5	4	15	19
		6	3	18	21
		7	6	42	48
		8	6	26	32
		10	3	11	14
		11	4	8	12
		12	5	13	18
		13	7	27	34
		14	3	19	22
		15	2	13	15
		16	11	8	19
		103	8	70	78
		109	3	49	52
	Total		88	414	502

IntNum * Bef2 * R_SiteType Crosstabulation

Count

			Bef2		
R_SiteType			-2	0	Total
0	IntNum	3	5	59	64
		9	2	42	44
		17	5	52	57
		18	7	46	53
		19	8	39	47
		20	2	19	21
		21	4	43	47
		22	3	36	39
		23	2	29	31
		24	4	24	28
		25	7	50	57
		26	4	32	36
		27	5	19	24
		28	4	23	27
		29	4	26	30
		122	6	33	39
	Total		72	572	644
1	IntNum	1	11	24	35
		2	8	52	60
		4	5	18	23
		5	3	16	19
		6	3	18	21
		7	9	39	48
		8	7	25	32
		10	5	9	14
		11	2	10	12
		12	3	15	18
		13	11	23	34
		14	5	17	22
		15	3	12	15
		16	1	18	19
		103	12	66	78
		109	8	44	52
	Total		96	406	502

IntNum * Bef1 * R_SiteType Crosstabulation

Count

			Bef1		
R_SiteType			-1	0	Total
0	IntNum	3	6	58	64
		9	4	40	44
		17	8	49	57
		18	8	45	53
		19	5	42	47
		20	2	19	21
		21	5	42	47
		22	3	36	39
		23	5	26	31
		24	5	23	28
		25	5	52	57
		26	3	33	36
		27	6	18	24
		28	8	19	27
		29	8	22	30
		122	5	34	39
	Total		86	558	644
1	IntNum	1	6	29	35
		2	9	51	60
		4	3	20	23
		5	0	19	19
		6	1	20	21
		7	4	44	48
		8	5	27	32
		10	1	13	14
		11	1	11	12
		12	4	14	18
		13	5	29	34
		14	0	22	22
		15	4	11	15
		16	1	18	19
		103	5	73	78
		109	2	50	52
	Total		51	451	502

IntNum * Aft1 * R_SiteType Crosstabulation

Count

			Aft1		
R_SiteType			0	1	Total
0	IntNum	3	55	9	64
		9	37	7	44
		17	47	10	57
		18	49	4	53
		19	36	11	47
		20	18	3	21
		21	45	2	47
		22	37	2	39
		23	26	5	31
		24	28	0	28
		25	54	3	57
		26	29	7	36
		27	20	4	24
		28	26	1	27
		29	25	5	30
		122	35	4	39
	Total		567	77	644
1	IntNum	1	34	1	35
		2	50	10	60
		4	20	3	23
		5	18	1	19
		6	17	4	21
		7	36	12	48
		8	29	3	32
		10	12	2	14
		11	11	1	12
		12	16	2	18
		13	29	5	34
		14	19	3	22
		15	14	1	15
		16	18	1	19
		103	75	3	78
		109	51	1	52
	Total		449	53	502

IntNum * Aft2 * R_SiteType Crosstabulation

Count

			Aft2		
R_SiteType			0	2	Total
0	IntNum	3	58	6	64
		9	40	4	44
		17	50	7	57
		18	46	7	53
		19	41	6	47
		20	20	1	21
		21	40	7	47
		22	36	3	39
		23	26	5	31
		24	24	4	28
		25	52	5	57
		26	29	7	36
		27	19	5	24
		28	20	7	27
		29	25	5	30
		122	35	4	39
	Total		561	83	644
1	IntNum	1	34	1	35
		2	52	8	60
		4	22	1	23
		5	19	0	19
		6	21	0	21
		7	42	6	48
		8	29	3	32
		10	13	1	14
		11	12	0	12
		12	17	1	18
		13	33	1	34
		14	18	4	22
		15	14	1	15
		16	18	1	19
		103	75	3	78
		109	50	2	52
	Total		469	33	502

IntNum * Aft3 * R_SiteType Crosstabulation

Count

			Aft3		
R_SiteType			0	3	Total
0	IntNum	3	60	4	64
		9	39	5	44
		17	50	7	57
		18	45	8	53
		19	41	6	47
		20	17	4	21
		21	43	4	47
		22	37	2	39
		23	28	3	31
		24	25	3	28
		25	53	4	57
		26	24	12	36
		27	22	2	24
		28	21	6	27
		29	30	0	30
		122	38	1	39
	Total		573	71	644
1	IntNum	1	34	1	35
		2	52	8	60
		4	22	1	23
		5	18	1	19
		6	19	2	21
		7	43	5	48
		8	31	1	32
		10	14	0	14
		11	12	0	12
		12	16	2	18
		13	33	1	34
		14	19	3	22
		15	13	2	15
		16	18	1	19
		103	70	8	78
		109	47	5	52
	Total		461	41	502

IntNum * InjuryYes * R_SiteType Crosstabulation

Count

R_SiteType			InjuryYes 0	1	99	Total
0	IntNum	3	42	19	3	64
		9	14	28	0	42
		17	29	22	6	57
		18	38	12	3	53
		19	28	19	0	47
		20	14	7	0	21
		21	29	14	4	47
		22	21	17	1	39
		23	21	6	4	31
		24	11	14	3	28
		25	28	28	1	57
		26	25	11	0	36
		27	15	9	0	24
		28	9	17	0	26
		29	18	10	2	30
		122	21	17	1	39
	Total		363	250	28	641
1	IntNum	1	23	12	0	35
		2	30	26	4	60
		4	15	8	0	23
		5	13	6	0	19
		6	14	3	4	21
		7	25	19	3	47
		8	22	8	2	32
		10	12	2	0	14
		11	11	0	1	12
		12	7	11	0	18
		13	13	20	1	34
		14	14	7	1	22
		15	5	8	1	14
		16	10	9	0	19
		103	53	21	4	78
		109	17	32	1	50
	Total		284	192	22	498

IntNum * PDO * R_SiteType Crosstabulation

Count

R_SiteType			PDO 1	Total
0	IntNum	3	42	42
		9	14	14
		17	29	29
		18	38	38
		19	28	28
		20	14	14
		21	29	29
		22	21	21
		23	21	21
		24	11	11
		25	28	28
		26	25	25
		27	15	15
		28	9	9
		29	18	18
		122	21	21
	Total		363	363
1	IntNum	1	23	23
		2	30	30
		4	15	15
		5	13	13
		6	14	14
		7	25	25
		8	22	22
		10	12	12
		11	11	11
		12	7	7
		13	13	13
		14	14	14
		15	5	5
		16	10	10
		103	53	53
		109	17	17
	Total		284	284

STEP 0b INTERSECTION DATA: AADTs, Geometry, Signal Ops

pulled from sheet 4-Ints_AADTs

vlookup column >>			2	3	4	5	6	7	9	10	11	12	13	14
			AADTmaj						AADTmin					
R_SiteType			Bef3Yr	Bef2Yr	Bef1Yr	Aft1Yr	Aft2Yr	Aft3Yr	Bef3Yr	Bef2Yr	Bef1Yr	Aft1Yr	Aft2Yr	Aft3Yr
0	IntNum	3	20000	20000	20000	19500	19000	19000	7000	7700	8400	7550	6700	6450
		9	65500	70000	72000	74000	67000	60000	16740	16625	16510	16395	16280	16165
		17	9800	9650	9500	9300	9100	9100	10000	9500	9000	9100	9200	9050
		18	24000	21500	19000	19000	19000	19500	3810	3810	3210	2610	2610	2610
		19	11000	10050	9100	9100	9100	8950	9860	9860	9765	9670	7050	7050
		20	11800	11500	11200	10900	10600	10600	6880	6953	7025	7098	7170	7170
		21	25000	25500	26000	22500	19000	19000	10000	10000	10000	9850	9700	9850
		22	64000	67000	70000	79000	88000	89000	31000	31500	32000	30500	29000	29000
		23	9800	8800	7800	7950	8100	8200	9260	9260	9260	9260	9260	9260
		24	15500	16000	15500	15000	15000	15000	6850	6900	6550	6200	6400	6600
		25	20000	22000	24000	22000	20000	20500	14120	14120	14240	14360	14480	14600
		26	7450	7500	7250	7000	7250	7500	10210	10210	10210	10210	10295	10380
		27	25000	25000	24500	24000	24000	24000	20000	20000	19000	18000	19500	21000
		28	19000	20000	20000	20000	19500	19000	10000	10000	10000	10000	11500	13000
		29	29000	30000	28500	27000	28000	29000	5300	5200	5050	4900	4800	4700
		122	89000	90000	89000	88000	89500	91000	29000	29000	28000	27000	28000	29000
1	IntNum	1	27000	26500	26000	25000	24000	23500	7000	7700	8400	7550	6700	6450
		2	21000	21500	22000	21500	21000	21000	4000	4150	4300	4700	5100	5050
		4	42000	44000	46000	44000	42000	42000	5210	4747	4283	3820	6955	10090
		5	41000	43000	42500	42000	40500	39000	2983	2500	2250	2000	2200	2400
		6	21000	22500	24000	23000	22000	21500	3000	3500	4000	3700	3400	3700
		7	66000	69000	72000	72000	72000	70000	10810	10810	10810	10810	10810	10810
		8	45000	46000	44000	42000	41500	41000	24000	29000	26000	23000	23000	23000
		10	20000	21500	23000	21500	20000	19500	4480	4497	4513	4530	5230	5230
		11	26000	25500	25000	24500	24000	24000	4800	4700	4600	4350	4100	4150
		12	55500	53000	55500	58000	57000	56000	4250	4135	4020	4735	5450	6165
		13	20000	21000	22000	21000	20000	21000	9500	9750	10000	10000	10000	10000
		14	12000	11500	11000	11000	11000	11000	10000	9600	9200	9350	9500	9750
		15	90500	85000	84000	83000	84500	86000	43500	45000	44500	44000	43000	42000
		16	90500	85000	84000	83000	84500	86000	51500	49000	48500	48000	45500	43000
		103	19000	19000	19000	19000	19000	19000	6450	6200	6150	6100	6200	6300
		109	67000	60000	63500	67000	64500	62000	16280	16165	16050	14815	13580	13580

BASE CASE, ALL CMF, C = 1.00

pulled from sheet 2-Intersections_prepped

Step 1b Determine Crash Modification Factors (CMFs) and Calibration Factors (Ci) for each intersection for each year

vlookup column >>		5	6	296	299	300	297	301														
				for CMF_1i	for CMF_2i		for CMF_3i	n_prohib	N_{bisv}													
R_SiteType		Approaches	Legs	AppsWLeftLns	AppsWLeftProt	LeftProtPerm	AppsWRgtLns	AppsRTORprohib	Bef3Yr	Bef2Yr	Bef1Yr	Aft1Yr	Aft2Yr	Aft3Yr	RLC	CMF_1i	CMF_2i	CMF_3i	CMF_4i	CMF_5i	CMF_6i	Ci
0 IntNum	3	2	4	0	0	0	1	0	0.34	0.35	0.35	0.34	0.32	0.32	0	1	1	1	1	1	1	1
	9	4	4	0	4	0	4	0	0.96	1.00	1.02	1.03	0.97	0.89	0	1	1	1	1	1	1	1
	17	2	4	0	0	0	0	0	0.23	0.22	0.22	0.22	0.21	0.21	0	1	1	1	1	1	1	1
	18	4	4	0	0	0	2	0	0.32	0.30	0.26	0.25	0.25	0.25	0	1	1	1	1	1	1	1
	19	3	4	0	0	0	0	0	0.25	0.23	0.22	0.22	0.20	0.20	0	1	1	1	1	1	1	1
	20	4	4	0	0	0	4	0	0.23	0.23	0.23	0.22	0.22	0.22	0	1	1	1	1	1	1	1
	21	4	4	0	0	2	4	0	0.43	0.44	0.44	0.40	0.36	0.36	0	1	1	1	1	1	1	1
	22	3	4	0	0	1	2	0	1.11	1.15	1.19	1.28	1.36	1.37	0	1	1	1	1	1	1	1
	23	2	4	0	0	0	1	0	0.22	0.21	0.19	0.19	0.20	0.20	0	1	1	1	1	1	1	1
	24	4	4	0	2	0	3	0	0.28	0.29	0.28	0.27	0.27	0.27	0	1	1	1	1	1	1	1
	25	3	4	0	0	0	1	0	0.41	0.44	0.46	0.44	0.41	0.42	0	1	1	1	1	1	1	1
	26	2	4	0	0	0	0	0	0.19	0.19	0.19	0.18	0.19	0.19	0	1	1	1	1	1	1	1
	27	4	4	1	2	2	4	0	0.52	0.52	0.51	0.49	0.50	0.51	0	1	1	1	1	1	1	1
	28	4	4	0	0	2	4	0	0.36	0.37	0.37	0.37	0.38	0.39	0	1	1	1	1	1	1	1
	29	4	4	0	0	0	4	1	0.40	0.41	0.39	0.38	0.38	0.39	0	1	1	1	1	1	1	1
	122	3	4	0	0	1	2	0	1.37	1.38	1.36	1.33	1.36	1.39	0	1	1	1	1	1	1	1
1 IntNum	1	2	4	0	0	0	0	1	0.41	0.42	0.42	0.40	0.38	0.37	1	1	1	1	1	1	1	1
	2	2	4	0	0	0	1	0	0.30	0.31	0.32	0.32	0.32	0.32	1	1	1	1	1	1	1	1
	4	4	4	0	0	1	3	1	0.52	0.52	0.52	0.49	0.56	0.62	1	1	1	1	1	1	1	1
	5	4	4	1	4	0	4	0	0.44	0.43	0.42	0.40	0.40	0.40	1	1	1	1	1	1	1	1
	6	4	4	0	2	0	4	0	0.28	0.30	0.33	0.31	0.30	0.30	1	1	1	1	1	1	1	1
	7	3	3	0	1	0	2	0	0.53	0.54	0.54	0.54	0.54	0.54	1	1	1	1	1	1	1	1
	8	4	4	0	4	0	4	0	0.82	0.87	0.82	0.77	0.77	0.76	1	1	1	1	1	1	1	1
	10	4	4	0	2	2	3	0	0.30	0.31	0.33	0.32	0.31	0.31	1	1	1	1	1	1	1	1
	11	4	4	0	1	0	3	1	0.36	0.36	0.35	0.34	0.33	0.33	1	1	1	1	1	1	1	1
	12	4	4	1	2	0	4	0	0.59	0.57	0.58	0.63	0.64	0.66	1	1	1	1	1	1	1	1
	13	4	4	0	2	0	4	0	0.37	0.38	0.40	0.38	0.37	0.38	1	1	1	1	1	1	1	1
	14	3	4	0	1	0	1	0	0.26	0.25	0.24	0.24	0.24	0.25	1	1	1	1	1	1	1	1
	15	2	3	0	1	0	0	0	1.05	1.03	1.02	1.01	1.01	1.01	1	1	1	1	1	1	1	1
	16	2	3	0	1	0	1	0	1.12	1.07	1.06	1.05	1.04	1.02	1	1	1	1	1	1	1	1
	103	2	4	0	0	0	1	0	0.32	0.32	0.32	0.31	0.32	0.32	1	1	1	1	1	1	1	1
	109	4	4	0	4	0	4	0	0.97	0.89	0.93	0.94	0.90	0.87	1	1	1	1	1	1	1	1

EB ESTIMATION IN BEFORE PERIOD

BASE CASE, ALL CMF, C = 1.00

STEP 1 CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR BEFORE TREATMENT

Step 1a Calculate Safety Performance Functions for each intersection for each year

				Bef3Yr					Bef2Yr					Bef1Yr				
R_SiteType			FormulaApplied	$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$	$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$	$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$
0	IntNum	3	4SG	5.17	1.64	3.34	1.70	3.47	5.29	1.67	3.42	1.74	3.55	5.39	1.71	3.49	1.77	3.62
		9	4SG	22.49	8.05	13.81	8.28	14.21	24.11	8.69	14.76	8.94	15.17	24.80	8.97	15.16	9.22	15.58
		17	4SG	2.62	0.76	1.76	0.79	1.82	2.54	0.74	1.71	0.77	1.77	2.47	0.72	1.66	0.75	1.72
		18	4SG	5.46	1.78	3.48	1.85	3.62	4.86	1.56	3.11	1.62	3.23	4.09	1.30	2.63	1.35	2.74
		19	4SG	2.95	0.87	1.97	0.91	2.05	2.68	0.78	1.80	0.81	1.87	2.40	0.70	1.62	0.72	1.68
		20	4SG	2.93	0.88	1.94	0.91	2.02	2.86	0.85	1.90	0.88	1.97	2.78	0.83	1.85	0.86	1.92
		21	4SG	7.13	2.31	4.57	2.39	4.74	7.28	2.36	4.66	2.45	4.83	7.43	2.42	4.76	2.50	4.93
		22	4SG	25.28	8.97	15.64	9.21	16.07	26.64	9.50	16.45	9.75	16.89	28.02	10.04	17.27	10.30	17.72
		23	4SG	2.57	0.75	1.73	0.78	1.79	2.29	0.66	1.55	0.69	1.60	2.01	0.57	1.37	0.60	1.42
		24	4SG	3.92	1.21	2.56	1.25	2.66	4.06	1.26	2.65	1.30	2.76	3.88	1.20	2.54	1.24	2.63
		25	4SG	6.08	1.91	3.95	1.98	4.10	6.73	2.14	4.36	2.22	4.51	7.40	2.38	4.77	2.46	4.94
		26	4SG	1.96	0.56	1.34	0.58	1.39	1.97	0.56	1.35	0.58	1.39	1.90	0.54	1.30	0.56	1.35
		27	4SG	8.36	2.69	5.40	2.78	5.58	8.36	2.69	5.40	2.78	5.58	8.08	2.59	5.22	2.68	5.40
		28	4SG	5.31	1.67	3.45	1.73	3.58	5.61	1.77	3.64	1.84	3.78	5.61	1.77	3.64	1.84	3.78
		29	4SG	7.22	2.39	4.57	2.48	4.74	7.45	2.48	4.71	2.57	4.88	7.01	2.32	4.43	2.40	4.60
		122	4SG	35.42	13.04	21.55	13.36	22.07	35.85	13.22	21.80	13.53	22.32	35.14	12.94	21.37	13.26	21.88
1	IntNum	1	4SG	7.13	2.34	4.54	2.42	4.71	7.14	2.33	4.56	2.42	4.72	7.14	2.32	4.56	2.41	4.73
		2	4SG	4.79	1.53	3.07	1.60	3.19	4.95	1.59	3.17	1.65	3.30	5.12	1.65	3.28	1.71	3.41
		4	4SG	10.69	3.69	6.63	3.82	6.87	10.99	3.81	6.80	3.95	7.04	11.26	3.93	6.95	4.07	7.19
		5	4SG	9.16	3.17	5.66	3.29	5.87	9.26	3.22	5.70	3.34	5.91	8.92	3.11	5.49	3.22	5.70
		6	4SG	4.48	1.44	2.87	1.50	2.98	5.00	1.62	3.19	1.68	3.32	5.53	1.80	3.52	1.87	3.66
		7	3SG	13.51	3.74	9.00	3.96	9.54	14.19	3.91	9.47	4.15	10.04	14.87	4.08	9.94	4.33	10.54
		8	4SG	16.35	5.60	10.27	5.77	10.58	17.48	5.99	10.99	6.16	11.32	16.26	5.55	10.23	5.71	10.54
		10	4SG	4.67	1.49	3.00	1.54	3.12	5.05	1.62	3.23	1.68	3.36	5.43	1.75	3.47	1.82	3.60
		11	4SG	6.28	2.06	3.99	2.13	4.14	6.12	2.00	3.89	2.08	4.04	5.96	1.94	3.79	2.02	3.94
		12	4SG	13.74	4.90	8.40	5.06	8.68	13.00	4.61	7.96	4.77	8.23	13.57	4.84	8.28	5.00	8.57
		13	4SG	5.55	1.75	3.60	1.82	3.73	5.88	1.87	3.80	1.94	3.94	6.22	1.98	4.01	2.06	4.16
		14	4SG	3.25	0.97	2.16	1.01	2.24	3.08	0.91	2.05	0.95	2.13	2.90	0.86	1.94	0.89	2.01
		15	3SG	27.54	6.53	19.59	6.89	20.65	25.91	6.16	18.43	6.50	19.42	25.50	6.08	18.12	6.41	19.09
		16	3SG	28.77	6.72	20.61	7.08	21.69	26.49	6.25	18.90	6.59	19.91	26.08	6.17	18.59	6.50	19.58
		103	4SG	4.80	1.51	3.11	1.57	3.23	4.76	1.50	3.08	1.56	3.20	4.75	1.50	3.07	1.56	3.19
		109	4SG	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90	21.54	7.69	13.25	7.91	13.63

Aft1Yr					Aft2Yr					Aft3Yr				
$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$
5.12	1.62	3.32	1.68	3.44	4.85	1.53	3.14	1.59	3.26	4.80	1.51	3.11	1.57	3.23
25.50	9.25	15.57	9.51	15.99	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90
2.42	0.70	1.63	0.73	1.69	2.37	0.69	1.60	0.71	1.66	2.36	0.68	1.59	0.71	1.65
3.90	1.24	2.50	1.29	2.61	3.90	1.24	2.50	1.29	2.61	4.01	1.28	2.57	1.33	2.68
2.40	0.69	1.62	0.72	1.68	2.23	0.65	1.50	0.67	1.56	2.19	0.64	1.47	0.66	1.53
2.71	0.80	1.81	0.83	1.88	2.64	0.78	1.76	0.81	1.83	2.64	0.78	1.76	0.81	1.83
6.34	2.03	4.09	2.10	4.24	5.28	1.66	3.43	1.72	3.56	5.29	1.66	3.44	1.72	3.57
31.55	11.46	19.31	11.75	19.80	35.00	12.87	21.30	13.18	21.82	35.42	13.04	21.55	13.36	22.07
2.06	0.59	1.39	0.61	1.45	2.10	0.60	1.42	0.62	1.47	2.12	0.61	1.44	0.63	1.49
3.70	1.14	2.42	1.18	2.52	3.72	1.14	2.44	1.19	2.53	3.75	1.15	2.46	1.20	2.55
6.76	2.15	4.38	2.22	4.53	6.11	1.92	3.98	1.99	4.12	6.29	1.98	4.09	2.05	4.23
1.83	0.52	1.25	0.53	1.30	1.91	0.54	1.30	0.56	1.35	1.98	0.56	1.35	0.58	1.40
7.81	2.50	5.05	2.59	5.22	7.95	2.55	5.15	2.63	5.32	8.09	2.59	5.24	2.68	5.42
5.61	1.77	3.64	1.84	3.78	5.64	1.77	3.67	1.84	3.80	5.64	1.77	3.68	1.83	3.81
6.57	2.16	4.17	2.24	4.33	6.80	2.24	4.30	2.33	4.47	7.02	2.33	4.44	2.42	4.61
34.43	12.67	20.94	12.98	21.45	35.35	13.03	21.49	13.34	22.01	36.28	13.39	22.04	13.71	22.57
6.68	2.17	4.27	2.25	4.43	6.22	2.01	3.98	2.09	4.13	6.03	1.95	3.86	2.02	4.01
5.10	1.63	3.27	1.70	3.40	5.07	1.62	3.26	1.68	3.38	5.05	1.62	3.25	1.68	3.37
10.46	3.64	6.46	3.77	6.69	11.42	3.93	7.11	4.06	7.36	12.44	4.26	7.78	4.41	8.04
8.57	2.99	5.27	3.10	5.47	8.43	2.92	5.20	3.03	5.40	8.26	2.85	5.11	2.96	5.30
5.19	1.68	3.31	1.75	3.44	4.85	1.56	3.10	1.63	3.22	4.83	1.55	3.09	1.61	3.21
14.87	4.08	9.94	4.33	10.54	14.87	4.08	9.94	4.33	10.54	14.42	3.97	9.63	4.21	10.21
15.04	5.11	9.48	5.27	9.77	14.85	5.04	9.36	5.19	9.65	14.65	4.97	9.25	5.12	9.53
5.05	1.62	3.24	1.69	3.37	4.84	1.54	3.12	1.60	3.24	4.71	1.49	3.04	1.55	3.16
5.76	1.88	3.67	1.95	3.81	5.56	1.81	3.54	1.88	3.68	5.57	1.81	3.55	1.88	3.69
14.77	5.28	9.01	5.46	9.31	14.97	5.34	9.16	5.51	9.46	15.11	5.37	9.26	5.55	9.57
5.91	1.88	3.83	1.95	3.97	5.61	1.77	3.64	1.84	3.78	5.91	1.88	3.83	1.95	3.97
2.92	0.86	1.95	0.90	2.02	2.93	0.87	1.95	0.90	2.03	2.94	0.87	1.97	0.90	2.04
25.09	5.99	17.81	6.32	18.77	25.44	6.08	18.06	6.41	19.03	25.78	6.17	18.29	6.50	19.28
25.66	6.08	18.28	6.41	19.26	25.82	6.14	18.36	6.47	19.35	25.94	6.19	18.42	6.53	19.42
4.74	1.50	3.07	1.55	3.19	4.76	1.50	3.08	1.56	3.20	4.78	1.51	3.09	1.57	3.21
22.40	8.05	13.73	8.28	14.12	21.08	7.55	12.93	7.77	13.31	20.21	7.20	12.42	7.42	12.79

BASE CASE, ALL CMF, C = 1.00

STEP 2 CALCULATE EXPECTED CRASH FREQUENCY BY SITE FOR ENTIRE BEFORE PERIOD

$N_{expected,B} = w_{i,B} * N_{predicted,B,i} + (1 - w_{i,B}) * N_{observed,B}$

$N_{pred,bi} = N_{bimv} * (CMF_{1i} * \ldots * CMF_{6i}) * C_i$

$w_{i,B} = 1 / [1 + k * sum(N_{predicted,B,i})$ over all years

Note: if CMF or C unknown, assume 1.00.

R_SiteType			Formula Applied	BefAllYrs $N_{bimv\text{-}nSG}$	$N_{bimv(FI)\text{-}nSG}$	$N_{bimv(PDO)\text{-}nSG}$	BefAllYrs $N_{pred,bi}$	$N_{pred,bi(FI)}$	$N_{pred,bi(PDO)}$	BefAllYrs $w_{i,B}$	$N_{expected,B}$
0	IntNum	3	4SG	15.85	5.21	10.64	15.85	5.21	10.64	0.14	15.98
		9	4SG	71.40	26.44	44.96	71.40	26.44	44.96	0.03	15.99
		17	4SG	7.63	2.31	5.32	7.63	2.31	5.32	0.25	22.88
		18	4SG	14.41	4.83	9.59	14.41	4.83	9.59	0.15	23.40
		19	4SG	8.03	2.44	5.59	8.03	2.44	5.59	0.24	16.35
		20	4SG	8.57	2.65	5.91	8.57	2.65	5.91	0.23	7.36
		21	4SG	21.84	7.34	14.50	21.84	7.34	14.50	0.11	13.03
		22	4SG	79.95	29.27	50.68	79.95	29.27	50.68	0.03	11.20
		23	4SG	6.88	2.06	4.81	6.88	2.06	4.81	0.27	10.61
		24	4SG	11.85	3.80	8.05	11.85	3.80	8.05	0.18	12.80
		25	4SG	20.21	6.66	13.55	20.21	6.66	13.55	0.11	17.36
		26	4SG	5.84	1.71	4.13	5.84	1.71	4.13	0.31	7.34
		27	4SG	24.80	8.24	16.56	24.80	8.24	16.56	0.09	14.11
		28	4SG	16.54	5.41	11.13	16.54	5.41	11.13	0.13	13.48
		29	4SG	21.68	7.45	14.22	21.68	7.45	14.22	0.11	18.39
		122	4SG	106.41	40.14	66.27	106.41	40.14	66.27	0.02	16.17
1	IntNum	1	4SG	21.41	7.25	14.16	21.41	7.25	14.16	0.11	26.40
		2	4SG	14.86	4.96	9.90	14.86	4.96	9.90	0.15	24.36
		4	4SG	32.94	11.84	21.11	32.94	11.84	21.11	0.07	13.51
		5	4SG	27.34	9.86	17.48	27.34	9.86	17.48	0.09	8.74
		6	4SG	15.01	5.05	9.96	15.01	5.05	9.96	0.15	8.17
		7	3SG	42.57	12.44	30.13	42.57	12.44	30.13	0.07	20.57
		8	4SG	50.09	17.64	32.45	50.09	17.64	32.45	0.05	19.56
		10	4SG	15.14	5.05	10.09	15.14	5.05	10.09	0.14	9.89
		11	4SG	18.36	6.23	12.13	18.36	6.23	12.13	0.12	8.39
		12	4SG	40.31	14.83	25.48	40.31	14.83	25.48	0.06	13.69
		13	4SG	17.64	5.81	11.83	17.64	5.81	11.83	0.13	22.32
		14	4SG	9.23	2.85	6.38	9.23	2.85	6.38	0.22	8.27
		15	3SG	78.95	19.79	59.16	78.95	19.79	59.16	0.04	11.59
		16	3SG	81.34	20.16	61.18	81.34	20.16	61.18	0.04	15.45
		103	4SG	14.32	4.69	9.62	14.32	4.69	9.62	0.15	23.38
		109	4SG	64.75	23.78	40.97	64.75	23.78	40.97	0.04	14.97

EB ESTIMATION IN AFTER PERIOD

BASE CASE, ALL CMF, C = 1.00

STEP 3 CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR AFTER TREATMENT

R_SiteType			Formula Applied	AftAllYrs $N_{aimv\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	AftAllYrs $N_{pred,ai}$	$N_{pred,ai(FI)}$	$N_{pred,ai(PDO)}$
0	IntNum	3	4SG	14.77	4.84	9.93	14.77	4.84	9.93
		9	4SG	68.70	25.37	43.33	68.70	25.37	43.33
		17	4SG	7.15	2.15	5.00	7.15	2.15	5.00
		18	4SG	11.81	3.92	7.89	11.81	3.92	7.89
		19	4SG	6.82	2.05	4.77	6.82	2.05	4.77
		20	4SG	7.98	2.45	5.53	7.98	2.45	5.53
		21	4SG	16.92	5.55	11.37	16.92	5.55	11.37
		22	4SG	101.97	38.28	63.69	101.97	38.28	63.69
		23	4SG	6.28	1.86	4.41	6.28	1.86	4.41
		24	4SG	11.17	3.57	7.60	11.17	3.57	7.60
		25	4SG	19.15	6.27	12.89	19.15	6.27	12.89
		26	4SG	5.72	1.68	4.05	5.72	1.68	4.05
		27	4SG	23.86	7.90	15.96	23.86	7.90	15.96
		28	4SG	16.90	5.51	11.39	16.90	5.51	11.39
		29	4SG	20.39	6.99	13.40	20.39	6.99	13.40
		122	4SG	106.06	40.03	66.03	106.06	40.03	66.03
1	IntNum	1	4SG	18.93	6.36	12.57	18.93	6.36	12.57
		2	4SG	15.22	5.06	10.16	15.22	5.06	10.16
		4	4SG	34.32	12.24	22.08	34.32	12.24	22.08
		5	4SG	25.27	9.09	16.18	25.27	9.09	16.18
		6	4SG	14.86	4.99	9.87	14.86	4.99	9.87
		7	3SG	44.17	12.87	31.29	44.17	12.87	31.29
		8	4SG	44.54	15.58	28.95	44.54	15.58	28.95
		10	4SG	14.60	4.83	9.76	14.60	4.83	9.76
		11	4SG	16.89	5.71	11.18	16.89	5.71	11.18
		12	4SG	44.85	16.51	28.34	44.85	16.51	28.34
		13	4SG	17.44	5.73	11.71	17.44	5.73	11.71
		14	4SG	8.78	2.70	6.09	8.78	2.70	6.09
		15	3SG	76.31	19.23	57.09	76.31	19.23	57.09
		16	3SG	77.42	19.40	58.02	77.42	19.40	58.02
		103	4SG	14.28	4.68	9.60	14.28	4.68	9.60
		109	4SG	63.69	23.47	40.22	63.69	23.47	40.22

ESTIMATION OF TREATED EFFECTIVENESS

BASE CASE, ALL CMF, C = 1.00

STEP 4 CALCULATE AN ADJUSTMENT FACTOR (ri) FOR DIFFERENCES BETWEEN BEFORE & AFTER PERIODS

STEP 5 CALCULATE EXPECTED CRASH FREQUENCY BY SITE FOR ENTIRE AFTER PERIOD IN ABSENCE OF TREATMENT

BASE CASE, ALL CMF, C = 1.00

STEP 6 ESTIMATE SAFETY EFFECTIVENESS AT EACH SITE VIA ODDS RATIO (omega)

STEP 7 ESTIMATE SAFETY EFFECTIVENESS AT EACH SITE AS A PERCENTAGE CRASH CHANGE

ri	$N_{expected,A}$	omega_i	SafeEff_i
0.932	14.89	1.276	-27.59
0.962	15.39	1.040	-3.99
0.938	21.45	1.119	-11.89
0.820	19.18	0.991	0.94
0.849	13.88	1.658	-65.76
0.932	6.86	1.167	-16.66
0.775	10.10	1.288	-28.76
1.275	14.29	0.490	51.02
0.913	9.68	1.343	-34.25
0.942	12.06	0.581	41.95
0.948	16.46	0.729	27.09
0.980	7.20	3.613	-261.32
0.962	13.57	0.811	18.93
1.022	13.77	1.017	-1.69
0.940	17.29	0.578	42.17
0.997	16.12	0.558	44.17
0.884	23.35	0.129	87.15
1.024	24.94	1.042	-4.24
1.042	14.08	0.355	64.48
0.924	8.08	0.248	75.25
0.990	8.09	0.742	25.81
1.038	21.34	1.078	-7.79
0.889	17.40	0.402	59.76
0.964	9.53	0.315	68.53
0.920	7.72	0.130	87.05
1.113	15.24	0.328	67.19
0.989	22.07	0.317	68.28
0.952	7.87	1.271	-27.09
0.967	11.20	0.357	64.28
0.952	14.71	0.204	79.61
0.998	23.32	0.600	39.97
0.984	14.73	0.543	45.68

ri = sum($N_{predicted,A,i}$)over after years / sum($N_{predicted,B,i}$)over before years

$N_{expected,A}$ = ri*$N_{expected,B}$

omega_i = $N_{observed,A}$/$N_{expected,A}$

SafeEff_i = 100*(1-omega_i)

BASE CASE, ALL CMF, C = 1.00

STEP 8 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT (ODDS RATIO omega') FOR ALL SITES COMBINED

R_SiteType	omega'
0 All Ints	1.04
1 All Ints	0.52

omega' = sum($N_{observed,A}$)all sites / sum($N_{expected,A}$)all sites

STEP 9 ADJUST ODDS RATIO TO OBTAIN UNBIASED ESTIMATE OF TREATMENT EFFECTIVENESS

R_SiteType	Var(Nexpected,A,all)	omega
0 All Ints	181.90	1.04
1 All Ints	215.40	0.52

Var(Nexpected,A,all) = sum[(ri^2)*$N_{expected,B}$ * (1-$w_{i,B}$)] over all sites

omega = omega' / {1+[var($N_{expected,A,all}$)] / [$N_{expected,A,all}$]^2}

STEP 10 CALCULATE OVERALL UNBIASED SAFETY EFFECTIVENESS AS A PERCENT CHANGE IN CRASH FREQUENCY ACROSS ALL SITES

R_SiteType	Safety Effectiveness
0 All Ints	-3.59
1 All Ints	48.06

Safety Effectiveness = 100*(1 - omega)

ESTIMATION OF PRECISION OF TREATED EFFECTIVENESS

STEP 11 CALCULATE VARIANCE OF UNBIASED ESTIMATED SAFETY EFFECTIVENESS AS AN ODDS RATIO

R_SiteType	$N_{observed,A,all\ sites}$	$N_{expected,A,all\ sites}$	var(omega)
0 All Ints	231	222.17	0.00863
1 All Ints	127	243.65	0.00311

var(omega) = {omega'^2 *
[(1/$N_{observed,A}$) + (var{sum[$N_{expected,A}$]over all sites}/(sum[$N_{expected,A}$]over all sites)^2)] /
[1 + (var{sum[$N_{expected,A}$] over all sites} / (sum[$N_{expected,A}$]over all sites)^2)]

STEP 12 CALCULATE STANDARD ERROR OF THE STEP 11 ODDS RATIO

R_SiteType	SE(omega)
0 All Ints	0.09
1 All Ints	0.06

SE(omega) = sqrt[var(omega)]

STEP 13 CALCULATE STANDARD ERROR OF THE STEP 10 UNBIASED SAFETY EFFECTIVENESS

R_SiteType	SE(Safety Effectiveness)
0 All Ints	9.29
1 All Ints	5.58

SE(Safety Effectiveness) =100 * SE(omega)

STEP 14 ASSESS STATISTICAL SIGNIFICANCE OF ESTIMATED SAFETY EFFECTIVENESS

R_SiteType	Performance Measure
0 All Ints	0.39
1 All Ints	8.61

Performance Measure = ABS[Safety Effectiveness / SE(Safety Effectiveness)]

PM < 1.7 Treatment Effect NOT significant at the (approx.) 90% confidence interval
PM >= 1.7 Treatment Effect IS significant at the (approx.) 90% confidence interval
PM >= 2.0 Treatment Effect IS significant at the (approx.) 95% confidence interval

InjuryStatusUr	1 fatal
InjuryStatusUr	2 injury
TAD_Unit1Ar	3 injury
TAD_Unit2Ar	4 injury
	5 no injury
	6 unknown

InjuryYes = 1
u1<5 or u2<5

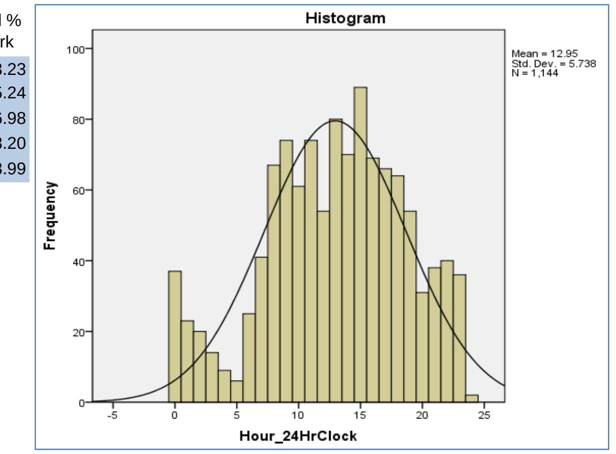
InjuryYes = 0
u1=5 and u2=5

InjuryYes = 99
(u1=6 or u2=6) when (u1>4 and u2>4)

PDO = 1
if(TAD1<>0 or TAD2<>0) when InjuryYes=0

Hour_24HrClock

		Frequency	Percent	Valid Pct	Cum Pct	Cumul % in Dark
Valid	0	37	3.2	3.2	3.2	3.23
	1	23	2.0	2.0	5.2	5.24
	2	20	1.7	1.7	7.0	6.98
	3	14	1.2	1.2	8.2	8.20
	4	9	.8	.8	9.0	8.99
	5	6	.5	.5	9.5	
	6	25	2.2	2.2	11.7	
	7	41	3.6	3.6	15.3	
	8	67	5.8	5.9	21.2	
	9	74	6.5	6.5	27.6	
	10	61	5.3	5.3	33.0	
	11	74	6.5	6.5	39.4	
	12	54	4.7	4.7	44.1	
	13	80	7.0	7.0	51.1	
	14	70	6.1	6.1	57.3	
	15	89	7.8	7.8	65.0	
	16	69	6.0	6.0	71.1	
	17	66	5.8	5.8	76.8	
	18	64	5.6	5.6	82.4	14.57
	19	54	4.7	4.7	87.2	19.28
	20	31	2.7	2.7	89.9	21.99
	21	38	3.3	3.3	93.2	25.31
	22	40	3.5	3.5	96.7	28.80
	23	36	3.1	3.1	99.8	31.94
	24	2	.2	.2	100.0	32.11
	Total	1144	99.8	100.0		
Missing	System	2	.2			
Total		1146	100.0			



Statistics

Hour_24HrClock

N	Valid	1144
	Missing	2
Mean		12.95
Median		13.00
Std. Deviation		5.738
Skewness		-.344
Std. Error of Skewness		.072
Kurtosis		-.387
Std. Error of Kurtosis		.145
Minimum		0
Maximum		24

Ci = calibration factor for intersection i, assume 1.0 if no knowledge.

From Srinivasan et al. (2008) for North Carolina:
3-year averages from 2007, 2008, 2009.

Piedmont Region	Intersection Type 3SG	4SG
Ci	2.86	4.10
n	10 ints	40 ints

Statewide	Intersection Type 3SG	4SG
Ci	2.47	2.79
n	31 ints	122 ints

CMF_5i = 1-0.38*p_ni

p_ni = Proportion of Crashes that Occur at Night

Table 12-27 CMF_5i

	HSM	Ral-AmbLgt	Ral-24hrClk	Ral-NgtCrashPct
3SG/4SG p_ni	0.235	26.44%	32.11%	29.37%
CMF_5i	0.9107	0.8995	0.8780	0.8884
		(conservative)	(less conservative)	

red = default value, can replace w local data

OUTPUT FROM SPSS: All crash data looked at for the frequency values of daytime/nighttime.

AmbientLight

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	809	70.6	70.6	70.6
	2	26	2.3	2.3	72.9
	3	8	.7	.7	73.6
	4	282	24.6	24.6	98.2
	5	18	1.6	1.6	99.7
	6	3	.3	.3	100.0
	Total	1146	100.0	100.0	

Values 4, 5, and 6 are for "Dark" conditions, with and without lighting.

Therefore, the sum of these percentages can approximate the percent of nighttime crashes.

CMF_6i = 1 - p_ra*(1-0.74) - p_re*(1-1.18)

0.74 = Persaud et al. CMF for right-angle collisions

1.18 = Persaud et al. CMF for rear-end collisions

p_ra = $[p_{ramv(FI)}*N_{bimv(FI)}+p_{ramv(PDO)}*N_{bimv(PDO)}]/[N_{bimv(FI)}+N_{bimv(PDO)}+N_{bisv}]$

p_re = $[p_{ramv(FI)}*N_{bimv(FI)}+p_{ramv(PDO)}*N_{bimv(PDO)}]/[N_{bimv(FI)}+N_{bimv(PDO)}+N_{bisv}]$

Nbisv = exp[a + b*ln(AADTmaj) + c*ln(AADTmin)]

Table 12-12 **Safety Performance Functions (N) with coefficients a, b, c, and overdispersion parameter k. (HSM, Table 12-12)**

Formula	$N_{bisv-3SG}$	$N_{bisv-4SG}$
a	-9.02	-10.21
b	0.42	0.68
c	0.40	0.27
k	0.36	0.36

CMF_1i Intersection Left-Turn Lanes (HSM Table 12-24)
CMF_2i Intersection Left-Turn Signal Phasing (HSM Table 12-25)
CMF_3i Intersection Right-Turn Lanes (HSM Table 12-26)
CMF_4i Right-Turn-on-Red (HSM Equation 12-35)
CMF_5i Lighting (HSM Equation 12-36, Table 12-27)
CMF_6i Red-Light Cameras (HSM Equations 12-37, 12-38, and 12-39)
Ci Calibration Factor

Meaning of CMF Values
<1 Lower crash frequency than base condition
1 Base condition of SPFs
>1 Higher crash frequency than base condition

Table 12-24 CMF_1i

		Approaches with Left-Turn Lanes				
		0	1	2	3	4
3-leg	3SG	1	0.93	0.86	0.80	
4-leg	4SG	1	0.90	0.81	0.73	0.66

Table 12-25 CMF_2i

	Type of Left-Turn Phasing		
	Perm	PP	Prot
CMF	1	0.99	0.94

careful with this one. Multiply these together if there are multiple approaches with left phasing

Table 12-26 CMF_3i

		Approaches with Right-Turn Lanes				
		0	1	2	3	4
3-leg	3SG	1	0.96	0.92		
4-leg	4SG	1	0.96	0.92	0.88	0.85

CMF_4i =0.98^n_prohib

n_prohib = number of approaches with RTOR prohibited at site i

Safety Performance Functions (N) with coefficients a, b, c, and overdispersion parameter k. (HSM, Table 12-10)

Formula	$N_{bimv\text{-}3SG}$	$N'_{bimv(FI)\text{-}3SG}$	$N'_{bimv(PDO)\text{-}3SG}$	$N_{bimv\text{-}4SG}$	$N'_{bimv(FI)\text{-}4SG}$	$N'_{bimv(PDO)\text{-}4SG}$
a	-12.13	-11.58	-13.24	-10.99	-13.14	-11.02
b	1.11	1.02	1.14	1.07	1.18	1.02
c	0.26	0.17	0.3	0.23	0.22	0.24
k	0.33	0.3	0.36	0.39	0.33	0.44

N_{bimv}= predicted number of multiple-vehicle crashes for intersection per year for base conditions;
N_{bisv} = predicted number of single-vehicle crashes for intersection per year for base conditions.

$N_{bimv\text{-}3SG}$ = exp[-12.13+1.11Ln(ADT_{maj})+0.26Ln(ADT_{min})] **(3.54)**
$N_{bimv\text{-}4SG}$ = exp[-10.99+1.07Ln(ADT_{maj})+0.23Ln(ADT_{min})] **(3.56)**

Safety performance functions for "FI" crashes are shown in Equations 3.57 through 3.60:
$N'_{bimv(FI)\text{-}3SG}$ = exp[-11.58+1.02Ln(ADT_{maj})+0.17Ln(ADT_{min})] **(3.58)**
$N'_{bimv(FI)\text{-}4SG}$ = exp[-13.14+1.18Ln(ADT_{maj})+0.22Ln(ADT_{min})] **(3.60)**

Safety performance functions for "PDO" crashes are shown in Equations 3.61 through 3.64:
$N'_{bimv(PDO)\text{-}3SG}$ = exp[-13.24+1.14Ln(ADT_{maj})+0.30Ln(ADT_{min})] **(3.62)**
$N'_{bimv(PDO)\text{-}4SG}$ = exp[-11.02+1.02Ln(ADT_{maj})+0.24Ln(ADT_{min})] **(3.64)**

where:
$N_{bimv\text{-}3SG}$, $N_{bimv\text{-}4SG}$= baseline total multi-vehicle intersection-related crashes per year for intersections of types 3SG and 4SG, respectively.
$N'_{bimv(FI)\text{-}3SG}$, $N'_{bimv(FI)\text{-}4SG}$= baseline "FI" multi-vehicle intersection-related crashes per year for intersections of types 3SG and 4SG, respectively.
$N'_{bimv(PDO)\text{-}3SG}$, $N'_{bimv(PDO)\text{-}4SG}$= baseline "PDO" multi-vehicle intersection-related crashes per year for intersections of types 3SG and 4SG, respectively.
ADT_{maj} = average daily traffic volume (veh/day) for major road (both directions of travel combined)
ADT_{min} = average daily traffic volume (veh/day) for minor road (both directions of travel combined)

p_ra = proportion of crashes that are multiple-vehicle, right-angle collisions
p_re = proportion of crashes that are multiple-vehicle, rear-end collisions
$p_{ramv(FI)}$ = proportion of crashes that are multiple-vehicle, right-angle collisions (fatalities & injuries only)
$p_{ramv(PDO)}$ = proportion of crashes that are multiple-vehicle, right-angle collisions (property damage only)
$p_{remv(FI)}$ = proportion of crashes that are multiple-vehicle, rear-end collisions (fatalities & injuries only)
$p_{remv(PDO)}$ = proportion of crashes that are multiple-vehicle, rear-end collisions (property damage only)
N_{bisv} = number of single-vehicle crashes at intersection i

CASE 2: BASE + ALL CMF; C = 1.00

pulled from sheet 2-Intersections_prepped

Step 1b Determine Crash Modification Factors (CMFs) and Calibration Factors (Ci) for each intersection for each year

					for CMF_1i	for CMF_2i		for CMF_3i	n_prohib			N_{bisv}											
vlookup column >>			5	6	296	299	300	297	301														
R_SiteType			Approaches	Legs	AppsWLeftLns	AppsWLeftProt	LeftProtPerm	AppsWRgtLns	AppsRTORprohib	Bef3Yr	Bef2Yr	Bef1Yr	Aft1Yr	Aft2Yr	Aft3Yr	RLC	CMF_1i	CMF_2i	CMF_3i	CMF_4i	CMF_5i	CMF_6i	Ci
0	IntNum	3	2	4	0	0	0	1	0	0.34	0.35	0.35	0.34	0.32	0.32	0	1.00	1.000	0.96	1.00	0.91		1
		9	4	4	0	4	0	4	0	0.96	1.00	1.02	1.03	0.97	0.89	0	1.00	0.781	0.85	1.00	0.91		1
		17	2	4	0	0	0	0	0	0.23	0.22	0.22	0.22	0.21	0.21	0	1.00	1.000	1.00	1.00	0.91		1
		18	4	4	0	0	0	2	0	0.32	0.30	0.26	0.25	0.25	0.25	0	1.00	1.000	0.92	1.00	0.91		1
		19	3	4	0	0	0	0	0	0.25	0.23	0.22	0.22	0.20	0.20	0	1.00	1.000	1.00	1.00	0.91		1
		20	4	4	0	0	0	4	0	0.23	0.23	0.23	0.22	0.22	0.22	0	1.00	1.000	0.85	1.00	0.91		1
		21	4	4	0	0	2	4	0	0.43	0.44	0.44	0.40	0.36	0.36	0	1.00	0.980	0.85	1.00	0.91		1
		22	3	4	0	0	1	2	0	1.11	1.15	1.19	1.28	1.36	1.37	0	1.00	0.990	0.92	1.00	0.91		1
		23	2	4	0	0	0	1	0	0.22	0.21	0.19	0.19	0.20	0.20	0	1.00	1.000	0.96	1.00	0.91		1
		24	4	4	0	2	0	3	0	0.28	0.29	0.28	0.27	0.27	0.27	0	1.00	0.884	0.88	1.00	0.91		1
		25	3	4	0	0	0	1	0	0.41	0.44	0.46	0.44	0.41	0.42	0	1.00	1.000	0.96	1.00	0.91		1
		26	2	4	0	0	0	0	0	0.19	0.19	0.19	0.18	0.19	0.19	0	1.00	1.000	1.00	1.00	0.91		1
		27	4	4	1	2	2	4	0	0.52	0.52	0.51	0.49	0.50	0.51	0	0.90	0.866	0.85	1.00	0.91		1
		28	4	4	0	0	2	4	0	0.36	0.37	0.37	0.37	0.38	0.39	0	1.00	0.980	0.85	1.00	0.91		1
		29	4	4	0	0	0	4	1	0.40	0.41	0.39	0.38	0.38	0.39	0	1.00	1.000	0.85	0.98	0.91		1
		122	3	4	0	0	1	2	0	1.37	1.38	1.36	1.33	1.36	1.39	0	1.00	0.990	0.92	1.00	0.91		1
1	IntNum	1	2	4	0	0	0	0	1	0.41	0.42	0.42	0.40	0.38	0.37	1	1.00	1.000	1.00	0.98	0.91		1
		2	2	4	0	0	0	1	0	0.30	0.31	0.32	0.32	0.32	0.32	1	1.00	1.000	0.96	1.00	0.91		1
		4	4	4	0	0	1	3	1	0.52	0.52	0.52	0.49	0.56	0.62	1	1.00	0.990	0.88	0.98	0.91		1
		5	4	4	1	4	0	4	0	0.44	0.43	0.42	0.40	0.40	0.40	1	0.90	0.781	0.85	1.00	0.91		1
		6	4	4	0	2	0	4	0	0.28	0.30	0.33	0.31	0.30	0.30	1	1.00	0.884	0.85	1.00	0.91		1
		7	3	3	0	1	0	2	0	0.53	0.54	0.54	0.54	0.54	0.54	1	1.00	0.940	0.92	1.00	0.91		1
		8	4	4	0	4	0	4	0	0.82	0.87	0.82	0.77	0.77	0.76	1	1.00	0.781	0.85	1.00	0.91		1
		10	4	4	0	2	2	3	0	0.30	0.31	0.33	0.32	0.31	0.31	1	1.00	0.866	0.88	1.00	0.91		1
		11	4	4	0	1	0	3	1	0.36	0.36	0.35	0.34	0.33	0.33	1	1.00	0.940	0.88	0.98	0.91		1
		12	4	4	1	2	0	4	0	0.59	0.57	0.58	0.63	0.64	0.66	1	0.90	0.884	0.85	1.00	0.91		1
		13	4	4	0	2	0	4	0	0.37	0.38	0.40	0.38	0.37	0.38	1	1.00	0.884	0.85	1.00	0.91		1
		14	3	4	0	1	0	1	0	0.26	0.25	0.24	0.24	0.24	0.25	1	1.00	0.940	0.96	1.00	0.91		1
		15	2	3	0	1	0	0	0	1.05	1.03	1.02	1.01	1.01	1.01	1	1.00	0.940	1.00	1.00	0.91		1
		16	2	3	0	1	0	1	0	1.12	1.07	1.06	1.05	1.04	1.02	1	1.00	0.940	0.96	1.00	0.91		1
		103	2	4	0	0	0	1	0	0.32	0.32	0.32	0.31	0.32	0.32	1	1.00	1.000	0.96	1.00	0.91		1
		109	4	4	0	4	0	4	0	0.97	0.89	0.93	0.94	0.90	0.87	1	1.00	0.781	0.85	1.00	0.91		1

EB ESTIMATION IN BEFORE PERIOD

CASE 2: BASE + ALL CMF; C = 1.00

STEP 1 CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR BEFORE TREATMENT

Step 1a Calculate Safety Performance Functions for each intersection for each year

R_SiteType			FormulaApplied	Bef3Yr $N_{bimv-nSG}$	Bef3Yr $N'_{bimv(FI)-nSG}$	Bef3Yr $N'_{bimv(PDO)-nSG}$	Bef3Yr $N_{bimv(FI)-nSG}$	Bef3Yr $N_{bimv(PDO)-nSG}$	Bef2Yr $N_{bimv-nSG}$	Bef2Yr $N'_{bimv(FI)-nSG}$	Bef2Yr $N'_{bimv(PDO)-nSG}$	Bef2Yr $N_{bimv(FI)-nSG}$	Bef2Yr $N_{bimv(PDO)-nSG}$	Bef1Yr $N_{bimv-nSG}$	Bef1Yr $N'_{bimv(FI)-nSG}$	Bef1Yr $N'_{bimv(PDO)-nSG}$	Bef1Yr $N_{bimv(FI)-nSG}$	Bef1Yr $N_{bimv(PDO)-nSG}$
0	IntNum	3	4SG	5.17	1.64	3.34	1.70	3.47	5.29	1.67	3.42	1.74	3.55	5.39	1.71	3.49	1.77	3.62
		9	4SG	22.49	8.05	13.81	8.28	14.21	24.11	8.69	14.76	8.94	15.17	24.80	8.97	15.16	9.22	15.58
		17	4SG	2.62	0.76	1.76	0.79	1.82	2.54	0.74	1.71	0.77	1.77	2.47	0.72	1.66	0.75	1.72
		18	4SG	5.46	1.78	3.48	1.85	3.62	4.86	1.56	3.11	1.62	3.23	4.09	1.30	2.63	1.35	2.74
		19	4SG	2.95	0.87	1.97	0.91	2.05	2.68	0.78	1.80	0.81	1.87	2.40	0.70	1.62	0.72	1.68
		20	4SG	2.93	0.88	1.94	0.91	2.02	2.86	0.85	1.90	0.88	1.97	2.78	0.83	1.85	0.86	1.92
		21	4SG	7.13	2.31	4.57	2.39	4.74	7.28	2.36	4.66	2.45	4.83	7.43	2.42	4.76	2.50	4.93
		22	4SG	25.28	8.97	15.64	9.21	16.07	26.64	9.50	16.45	9.75	16.89	28.02	10.04	17.27	10.30	17.72
		23	4SG	2.57	0.75	1.73	0.78	1.79	2.29	0.66	1.55	0.69	1.60	2.01	0.57	1.37	0.60	1.42
		24	4SG	3.92	1.21	2.56	1.25	2.66	4.06	1.26	2.65	1.30	2.76	3.88	1.20	2.54	1.24	2.63
		25	4SG	6.08	1.91	3.95	1.98	4.10	6.73	2.14	4.36	2.22	4.51	7.40	2.38	4.77	2.46	4.94
		26	4SG	1.96	0.56	1.34	0.58	1.39	1.97	0.56	1.35	0.58	1.39	1.90	0.54	1.30	0.56	1.35
		27	4SG	8.36	2.69	5.40	2.78	5.58	8.36	2.69	5.40	2.78	5.58	8.08	2.59	5.22	2.68	5.40
		28	4SG	5.31	1.67	3.45	1.73	3.58	5.61	1.77	3.64	1.84	3.78	5.61	1.77	3.64	1.84	3.78
		29	4SG	7.22	2.39	4.57	2.48	4.74	7.45	2.48	4.71	2.57	4.88	7.01	2.32	4.43	2.40	4.60
		122	4SG	35.42	13.04	21.55	13.36	22.07	35.85	13.22	21.80	13.53	22.32	35.14	12.94	21.37	13.26	21.88
1	IntNum	1	4SG	7.13	2.34	4.54	2.42	4.71	7.14	2.33	4.56	2.42	4.72	7.14	2.32	4.56	2.41	4.73
		2	4SG	4.79	1.53	3.07	1.60	3.19	4.95	1.59	3.17	1.65	3.30	5.12	1.65	3.28	1.71	3.41
		4	4SG	10.69	3.69	6.63	3.82	6.87	10.99	3.81	6.80	3.95	7.04	11.26	3.93	6.95	4.07	7.19
		5	4SG	9.16	3.17	5.66	3.29	5.87	9.26	3.22	5.70	3.34	5.91	8.92	3.11	5.49	3.22	5.70
		6	4SG	4.48	1.44	2.87	1.50	2.98	5.00	1.62	3.19	1.68	3.32	5.53	1.80	3.52	1.87	3.66
		7	3SG	13.51	3.74	9.00	3.96	9.54	14.19	3.91	9.47	4.15	10.04	14.87	4.08	9.94	4.33	10.54
		8	4SG	16.35	5.60	10.27	5.77	10.58	17.48	5.99	10.99	6.16	11.32	16.26	5.55	10.23	5.71	10.54
		10	4SG	4.67	1.49	3.00	1.54	3.12	5.05	1.62	3.23	1.68	3.36	5.43	1.75	3.47	1.82	3.60
		11	4SG	6.28	2.06	3.99	2.13	4.14	6.12	2.00	3.89	2.08	4.04	5.96	1.94	3.79	2.02	3.94
		12	4SG	13.74	4.90	8.40	5.06	8.68	13.00	4.61	7.96	4.77	8.23	13.57	4.84	8.28	5.00	8.57
		13	4SG	5.55	1.75	3.60	1.82	3.73	5.88	1.87	3.80	1.94	3.94	6.22	1.98	4.01	2.06	4.16
		14	4SG	3.25	0.97	2.16	1.01	2.24	3.08	0.91	2.05	0.95	2.13	2.90	0.86	1.94	0.89	2.01
		15	3SG	27.54	6.53	19.59	6.89	20.65	25.91	6.16	18.43	6.50	19.42	25.50	6.08	18.12	6.41	19.09
		16	3SG	28.77	6.72	20.61	7.08	21.69	26.49	6.25	18.90	6.59	19.91	26.08	6.17	18.59	6.50	19.58
		103	4SG	4.80	1.51	3.11	1.57	3.23	4.76	1.50	3.08	1.56	3.20	4.75	1.50	3.07	1.56	3.19
		109	4SG	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90	21.54	7.69	13.25	7.91	13.63

Aft1Yr					Aft2Yr					Aft3Yr				
$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$
5.12	1.62	3.32	1.68	3.44	4.85	1.53	3.14	1.59	3.26	4.80	1.51	3.11	1.57	3.23
25.50	9.25	15.57	9.51	15.99	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90
2.42	0.70	1.63	0.73	1.69	2.37	0.69	1.60	0.71	1.66	2.36	0.68	1.59	0.71	1.65
3.90	1.24	2.50	1.29	2.61	3.90	1.24	2.50	1.29	2.61	4.01	1.28	2.57	1.33	2.68
2.40	0.69	1.62	0.72	1.68	2.23	0.65	1.50	0.67	1.56	2.19	0.64	1.47	0.66	1.53
2.71	0.80	1.81	0.83	1.88	2.64	0.78	1.76	0.81	1.83	2.64	0.78	1.76	0.81	1.83
6.34	2.03	4.09	2.10	4.24	5.28	1.66	3.43	1.72	3.56	5.29	1.66	3.44	1.72	3.57
31.55	11.46	19.31	11.75	19.80	35.00	12.87	21.30	13.18	21.82	35.42	13.04	21.55	13.36	22.07
2.06	0.59	1.39	0.61	1.45	2.10	0.60	1.42	0.62	1.47	2.12	0.61	1.44	0.63	1.49
3.70	1.14	2.42	1.18	2.52	3.72	1.14	2.44	1.19	2.53	3.75	1.15	2.46	1.20	2.55
6.76	2.15	4.38	2.22	4.53	6.11	1.92	3.98	1.99	4.12	6.29	1.98	4.09	2.05	4.23
1.83	0.52	1.25	0.53	1.30	1.91	0.54	1.30	0.56	1.35	1.98	0.56	1.35	0.58	1.40
7.81	2.50	5.05	2.59	5.22	7.95	2.55	5.15	2.63	5.32	8.09	2.59	5.24	2.68	5.42
5.61	1.77	3.64	1.84	3.78	5.64	1.77	3.67	1.84	3.80	5.64	1.77	3.68	1.83	3.81
6.57	2.16	4.17	2.24	4.33	6.80	2.24	4.30	2.33	4.47	7.02	2.33	4.44	2.42	4.61
34.43	12.67	20.94	12.98	21.45	35.35	13.03	21.49	13.34	22.01	36.28	13.39	22.04	13.71	22.57
6.68	2.17	4.27	2.25	4.43	6.22	2.01	3.98	2.09	4.13	6.03	1.95	3.86	2.02	4.01
5.10	1.63	3.27	1.70	3.40	5.07	1.62	3.26	1.68	3.38	5.05	1.62	3.25	1.68	3.37
10.46	3.64	6.46	3.77	6.69	11.42	3.93	7.11	4.06	7.36	12.44	4.26	7.78	4.41	8.04
8.57	2.99	5.27	3.10	5.47	8.43	2.92	5.20	3.03	5.40	8.26	2.85	5.11	2.96	5.30
5.19	1.68	3.31	1.75	3.44	4.85	1.56	3.10	1.63	3.22	4.83	1.55	3.09	1.61	3.21
14.87	4.08	9.94	4.33	10.54	14.87	4.08	9.94	4.33	10.54	14.42	3.97	9.63	4.21	10.21
15.04	5.11	9.48	5.27	9.77	14.85	5.04	9.36	5.19	9.65	14.65	4.97	9.25	5.12	9.53
5.05	1.62	3.24	1.69	3.37	4.84	1.54	3.12	1.60	3.24	4.71	1.49	3.04	1.55	3.16
5.76	1.88	3.67	1.95	3.81	5.56	1.81	3.54	1.88	3.68	5.57	1.81	3.55	1.88	3.69
14.77	5.28	9.01	5.46	9.31	14.97	5.34	9.16	5.51	9.46	15.11	5.37	9.26	5.55	9.57
5.91	1.88	3.83	1.95	3.97	5.61	1.77	3.64	1.84	3.78	5.91	1.88	3.83	1.95	3.97
2.92	0.86	1.95	0.90	2.02	2.93	0.87	1.95	0.90	2.03	2.94	0.87	1.97	0.90	2.04
25.09	5.99	17.81	6.32	18.77	25.44	6.08	18.06	6.41	19.03	25.78	6.17	18.29	6.50	19.28
25.66	6.08	18.28	6.41	19.26	25.82	6.14	18.36	6.47	19.35	25.94	6.19	18.42	6.53	19.42
4.74	1.50	3.07	1.55	3.19	4.76	1.50	3.08	1.56	3.20	4.78	1.51	3.09	1.57	3.21
22.40	8.05	13.73	8.28	14.12	21.08	7.55	12.93	7.77	13.31	20.21	7.20	12.42	7.42	12.79

CASE 2: BASE + ALL CMF; C = 1.00

STEP 2 CALCULATE EXPECTED CRASH FREQUENCY BY SITE FOR ENTIRE BEFORE PERIOD

$N_{expected,B} = w_{i,B} * N_{predicted,B,i} + (1 - w_{i,B}) * N_{observed,B}$

$w_{i,B} = 1 / [1 + k * sum(N_{predicted,B,i})$ over all years

$N_{pred,bi} = N_{bimv} * (CMF_{1i} * \ldots * CMF_{6i}) * C_i$

Note: if CMF or C unknown, assume 1.00.

R_SiteType			Formula Applied	BefAllYrs $N_{bimv-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$	BefAllYrs $N_{pred,bi}$	$N_{pred,bi(FI)}$	$N_{pred,bi(PDO)}$	BefAllYrs $w_{i,B}$	$N_{expected,B}$
0	IntNum	3	4SG	15.85	5.21	10.64	13.86	4.55	9.30	0.14	15.70
		9	4SG	71.40	26.44	44.96	43.15	15.98	27.17	0.03	15.01
		17	4SG	7.63	2.31	5.32	6.95	2.10	4.85	0.25	22.71
		18	4SG	14.41	4.83	9.59	12.08	4.04	8.03	0.15	23.05
		19	4SG	8.03	2.44	5.59	7.32	2.22	5.09	0.24	16.17
		20	4SG	8.57	2.65	5.91	6.63	2.05	4.58	0.23	6.92
		21	4SG	21.84	7.34	14.50	16.57	5.57	11.00	0.11	12.48
		22	4SG	79.95	29.27	50.68	66.31	24.28	42.04	0.03	10.78
		23	4SG	6.88	2.06	4.81	6.01	1.80	4.21	0.27	10.37
		24	4SG	11.85	3.80	8.05	8.39	2.69	5.70	0.18	12.18
		25	4SG	20.21	6.66	13.55	17.67	5.82	11.85	0.11	17.07
		26	4SG	5.84	1.71	4.13	5.32	1.56	3.76	0.31	7.18
		27	4SG	24.80	8.24	16.56	14.96	4.97	9.99	0.09	13.18
		28	4SG	16.54	5.41	11.13	12.55	4.10	8.45	0.13	12.94
		29	4SG	21.68	7.45	14.22	16.45	5.66	10.79	0.11	17.84
		122	4SG	106.41	40.14	66.27	88.27	33.30	54.97	0.02	15.75
1	IntNum	1	4SG	21.41	7.25	14.16	19.11	6.47	12.64	0.11	26.16
		2	4SG	14.86	4.96	9.90	12.99	4.34	8.66	0.15	24.09
		4	4SG	32.94	11.84	21.11	25.61	9.20	16.41	0.07	12.98
		5	4SG	27.34	9.86	17.48	14.87	5.36	9.51	0.09	7.67
		6	4SG	15.01	5.05	9.96	10.27	3.45	6.81	0.15	7.48
		7	3SG	42.57	12.44	30.13	33.53	9.80	23.73	0.07	19.97
		8	4SG	50.09	17.64	32.45	30.27	10.66	19.61	0.05	18.60
		10	4SG	15.14	5.05	10.09	10.51	3.51	7.00	0.14	9.22
		11	4SG	18.36	6.23	12.13	13.55	4.60	8.95	0.12	7.80
		12	4SG	40.31	14.83	25.48	24.81	9.13	15.68	0.06	12.77
		13	4SG	17.64	5.81	11.83	12.07	3.97	8.09	0.13	21.61
		14	4SG	9.23	2.85	6.38	7.59	2.34	5.25	0.22	7.91
		15	3SG	78.95	19.79	59.16	67.58	16.94	50.64	0.04	11.17
		16	3SG	81.34	20.16	61.18	66.85	16.57	50.28	0.04	14.93
		103	4SG	14.32	4.69	9.62	12.52	4.10	8.41	0.15	23.10
		109	4SG	64.75	23.78	40.97	39.13	14.37	24.76	0.04	14.00

EB ESTIMATION IN AFTER PERIOD

CASE 2: BASE + ALL CMF; C = 1.00

STEP 3 CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR AFTER TREATMENT

R_SiteType			Formula Applied	AftAllYrs $N_{aimv-nSG}$	$N_{aimv(FI)-nSG}$	$N_{aimv(PDO)-nSG}$	AftAllYrs $N_{pred,ai}$	$N_{pred,ai(FI)}$	$N_{pred,ai(PDO)}$
0	IntNum	3	4SG	14.77	4.84	9.93	12.91	4.23	8.68
		9	4SG	68.70	25.37	43.33	41.52	15.33	26.19
		17	4SG	7.15	2.15	5.00	6.52	1.96	4.55
		18	4SG	11.81	3.92	7.89	9.90	3.29	6.61
		19	4SG	6.82	2.05	4.77	6.21	1.87	4.34
		20	4SG	7.98	2.45	5.53	6.18	1.90	4.28
		21	4SG	16.92	5.55	11.37	12.83	4.21	8.62
		22	4SG	101.97	38.28	63.69	84.58	31.76	52.82
		23	4SG	6.28	1.86	4.41	5.49	1.63	3.86
		24	4SG	11.17	3.57	7.60	7.91	2.53	5.38
		25	4SG	19.15	6.27	12.89	16.75	5.48	11.27
		26	4SG	5.72	1.68	4.05	5.21	1.53	3.69
		27	4SG	23.86	7.90	15.96	14.39	4.76	9.63
		28	4SG	16.90	5.51	11.39	12.82	4.18	8.64
		29	4SG	20.39	6.99	13.40	15.46	5.30	10.16
		122	4SG	106.06	40.03	66.03	87.97	33.20	54.77
1	IntNum	1	4SG	18.93	6.36	12.57	16.90	5.68	11.22
		2	4SG	15.22	5.06	10.16	13.30	4.42	8.88
		4	4SG	34.32	12.24	22.08	26.69	9.51	17.17
		5	4SG	25.27	9.09	16.18	13.74	4.94	8.80
		6	4SG	14.86	4.99	9.87	10.16	3.41	6.75
		7	3SG	44.17	12.87	31.29	34.78	10.14	24.65
		8	4SG	44.54	15.58	28.95	26.92	9.42	17.50
		10	4SG	14.60	4.83	9.76	10.13	3.35	6.78
		11	4SG	16.89	5.71	11.18	12.47	4.22	8.25
		12	4SG	44.85	16.51	28.34	27.61	10.17	17.44
		13	4SG	17.44	5.73	11.71	11.93	3.92	8.01
		14	4SG	8.78	2.70	6.09	7.22	2.22	5.00
		15	3SG	76.31	19.23	57.09	65.33	16.46	48.87
		16	3SG	77.42	19.40	58.02	63.63	15.94	47.68
		103	4SG	14.28	4.68	9.60	12.48	4.09	8.39
		109	4SG	63.69	23.47	40.22	38.49	14.18	24.31

ESTIMATION OF TREATED EFFECTIVENESS

CASE 2: BASE + ALL CMF; C = 1.00

STEP 4 CALCULATE AN ADJUSTMENT FACTOR (ri) FOR DIFFERENCES BETWEEN BEFORE & AFTER PERIODS

STEP 5 CALCULATE EXPECTED CRASH FREQUENCY BY SITE FOR ENTIRE AFTER PERIOD IN ABSENCE OF TREATMENT

CASE 2: BASE + ALL CMF; C = 1.00

STEP 6 ESTIMATE SAFETY EFFECTIVENESS AT EACH SITE VIA ODDS RATIO (omega)

STEP 7 ESTIMATE SAFETY EFFECTIVENESS AT EACH SITE AS A PERCENTAGE CRASH CHANGE

ri	$N_{expected,A}$	omega_i	SafeEff_i
0.932	14.63	1.298	-29.84
0.962	14.44	1.108	-10.77
0.938	21.29	1.127	-12.74
0.820	18.89	1.006	-0.58
0.849	13.73	1.675	-67.53
0.932	6.44	1.242	-24.18
0.775	9.67	1.345	-34.48
1.275	13.75	0.509	49.09
0.913	9.47	1.373	-37.29
0.942	11.48	0.610	39.01
0.948	16.19	0.741	25.87
0.980	7.04	3.693	-269.32
0.962	12.68	0.867	13.26
1.022	13.22	1.059	-5.90
0.940	16.77	0.596	40.38
0.997	15.69	0.573	42.65
0.884	23.13	0.130	87.03
1.024	24.66	1.054	-5.43
1.042	13.53	0.370	63.04
0.924	7.09	0.282	71.80
0.990	7.40	0.811	18.94
1.038	20.71	1.110	-11.03
0.889	16.54	0.423	57.67
0.964	8.89	0.338	66.24
0.920	7.18	0.139	86.07
1.113	14.21	0.352	64.80
0.989	21.37	0.328	67.24
0.952	7.53	1.328	-32.83
0.967	10.79	0.371	62.94
0.952	14.21	0.211	78.90
0.998	23.05	0.607	39.26
0.984	13.77	0.581	41.89

ri = sum($N_{predicted,A,i}$)over after years / sum($N_{predicted,B,i}$)over before years

$N_{expected,A}$ = ri*$N_{expected,B}$

omega_i = $N_{observed,A}$/$N_{expected,A}$

SafeEff_i = 100*(1-omega_i)

CASE 2: BASE + ALL CMF; C = 1.00

STEP 8 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT (ODDS RATIO omega') FOR ALL SITES COMBINED

R_SiteType	omega'
0 All Ints	1.07
1 All Ints	0.54

omega' = sum($N_{observed,A}$)all sites / sum($N_{expected,A}$)all sites

STEP 9 ADJUST ODDS RATIO TO OBTAIN UNBIASED ESTIMATE OF TREATMENT EFFECTIVENESS

R_SiteType	Var(Nexpected,A,all)	omega
0 All Ints	176.11	1.07
1 All Ints	206.83	0.54

Var(Nexpected,A,all) = sum[(ri^2)*$N_{expected,B}$ * (1-$w_{i,B}$)] over all sites

omega = omega' / {1+[var($N_{expected,A,all}$)] / [$N_{expected,A,all}$]^2}

STEP 10 CALCULATE OVERALL UNBIASED SAFETY EFFECTIVENESS AS A PERCENT CHANGE IN CRASH FREQUENCY ACROSS ALL SITES

R_SiteType	Safety Effectiveness
0 All Ints	-6.84
1 All Ints	45.94

Safety Effectiveness = 100*(1 - omega)

ESTIMATION OF PRECISION OF TREATED EFFECTIVENESS

STEP 11 CALCULATE VARIANCE OF UNBIASED ESTIMATED SAFETY EFFECTIVENESS AS AN ODDS RATIO

R_SiteType	$N_{observed,A,all\ sites}$	$N_{expected,A,all\ sites}$	var(omega)
0 All Ints	231	215.39	0.00931
1 All Ints	127	234.05	0.00342

var(omega) = {omega'^2 *
[(1/$N_{observed,A}$) + (var{sum[$N_{expected,A}$]over all sites}/(sum[$N_{expected,A}$]over all sites)^2)] /
[1 + (var{sum[$N_{expected,A}$] over all sites} / (sum[$N_{expected,A}$]over all sites)^2)]

STEP 12 CALCULATE STANDARD ERROR OF THE STEP 11 ODDS RATIO

R_SiteType	SE(omega)
0 All Ints	0.10
1 All Ints	0.06

SE(omega) = sqrt[var(omega)]

STEP 13 CALCULATE STANDARD ERROR OF THE STEP 10 UNBIASED SAFETY EFFECTIVENESS

R_SiteType	SE(Safety Effectiveness)
0 All Ints	9.65
1 All Ints	5.85

SE(Safety Effectiveness) =100 * SE(omega)

STEP 14 ASSESS STATISTICAL SIGNIFICANCE OF ESTIMATED SAFETY EFFECTIVENESS

R_SiteType	Performance Measure
0 All Ints	0.71
1 All Ints	7.86

Performance Measure = ABS[Safety Effectiveness / SE(Safety Effectiveness)]

PM < 1.7 Treatment Effect NOT significant at the (approx.) 90% confidence interval
PM >= 1.7 Treatment Effect IS significant at the (approx.) 90% confidence interval
PM >= 2.0 Treatment Effect IS significant at the (approx.) 95% confidence interval

CASE 3: BASE + ALL CMF + Ci_forNC

pulled from sheet 2-Intersections_prepped

Step 1b Determine Crash Modification Factors (CMFs) and Calibration Factors (Ci) for each intersection for each year

vlookup column >>			5	6	296	299	300	297	301														
					for CMF_1i	for CMF_2i		for CMF_3i	n_prohib	N_{bisv}													
R_SiteType			Approaches	Legs	AppsWLeftLns	AppsWLeftProt	LeftProtPerm	AppsWRgtLns	AppsRTORprohib	Bef3Yr	Bef2Yr	Bef1Yr	Aft1Yr	Aft2Yr	Aft3Yr	RLC	CMF_1i	CMF_2i	CMF_3i	CMF_4i	CMF_5i	CMF_6i	Ci
0	IntNum	3	2	4	0	0	0	1	0	0.34	0.35	0.35	0.34	0.32	0.32	0	1.00	1.000	0.96	1.00	0.91		2.79
		9	4	4	0	4	0	4	0	0.96	1.00	1.02	1.03	0.97	0.89	0	1.00	0.781	0.85	1.00	0.91		2.79
		17	2	4	0	0	0	0	0	0.23	0.22	0.22	0.22	0.21	0.21	0	1.00	1.000	1.00	1.00	0.91		2.79
		18	4	4	0	0	0	2	0	0.32	0.30	0.26	0.25	0.25	0.25	0	1.00	1.000	0.92	1.00	0.91		2.79
		19	3	4	0	0	0	0	0	0.25	0.23	0.22	0.22	0.20	0.20	0	1.00	1.000	1.00	1.00	0.91		2.79
		20	4	4	0	0	0	4	0	0.23	0.23	0.23	0.22	0.22	0.22	0	1.00	1.000	0.85	1.00	0.91		2.79
		21	4	4	0	0	2	4	0	0.43	0.44	0.44	0.40	0.36	0.36	0	1.00	0.980	0.85	1.00	0.91		2.79
		22	3	4	0	0	1	2	0	1.11	1.15	1.19	1.28	1.36	1.37	0	1.00	0.990	0.92	1.00	0.91		2.79
		23	2	4	0	0	0	1	0	0.22	0.21	0.19	0.19	0.20	0.20	0	1.00	1.000	0.96	1.00	0.91		2.79
		24	4	4	0	2	0	3	0	0.28	0.29	0.28	0.27	0.27	0.27	0	1.00	0.884	0.88	1.00	0.91		2.79
		25	3	4	0	0	0	1	0	0.41	0.44	0.46	0.44	0.41	0.42	0	1.00	1.000	0.96	1.00	0.91		2.79
		26	2	4	0	0	0	0	0	0.19	0.19	0.19	0.18	0.19	0.19	0	1.00	1.000	1.00	1.00	0.91		2.79
		27	4	4	1	2	2	4	0	0.52	0.52	0.51	0.49	0.50	0.51	0	0.90	0.866	0.85	1.00	0.91		2.79
		28	4	4	0	0	2	4	0	0.36	0.37	0.37	0.37	0.38	0.39	0	1.00	0.980	0.85	1.00	0.91		2.79
		29	4	4	0	0	0	4	1	0.40	0.41	0.39	0.38	0.38	0.39	0	1.00	1.000	0.85	0.98	0.91		2.79
		122	3	4	0	0	1	2	0	1.37	1.38	1.36	1.33	1.36	1.39	0	1.00	0.990	0.92	1.00	0.91		2.79
1	IntNum	1	2	4	0	0	0	0	1	0.41	0.42	0.42	0.40	0.38	0.37	1	1.00	1.000	1.00	0.98	0.91		2.79
		2	2	4	0	0	0	1	0	0.30	0.31	0.32	0.32	0.32	0.32	1	1.00	1.000	0.96	1.00	0.91		2.79
		4	4	4	0	0	1	3	1	0.52	0.52	0.52	0.49	0.56	0.62	1	1.00	0.990	0.88	0.98	0.91		2.79
		5	4	4	1	4	0	4	0	0.44	0.43	0.42	0.40	0.40	0.40	1	0.90	0.781	0.85	1.00	0.91		2.79
		6	4	4	0	2	0	4	0	0.28	0.30	0.33	0.31	0.30	0.30	1	1.00	0.884	0.85	1.00	0.91		2.79
		7	3	3	0	1	0	2	0	0.53	0.54	0.54	0.54	0.54	0.54	1	1.00	0.940	0.92	1.00	0.91		2.47
		8	4	4	0	4	0	4	0	0.82	0.87	0.82	0.77	0.77	0.76	1	1.00	0.781	0.85	1.00	0.91		2.79
		10	4	4	0	2	2	3	0	0.30	0.31	0.33	0.32	0.31	0.31	1	1.00	0.866	0.88	1.00	0.91		2.79
		11	4	4	0	1	0	3	1	0.36	0.36	0.35	0.34	0.33	0.33	1	1.00	0.940	0.88	0.98	0.91		2.79
		12	4	4	1	2	0	4	0	0.59	0.57	0.58	0.63	0.64	0.66	1	0.90	0.884	0.85	1.00	0.91		2.79
		13	4	4	0	2	0	4	0	0.37	0.38	0.40	0.38	0.37	0.38	1	1.00	0.884	0.85	1.00	0.91		2.79
		14	3	4	0	1	0	1	0	0.26	0.25	0.24	0.24	0.24	0.25	1	1.00	0.940	0.96	1.00	0.91		2.79
		15	2	3	0	1	0	0	0	1.05	1.03	1.02	1.01	1.01	1.01	1	1.00	0.940	1.00	1.00	0.91		2.47
		16	2	3	0	1	0	1	0	1.12	1.07	1.06	1.05	1.04	1.02	1	1.00	0.940	0.96	1.00	0.91		2.47
		103	2	4	0	0	0	1	0	0.32	0.32	0.32	0.31	0.32	0.32	1	1.00	1.000	0.96	1.00	0.91		2.79
		109	4	4	0	4	0	4	0	0.97	0.89	0.93	0.94	0.90	0.87	1	1.00	0.781	0.85	1.00	0.91		2.79

EB ESTIMATION IN BEFORE PERIOD

CASE 3: BASE + ALL CMF + Ci_forNC

STEP 1 CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR BEFORE TREATMENT

Step 1a Calculate Safety Performance Functions for each intersection for each year

R_SiteType			FormulaApplied	Bef3Yr $N_{bimv-nSG}$	Bef3Yr $N'_{bimv(FI)-nSG}$	Bef3Yr $N'_{bimv(PDO)-nSG}$	Bef3Yr $N_{bimv(FI)-nSG}$	Bef3Yr $N_{bimv(PDO)-nSG}$	Bef2Yr $N_{bimv-nSG}$	Bef2Yr $N'_{bimv(FI)-nSG}$	Bef2Yr $N'_{bimv(PDO)-nSG}$	Bef2Yr $N_{bimv(FI)-nSG}$	Bef2Yr $N_{bimv(PDO)-nSG}$	Bef1Yr $N_{bimv-nSG}$	Bef1Yr $N'_{bimv(FI)-nSG}$	Bef1Yr $N'_{bimv(PDO)-nSG}$	Bef1Yr $N_{bimv(FI)-nSG}$	Bef1Yr $N_{bimv(PDO)-nSG}$
0	IntNum	3	4SG	5.17	1.64	3.34	1.70	3.47	5.29	1.67	3.42	1.74	3.55	5.39	1.71	3.49	1.77	3.62
		9	4SG	22.49	8.05	13.81	8.28	14.21	24.11	8.69	14.76	8.94	15.17	24.80	8.97	15.16	9.22	15.58
		17	4SG	2.62	0.76	1.76	0.79	1.82	2.54	0.74	1.71	0.77	1.77	2.47	0.72	1.66	0.75	1.72
		18	4SG	5.46	1.78	3.48	1.85	3.62	4.86	1.56	3.11	1.62	3.23	4.09	1.30	2.63	1.35	2.74
		19	4SG	2.95	0.87	1.97	0.91	2.05	2.68	0.78	1.80	0.81	1.87	2.40	0.70	1.62	0.72	1.68
		20	4SG	2.93	0.88	1.94	0.91	2.02	2.86	0.85	1.90	0.88	1.97	2.78	0.83	1.85	0.86	1.92
		21	4SG	7.13	2.31	4.57	2.39	4.74	7.28	2.36	4.66	2.45	4.83	7.43	2.42	4.76	2.50	4.93
		22	4SG	25.28	8.97	15.64	9.21	16.07	26.64	9.50	16.45	9.75	16.89	28.02	10.04	17.27	10.30	17.72
		23	4SG	2.57	0.75	1.73	0.78	1.79	2.29	0.66	1.55	0.69	1.60	2.01	0.57	1.37	0.60	1.42
		24	4SG	3.92	1.21	2.56	1.25	2.66	4.06	1.26	2.65	1.30	2.76	3.88	1.20	2.54	1.24	2.63
		25	4SG	6.08	1.91	3.95	1.98	4.10	6.73	2.14	4.36	2.22	4.51	7.40	2.38	4.77	2.46	4.94
		26	4SG	1.96	0.56	1.34	0.58	1.39	1.97	0.56	1.35	0.58	1.39	1.90	0.54	1.30	0.56	1.35
		27	4SG	8.36	2.69	5.40	2.78	5.58	8.36	2.69	5.40	2.78	5.58	8.08	2.59	5.22	2.68	5.40
		28	4SG	5.31	1.67	3.45	1.73	3.58	5.61	1.77	3.64	1.84	3.78	5.61	1.77	3.64	1.84	3.78
		29	4SG	7.22	2.39	4.57	2.48	4.74	7.45	2.48	4.71	2.57	4.88	7.01	2.32	4.43	2.40	4.60
		122	4SG	35.42	13.04	21.55	13.36	22.07	35.85	13.22	21.80	13.53	22.32	35.14	12.94	21.37	13.26	21.88
1	IntNum	1	4SG	7.13	2.34	4.54	2.42	4.71	7.14	2.33	4.56	2.42	4.72	7.14	2.32	4.56	2.41	4.73
		2	4SG	4.79	1.53	3.07	1.60	3.19	4.95	1.59	3.17	1.65	3.30	5.12	1.65	3.28	1.71	3.41
		4	4SG	10.69	3.69	6.63	3.82	6.87	10.99	3.81	6.80	3.95	7.04	11.26	3.93	6.95	4.07	7.19
		5	4SG	9.16	3.17	5.66	3.29	5.87	9.26	3.22	5.70	3.34	5.91	8.92	3.11	5.49	3.22	5.70
		6	4SG	4.48	1.44	2.87	1.50	2.98	5.00	1.62	3.19	1.68	3.32	5.53	1.80	3.52	1.87	3.66
		7	3SG	13.51	3.74	9.00	3.96	9.54	14.19	3.91	9.47	4.15	10.04	14.87	4.08	9.94	4.33	10.54
		8	4SG	16.35	5.60	10.27	5.77	10.58	17.48	5.99	10.99	6.16	11.32	16.26	5.55	10.23	5.71	10.54
		10	4SG	4.67	1.49	3.00	1.54	3.12	5.05	1.62	3.23	1.68	3.36	5.43	1.75	3.47	1.82	3.60
		11	4SG	6.28	2.06	3.99	2.13	4.14	6.12	2.00	3.89	2.08	4.04	5.96	1.94	3.79	2.02	3.94
		12	4SG	13.74	4.90	8.40	5.06	8.68	13.00	4.61	7.96	4.77	8.23	13.57	4.84	8.28	5.00	8.57
		13	4SG	5.55	1.75	3.60	1.82	3.73	5.88	1.87	3.80	1.94	3.94	6.22	1.98	4.01	2.06	4.16
		14	4SG	3.25	0.97	2.16	1.01	2.24	3.08	0.91	2.05	0.95	2.13	2.90	0.86	1.94	0.89	2.01
		15	3SG	27.54	6.53	19.59	6.89	20.65	25.91	6.16	18.43	6.50	19.42	25.50	6.08	18.12	6.41	19.09
		16	3SG	28.77	6.72	20.61	7.08	21.69	26.49	6.25	18.90	6.59	19.91	26.08	6.17	18.59	6.50	19.58
		103	4SG	4.80	1.51	3.11	1.57	3.23	4.76	1.50	3.08	1.56	3.20	4.75	1.50	3.07	1.56	3.19
		109	4SG	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90	21.54	7.69	13.25	7.91	13.63

Aft1Yr					Aft2Yr					Aft3Yr				
$N_{aimv-nSG}$	$N'_{aimv(FI)-nSG}$	$N'_{aimv(PDO)-nSG}$	$N_{aimv(FI)-nSG}$	$N_{aimv(PDO)-nSG}$	$N_{aimv-nSG}$	$N'_{aimv(FI)-nSG}$	$N'_{aimv(PDO)-nSG}$	$N_{aimv(FI)-nSG}$	$N_{aimv(PDO)-nSG}$	$N_{aimv-nSG}$	$N'_{aimv(FI)-nSG}$	$N'_{aimv(PDO)-nSG}$	$N_{aimv(FI)-nSG}$	$N_{aimv(PDO)-nSG}$
5.12	1.62	3.32	1.68	3.44	4.85	1.53	3.14	1.59	3.26	4.80	1.51	3.11	1.57	3.23
25.50	9.25	15.57	9.51	15.99	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90
2.42	0.70	1.63	0.73	1.69	2.37	0.69	1.60	0.71	1.66	2.36	0.68	1.59	0.71	1.65
3.90	1.24	2.50	1.29	2.61	3.90	1.24	2.50	1.29	2.61	4.01	1.28	2.57	1.33	2.68
2.40	0.69	1.62	0.72	1.68	2.23	0.65	1.50	0.67	1.56	2.19	0.64	1.47	0.66	1.53
2.71	0.80	1.81	0.83	1.88	2.64	0.78	1.76	0.81	1.83	2.64	0.78	1.76	0.81	1.83
6.34	2.03	4.09	2.10	4.24	5.28	1.66	3.43	1.72	3.56	5.29	1.66	3.44	1.72	3.57
31.55	11.46	19.31	11.75	19.80	35.00	12.87	21.30	13.18	21.82	35.42	13.04	21.55	13.36	22.07
2.06	0.59	1.39	0.61	1.45	2.10	0.60	1.42	0.62	1.47	2.12	0.61	1.44	0.63	1.49
3.70	1.14	2.42	1.18	2.52	3.72	1.14	2.44	1.19	2.53	3.75	1.15	2.46	1.20	2.55
6.76	2.15	4.38	2.22	4.53	6.11	1.92	3.98	1.99	4.12	6.29	1.98	4.09	2.05	4.23
1.83	0.52	1.25	0.53	1.30	1.91	0.54	1.30	0.56	1.35	1.98	0.56	1.35	0.58	1.40
7.81	2.50	5.05	2.59	5.22	7.95	2.55	5.15	2.63	5.32	8.09	2.59	5.24	2.68	5.42
5.61	1.77	3.64	1.84	3.78	5.64	1.77	3.67	1.84	3.80	5.64	1.77	3.68	1.83	3.81
6.57	2.16	4.17	2.24	4.33	6.80	2.24	4.30	2.33	4.47	7.02	2.33	4.44	2.42	4.61
34.43	12.67	20.94	12.98	21.45	35.35	13.03	21.49	13.34	22.01	36.28	13.39	22.04	13.71	22.57
6.68	2.17	4.27	2.25	4.43	6.22	2.01	3.98	2.09	4.13	6.03	1.95	3.86	2.02	4.01
5.10	1.63	3.27	1.70	3.40	5.07	1.62	3.26	1.68	3.38	5.05	1.62	3.25	1.68	3.37
10.46	3.64	6.46	3.77	6.69	11.42	3.93	7.11	4.06	7.36	12.44	4.26	7.78	4.41	8.04
8.57	2.99	5.27	3.10	5.47	8.43	2.92	5.20	3.03	5.40	8.26	2.85	5.11	2.96	5.30
5.19	1.68	3.31	1.75	3.44	4.85	1.56	3.10	1.63	3.22	4.83	1.55	3.09	1.61	3.21
14.87	4.08	9.94	4.33	10.54	14.87	4.08	9.94	4.33	10.54	14.42	3.97	9.63	4.21	10.21
15.04	5.11	9.48	5.27	9.77	14.85	5.04	9.36	5.19	9.65	14.65	4.97	9.25	5.12	9.53
5.05	1.62	3.24	1.69	3.37	4.84	1.54	3.12	1.60	3.24	4.71	1.49	3.04	1.55	3.16
5.76	1.88	3.67	1.95	3.81	5.56	1.81	3.54	1.88	3.68	5.57	1.81	3.55	1.88	3.69
14.77	5.28	9.01	5.46	9.31	14.97	5.34	9.16	5.51	9.46	15.11	5.37	9.26	5.55	9.57
5.91	1.88	3.83	1.95	3.97	5.61	1.77	3.64	1.84	3.78	5.91	1.88	3.83	1.95	3.97
2.92	0.86	1.95	0.90	2.02	2.93	0.87	1.95	0.90	2.03	2.94	0.87	1.97	0.90	2.04
25.09	5.99	17.81	6.32	18.77	25.44	6.08	18.06	6.41	19.03	25.78	6.17	18.29	6.50	19.28
25.66	6.08	18.28	6.41	19.26	25.82	6.14	18.36	6.47	19.35	25.94	6.19	18.42	6.53	19.42
4.74	1.50	3.07	1.55	3.19	4.76	1.50	3.08	1.56	3.20	4.78	1.51	3.09	1.57	3.21
22.40	8.05	13.73	8.28	14.12	21.08	7.55	12.93	7.77	13.31	20.21	7.20	12.42	7.42	12.79

CASE 3: BASE + ALL CMF + Ci_forNC

STEP 2 CALCULATE EXPECTED CRASH FREQUENCY BY SITE FOR ENTIRE BEFORE PERIOD

$N_{expected,B} = w_{i,B} * N_{predicted,B,i} + (1 - w_{i,B}) * N_{observed,B}$ $N_{pred,bi} = N_{bimv} * (CMF_{1i} * \ldots * CMF_{6i}) * C_i$

$w_{i,B} = 1 / [1 + k * sum(N_{predicted,B,i})$ over all years Note: if CMF or C unknown, assume 1.00.

R_SiteType			Formula Applied	BefAllYrs $N_{bimv\text{-}nSG}$	$N_{bimv(FI)\text{-}nSG}$	$N_{bimv(PDO)\text{-}nSG}$	BefAllYrs $N_{pred,bi}$	$N_{pred,bi(FI)}$	$N_{pred,bi(PDO)}$	BefAllYrs $w_{i,B}$	$N_{expected,B}$
0	IntNum	3	4SG	15.85	5.21	10.64	38.66	12.70	25.95	0.14	19.16
		9	4SG	71.40	26.44	44.96	120.39	44.58	75.82	0.03	17.69
		17	4SG	7.63	2.31	5.32	19.39	5.87	13.52	0.25	25.83
		18	4SG	14.41	4.83	9.59	33.69	11.28	22.41	0.15	26.31
		19	4SG	8.03	2.44	5.59	20.41	6.20	14.21	0.24	19.34
		20	4SG	8.57	2.65	5.91	18.50	5.73	12.77	0.23	9.65
		21	4SG	21.84	7.34	14.50	46.23	15.54	30.69	0.11	15.60
		22	4SG	79.95	29.27	50.68	185.01	67.73	117.28	0.03	14.47
		23	4SG	6.88	2.06	4.81	16.77	5.03	11.74	0.27	13.30
		24	4SG	11.85	3.80	8.05	23.42	7.51	15.91	0.18	14.85
		25	4SG	20.21	6.66	13.55	49.29	16.24	33.05	0.11	20.64
		26	4SG	5.84	1.71	4.13	14.84	4.35	10.48	0.31	10.09
		27	4SG	24.80	8.24	16.56	41.75	13.87	27.88	0.09	15.69
		28	4SG	16.54	5.41	11.13	35.01	11.44	23.57	0.13	15.95
		29	4SG	21.68	7.45	14.22	45.88	15.78	30.11	0.11	20.95
		122	4SG	106.41	40.14	66.27	246.27	92.90	153.36	0.02	19.46
1	IntNum	1	4SG	21.41	7.25	14.16	53.32	18.06	35.26	0.11	29.81
		2	4SG	14.86	4.96	9.90	36.26	12.11	24.15	0.15	27.51
		4	4SG	32.94	11.84	21.11	71.46	25.68	45.79	0.07	16.29
		5	4SG	27.34	9.86	17.48	41.49	14.96	26.53	0.09	9.96
		6	4SG	15.01	5.05	9.96	28.65	9.64	19.01	0.15	10.16
		7	3SG	42.57	12.44	30.13	82.81	24.20	58.61	0.07	23.24
		8	4SG	50.09	17.64	32.45	84.46	29.75	54.71	0.05	21.24
		10	4SG	15.14	5.05	10.09	29.32	9.78	19.54	0.14	11.94
		11	4SG	18.36	6.23	12.13	37.81	12.84	24.98	0.12	10.78
		12	4SG	40.31	14.83	25.48	69.22	25.47	43.75	0.06	15.42
		13	4SG	17.64	5.81	11.83	33.67	11.09	22.58	0.13	24.35
		14	4SG	9.23	2.85	6.38	21.16	6.53	14.63	0.22	10.86
		15	3SG	78.95	19.79	59.16	166.93	41.84	125.09	0.04	14.84
		16	3SG	81.34	20.16	61.18	165.11	40.92	124.19	0.04	18.46
		103	4SG	14.32	4.69	9.62	34.92	11.44	23.47	0.15	26.51
		109	4SG	64.75	23.78	40.97	109.17	40.09	69.08	0.04	16.66

EB ESTIMATION IN AFTER PERIOD

CASE 3: BASE + ALL CMF + Ci_forNC

STEP 3 CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR AFTER TREATMENT

R_SiteType			Formula Applied	AftAllYrs $N_{aimv\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	AftAllYrs $N_{pred,ai}$	$N_{pred,ai(FI)}$	$N_{pred,ai(PDO)}$
0	IntNum	3	4SG	14.77	4.84	9.93	36.03	11.80	24.23
		9	4SG	68.70	25.37	43.33	115.85	42.78	73.07
		17	4SG	7.15	2.15	5.00	18.18	5.47	12.71
		18	4SG	11.81	3.92	7.89	27.62	9.17	18.45
		19	4SG	6.82	2.05	4.77	17.33	5.22	12.11
		20	4SG	7.98	2.45	5.53	17.24	5.30	11.94
		21	4SG	16.92	5.55	11.37	35.81	11.74	24.06
		22	4SG	101.97	38.28	63.69	235.98	88.60	147.38
		23	4SG	6.28	1.86	4.41	15.31	4.54	10.77
		24	4SG	11.17	3.57	7.60	22.07	7.05	15.02
		25	4SG	19.15	6.27	12.89	46.72	15.29	31.43
		26	4SG	5.72	1.68	4.05	14.54	4.26	10.29
		27	4SG	23.86	7.90	15.96	40.16	13.29	26.87
		28	4SG	16.90	5.51	11.39	35.77	11.66	24.11
		29	4SG	20.39	6.99	13.40	43.15	14.79	28.36
		122	4SG	106.06	40.03	66.03	245.44	92.64	152.80
1	IntNum	1	4SG	18.93	6.36	12.57	47.14	15.83	31.31
		2	4SG	15.22	5.06	10.16	37.12	12.35	24.77
		4	4SG	34.32	12.24	22.08	74.45	26.55	47.91
		5	4SG	25.27	9.09	16.18	38.34	13.79	24.55
		6	4SG	14.86	4.99	9.87	28.36	9.52	18.84
		7	3SG	44.17	12.87	31.29	85.92	25.04	60.88
		8	4SG	44.54	15.58	28.95	75.10	26.28	48.82
		10	4SG	14.60	4.83	9.76	28.27	9.36	18.91
		11	4SG	16.89	5.71	11.18	34.79	11.76	23.03
		12	4SG	44.85	16.51	28.34	77.03	28.36	48.67
		13	4SG	17.44	5.73	11.71	33.28	10.94	22.35
		14	4SG	8.78	2.70	6.09	20.14	6.18	13.96
		15	3SG	76.31	19.23	57.09	161.36	40.65	120.71
		16	3SG	77.42	19.40	58.02	157.16	39.38	117.78
		103	4SG	14.28	4.68	9.60	34.83	11.42	23.42
		109	4SG	63.69	23.47	40.22	107.40	39.57	67.83

ESTIMATION OF TREATED EFFECTIVENESS

CASE 3: BASE + ALL CMF + Ci_forNC

STEP 4 CALCULATE AN ADJUSTMENT FACTOR (ri) FOR DIFFERENCES BETWEEN BEFORE & AFTER PERIODS

STEP 5 CALCULATE EXPECTED CRASH FREQUENCY BY SITE FOR ENTIRE AFTER PERIOD IN ABSENCE OF TREATMENT

CASE 3: BASE + ALL CMF + Ci_forNC

STEP 6 ESTIMATE SAFETY EFFECTIVENESS AT EACH SITE VIA ODDS RATIO (omega)

STEP 7 ESTIMATE SAFETY EFFECTIVENESS AT EACH SITE AS A PERCENTAGE CRASH CHANGE

ri	$N_{expected,A}$	omega_i	SafeEff_i
0.932	17.85	1.064	-6.43
0.962	17.02	0.940	6.00
0.938	24.22	0.991	0.91
0.820	21.57	0.881	11.90
0.849	16.42	1.401	-40.09
0.932	8.99	0.890	11.01
0.775	12.08	1.076	-7.61
1.275	18.46	0.379	62.07
0.913	12.14	1.071	-7.11
0.942	14.00	0.500	49.99
0.948	19.56	0.613	38.66
0.980	9.89	2.630	-162.97
0.962	15.10	0.729	27.13
1.022	16.30	0.859	14.11
0.940	19.70	0.508	49.24
0.997	19.40	0.464	53.61
0.884	26.36	0.114	88.62
1.024	28.16	0.923	7.68
1.042	16.98	0.295	70.55
0.924	9.20	0.217	78.26
0.990	10.06	0.597	40.34
1.038	24.11	0.954	4.61
0.889	18.88	0.371	62.93
0.964	11.51	0.261	73.94
0.920	9.91	0.101	89.91
1.113	17.16	0.291	70.87
0.989	24.08	0.291	70.92
0.952	10.34	0.967	3.27
0.967	14.34	0.279	72.11
0.952	17.57	0.171	82.93
0.998	26.44	0.529	47.05
0.984	16.39	0.488	51.20

ri = sum($N_{predicted,A,i}$)over after years / sum($N_{predicted,B,i}$)over before years

$N_{expected,A}$ = ri*$N_{expected,B}$

omega_i = $N_{observed,A}/N_{expected,A}$

SafeEff_i = 100*(1-omega_i)

CASE 3: BASE + ALL CMF + Ci_forNC

STEP 8 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT (ODDS RATIO omega') FOR ALL SITES COMBINED

R_SiteType	omega'
0 All Ints	0.88
1 All Ints	0.45

omega' = sum($N_{observed,A}$)all sites / sum($N_{expected,A}$)all sites

STEP 9 ADJUST ODDS RATIO TO OBTAIN UNBIASED ESTIMATE OF TREATMENT EFFECTIVENESS

R_SiteType	Var(Nexpected,A,all)	omega
0 All Ints	215.46	0.88
1 All Ints	248.72	0.45

Var(Nexpected,A,all) = sum[(ri^2)*$N_{expected,B}$ * (1-$w_{i,B}$)] over all sites

omega = omega' / {1+[var($N_{expected,A,all}$)] / [$N_{expected,A,all}$]^2}

STEP 10 CALCULATE OVERALL UNBIASED SAFETY EFFECTIVENESS AS A PERCENT CHANGE IN CRASH FREQUENCY ACROSS ALL SITES

R_SiteType	Safety Effectiveness
0 All Ints	12.33
1 All Ints	55.03

Safety Effectiveness = 100*(1 - omega)

ESTIMATION OF PRECISION OF TREATED EFFECTIVENESS

STEP 11 CALCULATE VARIANCE OF UNBIASED ESTIMATED SAFETY EFFECTIVENESS AS AN ODDS RATIO

R_SiteType	$N_{observed,A,all\ sites}$	$N_{expected,A,all\ sites}$	var(omega)
0 All Ints	231	262.68	0.00574
1 All Ints	127	281.51	0.00223

var(omega) = {omega'^2 *
[(1/$N_{observed,A}$) + (var{sum[$N_{expected,A}$]over all sites}/(sum[$N_{expected,A}$]over all sites)^2)] /
[1 + (var{sum[$N_{expected,A}$] over all sites} / (sum[$N_{expected,A}$]over all sites)^2)]

STEP 12 CALCULATE STANDARD ERROR OF THE STEP 11 ODDS RATIO

R_SiteType	SE(omega)
0 All Ints	0.08
1 All Ints	0.05

SE(omega) = sqrt[var(omega)]

STEP 13 CALCULATE STANDARD ERROR OF THE STEP 10 UNBIASED SAFETY EFFECTIVENESS

R_SiteType	SE(Safety Effectiveness)
0 All Ints	7.58
1 All Ints	4.73

SE(Safety Effectiveness) =100 * SE(omega)

STEP 14 ASSESS STATISTICAL SIGNIFICANCE OF ESTIMATED SAFETY EFFECTIVENESS

R_SiteType	Performance Measure
0 All Ints	1.63
1 All Ints	11.64

Performance Measure = ABS[Safety Effectiveness / SE(Safety Effectiveness)]

PM < 1.7 Treatment Effect NOT significant at the (approx.) 90% confidence interval
PM >= 1.7 Treatment Effect IS significant at the (approx.) 90% confidence interval
PM >= 2.0 Treatment Effect IS significant at the (approx.) 95% confidence interval

CASE 4: BASE + ALL CMF + Ci_forPiedmont

pulled from sheet 2-Intersections_prepped

Step 1b Determine Crash Modification Factors (CMFs) and Calibration Factors (Ci) for each intersection for each year

vlookup column >>		5	6	296	299	300	297	301														
				for CMF_1i	for CMF_2i		for CMF_3i	n_prohib			N_{bisv}											
R_SiteType		Approaches	Legs	AppsWLeftLns	AppsWLeftProt	LeftProtPerm	AppsWRgtLns	AppsRTORprohib	Bef3Yr	Bef2Yr	Bef1Yr	Aft1Yr	Aft2Yr	Aft3Yr	RLC	CMF_1i	CMF_2i	CMF_3i	CMF_4i	CMF_5i	CMF_6i	Ci
0 IntNum	3	2	4	0	0	0	1	0	0.34	0.35	0.35	0.34	0.32	0.32	0	1.00	1.000	0.96	1.00	0.9107		4.10
	9	4	4	0	4	0	4	0	0.96	1.00	1.02	1.03	0.97	0.89	0	1.00	0.781	0.85	1.00	0.9107		4.10
	17	2	4	0	0	0	0	0	0.23	0.22	0.22	0.22	0.21	0.21	0	1.00	1.000	1.00	1.00	0.9107		4.10
	18	4	4	0	0	0	2	0	0.32	0.30	0.26	0.25	0.25	0.25	0	1.00	1.000	0.92	1.00	0.9107		4.10
	19	3	4	0	0	0	0	0	0.25	0.23	0.22	0.22	0.20	0.20	0	1.00	1.000	1.00	1.00	0.9107		4.10
	20	4	4	0	0	0	4	0	0.23	0.23	0.23	0.22	0.22	0.22	0	1.00	1.000	0.85	1.00	0.9107		4.10
	21	4	4	0	0	2	4	0	0.43	0.44	0.44	0.40	0.36	0.36	0	1.00	0.980	0.85	1.00	0.9107		4.10
	22	3	4	0	0	1	2	0	1.11	1.15	1.19	1.28	1.36	1.37	0	1.00	0.990	0.92	1.00	0.9107		4.10
	23	2	4	0	0	0	1	0	0.22	0.21	0.19	0.19	0.20	0.20	0	1.00	1.000	0.96	1.00	0.9107		4.10
	24	4	4	0	2	0	3	0	0.28	0.29	0.28	0.27	0.27	0.27	0	1.00	0.884	0.88	1.00	0.9107		4.10
	25	3	4	0	0	0	1	0	0.41	0.44	0.46	0.44	0.41	0.42	0	1.00	1.000	0.96	1.00	0.9107		4.10
	26	2	4	0	0	0	0	0	0.19	0.19	0.19	0.18	0.19	0.19	0	1.00	1.000	1.00	1.00	0.9107		4.10
	27	4	4	1	2	2	4	0	0.52	0.52	0.51	0.49	0.50	0.51	0	0.90	0.866	0.85	1.00	0.9107		4.10
	28	4	4	0	0	2	4	0	0.36	0.37	0.37	0.37	0.38	0.39	0	1.00	0.980	0.85	1.00	0.9107		4.10
	29	4	4	0	0	0	4	1	0.40	0.41	0.39	0.38	0.38	0.39	0	1.00	1.000	0.85	0.98	0.9107		4.10
	122	3	4	0	0	1	2	0	1.37	1.38	1.36	1.33	1.36	1.39	0	1.00	0.990	0.92	1.00	0.9107		4.10
1 IntNum	1	2	4	0	0	0	0	1	0.41	0.42	0.42	0.40	0.38	0.37	1	1.00	1.000	1.00	0.98	0.9107		4.10
	2	2	4	0	0	0	1	0	0.30	0.31	0.32	0.32	0.32	0.32	1	1.00	1.000	0.96	1.00	0.9107		4.10
	4	4	4	0	0	1	3	1	0.52	0.52	0.52	0.49	0.56	0.62	1	1.00	0.990	0.88	0.98	0.9107		4.10
	5	4	4	1	4	0	4	0	0.44	0.43	0.42	0.40	0.40	0.40	1	0.90	0.781	0.85	1.00	0.9107		4.10
	6	4	4	0	2	0	4	0	0.28	0.30	0.33	0.31	0.30	0.30	1	1.00	0.884	0.85	1.00	0.9107		4.10
	7	3	3	0	1	0	2	0	0.53	0.54	0.54	0.54	0.54	0.54	1	1.00	0.940	0.92	1.00	0.9107		2.86
	8	4	4	0	4	0	4	0	0.82	0.87	0.82	0.77	0.77	0.76	1	1.00	0.781	0.85	1.00	0.9107		4.10
	10	4	4	0	2	2	3	0	0.30	0.31	0.33	0.32	0.31	0.31	1	1.00	0.866	0.88	1.00	0.9107		4.10
	11	4	4	0	1	0	3	1	0.36	0.36	0.35	0.34	0.33	0.33	1	1.00	0.940	0.88	0.98	0.9107		4.10
	12	4	4	1	2	0	4	0	0.59	0.57	0.58	0.63	0.64	0.66	1	0.90	0.884	0.85	1.00	0.9107		4.10
	13	4	4	0	2	0	4	0	0.37	0.38	0.40	0.38	0.37	0.38	1	1.00	0.884	0.85	1.00	0.9107		4.10
	14	3	4	0	1	0	1	0	0.26	0.25	0.24	0.24	0.24	0.25	1	1.00	0.940	0.96	1.00	0.9107		4.10
	15	2	3	0	1	0	0	0	1.05	1.03	1.02	1.01	1.01	1.01	1	1.00	0.940	1.00	1.00	0.9107		2.86
	16	2	3	0	1	0	1	0	1.12	1.07	1.06	1.05	1.04	1.02	1	1.00	0.940	0.96	1.00	0.9107		2.86
	103	2	4	0	0	0	1	0	0.32	0.32	0.32	0.31	0.32	0.32	1	1.00	1.000	0.96	1.00	0.9107		4.10
	109	4	4	0	4	0	4	0	0.97	0.89	0.93	0.94	0.90	0.87	1	1.00	0.781	0.85	1.00	0.9107		4.10

EB ESTIMATION IN BEFORE PERIOD

CASE 4: BASE + ALL CMF + Ci_forPiedmont

STEP 1 CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR BEFORE TREATMENT

Step 1a Calculate Safety Performance Functions for each intersection for each year

R_SiteType			FormulaApplied	Bef3Yr					Bef2Yr					Bef1Yr				
				$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$	$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$	$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$
0	IntNum	3	4SG	5.17	1.64	3.34	1.70	3.47	5.29	1.67	3.42	1.74	3.55	5.39	1.71	3.49	1.77	3.62
		9	4SG	22.49	8.05	13.81	8.28	14.21	24.11	8.69	14.76	8.94	15.17	24.80	8.97	15.16	9.22	15.58
		17	4SG	2.62	0.76	1.76	0.79	1.82	2.54	0.74	1.71	0.77	1.77	2.47	0.72	1.66	0.75	1.72
		18	4SG	5.46	1.78	3.48	1.85	3.62	4.86	1.56	3.11	1.62	3.23	4.09	1.30	2.63	1.35	2.74
		19	4SG	2.95	0.87	1.97	0.91	2.05	2.68	0.78	1.80	0.81	1.87	2.40	0.70	1.62	0.72	1.68
		20	4SG	2.93	0.88	1.94	0.91	2.02	2.86	0.85	1.90	0.88	1.97	2.78	0.83	1.85	0.86	1.92
		21	4SG	7.13	2.31	4.57	2.39	4.74	7.28	2.36	4.66	2.45	4.83	7.43	2.42	4.76	2.50	4.93
		22	4SG	25.28	8.97	15.64	9.21	16.07	26.64	9.50	16.45	9.75	16.89	28.02	10.04	17.27	10.30	17.72
		23	4SG	2.57	0.75	1.73	0.78	1.79	2.29	0.66	1.55	0.69	1.60	2.01	0.57	1.37	0.60	1.42
		24	4SG	3.92	1.21	2.56	1.25	2.66	4.06	1.26	2.65	1.30	2.76	3.88	1.20	2.54	1.24	2.63
		25	4SG	6.08	1.91	3.95	1.98	4.10	6.73	2.14	4.36	2.22	4.51	7.40	2.38	4.77	2.46	4.94
		26	4SG	1.96	0.56	1.34	0.58	1.39	1.97	0.56	1.35	0.58	1.39	1.90	0.54	1.30	0.56	1.35
		27	4SG	8.36	2.69	5.40	2.78	5.58	8.36	2.69	5.40	2.78	5.58	8.08	2.59	5.22	2.68	5.40
		28	4SG	5.31	1.67	3.45	1.73	3.58	5.61	1.77	3.64	1.84	3.78	5.61	1.77	3.64	1.84	3.78
		29	4SG	7.22	2.39	4.57	2.48	4.74	7.45	2.48	4.71	2.57	4.88	7.01	2.32	4.43	2.40	4.60
		122	4SG	35.42	13.04	21.55	13.36	22.07	35.85	13.22	21.80	13.53	22.32	35.14	12.94	21.37	13.26	21.88
1	IntNum	1	4SG	7.13	2.34	4.54	2.42	4.71	7.14	2.33	4.56	2.42	4.72	7.14	2.32	4.56	2.41	4.73
		2	4SG	4.79	1.53	3.07	1.60	3.19	4.95	1.59	3.17	1.65	3.30	5.12	1.65	3.28	1.71	3.41
		4	4SG	10.69	3.69	6.63	3.82	6.87	10.99	3.81	6.80	3.95	7.04	11.26	3.93	6.95	4.07	7.19
		5	4SG	9.16	3.17	5.66	3.29	5.87	9.26	3.22	5.70	3.34	5.91	8.92	3.11	5.49	3.22	5.70
		6	4SG	4.48	1.44	2.87	1.50	2.98	5.00	1.62	3.19	1.68	3.32	5.53	1.80	3.52	1.87	3.66
		7	3SG	13.51	3.74	9.00	3.96	9.54	14.19	3.91	9.47	4.15	10.04	14.87	4.08	9.94	4.33	10.54
		8	4SG	16.35	5.60	10.27	5.77	10.58	17.48	5.99	10.99	6.16	11.32	16.26	5.55	10.23	5.71	10.54
		10	4SG	4.67	1.49	3.00	1.54	3.12	5.05	1.62	3.23	1.68	3.36	5.43	1.75	3.47	1.82	3.60
		11	4SG	6.28	2.06	3.99	2.13	4.14	6.12	2.00	3.89	2.08	4.04	5.96	1.94	3.79	2.02	3.94
		12	4SG	13.74	4.90	8.40	5.06	8.68	13.00	4.61	7.96	4.77	8.23	13.57	4.84	8.28	5.00	8.57
		13	4SG	5.55	1.75	3.60	1.82	3.73	5.88	1.87	3.80	1.94	3.94	6.22	1.98	4.01	2.06	4.16
		14	4SG	3.25	0.97	2.16	1.01	2.24	3.08	0.91	2.05	0.95	2.13	2.90	0.86	1.94	0.89	2.01
		15	3SG	27.54	6.53	19.59	6.89	20.65	25.91	6.16	18.43	6.50	19.42	25.50	6.08	18.12	6.41	19.09
		16	3SG	28.77	6.72	20.61	7.08	21.69	26.49	6.25	18.90	6.59	19.91	26.08	6.17	18.59	6.50	19.58
		103	4SG	4.80	1.51	3.11	1.57	3.23	4.76	1.50	3.08	1.56	3.20	4.75	1.50	3.07	1.56	3.19
		109	4SG	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90	21.54	7.69	13.25	7.91	13.63

Aft1Yr					Aft2Yr					Aft3Yr				
$N_{aimv-nSG}$	$N'_{aimv(FI)-nSG}$	$N'_{aimv(PDO)-nSG}$	$N_{aimv(FI)-nSG}$	$N_{aimv(PDO)-nSG}$	$N_{aimv-nSG}$	$N'_{aimv(FI)-nSG}$	$N'_{aimv(PDO)-nSG}$	$N_{aimv(FI)-nSG}$	$N_{aimv(PDO)-nSG}$	$N_{aimv-nSG}$	$N'_{aimv(FI)-nSG}$	$N'_{aimv(PDO)-nSG}$	$N_{aimv(FI)-nSG}$	$N_{aimv(PDO)-nSG}$
5.12	1.62	3.32	1.68	3.44	4.85	1.53	3.14	1.59	3.26	4.80	1.51	3.11	1.57	3.23
25.50	9.25	15.57	9.51	15.99	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90
2.42	0.70	1.63	0.73	1.69	2.37	0.69	1.60	0.71	1.66	2.36	0.68	1.59	0.71	1.65
3.90	1.24	2.50	1.29	2.61	3.90	1.24	2.50	1.29	2.61	4.01	1.28	2.57	1.33	2.68
2.40	0.69	1.62	0.72	1.68	2.23	0.65	1.50	0.67	1.56	2.19	0.64	1.47	0.66	1.53
2.71	0.80	1.81	0.83	1.88	2.64	0.78	1.76	0.81	1.83	2.64	0.78	1.76	0.81	1.83
6.34	2.03	4.09	2.10	4.24	5.28	1.66	3.43	1.72	3.56	5.29	1.66	3.44	1.72	3.57
31.55	11.46	19.31	11.75	19.80	35.00	12.87	21.30	13.18	21.82	35.42	13.04	21.55	13.36	22.07
2.06	0.59	1.39	0.61	1.45	2.10	0.60	1.42	0.62	1.47	2.12	0.61	1.44	0.63	1.49
3.70	1.14	2.42	1.18	2.52	3.72	1.14	2.44	1.19	2.53	3.75	1.15	2.46	1.20	2.55
6.76	2.15	4.38	2.22	4.53	6.11	1.92	3.98	1.99	4.12	6.29	1.98	4.09	2.05	4.23
1.83	0.52	1.25	0.53	1.30	1.91	0.54	1.30	0.56	1.35	1.98	0.56	1.35	0.58	1.40
7.81	2.50	5.05	2.59	5.22	7.95	2.55	5.15	2.63	5.32	8.09	2.59	5.24	2.68	5.42
5.61	1.77	3.64	1.84	3.78	5.64	1.77	3.67	1.84	3.80	5.64	1.77	3.68	1.83	3.81
6.57	2.16	4.17	2.24	4.33	6.80	2.24	4.30	2.33	4.47	7.02	2.33	4.44	2.42	4.61
34.43	12.67	20.94	12.98	21.45	35.35	13.03	21.49	13.34	22.01	36.28	13.39	22.04	13.71	22.57
6.68	2.17	4.27	2.25	4.43	6.22	2.01	3.98	2.09	4.13	6.03	1.95	3.86	2.02	4.01
5.10	1.63	3.27	1.70	3.40	5.07	1.62	3.26	1.68	3.38	5.05	1.62	3.25	1.68	3.37
10.46	3.64	6.46	3.77	6.69	11.42	3.93	7.11	4.06	7.36	12.44	4.26	7.78	4.41	8.04
8.57	2.99	5.27	3.10	5.47	8.43	2.92	5.20	3.03	5.40	8.26	2.85	5.11	2.96	5.30
5.19	1.68	3.31	1.75	3.44	4.85	1.56	3.10	1.63	3.22	4.83	1.55	3.09	1.61	3.21
14.87	4.08	9.94	4.33	10.54	14.87	4.08	9.94	4.33	10.54	14.42	3.97	9.63	4.21	10.21
15.04	5.11	9.48	5.27	9.77	14.85	5.04	9.36	5.19	9.65	14.65	4.97	9.25	5.12	9.53
5.05	1.62	3.24	1.69	3.37	4.84	1.54	3.12	1.60	3.24	4.71	1.49	3.04	1.55	3.16
5.76	1.88	3.67	1.95	3.81	5.56	1.81	3.54	1.88	3.68	5.57	1.81	3.55	1.88	3.69
14.77	5.28	9.01	5.46	9.31	14.97	5.34	9.16	5.51	9.46	15.11	5.37	9.26	5.55	9.57
5.91	1.88	3.83	1.95	3.97	5.61	1.77	3.64	1.84	3.78	5.91	1.88	3.83	1.95	3.97
2.92	0.86	1.95	0.90	2.02	2.93	0.87	1.95	0.90	2.03	2.94	0.87	1.97	0.90	2.04
25.09	5.99	17.81	6.32	18.77	25.44	6.08	18.06	6.41	19.03	25.78	6.17	18.29	6.50	19.28
25.66	6.08	18.28	6.41	19.26	25.82	6.14	18.36	6.47	19.35	25.94	6.19	18.42	6.53	19.42
4.74	1.50	3.07	1.55	3.19	4.76	1.50	3.08	1.56	3.20	4.78	1.51	3.09	1.57	3.21
22.40	8.05	13.73	8.28	14.12	21.08	7.55	12.93	7.77	13.31	20.21	7.20	12.42	7.42	12.79

CASE 4: BASE + ALL CMF + Ci_forPiedmont

STEP 2 CALCULATE EXPECTED CRASH FREQUENCY BY SITE FOR ENTIRE BEFORE PERIOD

$N_{expected,B} = w_{i,B} * N_{predicted,B,i} + (1 - w_{i,B}) * N_{observed,B}$ $N_{pred,bi} = N_{bimv} * (CMF_{1i} * \ldots * CMF_{6i}) * C_i$

$w_{i,B} = 1 / [1 + k*sum(N_{predicted,B,i})$ over all years Note: if CMF or C unknown, assume 1.00.

R_SiteType			Formula Applied	BefAllYrs $N_{bimv\text{-}nSG}$	$N_{bimv(FI)\text{-}nSG}$	$N_{bimv(PDO)\text{-}nSG}$	BefAllYrs $N_{pred,bi}$	$N_{pred,bi(FI)}$	$N_{pred,bi(PDO)}$	BefAllYrs $w_{i,B}$	$N_{expected,B}$
0	IntNum	3	4SG	15.85	5.21	10.64	56.81	18.67	38.14	0.14	21.68
		9	4SG	71.40	26.44	44.96	176.92	65.51	111.42	0.03	19.65
		17	4SG	7.63	2.31	5.32	28.49	8.62	19.87	0.25	28.12
		18	4SG	14.41	4.83	9.59	49.51	16.57	32.94	0.15	28.70
		19	4SG	8.03	2.44	5.59	30.00	9.12	20.88	0.24	21.66
		20	4SG	8.57	2.65	5.91	27.19	8.42	18.77	0.23	11.65
		21	4SG	21.84	7.34	14.50	67.93	22.83	45.10	0.11	17.88
		22	4SG	79.95	29.27	50.68	271.88	99.53	172.35	0.03	17.17
		23	4SG	6.88	2.06	4.81	24.64	7.39	17.26	0.27	15.43
		24	4SG	11.85	3.80	8.05	34.41	11.03	23.38	0.18	16.81
		25	4SG	20.21	6.66	13.55	72.43	23.86	48.57	0.11	23.24
		26	4SG	5.84	1.71	4.13	21.80	6.40	15.41	0.31	12.21
		27	4SG	24.80	8.24	16.56	61.35	20.38	40.97	0.09	17.53
		28	4SG	16.54	5.41	11.13	51.45	16.82	34.63	0.13	18.16
		29	4SG	21.68	7.45	14.22	67.43	23.19	44.24	0.11	23.23
		122	4SG	106.41	40.14	66.27	361.90	136.52	225.37	0.02	22.19
1	IntNum	1	4SG	21.41	7.25	14.16	78.35	26.53	51.82	0.11	32.49
		2	4SG	14.86	4.96	9.90	53.28	17.79	35.49	0.15	30.01
		4	4SG	32.94	11.84	21.11	105.02	37.73	67.28	0.07	18.72
		5	4SG	27.34	9.86	17.48	60.97	21.98	38.99	0.09	11.63
		6	4SG	15.01	5.05	9.96	42.10	14.16	27.93	0.15	12.12
		7	3SG	42.57	12.44	30.13	95.88	28.02	67.86	0.07	24.11
		8	4SG	50.09	17.64	32.45	124.12	43.72	80.40	0.05	23.17
		10	4SG	15.14	5.05	10.09	43.09	14.38	28.71	0.14	13.94
		11	4SG	18.36	6.23	12.13	55.57	18.86	36.70	0.12	12.95
		12	4SG	40.31	14.83	25.48	101.73	37.43	64.30	0.06	17.37
		13	4SG	17.64	5.81	11.83	49.48	16.29	33.18	0.13	26.36
		14	4SG	9.23	2.85	6.38	31.10	9.59	21.51	0.22	13.02
		15	3SG	78.95	19.79	59.16	193.29	48.45	144.84	0.04	15.81
		16	3SG	81.34	20.16	61.18	191.18	47.39	143.79	0.04	19.40
		103	4SG	14.32	4.69	9.62	51.31	16.82	34.50	0.15	29.00
		109	4SG	64.75	23.78	40.97	160.44	58.91	101.52	0.04	18.62

EB ESTIMATION IN AFTER PERIOD

CASE 4: BASE + ALL CMF + Ci_forPiedmont

STEP 3 CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR AFTER TREATMENT

R_SiteType			Formula Applied	AftAllYrs $N_{aimv\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	AftAllYrs $N_{pred,ai}$	$N_{pred,ai(FI)}$	$N_{pred,ai(PDO)}$
0	IntNum	3	4SG	14.77	4.84	9.93	52.95	17.35	35.60
		9	4SG	68.70	25.37	43.33	170.24	62.87	107.37
		17	4SG	7.15	2.15	5.00	26.71	8.04	18.67
		18	4SG	11.81	3.92	7.89	40.58	13.47	27.11
		19	4SG	6.82	2.05	4.77	25.46	7.67	17.79
		20	4SG	7.98	2.45	5.53	25.33	7.78	17.55
		21	4SG	16.92	5.55	11.37	52.62	17.26	35.36
		22	4SG	101.97	38.28	63.69	346.78	130.20	216.58
		23	4SG	6.28	1.86	4.41	22.50	6.67	15.82
		24	4SG	11.17	3.57	7.60	32.43	10.36	22.07
		25	4SG	19.15	6.27	12.89	68.66	22.47	46.19
		26	4SG	5.72	1.68	4.05	21.37	6.26	15.12
		27	4SG	23.86	7.90	15.96	59.01	19.53	39.48
		28	4SG	16.90	5.51	11.39	52.57	17.14	35.43
		29	4SG	20.39	6.99	13.40	63.40	21.73	41.67
		122	4SG	106.06	40.03	66.03	360.68	136.13	224.54
1	IntNum	1	4SG	18.93	6.36	12.57	69.28	23.27	46.01
		2	4SG	15.22	5.06	10.16	54.55	18.14	36.41
		4	4SG	34.32	12.24	22.08	109.41	39.01	70.40
		5	4SG	25.27	9.09	16.18	56.34	20.27	36.07
		6	4SG	14.86	4.99	9.87	41.68	13.99	27.69
		7	3SG	44.17	12.87	31.29	99.48	28.99	70.49
		8	4SG	44.54	15.58	28.95	110.36	38.62	71.75
		10	4SG	14.60	4.83	9.76	41.54	13.76	27.78
		11	4SG	16.89	5.71	11.18	51.12	17.28	33.84
		12	4SG	44.85	16.51	28.34	113.20	41.68	71.52
		13	4SG	17.44	5.73	11.71	48.91	16.07	32.84
		14	4SG	8.78	2.70	6.09	29.60	9.09	20.51
		15	3SG	76.31	19.23	57.09	186.84	47.07	139.77
		16	3SG	77.42	19.40	58.02	181.97	45.60	136.37
		103	4SG	14.28	4.68	9.60	51.19	16.78	34.41
		109	4SG	63.69	23.47	40.22	157.82	58.15	99.67

ESTIMATION OF TREATED EFFECTIVENESS

CASE 4: BASE + ALL CMF + Ci_forPiedmont

STEP 4 CALCULATE AN ADJUSTMENT FACTOR (ri) FOR DIFFERENCES BETWEEN BEFORE & AFTER PERIODS

STEP 5 CALCULATE EXPECTED CRASH FREQUENCY BY SITE FOR ENTIRE AFTER PERIOD IN ABSENCE OF TREATMENT

CASE 4: BASE + ALL CMF + Ci_forPiedmont

STEP 6 ESTIMATE SAFETY EFFECTIVENESS AT EACH SITE VIA ODDS RATIO (omega)

STEP 7 ESTIMATE SAFETY EFFECTIVENESS AT EACH SITE AS A PERCENTAGE CRASH CHANGE

ri	$N_{expected,A}$	omega_i	SafeEff_i
0.932	20.21	0.940	5.98
0.962	18.91	0.846	15.37
0.938	26.37	0.910	8.98
0.820	23.52	0.808	19.23
0.849	18.39	1.251	-25.09
0.932	10.85	0.737	26.30
0.775	13.85	0.939	6.12
1.275	21.90	0.320	68.03
0.913	14.09	0.923	7.73
0.942	15.84	0.442	55.81
0.948	22.03	0.545	45.54
0.980	11.97	2.172	-117.20
0.962	16.86	0.652	34.77
1.022	18.55	0.755	24.55
0.940	21.84	0.458	54.22
0.997	22.11	0.407	59.30
0.884	28.73	0.104	89.56
1.024	30.73	0.846	15.39
1.042	19.50	0.256	74.36
0.924	10.75	0.186	81.39
0.990	12.00	0.500	50.00
1.038	25.01	0.919	8.05
0.889	20.60	0.340	66.02
0.964	13.44	0.223	77.67
0.920	11.92	0.084	91.61
1.113	19.33	0.259	74.13
0.989	26.06	0.269	73.14
0.952	12.39	0.807	19.32
0.967	15.28	0.262	73.83
0.952	18.47	0.162	83.75
0.998	28.93	0.484	51.60
0.984	18.31	0.437	56.32

ri = sum($N_{predicted,A,i}$)over after years / sum($N_{predicted,B,i}$)over before years

$N_{expected,A}$ = ri*$N_{expected,B}$

omega_i = $N_{observed,A}$/$N_{expected,A}$

SafeEff_i = 100*(1-omega_i)

CASE 4: BASE + ALL CMF + Ci_forPiedmont

STEP 8 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT (ODDS RATIO omega') FOR ALL SITES COMBINED

R_SiteType	omega'
0 All Ints	0.78
1 All Ints	0.41

omega' = sum($N_{observed,A}$)all sites / sum($N_{expected,A}$)all sites

STEP 9 ADJUST ODDS RATIO TO OBTAIN UNBIASED ESTIMATE OF TREATMENT EFFECTIVENESS

R_SiteType	Var(Nexpected,A,all)	omega
0 All Ints	244.25	0.77
1 All Ints	274.86	0.41

Var(Nexpected,A,all) = sum[(ri^2)*$N_{expected,B}$ * (1-$w_{i,B}$)] over all sites

omega = omega' / {1+[var($N_{expected,A,all}$)] / [$N_{expected,A,all}$]^2}

STEP 10 CALCULATE OVERALL UNBIASED SAFETY EFFECTIVENESS AS A PERCENT CHANGE IN CRASH FREQUENCY ACROSS ALL SITES

R_SiteType	Safety Effectiveness
0 All Ints	22.51
1 All Ints	59.34

Safety Effectiveness = 100*(1 - omega)

ESTIMATION OF PRECISION OF TREATED EFFECTIVENESS

STEP 11 CALCULATE VARIANCE OF UNBIASED ESTIMATED SAFETY EFFECTIVENESS AS AN ODDS RATIO

R_SiteType	$N_{observed,A,all\ sites}$	$N_{expected,A,all\ sites}$	var(omega)
0 All Ints	231	297.30	0.00427
1 All Ints	127	311.44	0.00178

var(omega) = {omega'^2 *
[(1/$N_{observed,A}$) + (var{sum[$N_{expected,A}$]over all sites}/(sum[$N_{expected,A}$]over all sites)^2)] /
[1 + (var{sum[$N_{expected,A}$] over all sites} / (sum[$N_{expected,A}$]over all sites)^2)]

STEP 12 CALCULATE STANDARD ERROR OF THE STEP 11 ODDS RATIO

R_SiteType	SE(omega)
0 All Ints	0.07
1 All Ints	0.04

SE(omega) = sqrt[var(omega)]

STEP 13 CALCULATE STANDARD ERROR OF THE STEP 10 UNBIASED SAFETY EFFECTIVENESS

R_SiteType	SE(Safety Effectiveness)
0 All Ints	6.53
1 All Ints	4.21

SE(Safety Effectiveness) =100 * SE(omega)

STEP 14 ASSESS STATISTICAL SIGNIFICANCE OF ESTIMATED SAFETY EFFECTIVENESS

R_SiteType	Performance Measure
0 All Ints	3.45
1 All Ints	14.08

Performance Measure = ABS[Safety Effectiveness / SE(Safety Effectiveness)]

PM < 1.7 Treatment Effect NOT significant at the (approx.) 90% confidence interval
PM >= 1.7 Treatment Effect IS significant at the (approx.) 90% confidence interval
PM >= 2.0 Treatment Effect IS significant at the (approx.) 95% confidence interval

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

pulled from sheet 2-Intersections_prepped

Step 1b Determine Crash Modification Factors (CMFs) and Calibration Factors (Ci) for each intersection for each year

vlookup column >>			5	6	296	299	300	297	301							
					for CMF_1i	for CMF_2i		for CMF_3i	n_prohib	N_{bisv}						
R_SiteType			Approaches	Legs	AppsWLeftLns	AppsWLeftProt	LeftProtPerm	AppsWRgtLns	AppsRTORprohib	Bef3Yr	Bef2Yr	Bef1Yr	Aft1Yr	Aft2Yr	Aft3Yr	RLC
0	IntNum	3	2	4	0	0	0	1	0	0.34	0.35	0.35	0.34	0.32	0.32	0
		9	4	4	0	4	0	4	0	0.96	1.00	1.02	1.03	0.97	0.89	0
		17	2	4	0	0	0	0	0	0.23	0.22	0.22	0.22	0.21	0.21	0
		18	4	4	0	0	0	2	0	0.32	0.30	0.26	0.25	0.25	0.25	0
		19	3	4	0	0	0	0	0	0.25	0.23	0.22	0.22	0.20	0.20	0
		20	4	4	0	0	0	4	0	0.23	0.23	0.23	0.22	0.22	0.22	0
		21	4	4	0	0	2	4	0	0.43	0.44	0.44	0.40	0.36	0.36	0
		22	3	4	0	0	1	2	0	1.11	1.15	1.19	1.28	1.36	1.37	0
		23	2	4	0	0	0	1	0	0.22	0.21	0.19	0.19	0.20	0.20	0
		24	4	4	0	2	0	3	0	0.28	0.29	0.28	0.27	0.27	0.27	0
		25	3	4	0	0	0	1	0	0.41	0.44	0.46	0.44	0.41	0.42	0
		26	2	4	0	0	0	0	0	0.19	0.19	0.19	0.18	0.19	0.19	0
		27	4	4	1	2	2	4	0	0.52	0.52	0.51	0.49	0.50	0.51	0
		28	4	4	0	0	2	4	0	0.36	0.37	0.37	0.37	0.38	0.39	0
		29	4	4	0	0	0	4	1	0.40	0.41	0.39	0.38	0.38	0.39	0
		122	3	4	0	0	1	2	0	1.37	1.38	1.36	1.33	1.36	1.39	0
1	IntNum	1	2	4	0	0	0	0	1	0.41	0.42	0.42	0.40	0.38	0.37	1
		2	2	4	0	0	0	1	0	0.30	0.31	0.32	0.32	0.32	0.32	1
		4	4	4	0	0	1	3	1	0.52	0.52	0.52	0.49	0.56	0.62	1
		5	4	4	1	4	0	4	0	0.44	0.43	0.42	0.40	0.40	0.40	1
		6	4	4	0	2	0	4	0	0.28	0.30	0.33	0.31	0.30	0.30	1
		7	3	3	0	1	0	2	0	0.53	0.54	0.54	0.54	0.54	0.54	1
		8	4	4	0	4	0	4	0	0.82	0.87	0.82	0.77	0.77	0.76	1
		10	4	4	0	2	2	3	0	0.30	0.31	0.33	0.32	0.31	0.31	1
		11	4	4	0	1	0	3	1	0.36	0.36	0.35	0.34	0.33	0.33	1
		12	4	4	1	2	0	4	0	0.59	0.57	0.58	0.63	0.64	0.66	1
		13	4	4	0	2	0	4	0	0.37	0.38	0.40	0.38	0.37	0.38	1
		14	3	4	0	1	0	1	0	0.26	0.25	0.24	0.24	0.24	0.25	1
		15	2	3	0	1	0	0	0	1.05	1.03	1.02	1.01	1.01	1.01	1
		16	2	3	0	1	0	1	0	1.12	1.07	1.06	1.05	1.04	1.02	1
		103	2	4	0	0	0	1	0	0.32	0.32	0.32	0.31	0.32	0.32	1
		109	4	4	0	4	0	4	0	0.97	0.89	0.93	0.94	0.90	0.87	1

R_SiteType			CMF_1i	CMF_2i	CMF_3i	CMF_4i	CMF_5i	CMF_6i	Ci
0	IntNum	3	1.00	1.000	0.96	1.00	0.8995		4.10
		9	1.00	0.781	0.85	1.00	0.8995		4.10
		17	1.00	1.000	1.00	1.00	0.8995		4.10
		18	1.00	1.000	0.92	1.00	0.8995		4.10
		19	1.00	1.000	1.00	1.00	0.8995		4.10
		20	1.00	1.000	0.85	1.00	0.8995		4.10
		21	1.00	0.980	0.85	1.00	0.8995		4.10
		22	1.00	0.990	0.92	1.00	0.8995		4.10
		23	1.00	1.000	0.96	1.00	0.8995		4.10
		24	1.00	0.884	0.88	1.00	0.8995		4.10
		25	1.00	1.000	0.96	1.00	0.8995		4.10
		26	1.00	1.000	1.00	1.00	0.8995		4.10
		27	0.90	0.866	0.85	1.00	0.8995		4.10
		28	1.00	0.980	0.85	1.00	0.8995		4.10
		29	1.00	1.000	0.85	0.98	0.8995		4.10
		122	1.00	0.990	0.92	1.00	0.8995		4.10
1	IntNum	1	1.00	1.000	1.00	0.98	0.8995		4.10
		2	1.00	1.000	0.96	1.00	0.8995		4.10
		4	1.00	0.990	0.88	0.98	0.8995		4.10
		5	0.90	0.781	0.85	1.00	0.8995		4.10
		6	1.00	0.884	0.85	1.00	0.8995		4.10
		7	1.00	0.940	0.92	1.00	0.8995		2.86
		8	1.00	0.781	0.85	1.00	0.8995		4.10
		10	1.00	0.866	0.88	1.00	0.8995		4.10
		11	1.00	0.940	0.88	0.98	0.8995		4.10
		12	0.90	0.884	0.85	1.00	0.8995		4.10
		13	1.00	0.884	0.85	1.00	0.8995		4.10
		14	1.00	0.940	0.96	1.00	0.8995		4.10
		15	1.00	0.940	1.00	1.00	0.8995		2.86
		16	1.00	0.940	0.96	1.00	0.8995		2.86
		103	1.00	1.000	0.96	1.00	0.8995		4.10
		109	1.00	0.781	0.85	1.00	0.8995		4.10

EB ESTIMATION IN BEFORE PERIOD

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

STEP 1 CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR BEFORE TREATMENT

Step 1a Calculate Safety Performance Functions for each intersection for each year

				Bef3Yr					Bef2Yr					Bef1Yr				
R_SiteType			FormulaApplied	$N_{bimv\text{-}nSG}$	$N'_{bimv(FI)\text{-}nSG}$	$N'_{bimv(PDO)\text{-}nSG}$	$N_{bimv(FI)\text{-}nSG}$	$N_{bimv(PDO)\text{-}nSG}$	$N_{bimv\text{-}nSG}$	$N'_{bimv(FI)\text{-}nSG}$	$N'_{bimv(PDO)\text{-}nSG}$	$N_{bimv(FI)\text{-}nSG}$	$N_{bimv(PDO)\text{-}nSG}$	$N_{bimv\text{-}nSG}$	$N'_{bimv(FI)\text{-}nSG}$	$N'_{bimv(PDO)\text{-}nSG}$	$N_{bimv(FI)\text{-}nSG}$	$N_{bimv(PDO)\text{-}nSG}$
0	IntNum	3	4SG	5.17	1.64	3.34	1.70	3.47	5.29	1.67	3.42	1.74	3.55	5.39	1.71	3.49	1.77	3.62
		9	4SG	22.49	8.05	13.81	8.28	14.21	24.11	8.69	14.76	8.94	15.17	24.80	8.97	15.16	9.22	15.58
		17	4SG	2.62	0.76	1.76	0.79	1.82	2.54	0.74	1.71	0.77	1.77	2.47	0.72	1.66	0.75	1.72
		18	4SG	5.46	1.78	3.48	1.85	3.62	4.86	1.56	3.11	1.62	3.23	4.09	1.30	2.63	1.35	2.74
		19	4SG	2.95	0.87	1.97	0.91	2.05	2.68	0.78	1.80	0.81	1.87	2.40	0.70	1.62	0.72	1.68
		20	4SG	2.93	0.88	1.94	0.91	2.02	2.86	0.85	1.90	0.88	1.97	2.78	0.83	1.85	0.86	1.92
		21	4SG	7.13	2.31	4.57	2.39	4.74	7.28	2.36	4.66	2.45	4.83	7.43	2.42	4.76	2.50	4.93
		22	4SG	25.28	8.97	15.64	9.21	16.07	26.64	9.50	16.45	9.75	16.89	28.02	10.04	17.27	10.30	17.72
		23	4SG	2.57	0.75	1.73	0.78	1.79	2.29	0.66	1.55	0.69	1.60	2.01	0.57	1.37	0.60	1.42
		24	4SG	3.92	1.21	2.56	1.25	2.66	4.06	1.26	2.65	1.30	2.76	3.88	1.20	2.54	1.24	2.63
		25	4SG	6.08	1.91	3.95	1.98	4.10	6.73	2.14	4.36	2.22	4.51	7.40	2.38	4.77	2.46	4.94
		26	4SG	1.96	0.56	1.34	0.58	1.39	1.97	0.56	1.35	0.58	1.39	1.90	0.54	1.30	0.56	1.35
		27	4SG	8.36	2.69	5.40	2.78	5.58	8.36	2.69	5.40	2.78	5.58	8.08	2.59	5.22	2.68	5.40
		28	4SG	5.31	1.67	3.45	1.73	3.58	5.61	1.77	3.64	1.84	3.78	5.61	1.77	3.64	1.84	3.78
		29	4SG	7.22	2.39	4.57	2.48	4.74	7.45	2.48	4.71	2.57	4.88	7.01	2.32	4.43	2.40	4.60
		122	4SG	35.42	13.04	21.55	13.36	22.07	35.85	13.22	21.80	13.53	22.32	35.14	12.94	21.37	13.26	21.88
1	IntNum	1	4SG	7.13	2.34	4.54	2.42	4.71	7.14	2.33	4.56	2.42	4.72	7.14	2.32	4.56	2.41	4.73
		2	4SG	4.79	1.53	3.07	1.60	3.19	4.95	1.59	3.17	1.65	3.30	5.12	1.65	3.28	1.71	3.41
		4	4SG	10.69	3.69	6.63	3.82	6.87	10.99	3.81	6.80	3.95	7.04	11.26	3.93	6.95	4.07	7.19
		5	4SG	9.16	3.17	5.66	3.29	5.87	9.26	3.22	5.70	3.34	5.91	8.92	3.11	5.49	3.22	5.70
		6	4SG	4.48	1.44	2.87	1.50	2.98	5.00	1.62	3.19	1.68	3.32	5.53	1.80	3.52	1.87	3.66
		7	3SG	13.51	3.74	9.00	3.96	9.54	14.19	3.91	9.47	4.15	10.04	14.87	4.08	9.94	4.33	10.54
		8	4SG	16.35	5.60	10.27	5.77	10.58	17.48	5.99	10.99	6.16	11.32	16.26	5.55	10.23	5.71	10.54
		10	4SG	4.67	1.49	3.00	1.54	3.12	5.05	1.62	3.23	1.68	3.36	5.43	1.75	3.47	1.82	3.60
		11	4SG	6.28	2.06	3.99	2.13	4.14	6.12	2.00	3.89	2.08	4.04	5.96	1.94	3.79	2.02	3.94
		12	4SG	13.74	4.90	8.40	5.06	8.68	13.00	4.61	7.96	4.77	8.23	13.57	4.84	8.28	5.00	8.57
		13	4SG	5.55	1.75	3.60	1.82	3.73	5.88	1.87	3.80	1.94	3.94	6.22	1.98	4.01	2.06	4.16
		14	4SG	3.25	0.97	2.16	1.01	2.24	3.08	0.91	2.05	0.95	2.13	2.90	0.86	1.94	0.89	2.01
		15	3SG	27.54	6.53	19.59	6.89	20.65	25.91	6.16	18.43	6.50	19.42	25.50	6.08	18.12	6.41	19.09
		16	3SG	28.77	6.72	20.61	7.08	21.69	26.49	6.25	18.90	6.59	19.91	26.08	6.17	18.59	6.50	19.58
		103	4SG	4.80	1.51	3.11	1.57	3.23	4.76	1.50	3.08	1.56	3.20	4.75	1.50	3.07	1.56	3.19
		109	4SG	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90	21.54	7.69	13.25	7.91	13.63

Aft1Yr					Aft2Yr					Aft3Yr				
$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$
5.12	1.62	3.32	1.68	3.44	4.85	1.53	3.14	1.59	3.26	4.80	1.51	3.11	1.57	3.23
25.50	9.25	15.57	9.51	15.99	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90
2.42	0.70	1.63	0.73	1.69	2.37	0.69	1.60	0.71	1.66	2.36	0.68	1.59	0.71	1.65
3.90	1.24	2.50	1.29	2.61	3.90	1.24	2.50	1.29	2.61	4.01	1.28	2.57	1.33	2.68
2.40	0.69	1.62	0.72	1.68	2.23	0.65	1.50	0.67	1.56	2.19	0.64	1.47	0.66	1.53
2.71	0.80	1.81	0.83	1.88	2.64	0.78	1.76	0.81	1.83	2.64	0.78	1.76	0.81	1.83
6.34	2.03	4.09	2.10	4.24	5.28	1.66	3.43	1.72	3.56	5.29	1.66	3.44	1.72	3.57
31.55	11.46	19.31	11.75	19.80	35.00	12.87	21.30	13.18	21.82	35.42	13.04	21.55	13.36	22.07
2.06	0.59	1.39	0.61	1.45	2.10	0.60	1.42	0.62	1.47	2.12	0.61	1.44	0.63	1.49
3.70	1.14	2.42	1.18	2.52	3.72	1.14	2.44	1.19	2.53	3.75	1.15	2.46	1.20	2.55
6.76	2.15	4.38	2.22	4.53	6.11	1.92	3.98	1.99	4.12	6.29	1.98	4.09	2.05	4.23
1.83	0.52	1.25	0.53	1.30	1.91	0.54	1.30	0.56	1.35	1.98	0.56	1.35	0.58	1.40
7.81	2.50	5.05	2.59	5.22	7.95	2.55	5.15	2.63	5.32	8.09	2.59	5.24	2.68	5.42
5.61	1.77	3.64	1.84	3.78	5.64	1.77	3.67	1.84	3.80	5.64	1.77	3.68	1.83	3.81
6.57	2.16	4.17	2.24	4.33	6.80	2.24	4.30	2.33	4.47	7.02	2.33	4.44	2.42	4.61
34.43	12.67	20.94	12.98	21.45	35.35	13.03	21.49	13.34	22.01	36.28	13.39	22.04	13.71	22.57
6.68	2.17	4.27	2.25	4.43	6.22	2.01	3.98	2.09	4.13	6.03	1.95	3.86	2.02	4.01
5.10	1.63	3.27	1.70	3.40	5.07	1.62	3.26	1.68	3.38	5.05	1.62	3.25	1.68	3.37
10.46	3.64	6.46	3.77	6.69	11.42	3.93	7.11	4.06	7.36	12.44	4.26	7.78	4.41	8.04
8.57	2.99	5.27	3.10	5.47	8.43	2.92	5.20	3.03	5.40	8.26	2.85	5.11	2.96	5.30
5.19	1.68	3.31	1.75	3.44	4.85	1.56	3.10	1.63	3.22	4.83	1.55	3.09	1.61	3.21
14.87	4.08	9.94	4.33	10.54	14.87	4.08	9.94	4.33	10.54	14.42	3.97	9.63	4.21	10.21
15.04	5.11	9.48	5.27	9.77	14.85	5.04	9.36	5.19	9.65	14.65	4.97	9.25	5.12	9.53
5.05	1.62	3.24	1.69	3.37	4.84	1.54	3.12	1.60	3.24	4.71	1.49	3.04	1.55	3.16
5.76	1.88	3.67	1.95	3.81	5.56	1.81	3.54	1.88	3.68	5.57	1.81	3.55	1.88	3.69
14.77	5.28	9.01	5.46	9.31	14.97	5.34	9.16	5.51	9.46	15.11	5.37	9.26	5.55	9.57
5.91	1.88	3.83	1.95	3.97	5.61	1.77	3.64	1.84	3.78	5.91	1.88	3.83	1.95	3.97
2.92	0.86	1.95	0.90	2.02	2.93	0.87	1.95	0.90	2.03	2.94	0.87	1.97	0.90	2.04
25.09	5.99	17.81	6.32	18.77	25.44	6.08	18.06	6.41	19.03	25.78	6.17	18.29	6.50	19.28
25.66	6.08	18.28	6.41	19.26	25.82	6.14	18.36	6.47	19.35	25.94	6.19	18.42	6.53	19.42
4.74	1.50	3.07	1.55	3.19	4.76	1.50	3.08	1.56	3.20	4.78	1.51	3.09	1.57	3.21
22.40	8.05	13.73	8.28	14.12	21.08	7.55	12.93	7.77	13.31	20.21	7.20	12.42	7.42	12.79

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

STEP 2 CALCULATE EXPECTED CRASH FREQUENCY BY SITE FOR ENTIRE BEFORE PERIOD

$N_{expected,B} = w_{i,B}*N_{predicted,B,i} + (1 - w_{i,B})*N_{observed,B}$

$w_{i,B} = 1 / [1 + k*sum(N_{predicted,B,i})$ over all years

$N_{pred,bi} = N_{bimv}*(CMF_{1i}*\ldots*CMF_{6i})*C_i$

Note: if CMF or C unknown, assume 1.00.

R_SiteType			Formula Applied	BefAllYrs			BefAllYrs			BefAllYrs	
				$N_{bimv\text{-}nSG}$	$N_{bimv(FI)\text{-}nSG}$	$N_{bimv(PDO)\text{-}nSG}$	$N_{pred,bi}$	$N_{pred,bi(FI)}$	$N_{pred,bi(PDO)}$	$w_{i,B}$	$N_{expected,B}$
0	IntNum	3	4SG	15.85	5.21	10.64	56.11	18.44	37.67	0.14	21.59
		9	4SG	71.40	26.44	44.96	174.75	64.70	110.05	0.03	19.57
		17	4SG	7.63	2.31	5.32	28.14	8.51	19.63	0.25	28.04
		18	4SG	14.41	4.83	9.59	48.90	16.37	32.53	0.15	28.61
		19	4SG	8.03	2.44	5.59	29.63	9.00	20.63	0.24	21.57
		20	4SG	8.57	2.65	5.91	26.86	8.32	18.54	0.23	11.57
		21	4SG	21.84	7.34	14.50	67.10	22.55	44.55	0.11	17.79
		22	4SG	79.95	29.27	50.68	268.55	98.31	170.24	0.03	17.07
		23	4SG	6.88	2.06	4.81	24.34	7.30	17.05	0.27	15.35
		24	4SG	11.85	3.80	8.05	33.99	10.90	23.09	0.18	16.73
		25	4SG	20.21	6.66	13.55	71.54	23.57	47.97	0.11	23.14
		26	4SG	5.84	1.71	4.13	21.54	6.32	15.22	0.31	12.13
		27	4SG	24.80	8.24	16.56	60.60	20.13	40.47	0.09	17.46
		28	4SG	16.54	5.41	11.13	50.82	16.61	34.21	0.13	18.08
		29	4SG	21.68	7.45	14.22	66.60	22.90	43.70	0.11	23.14
		122	4SG	106.41	40.14	66.27	357.46	134.85	222.61	0.02	22.08
1	IntNum	1	4SG	21.41	7.25	14.16	77.39	26.21	51.18	0.11	32.39
		2	4SG	14.86	4.96	9.90	52.62	17.57	35.05	0.15	29.92
		4	4SG	32.94	11.84	21.11	103.73	37.27	66.46	0.07	18.62
		5	4SG	27.34	9.86	17.48	60.22	21.71	38.51	0.09	11.56
		6	4SG	15.01	5.05	9.96	41.58	13.99	27.59	0.15	12.04
		7	3SG	42.57	12.44	30.13	94.71	27.68	67.03	0.07	24.03
		8	4SG	50.09	17.64	32.45	122.59	43.18	79.41	0.05	23.09
		10	4SG	15.14	5.05	10.09	42.56	14.20	28.36	0.14	13.86
		11	4SG	18.36	6.23	12.13	54.89	18.63	36.25	0.12	12.87
		12	4SG	40.31	14.83	25.48	100.48	36.97	63.51	0.06	17.29
		13	4SG	17.64	5.81	11.83	48.87	16.09	32.77	0.13	26.28
		14	4SG	9.23	2.85	6.38	30.72	9.48	21.24	0.22	12.94
		15	3SG	78.95	19.79	59.16	190.92	47.86	143.06	0.04	15.72
		16	3SG	81.34	20.16	61.18	188.84	46.81	142.03	0.04	19.32
		103	4SG	14.32	4.69	9.62	50.68	16.61	34.07	0.15	28.90
		109	4SG	64.75	23.78	40.97	158.47	58.19	100.28	0.04	18.54

EB ESTIMATION IN AFTER PERIOD

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

STEP 3 CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR AFTER TREATMENT

R_SiteType			Formula Applied	AftAllYrs			AftAllYrs		
				$N_{aimv\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	$N_{pred,ai}$	$N_{pred,ai(FI)}$	$N_{pred,ai(PDO)}$
0	IntNum	3	4SG	14.77	4.84	9.93	52.30	17.13	35.16
		9	4SG	68.70	25.37	43.33	168.15	62.10	106.06
		17	4SG	7.15	2.15	5.00	26.38	7.94	18.44
		18	4SG	11.81	3.92	7.89	40.08	13.30	26.78
		19	4SG	6.82	2.05	4.77	25.15	7.57	17.58
		20	4SG	7.98	2.45	5.53	25.02	7.69	17.33
		21	4SG	16.92	5.55	11.37	51.97	17.05	34.93
		22	4SG	101.97	38.28	63.69	342.53	128.60	213.92
		23	4SG	6.28	1.86	4.41	22.22	6.59	15.63
		24	4SG	11.17	3.57	7.60	32.03	10.23	21.80
		25	4SG	19.15	6.27	12.89	67.82	22.20	45.62
		26	4SG	5.72	1.68	4.05	21.11	6.18	14.93
		27	4SG	23.86	7.90	15.96	58.29	19.29	39.00
		28	4SG	16.90	5.51	11.39	51.92	16.93	35.00
		29	4SG	20.39	6.99	13.40	62.63	21.47	41.16
		122	4SG	106.06	40.03	66.03	356.25	134.46	221.79
1	IntNum	1	4SG	18.93	6.36	12.57	68.43	22.98	45.45
		2	4SG	15.22	5.06	10.16	53.88	17.92	35.96
		4	4SG	34.32	12.24	22.08	108.07	38.53	69.54
		5	4SG	25.27	9.09	16.18	55.65	20.02	35.63
		6	4SG	14.86	4.99	9.87	41.16	13.82	27.35
		7	3SG	44.17	12.87	31.29	98.26	28.64	69.63
		8	4SG	44.54	15.58	28.95	109.01	38.14	70.87
		10	4SG	14.60	4.83	9.76	41.03	13.59	27.44
		11	4SG	16.89	5.71	11.18	50.50	17.07	33.43
		12	4SG	44.85	16.51	28.34	111.81	41.17	70.64
		13	4SG	17.44	5.73	11.71	48.31	15.88	32.43
		14	4SG	8.78	2.70	6.09	29.24	8.97	20.26
		15	3SG	76.31	19.23	57.09	184.55	46.50	138.05
		16	3SG	77.42	19.40	58.02	179.74	45.04	134.70
		103	4SG	14.28	4.68	9.60	50.56	16.57	33.99
		109	4SG	63.69	23.47	40.22	155.89	57.43	98.45

ESTIMATION OF TREATED EFFECTIVENESS

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

STEP 4 CALCULATE AN ADJUSTMENT FACTOR (ri) FOR DIFFERENCES BETWEEN BEFORE & AFTER PERIODS

STEP 5 CALCULATE EXPECTED CRASH FREQUENCY BY SITE FOR ENTIRE AFTER PERIOD IN ABSENCE OF TREATMENT

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

STEP 6 ESTIMATE SAFETY EFFECTIVENESS AT EACH SITE VIA ODDS RATIO (theta)

STEP 7 ESTIMATE SAFETY EFFECTIVENESS AT EACH SITE AS A PERCENTAGE CRASH CHANGE

ri	$N_{expected,A}$	theta_i	SafeEff_i
0.932	20.12	0.944	5.55
0.962	18.83	0.850	15.05
0.938	26.29	0.913	8.70
0.820	23.45	0.810	18.98
0.849	18.31	1.256	-25.61
0.932	10.78	0.742	25.81
0.775	13.78	0.943	5.66
1.275	21.77	0.322	67.84
0.913	14.01	0.928	7.24
0.942	15.77	0.444	55.61
0.948	21.94	0.547	45.30
0.980	11.89	2.187	-118.66
0.962	16.79	0.655	34.50
1.022	18.47	0.758	24.19
0.940	21.76	0.460	54.04
0.997	22.01	0.409	59.10
0.884	28.64	0.105	89.52
1.024	30.63	0.849	15.12
1.042	19.40	0.258	74.23
0.924	10.69	0.187	81.28
0.990	11.92	0.503	49.69
1.038	24.93	0.922	7.75
0.889	20.53	0.341	65.91
0.964	13.36	0.225	77.55
0.920	11.84	0.084	91.55
1.113	19.24	0.260	74.02
0.989	25.98	0.269	73.06
0.952	12.32	0.812	18.80
0.967	15.20	0.263	73.68
0.952	18.39	0.163	83.68
0.998	28.83	0.486	51.44
0.984	18.24	0.439	56.14

ri = sum($N_{predicted,A,i}$)over after years / sum($N_{predicted,B,i}$)over before years

$N_{expected,A}$ = ri*$N_{expected,B}$

theta_i = $N_{observed,A}$/$N_{expected,A}$

SafeEff_i = 100*(1-omega_i)

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

STEP 8 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT (ODDS RATIO omega') FOR ALL SITES COMBINED

R_SiteType	omega'
0 All Ints	0.78
1 All Ints	0.41

omega' = sum($N_{observed,A}$)all sites / sum($N_{expected,A}$)all sites

STEP 9 ADJUST ODDS RATIO TO OBTAIN UNBIASED ESTIMATE OF TREATMENT EFFECTIVENESS

R_SiteType	Var(Nexpected,A,all)	omega
0 All Ints	243.14	0.78
1 All Ints	273.72	0.41

Var(Nexpected,A,all) = sum[(ri^2)*$N_{expected,B}$ * (1-$w_{i,B}$)] over all sites

omega = omega' / {1+[var($N_{expected,A,all}$)] / [$N_{expected,A,all}$]^2}

STEP 10 CALCULATE OVERALL UNBIASED SAFETY EFFECTIVENESS AS A PERCENT CHANGE IN CRASH FREQUENCY ACROSS ALL SITES

R_SiteType	Safety Effectiveness
0 All Ints	22.17
1 All Ints	59.17

Safety Effectiveness = 100*(1 - omega)

ESTIMATION OF PRECISION OF TREATED EFFECTIVENESS

STEP 11 CALCULATE VARIANCE OF UNBIASED ESTIMATED SAFETY EFFECTIVENESS AS AN ODDS RATIO

R_SiteType	$N_{observed,A,all\ sites}$	$N_{expected,A,all\ sites}$	var(omega)
0 All Ints	231	295.97	0.00432
1 All Ints	127	310.15	0.00179

var(omega) = {omega'^2 *
[(1/$N_{observed,A}$) + (var{sum[$N_{expected,A}$]over all sites}/(sum[$N_{expected,A}$]over all sites)^2)] /
[1 + (var{sum[$N_{expected,A}$] over all sites} / (sum[$N_{expected,A}$]over all sites)^2)]

STEP 12 CALCULATE STANDARD ERROR OF THE STEP 11 ODDS RATIO

R_SiteType	SE(omega)
0 All Ints	0.07
1 All Ints	0.04

SE(omega) = sqrt[var(omega)]

STEP 13 CALCULATE STANDARD ERROR OF THE STEP 10 UNBIASED SAFETY EFFECTIVENESS

R_SiteType	SE(Safety Effectiveness)
0 All Ints	6.57
1 All Ints	4.23

SE(Safety Effectiveness) =100 * SE(omega)

STEP 14 ASSESS STATISTICAL SIGNIFICANCE OF ESTIMATED SAFETY EFFECTIVENESS

R_SiteType	Performance Measure
0 All Ints	3.37
1 All Ints	13.98

Performance Measure = ABS[Safety Effectiveness / SE(Safety Effectiveness)]

PM < 1.7 Treatment Effect NOT significant at the (approx.) 90% confidence interval
PM >= 1.7 Treatment Effect IS significant at the (approx.) 90% confidence interval
PM >= 2.0 Treatment Effect IS significant at the (approx.) 95% confidence interval

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APPENDIX H. COMPUTATIONS: BEFORE-AFTER COMPARISON-GROUP SAFETY EVALUATION

COMPARISON GROUP BEFORE-AFTER OBSERVATIONAL STUDY

Following the Highway Safety Manual Procedure in Chapter 9, see Figure 9-3.

INPUT DATA FOR BEFORE-AFTER ANALYSIS

STEP 0a OUTPUT FROM SPSS, OBSERVED CRASH FREQUENCY BY SITE BY YEAR BEFORE AND AFTER TREATMENT (crosstabulations)

STEP 0b PULL DATA FROM OTHER SHEETS (such as intersection and traffic volume data)

ESTIMATION OF MEAN TREATMENT EFFECTIVENESS

STEP 1 CALCULATE PREDICTED CRASH FREQUENCY BY TREATMENT SITE FOR BEFORE & AFTER PERIODS

STEP 2 CALCULATE PREDICTED CRASH FREQUENCY BY COMPARISON SITE FOR BEFORE & AFTER PERIODS

STEP 3 CALCULATE ADJUSTMENT FACTOR FOR EACH COMBINATION OF TREATMENT & COMPARISON SITE, SEPARATELY FOR BEFORE & AFTER PE

STEP 4 CALCULATE EXPECTED AVERAGE CRASH FREQUENCY (ADJUSTED CRASH FREQUENCY) FOR EACH COMBINATION, SEPARATELY FOR BEFO

STEP 5 CALCULATE TOTAL COMPARISON GROUP ADJUSTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN BEFORE PERIOD

STEP 6 CALCULATE TOTAL COMPARISON GROUP ADJUSTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN AFTER PERIOD

STEP 7 CALCULATE COMPARISON RATIO FOR EACH TREATMENT SITE

STEP 8 CALCULATE EXPECTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN THE AFTER PERIOD, HAD NO TREATMENT BEEN IMPLEMENT

STEP 9 CALCULATE SAFETY EFFECTIVENESS EXPRESSED AS AN ODDS RATIO AT AN INDIVIDUAL TREATMENT SITE

STEP 10 CALCULATE LOG ODDS RATIO FOR EACH TREATMENT SITE

STEP 11 CALCULATE WEIGHT FOR EACH TREATMENT SITE

STEP 12 CALCULATE WEIGHTED AVERAGE LOG ODDS RATIO ACROSS ALL TREATMENT SITES

STEP 13 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT EXPRESSED AS AN ODDS RATIO

STEP 14 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT EXPRESSED AS A PERCENTAGE CHANGE IN CRASH FREQUENCY

ESTIMATION OF PRECISION OF TREATMENT EFFECTIVENESS

STEP 15 CALCULATE STANDARD ERROR OF TREATMENT EFFECTIVENESS

STEP 16 ASSESS STATISTICAL SIGNIFICANCE OF ESTIMATED SAFETY EFFECTIVENESS

INPUT DATA FOR BEFORE-AFTER ANALYSIS

STEP 0a OUTPUT FROM SPSS, OBSERVED CRASH FREQUENCY BY SITE BY YEAR BEFORE AND AFTER TREATMENT (crosstabulations)

ERIODS
RE & AFTER
ED

IntNum * Bef3 * R_SiteType Crosstabulation

Count

R_SiteType			Bef3		Total
			-3	0	
0	IntNum	3	5	59	64
		9	8	36	44
		17	15	42	57
		18	10	43	53
		19	6	41	47
		20	3	18	21
		21	3	44	47
		22	3	36	39
		23	5	26	31
		24	4	24	28
		25	5	52	57
		26	1	35	36
		27	2	22	24
		28	1	26	27
		29	6	24	30
		122	3	36	39
	Total		80	564	644
1	IntNum	1	10	25	35
		2	9	51	60
		4	4	19	23
		5	4	15	19
		6	3	18	21
		7	6	42	48
		8	6	26	32
		10	3	11	14
		11	4	8	12
		12	5	13	18
		13	7	27	34
		14	3	19	22
		15	2	13	15
		16	11	8	19
		103	8	70	78
		109	3	49	52
	Total		88	414	502

IntNum * Bef2 * R_SiteType Crosstabulation

Count

R_SiteType			Bef2		Total
			-2	0	
0	IntNum	3	5	59	64
		9	2	42	44
		17	5	52	57
		18	7	46	53
		19	8	39	47
		20	2	19	21
		21	4	43	47
		22	3	36	39
		23	2	29	31
		24	4	24	28
		25	7	50	57
		26	4	32	36
		27	5	19	24
		28	4	23	27
		29	4	26	30
		122	6	33	39
	Total		72	572	644
1	IntNum	1	11	24	35
		2	8	52	60
		4	5	18	23
		5	3	16	19
		6	3	18	21
		7	9	39	48
		8	7	25	32
		10	5	9	14
		11	2	10	12
		12	3	15	18
		13	11	23	34
		14	5	17	22
		15	3	12	15
		16	1	18	19
		103	12	66	78
		109	8	44	52
	Total		96	406	502

IntNum * Bef1 * R_SiteType Crosstabulation

Count

R_SiteType			Bef1		Total
			-1	0	
0	IntNum	3	6	58	64
		9	4	40	44
		17	8	49	57
		18	8	45	53
		19	5	42	47
		20	2	19	21
		21	5	42	47
		22	3	36	39
		23	5	26	31
		24	5	23	28
		25	5	52	57
		26	3	33	36
		27	6	18	24
		28	8	19	27
		29	8	22	30
		122	5	34	39
	Total		86	558	644
1	IntNum	1	6	29	35
		2	9	51	60
		4	3	20	23
		5	0	19	19
		6	1	20	21
		7	4	44	48
		8	5	27	32
		10	1	13	14
		11	1	11	12
		12	4	14	18
		13	5	29	34
		14	0	22	22
		15	4	11	15
		16	1	18	19
		103	5	73	78
		109	2	50	52
	Total		51	451	502

IntNum * Aft1 * R_SiteType Crosstabulation

Count

R_SiteType			Aft1		Total
			0	1	
0	IntNum	3	55	9	64
		9	37	7	44
		17	47	10	57
		18	49	4	53
		19	36	11	47
		20	18	3	21
		21	45	2	47
		22	37	2	39
		23	26	5	31
		24	28	0	28
		25	54	3	57
		26	29	7	36
		27	20	4	24
		28	26	1	27
		29	25	5	30
		122	35	4	39
	Total		567	77	644
1	IntNum	1	34	1	35
		2	50	10	60
		4	20	3	23
		5	18	1	19
		6	17	4	21
		7	36	12	48
		8	29	3	32
		10	12	2	14
		11	11	1	12
		12	16	2	18
		13	29	5	34
		14	19	3	22
		15	14	1	15
		16	18	1	19
		103	75	3	78
		109	51	1	52
	Total		449	53	502

IntNum * Aft2 * R_SiteType Crosstabulation

Count

R_SiteType			Aft2		Total
			0	2	
0	IntNum	3	58	6	64
		9	40	4	44
		17	50	7	57
		18	46	7	53
		19	41	6	47
		20	20	1	21
		21	40	7	47
		22	36	3	39
		23	26	5	31
		24	24	4	28
		25	52	5	57
		26	29	7	36
		27	19	5	24
		28	20	7	27
		29	25	5	30
		122	35	4	39
	Total		561	83	644
1	IntNum	1	34	1	35
		2	52	8	60
		4	22	1	23
		5	19	0	19
		6	21	0	21
		7	42	6	48
		8	29	3	32
		10	13	1	14
		11	12	0	12
		12	17	1	18
		13	33	1	34
		14	18	4	22
		15	14	1	15
		16	18	1	19
		103	75	3	78
		109	50	2	52
	Total		469	33	502

IntNum * Aft3 * R_SiteType Crosstabulation

Count

R_SiteType			Aft3		Total
			0	3	
0	IntNum	3	60	4	64
		9	39	5	44
		17	50	7	57
		18	45	8	53
		19	41	6	47
		20	17	4	21
		21	43	4	47
		22	37	2	39
		23	28	3	31
		24	25	3	28
		25	53	4	57
		26	24	12	36
		27	22	2	24
		28	21	6	27
		29	30	0	30
		122	38	1	39
	Total		573	71	644
1	IntNum	1	34	1	35
		2	52	8	60
		4	22	1	23
		5	18	1	19
		6	19	2	21
		7	43	5	48
		8	31	1	32
		10	14	0	14
		11	12	0	12
		12	16	2	18
		13	33	1	34
		14	19	3	22
		15	13	2	15
		16	18	1	19
		103	70	8	78
		109	47	5	52
	Total		461	41	502

STEP 0b INTERSECTION DATA: AADTs, Geometry, Signal Ops
pulled from sheet 4-Ints_AADTs

IntNum * InjuryYes * R_SiteType Crosstabulation

Count

R_SiteType			InjuryYes 0	1	99	Total
0	IntNum	3	42	19	3	64
		9	14	28	0	42
		17	29	22	6	57
		18	38	12	3	53
		19	28	19	0	47
		20	14	7	0	21
		21	29	14	4	47
		22	21	17	1	39
		23	21	6	4	31
		24	11	14	3	28
		25	28	28	1	57
		26	25	11	0	36
		27	15	9	0	24
		28	9	17	0	26
		29	18	10	2	30
		122	21	17	1	39
	Total		363	250	28	641
1	IntNum	1	23	12	0	35
		2	30	26	4	60
		4	15	8	0	23
		5	13	6	0	19
		6	14	3	4	21
		7	25	19	3	47
		8	22	8	2	32
		10	12	2	0	14
		11	11	0	1	12
		12	7	11	0	18
		13	13	20	1	34
		14	14	7	1	22
		15	5	8	1	14
		16	10	9	0	19
		103	53	21	4	78
		109	17	32	1	50
	Total		284	192	22	498

IntNum * PDO * R_SiteType Crosstabulation

Count

R_SiteType			PDO 1	Total
0	IntNum	3	42	42
		9	14	14
		17	29	29
		18	38	38
		19	28	28
		20	14	14
		21	29	29
		22	21	21
		23	21	21
		24	11	11
		25	28	28
		26	25	25
		27	15	15
		28	9	9
		29	18	18
		122	21	21
	Total		363	363
1	IntNum	1	23	23
		2	30	30
		4	15	15
		5	13	13
		6	14	14
		7	25	25
		8	22	22
		10	12	12
		11	11	11
		12	7	7
		13	13	13
		14	14	14
		15	5	5
		16	10	10
		103	53	53
		109	17	17
	Total		284	284

vlookup column >>			2	3	4	5	6	7	9	10	11	12	13	14
			AADTmaj						AADTmin					
R_SiteType			Bef3Yr	Bef2Yr	Bef1Yr	Aft1Yr	Aft2Yr	Aft3Yr	Bef3Yr	Bef2Yr	Bef1Yr	Aft1Yr	Aft2Yr	Aft3Yr
0	IntNum	3	20000	20000	20000	19500	19000	19000	7000	7700	8400	7550	6700	6450
		9	65500	70000	72000	74000	67000	60000	16740	16625	16510	16395	16280	16165
		17	9800	9650	9500	9300	9100	9100	10000	9500	9000	9100	9200	9050
		18	24000	21500	19000	19000	19000	19500	3810	3810	3210	2610	2610	2610
		19	11000	10050	9100	9100	9100	8950	9860	9860	9765	9670	7050	7050
		20	11800	11500	11200	10900	10600	10600	6880	6953	7025	7098	7170	7170
		21	25000	25500	26000	22500	19000	19000	10000	10000	10000	9850	9700	9850
		22	64000	67000	70000	79000	88000	89000	31000	31500	32000	30500	29000	29000
		23	9800	8800	7800	7950	8100	8200	9260	9260	9260	9260	9260	9260
		24	15500	16000	15500	15000	15000	15000	6850	6900	6550	6200	6400	6600
		25	20000	22000	24000	22000	20000	20500	14120	14120	14240	14360	14480	14600
		26	7450	7500	7250	7000	7250	7500	10210	10210	10210	10210	10295	10380
		27	25000	25000	24500	24000	24000	24000	20000	20000	19000	18000	19500	21000
		28	19000	20000	20000	20000	19500	19000	10000	10000	10000	10000	11500	13000
		29	29000	30000	28500	27000	28000	29000	5300	5200	5050	4900	4800	4700
		122	89000	90000	89000	88000	89500	91000	29000	29000	28000	27000	28000	29000
1	IntNum	1	27000	26500	26000	25000	24000	23500	7000	7700	8400	7550	6700	6450
		2	21000	21500	22000	21500	21000	21000	4000	4150	4300	4700	5100	5050
		4	42000	44000	46000	44000	42000	42000	5210	4747	4283	3820	6955	10090
		5	41000	43000	42500	42000	40500	39000	2983	2500	2250	2000	2200	2400
		6	21000	22500	24000	23000	22000	21500	3000	3500	4000	3700	3400	3700
		7	66000	69000	72000	72000	72000	70000	10810	10810	10810	10810	10810	10810
		8	45000	46000	44000	42000	41500	41000	24000	29000	26000	23000	23000	23000
		10	20000	21500	23000	21500	20000	19500	4480	4497	4513	4530	5230	5230
		11	26000	25500	25000	24500	24000	24000	4800	4700	4600	4350	4100	4150
		12	55500	53000	55500	58000	57000	56000	4250	4135	4020	4735	5450	6165
		13	20000	21000	22000	21000	20000	21000	9500	9750	10000	10000	10000	10000
		14	12000	11500	11000	11000	11000	11000	10000	9600	9200	9350	9500	9750
		15	90500	85000	84000	83000	84500	86000	43500	45000	44500	44000	43000	42000
		16	90500	85000	84000	83000	84500	86000	51500	49000	48500	48000	45500	43000
		103	19000	19000	19000	19000	19000	19000	6450	6200	6150	6100	6200	6300
		109	67000	60000	63500	67000	64500	62000	16280	16165	16050	14815	13580	13580

InjuryStatusUn	1 fatal
InjuryStatusUn	2 injury
TAD_Unit1Ar	3 injury
TAD_Unit2Ar	4 injury
	5 no injury
	6 unknown

BASE CASE, ALL CMF, C = 1.00

pulled from sheet 2-Intersections_prepped

Step 1b Determine Crash Modification Factors (CMFs) and Calibration Factors (Ci) for each intersection for each year

vlookup column >>		5	6	296	299	300	297	301														
				for CMF_1i	for CMF_2i		for CMF_3i	n_prohib			N_{bisv}											
R_SiteType		Approaches	Legs	AppsWLeftLns	AppsWLeftProt	LeftProtPerm	AppsWRgtLns	AppsRTORprohib	Bef3Yr	Bef2Yr	Bef1Yr	Aft1Yr	Aft2Yr	Aft3Yr	RLC	CMF_1i	CMF_2i	CMF_3i	CMF_4i	CMF_5i	CMF_6i	Ci
0 IntNum	3	2	4	0	0	0	1	0	0.34	0.35	0.35	0.34	0.32	0.32	0	1	1	1	1	1		1
	9	4	4	0	4	0	4	0	0.96	1.00	1.02	1.03	0.97	0.89	0	1	1	1	1	1		1
	17	2	4	0	0	0	0	0	0.23	0.22	0.22	0.22	0.21	0.21	0	1	1	1	1	1		1
	18	4	4	0	0	0	2	0	0.32	0.30	0.26	0.25	0.25	0.25	0	1	1	1	1	1		1
	19	3	4	0	0	0	0	0	0.25	0.23	0.22	0.22	0.20	0.20	0	1	1	1	1	1		1
	20	4	4	0	0	0	4	0	0.23	0.23	0.23	0.22	0.22	0.22	0	1	1	1	1	1		1
	21	4	4	0	0	2	4	0	0.43	0.44	0.44	0.40	0.36	0.36	0	1	1	1	1	1		1
	22	3	4	0	0	1	2	0	1.11	1.15	1.19	1.28	1.36	1.37	0	1	1	1	1	1		1
	23	2	4	0	0	0	1	0	0.22	0.21	0.19	0.19	0.20	0.20	0	1	1	1	1	1		1
	24	4	4	0	2	0	3	0	0.28	0.29	0.28	0.27	0.27	0.27	0	1	1	1	1	1		1
	25	3	4	0	0	0	1	0	0.41	0.44	0.46	0.44	0.41	0.42	0	1	1	1	1	1		1
	26	2	4	0	0	0	0	0	0.19	0.19	0.19	0.18	0.19	0.19	0	1	1	1	1	1		1
	27	4	4	1	2	2	4	0	0.52	0.52	0.51	0.49	0.50	0.51	0	1	1	1	1	1		1
	28	4	4	0	0	2	4	0	0.36	0.37	0.37	0.37	0.38	0.39	0	1	1	1	1	1		1
	29	4	4	0	0	0	4	1	0.40	0.41	0.39	0.38	0.38	0.39	0	1	1	1	1	1		1
	122	3	4	0	0	1	2	0	1.37	1.38	1.36	1.33	1.36	1.39	0	1	1	1	1	1		1
1 IntNum	1	2	4	0	0	0	0	1	0.41	0.42	0.42	0.40	0.38	0.37	1	1	1	1	1	1		1
	2	2	4	0	0	0	1	0	0.30	0.31	0.32	0.32	0.32	0.32	1	1	1	1	1	1		1
	4	4	4	0	0	1	3	1	0.52	0.52	0.52	0.49	0.56	0.62	1	1	1	1	1	1		1
	5	4	4	1	4	0	4	0	0.44	0.43	0.42	0.40	0.40	0.40	1	1	1	1	1	1		1
	6	4	4	0	2	0	4	0	0.28	0.30	0.33	0.31	0.30	0.30	1	1	1	1	1	1		1
	7	3	3	0	1	0	2	0	0.53	0.54	0.54	0.54	0.54	0.54	1	1	1	1	1	1		1
	8	4	4	0	4	0	4	0	0.82	0.87	0.82	0.77	0.77	0.76	1	1	1	1	1	1		1
	10	4	4	0	2	2	3	0	0.30	0.31	0.33	0.32	0.31	0.31	1	1	1	1	1	1		1
	11	4	4	0	1	0	3	1	0.36	0.36	0.35	0.34	0.33	0.33	1	1	1	1	1	1		1
	12	4	4	1	2	0	4	0	0.59	0.57	0.58	0.63	0.64	0.66	1	1	1	1	1	1		1
	13	4	4	0	2	0	4	0	0.37	0.38	0.40	0.38	0.37	0.38	1	1	1	1	1	1		1
	14	3	4	0	1	0	1	0	0.26	0.25	0.24	0.24	0.24	0.25	1	1	1	1	1	1		1
	15	2	3	0	1	0	0	0	1.05	1.03	1.02	1.01	1.01	1.01	1	1	1	1	1	1		1
	16	2	3	0	1	0	1	0	1.12	1.07	1.06	1.05	1.04	1.02	1	1	1	1	1	1		1
	103	2	4	0	0	0	1	0	0.32	0.32	0.32	0.31	0.32	0.32	1	1	1	1	1	1		1
	109	4	4	0	4	0	4	0	0.97	0.89	0.93	0.94	0.90	0.87	1	1	1	1	1	1		1

ESTIMATION OF MEAN TREATMENT EFFECTIVENESS

BASE CASE, ALL CMF, C = 1.00

STEPS 1b & 2b CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR BEFORE TREATMENT

Step 2.b.1 Calculate Safety Performance Functions for each COMPARISON intersection for each BEFORE year

Step 1.b.1 Calculate Safety Performance Functions for each TREATMENT intersection for each BEFORE year

R_SiteType			FormulaApplied	Bef3Yr					Bef2Yr					Bef1Yr				
				$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$	$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$	$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$
0	IntNum	3	4SG	5.17	1.64	3.34	1.70	3.47	5.29	1.67	3.42	1.74	3.55	5.39	1.71	3.49	1.77	3.62
		9	4SG	22.49	8.05	13.81	8.28	14.21	24.11	8.69	14.76	8.94	15.17	24.80	8.97	15.16	9.22	15.58
		17	4SG	2.62	0.76	1.76	0.79	1.82	2.54	0.74	1.71	0.77	1.77	2.47	0.72	1.66	0.75	1.72
		18	4SG	5.46	1.78	3.48	1.85	3.62	4.86	1.56	3.11	1.62	3.23	4.09	1.30	2.63	1.35	2.74
		19	4SG	2.95	0.87	1.97	0.91	2.05	2.68	0.78	1.80	0.81	1.87	2.40	0.70	1.62	0.72	1.68
		20	4SG	2.93	0.88	1.94	0.91	2.02	2.86	0.85	1.90	0.88	1.97	2.78	0.83	1.85	0.86	1.92
		21	4SG	7.13	2.31	4.57	2.39	4.74	7.28	2.36	4.66	2.45	4.83	7.43	2.42	4.76	2.50	4.93
		22	4SG	25.28	8.97	15.64	9.21	16.07	26.64	9.50	16.45	9.75	16.89	28.02	10.04	17.27	10.30	17.72
		23	4SG	2.57	0.75	1.73	0.78	1.79	2.29	0.66	1.55	0.69	1.60	2.01	0.57	1.37	0.60	1.42
		24	4SG	3.92	1.21	2.56	1.25	2.66	4.06	1.26	2.65	1.30	2.76	3.88	1.20	2.54	1.24	2.63
		25	4SG	6.08	1.91	3.95	1.98	4.10	6.73	2.14	4.36	2.22	4.51	7.40	2.38	4.77	2.46	4.94
		26	4SG	1.96	0.56	1.34	0.58	1.39	1.97	0.56	1.35	0.58	1.39	1.90	0.54	1.30	0.56	1.35
		27	4SG	8.36	2.69	5.40	2.78	5.58	8.36	2.69	5.40	2.78	5.58	8.08	2.59	5.22	2.68	5.40
		28	4SG	5.31	1.67	3.45	1.73	3.58	5.61	1.77	3.64	1.84	3.78	5.61	1.77	3.64	1.84	3.78
		29	4SG	7.22	2.39	4.57	2.48	4.74	7.45	2.48	4.71	2.57	4.88	7.01	2.32	4.43	2.40	4.60
		122	4SG	35.42	13.04	21.55	13.36	22.07	35.85	13.22	21.80	13.53	22.32	35.14	12.94	21.37	13.26	21.88
1	IntNum	1	4SG	7.13	2.34	4.54	2.42	4.71	7.14	2.33	4.56	2.42	4.72	7.14	2.32	4.56	2.41	4.73
		2	4SG	4.79	1.53	3.07	1.60	3.19	4.95	1.59	3.17	1.65	3.30	5.12	1.65	3.28	1.71	3.41
		4	4SG	10.69	3.69	6.63	3.82	6.87	10.99	3.81	6.80	3.95	7.04	11.26	3.93	6.95	4.07	7.19
		5	4SG	9.16	3.17	5.66	3.29	5.87	9.26	3.22	5.70	3.34	5.91	8.92	3.11	5.49	3.22	5.70
		6	4SG	4.48	1.44	2.87	1.50	2.98	5.00	1.62	3.19	1.68	3.32	5.53	1.80	3.52	1.87	3.66
		7	3SG	13.51	3.74	9.00	3.96	9.54	14.19	3.91	9.47	4.15	10.04	14.87	4.08	9.94	4.33	10.54
		8	4SG	16.35	5.60	10.27	5.77	10.58	17.48	5.99	10.99	6.16	11.32	16.26	5.55	10.23	5.71	10.54
		10	4SG	4.67	1.49	3.00	1.54	3.12	5.05	1.62	3.23	1.68	3.36	5.43	1.75	3.47	1.82	3.60
		11	4SG	6.28	2.06	3.99	2.13	4.14	6.12	2.00	3.89	2.08	4.04	5.96	1.94	3.79	2.02	3.94
		12	4SG	13.74	4.90	8.40	5.06	8.68	13.00	4.61	7.96	4.77	8.23	13.57	4.84	8.28	5.00	8.57
		13	4SG	5.55	1.75	3.60	1.82	3.73	5.88	1.87	3.80	1.94	3.94	6.22	1.98	4.01	2.06	4.16
		14	4SG	3.25	0.97	2.16	1.01	2.24	3.08	0.91	2.05	0.95	2.13	2.90	0.86	1.94	0.89	2.01
		15	3SG	27.54	6.53	19.59	6.89	20.65	25.91	6.16	18.43	6.50	19.42	25.50	6.08	18.12	6.41	19.09
		16	3SG	28.77	6.72	20.61	7.08	21.69	26.49	6.25	18.90	6.59	19.91	26.08	6.17	18.59	6.50	19.58
		103	4SG	4.80	1.51	3.11	1.57	3.23	4.76	1.50	3.08	1.56	3.20	4.75	1.50	3.07	1.56	3.19
		109	4SG	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90	21.54	7.69	13.25	7.91	13.63

BASE CASE, ALL CMF, C = 1.00

STEPS 1a & 2a CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR AFTER TREATMENT

		1 TREAT	b before	1 by year
Step 2.a.1	Calculate Safety Performance Functions for each COMPARISON intersection for each AFTER year	2 COMP	a after	2 all years
Step 1.a.1	Calculate Safety Performance Functions for each TREATMENT intersection for each AFTER year			

Aft1Yr					Aft2Yr					Aft3Yr				
$N_{aimv-nSG}$	$N'_{aimv(FI)-nSG}$	$N'_{aimv(PDO)-nSG}$	$N_{aimv(FI)-nSG}$	$N_{aimv(PDO)-nSG}$	$N_{aimv-nSG}$	$N'_{aimv(FI)-nSG}$	$N'_{aimv(PDO)-nSG}$	$N_{aimv(FI)-nSG}$	$N_{aimv(PDO)-nSG}$	$N_{aimv-nSG}$	$N'_{aimv(FI)-nSG}$	$N'_{aimv(PDO)-nSG}$	$N_{aimv(FI)-nSG}$	$N_{aimv(PDO)-nSG}$
5.12	1.62	3.32	1.68	3.44	4.85	1.53	3.14	1.59	3.26	4.80	1.51	3.11	1.57	3.23
25.50	9.25	15.57	9.51	15.99	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90
2.42	0.70	1.63	0.73	1.69	2.37	0.69	1.60	0.71	1.66	2.36	0.68	1.59	0.71	1.65
3.90	1.24	2.50	1.29	2.61	3.90	1.24	2.50	1.29	2.61	4.01	1.28	2.57	1.33	2.68
2.40	0.69	1.62	0.72	1.68	2.23	0.65	1.50	0.67	1.56	2.19	0.64	1.47	0.66	1.53
2.71	0.80	1.81	0.83	1.88	2.64	0.78	1.76	0.81	1.83	2.64	0.78	1.76	0.81	1.83
6.34	2.03	4.09	2.10	4.24	5.28	1.66	3.43	1.72	3.56	5.29	1.66	3.44	1.72	3.57
31.55	11.46	19.31	11.75	19.80	35.00	12.87	21.30	13.18	21.82	35.42	13.04	21.55	13.36	22.07
2.06	0.59	1.39	0.61	1.45	2.10	0.60	1.42	0.62	1.47	2.12	0.61	1.44	0.63	1.49
3.70	1.14	2.42	1.18	2.52	3.72	1.14	2.44	1.19	2.53	3.75	1.15	2.46	1.20	2.55
6.76	2.15	4.38	2.22	4.53	6.11	1.92	3.98	1.99	4.12	6.29	1.98	4.09	2.05	4.23
1.83	0.52	1.25	0.53	1.30	1.91	0.54	1.30	0.56	1.35	1.98	0.56	1.35	0.58	1.40
7.81	2.50	5.05	2.59	5.22	7.95	2.55	5.15	2.63	5.32	8.09	2.59	5.24	2.68	5.42
5.61	1.77	3.64	1.84	3.78	5.64	1.77	3.67	1.84	3.80	5.64	1.77	3.68	1.83	3.81
6.57	2.16	4.17	2.24	4.33	6.80	2.24	4.30	2.33	4.47	7.02	2.33	4.44	2.42	4.61
34.43	12.67	20.94	12.98	21.45	35.35	13.03	21.49	13.34	22.01	36.28	13.39	22.04	13.71	22.57
6.68	2.17	4.27	2.25	4.43	6.22	2.01	3.98	2.09	4.13	6.03	1.95	3.86	2.02	4.01
5.10	1.63	3.27	1.70	3.40	5.07	1.62	3.26	1.68	3.38	5.05	1.62	3.25	1.68	3.37
10.46	3.64	6.46	3.77	6.69	11.42	3.93	7.11	4.06	7.36	12.44	4.26	7.78	4.41	8.04
8.57	2.99	5.27	3.10	5.47	8.43	2.92	5.20	3.03	5.40	8.26	2.85	5.11	2.96	5.30
5.19	1.68	3.31	1.75	3.44	4.85	1.56	3.10	1.63	3.22	4.83	1.55	3.09	1.61	3.21
14.87	4.08	9.94	4.33	10.54	14.87	4.08	9.94	4.33	10.54	14.42	3.97	9.63	4.21	10.21
15.04	5.11	9.48	5.27	9.77	14.85	5.04	9.36	5.19	9.65	14.65	4.97	9.25	5.12	9.53
5.05	1.62	3.24	1.69	3.37	4.84	1.54	3.12	1.60	3.24	4.71	1.49	3.04	1.55	3.16
5.76	1.88	3.67	1.95	3.81	5.56	1.81	3.54	1.88	3.68	5.57	1.81	3.55	1.88	3.69
14.77	5.28	9.01	5.46	9.31	14.97	5.34	9.16	5.51	9.46	15.11	5.37	9.26	5.55	9.57
5.91	1.88	3.83	1.95	3.97	5.61	1.77	3.64	1.84	3.78	5.91	1.88	3.83	1.95	3.97
2.92	0.86	1.95	0.90	2.02	2.93	0.87	1.95	0.90	2.03	2.94	0.87	1.97	0.90	2.04
25.09	5.99	17.81	6.32	18.77	25.44	6.08	18.06	6.41	19.03	25.78	6.17	18.29	6.50	19.28
25.66	6.08	18.28	6.41	19.26	25.82	6.14	18.36	6.47	19.35	25.94	6.19	18.42	6.53	19.42
4.74	1.50	3.07	1.55	3.19	4.76	1.50	3.08	1.56	3.20	4.78	1.51	3.09	1.57	3.21
22.40	8.05	13.73	8.28	14.12	21.08	7.55	12.93	7.77	13.31	20.21	7.20	12.42	7.42	12.79

BASE CASE, ALL CMF, C = 1.00

$N_{pred,bi} = N_{bimv} * (CMF_{1i} * \ldots * CMF_{6i}) * C_i$

Note: if CMF or C unknown, assume 1.00.

STEPS 1b & 2b CALCULATE PREDICTED CRASH FREQUENCY BY SITE FOR ENTIRE BEFORE PERIOD

Step 2.b.2 Calculate SPFs for each COMPARISON intersection for entire BEFORE period

Step 1.b.2 Calculate SPFs for each TREATMENT intersection for entire BEFORE period

RESULTS OF STEPS 1b & 2b

R_SiteType			FormulaApplied	BefAllYrs $N_{bimv\text{-}nSG}$	$N_{bimv(FI)\text{-}nSG}$	$N_{bimv(PDO)\text{-}nSG}$	BefAllYrs $N_{pred,bi}$	$N_{pred,bi(FI)}$	$N_{pred,bi(PDO)}$
0	IntNum	3	4SG	15.85	5.21	10.64	15.85	5.21	10.64
		9	4SG	71.40	26.44	44.96	71.40	26.44	44.96
		17	4SG	7.63	2.31	5.32	7.63	2.31	5.32
		18	4SG	14.41	4.83	9.59	14.41	4.83	9.59
		19	4SG	8.03	2.44	5.59	8.03	2.44	5.59
		20	4SG	8.57	2.65	5.91	8.57	2.65	5.91
		21	4SG	21.84	7.34	14.50	21.84	7.34	14.50
		22	4SG	79.95	29.27	50.68	79.95	29.27	50.68
		23	4SG	6.88	2.06	4.81	6.88	2.06	4.81
		24	4SG	11.85	3.80	8.05	11.85	3.80	8.05
		25	4SG	20.21	6.66	13.55	20.21	6.66	13.55
		26	4SG	5.84	1.71	4.13	5.84	1.71	4.13
		27	4SG	24.80	8.24	16.56	24.80	8.24	16.56
		28	4SG	16.54	5.41	11.13	16.54	5.41	11.13
		29	4SG	21.68	7.45	14.22	21.68	7.45	14.22
		122	4SG	106.41	40.14	66.27	106.41	40.14	66.27
1	IntNum	1	4SG	21.41	7.25	14.16	21.41	7.25	14.16
		2	4SG	14.86	4.96	9.90	14.86	4.96	9.90
		4	4SG	32.94	11.84	21.11	32.94	11.84	21.11
		5	4SG	27.34	9.86	17.48	27.34	9.86	17.48
		6	4SG	15.01	5.05	9.96	15.01	5.05	9.96
		7	3SG	42.57	12.44	30.13	42.57	12.44	30.13
		8	4SG	50.09	17.64	32.45	50.09	17.64	32.45
		10	4SG	15.14	5.05	10.09	15.14	5.05	10.09
		11	4SG	18.36	6.23	12.13	18.36	6.23	12.13
		12	4SG	40.31	14.83	25.48	40.31	14.83	25.48
		13	4SG	17.64	5.81	11.83	17.64	5.81	11.83
		14	4SG	9.23	2.85	6.38	9.23	2.85	6.38
		15	3SG	78.95	19.79	59.16	78.95	19.79	59.16
		16	3SG	81.34	20.16	61.18	81.34	20.16	61.18
		103	4SG	14.32	4.69	9.62	14.32	4.69	9.62
		109	4SG	64.75	23.78	40.97	64.75	23.78	40.97

BASE CASE, ALL CMF, C = 1.00

STEPS 1a & 2a CALCULATE PREDICTED CRASH FREQUENCY BY SITE IN PERIOD AFTER TREATMENT

Step 2.a.2 Calculate SPFs for each COMPARISON intersection for entire AFTER period

Step 1.a.2 Calculate SPFs for each TREATMENT intersection for entire AFTER period

RESULTS OF STEPS 1a & 2a

R_SiteType			FormulaApplied	AftAllYrs $N_{aimv\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	AftAllYrs $N_{pred,ai}$	$N_{pred,ai(FI)}$	$N_{pred,ai(PDO)}$
0	IntNum	3	4SG	14.77	4.84	9.93	14.77	4.84	9.93
		9	4SG	68.70	25.37	43.33	68.70	25.37	43.33
		17	4SG	7.15	2.15	5.00	7.15	2.15	5.00
		18	4SG	11.81	3.92	7.89	11.81	3.92	7.89
		19	4SG	6.82	2.05	4.77	6.82	2.05	4.77
		20	4SG	7.98	2.45	5.53	7.98	2.45	5.53
		21	4SG	16.92	5.55	11.37	16.92	5.55	11.37
		22	4SG	101.97	38.28	63.69	101.97	38.28	63.69
		23	4SG	6.28	1.86	4.41	6.28	1.86	4.41
		24	4SG	11.17	3.57	7.60	11.17	3.57	7.60
		25	4SG	19.15	6.27	12.89	19.15	6.27	12.89
		26	4SG	5.72	1.68	4.05	5.72	1.68	4.05
		27	4SG	23.86	7.90	15.96	23.86	7.90	15.96
		28	4SG	16.90	5.51	11.39	16.90	5.51	11.39
		29	4SG	20.39	6.99	13.40	20.39	6.99	13.40
		122	4SG	106.06	40.03	66.03	106.06	40.03	66.03
1	IntNum	1	4SG	18.93	6.36	12.57	18.93	6.36	12.57
		2	4SG	15.22	5.06	10.16	15.22	5.06	10.16
		4	4SG	34.32	12.24	22.08	34.32	12.24	22.08
		5	4SG	25.27	9.09	16.18	25.27	9.09	16.18
		6	4SG	14.86	4.99	9.87	14.86	4.99	9.87
		7	3SG	44.17	12.87	31.29	44.17	12.87	31.29
		8	4SG	44.54	15.58	28.95	44.54	15.58	28.95
		10	4SG	14.60	4.83	9.76	14.60	4.83	9.76
		11	4SG	16.89	5.71	11.18	16.89	5.71	11.18
		12	4SG	44.85	16.51	28.34	44.85	16.51	28.34
		13	4SG	17.44	5.73	11.71	17.44	5.73	11.71
		14	4SG	8.78	2.70	6.09	8.78	2.70	6.09
		15	3SG	76.31	19.23	57.09	76.31	19.23	57.09
		16	3SG	77.42	19.40	58.02	77.42	19.40	58.02
		103	4SG	14.28	4.68	9.60	14.28	4.68	9.60
		109	4SG	63.69	23.47	40.22	63.69	23.47	40.22

BASE CASE, ALL CMF, C = 1.00

STEP 3 CALCULATE ADJUSTMENT FACTOR FOR EACH COMBINATION OF TREATMENT & COMPARISON SITE, SEPARATELY FOR BEFORE & AFTER PERIODS

DO NOT SORT **DO NOT SORT**

R_SiteType	1	0
Pairings	Treatment IntNum	Comparison IntNum
	1	23
	2	17
	4	3
	5	24
	6	21
	7	22
	8	9
	10	20
	11	18
	12	27
	13	19
	14	25
	15	29
	16	122
	103	26
	109	28

Note: each color represents a different three-year span of time since cameras were installed at various times. The colors will have to be referred to for the next steps when adjustments are made because they should only use other intersections from the same time period for the calculations to be valid.

Adj_{ijb}		$N_{pred,Tbi}$	21.41	14.86	32.94	42.57	18.36	17.64	27.34	15.01	50.09	15.14	9.23	40.31	78.95	81.34	14.32	64.75
		Y_{BT}	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
$N_{pred,Cbj}$	Y_{BC}	CIntNum																
15.85	3	3	1.351	0.938	2.078	2.686	1.158	1.113										
7.63	3	17	2.806	1.948	4.317	5.579	2.406	2.312										
14.41	3	18	1.486	1.031	2.286	2.953	1.274	1.224										
8.03	3	19	2.665	1.850	4.100	5.298	2.285	2.196										
79.95	3	22	0.268	0.186	0.412	0.532	0.230	0.221										
6.88	3	23	3.114	2.162	4.791	6.192	2.670	2.566										
71.40	3	9							0.383	0.210	0.702	0.212	0.129					
8.57	3	20							3.191	1.752	5.846	1.767	1.077					
21.84	3	21							1.252	0.687	2.294	0.693	0.423					
11.85	3	24							2.307	1.266	4.226	1.277	0.779					
20.21	3	25							1.353	0.743	2.479	0.749	0.457					
5.84	3	26												6.902	13.519	13.929	2.451	11.087
24.80	3	27												1.625	3.183	3.280	0.577	2.611
16.54	3	28												2.437	4.773	4.918	0.865	3.915
21.68	3	29												1.859	3.642	3.752	0.660	2.987
106.41	3	122												0.379	0.742	0.764	0.135	0.608

Adj_{ijb} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during BEFORE period (

$= (N_{pred,Tbi} / N_{pred,Cbj})*(Y_{BT} / Y_{BC})$

Adj_{ija}		$N_{pred,Tai}$	18.93	15.22	34.32	44.17	16.89	17.44	25.27	14.86	44.54	14.60	8.78	44.85	76.31	77.42	14.28	63.69
		Y_{AT}	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
$N_{pred,Caj}$	Y_{AC}	CIntNum																
14.77	3	3	1.282	1.030	2.324	2.990	1.143	1.181										
7.15	3	17	2.646	2.127	4.797	6.173	2.361	2.438										
11.81	3	18	1.603	1.288	2.905	3.739	1.430	1.476										
6.82	3	19	2.776	2.231	5.033	6.476	2.477	2.557										
101.97	3	22	0.186	0.149	0.337	0.433	0.166	0.171										
6.28	3	23	3.017	2.425	5.469	7.037	2.691	2.779										
68.70	3	9							0.368	0.216	0.648	0.212	0.128					
7.98	3	20							3.165	1.862	5.580	1.829	1.101					
16.92	3	21							1.494	0.879	2.633	0.863	0.519					
11.17	3	24							2.262	1.330	3.987	1.307	0.786					
19.15	3	25							1.319	0.776	2.325	0.762	0.459					
5.72	3	26												7.835	13.331	13.525	2.495	11.126
23.86	3	27												1.880	3.199	3.245	0.599	2.670
16.90	3	28												2.654	4.516	4.582	0.845	3.769
20.39	3	29												2.200	3.744	3.798	0.701	3.124
106.06	3	122												0.423	0.720	0.730	0.135	0.601

Adj_{ija} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during AFTER period (a)

$= (N_{pred,Tai} / N_{pred,Caj})*(Y_{AT} / Y_{AC})$

BASE CASE, ALL CMF, C = 1.00

STEP 4 CALCULATE EXPECTED AVERAGE CRASH FREQUENCY (ADJUSTED CRASH FREQUENCY) FOR EACH COMBINATION, SEPARATELY FOR BEFORE & AFTER PERIODS

STEP 5 CALCULATE TOTAL COMPARISON GROUP ADJUSTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN BEFORE PERIOD

STEP 6 CALCULATE TOTAL COMPARISON GROUP ADJUSTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN AFTER PERIOD

	R_SiteType			BefAllYrs $N_{observed,B}$	AftAllYrs $N_{observed,A}$
	0	IntNum	3	16	19
			9	14	16
			17	28	24
			18	25	19
			19	19	23
			20	7	8
			21	12	13
			22	9	7
			23	12	13
			24	13	7
			25	17	12
			26	8	26
			27	13	11
			28	13	14
			29	18	10
			122	14	9
b)	1	IntNum	1	27	3
			2	26	26
			4	12	5
			5	7	2
			6	7	6
			7	19	23
			8	18	7
			10	9	3
			11	7	1
			12	12	5
			13	23	7
			14	8	10
			15	9	4
			16	13	3
			103	25	14
			109	13	8

$N_{exptd,CB}$	$N_{pred,Tbi}$ / Y_{BT} / TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
$N_{obsvd,Cbj}$	CIntNum																
16	3	21.62	15.00	33.26	42.97	18.53	17.81										
28	17	78.57	54.54	120.88	156.21	67.37	64.74										
25	18	37.14	25.78	57.14	73.83	31.84	30.60										
19	19	50.64	35.15	77.90	100.67	43.41	41.72										
9	22	2.41	1.67	3.71	4.79	2.07	1.99										
12	23	37.37	25.94	57.50	74.30	32.04	30.79										
14	9							5.36	2.94	9.82	2.97	1.81					
7	20							22.34	12.26	40.92	12.37	7.54					
12	21							15.02	8.25	27.52	8.32	5.07					
13	24							29.98	16.46	54.93	16.61	10.12					
17	25							23.00	12.63	42.14	12.74	7.77					
8	26												55.22	108.15	111.43	19.61	88.70
13	27												21.13	41.38	42.64	7.50	33.94
13	28												31.68	62.05	63.93	11.25	50.89
18	29												33.47	65.55	67.54	11.89	53.76
14	122												5.30	10.39	10.70	1.88	8.52
	$N_{exptd,CB,total}$	**227.75**	**158.09**	**350.39**	**452.77**	**195.27**	**187.66**	**95.71**	**52.55**	**175.34**	**53.01**	**32.31**	**146.79**	**287.52**	**296.24**	**52.14**	**235.80**

Adj_{ijb} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during BEFORE period (

$= (N_{pred,Tbi} / N_{pred,Cbj})*(Y_{BT} / Y_{BC})$

$N_{exptd,CA}$		$N_{pred,Tai}$ / Y_{AT} / TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
$N_{obsvd,Caj}$	Y_{AC}	CIntNum																
19	3	3	24.35	19.57	44.15	56.81	21.73	22.44										
24	3	17	63.52	51.05	115.14	148.16	56.66	58.51										
19	3	18	30.45	24.47	55.20	71.03	27.16	28.05										
23	3	19	63.85	51.32	115.75	148.95	56.96	58.82										
7	3	22	1.30	1.04	2.36	3.03	1.16	1.20										
13	3	23	39.22	31.52	71.09	91.49	34.99	36.13										
16	3	9							5.88	3.46	10.37	3.40	2.05					
8	3	20							25.32	14.90	44.64	14.63	8.80					
13	3	21							19.42	11.42	34.23	11.22	6.75					
7	3	24							15.83	9.31	27.91	9.15	5.51					
12	3	25							15.83	9.31	27.90	9.14	5.50					
26	3	26												203.72	346.62	351.65	64.86	289.29
11	3	27												20.68	35.19	35.70	6.58	29.37
14	3	28												37.16	63.22	64.14	11.83	52.77
10	3	29												22.00	37.44	37.98	7.01	31.24
9	3	122												3.81	6.48	6.57	1.21	5.40
		$N_{exptd,CA,total}$	**222.69**	**178.99**	**403.69**	**519.48**	**198.66**	**205.14**	**82.28**	**48.40**	**145.06**	**47.54**	**28.61**	**287.36**	**488.94**	**496.04**	**91.49**	**408.07**

Adj_{ija} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during AFTER period (a)

$= (N_{pred,Tai} / N_{pred,Caj})*(Y_{AT} / Y_{AC})$

BASE CASE, ALL CMF, C = 1.00

STEP 7 CALCULATE COMPARISON RATIO FOR EACH TREATMENT SITE
STEP 8 CALCULATE EXPECTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN THE AFTER PERIOD, HAD NO TREATMENT BEEN IMPLEMENTED
STEP 9 CALCULATE SAFETY EFFECTIVENESS EXPRESSED AS AN ODDS RATIO AT AN INDIVIDUAL TREATMENT SITE
STEP 10 CALCULATE LOG ODDS RATIO FOR EACH TREATMENT SITE
STEP 11 CALCULATE WEIGHT FOR EACH TREATMENT SITE

	TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109	
STEP 6	$N_{exptd,CA,total}$	222.69	178.99	403.69	519.48	198.66	205.14	82.28	48.40	145.06	47.54	28.61	287.36	488.94	496.04	91.49	408.07	
STEP 5	$N_{exptd,CB,total}$	227.75	158.09	350.39	452.77	195.27	187.66	95.71	52.55	175.34	53.01	32.31	146.79	287.52	296.24	52.14	235.80	
STEP 7	$r_{i,C}$	0.9778	1.1322	1.1521	1.1473	1.0174	1.0932	0.8597	0.9211	0.8273	0.8969	0.8855	1.9576	1.7005	1.6745	1.7549	1.7305	
	$N_{observedTB}$	27	26	12	19	7	23	7	7	18	9	8	12	9	13	25	13	
STEP 8	$N_{exptd,TA}$	26.40	29.44	13.83	21.80	7.12	25.14	6.02	6.45	14.89	8.07	7.08	23.49	15.30	21.77	43.87	22.50	
	$N_{observedTA}$	3	26	5	23	1	7	2	6	7	3	10	5	4	3	14	8	
STEP 9	$omega_i$	0.114	0.883	0.362	1.055	0.140	0.278	0.332	0.931	0.470	0.372	1.412	0.213	0.261	0.138	0.319	0.356	
	omega check:	0.114	0.883	0.362	1.055	0.140	0.278	0.332	0.931	0.470	0.372	1.412	0.213	0.261	0.138	0.319	0.356	
STEP 10	R_i	-2.175	-0.124	-1.017	0.0536	-1.963	-1.279	-1.102	-0.072	-0.755	-0.99	0.3448	-1.547	-1.342	-1.982	-1.142	-1.034	
	$R_{i(SE)}^2$	0.3793	0.0888	0.2887	0.1002	1.153	0.1965	0.6655	0.3492	0.211	0.4843	0.2909	0.2936	0.3666	0.4156	0.1415	0.2086	Totals
STEP 11	w_i	2.637	11.257	3.464	9.976	0.867	5.088	1.503	2.864	4.739	2.065	3.438	3.406	2.728	2.406	7.065	4.794	**68.294**
	w_iR_i	-5.734	-1.397	-3.523	0.5349	-1.703	-6.506	-1.655	-0.206	-3.577	-2.044	1.1852	-5.269	-3.66	-4.768	-8.07	-4.956	**-51.349**

$r_{i,C} = N_{exptd,C,A,total} / N_{exptd,C,B,total}$

$N_{exptd,TA} = sum(N_{obsvd,T,B} * r_{iC})$ over all sites

$omega_i = sum(N_{observed,T,A} / N_{expected,T,A})$ over all sites

$= (N_{observed,T,A,total} / N_{observed,T,B,total}) * (N_{expected,C,B,total} / N_{expected,C,A,total})$

b)

$R_{i(SE)}^2 = (1/N_{observed,T,A,total}) + (1/ N_{observed,T,B,total}) + (1/N_{expected,C,B,total}) + (1/N_{expected,C,A,total})$

$w_i = 1/R_{i(SE)}^2$

BASE CASE, ALL CMF, C = 1.00

STEP 12 CALCULATE WEIGHTED AVERAGE LOG ODDS RATIO ACROSS ALL TREATMENT SITES

$sum(w_i*R_i)$ -51.349

$sum(w_i)$ 68.294

-0.752 = R =sum(wi*Ri)/sum(wi)

STEP 13 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT EXPRESSED AS AN ODDS RATIO

0.47 = OR = exp(R)

STEP 14 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT EXPRESSED AS A PERCENTAGE CHANGE IN CRASH FREQUENCY

52.85 = Safety Effectiveness = 100 * (1 - R)

52.85% = Safety Effectiveness

ESTIMATION OF PRECISION OF TREATMENT EFFECTIVENESS

STEP 15 CALCULATE STANDARD ERROR OF TREATMENT EFFECTIVENESS

5.71 = SE(Safety Effectiveness) = 100 * OR / sqrt(sum(wi))

STEP 16 ASSESS STATISTICAL SIGNIFICANCE OF ESTIMATED SAFETY EFFECTIVENESS

9.26 = Performance Measure = ABS[Safety Effectiveness / SE(Safety Effectiveness)]

PM < 1.7 Treatment Effect NOT significant at the (approx.) 90% confidence interval

PM >= 1.7 Treatment Effect IS significant at the (approx.) 90% confidence interval

PM >= 2.0 Treatment Effect IS significant at the (approx.) 95% confidence interval

InjuryStatusUn	1 fatal
InjuryStatusUn	2 injury
TAD_Unit1Ar	3 injury
TAD_Unit2Ar	4 injury
	5 no injury
	6 unknown

InjuryYes = 1
u1<5 or u2<5

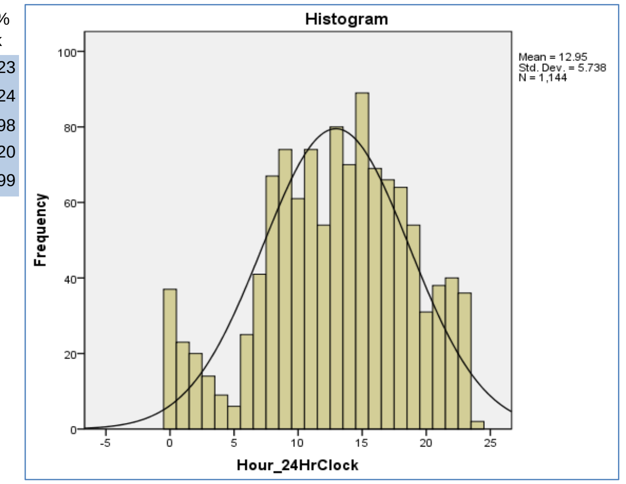
InjuryYes = 0
u1=5 and u2=5

InjuryYes = 99
(u1=6 or u2=6) when (u1>4 and u2>4)

PDO = 1
if(TAD1<>0 or TAD2<>0) when InjuryYes=0

Hour_24HrClock

		Frequency	Percent	Valid Pct	Cum Pct	Cumul % in Dark
Valid	0	37	3.2	3.2	3.2	3.23
	1	23	2.0	2.0	5.2	5.24
	2	20	1.7	1.7	7.0	6.98
	3	14	1.2	1.2	8.2	8.20
	4	9	.8	.8	9.0	8.99
	5	6	.5	.5	9.5	
	6	25	2.2	2.2	11.7	
	7	41	3.6	3.6	15.3	
	8	67	5.8	5.9	21.2	
	9	74	6.5	6.5	27.6	
	10	61	5.3	5.3	33.0	
	11	74	6.5	6.5	39.4	
	12	54	4.7	4.7	44.1	
	13	80	7.0	7.0	51.1	
	14	70	6.1	6.1	57.3	
	15	89	7.8	7.8	65.0	
	16	69	6.0	6.0	71.1	
	17	66	5.8	5.8	76.8	
	18	64	5.6	5.6	82.4	14.57
	19	54	4.7	4.7	87.2	19.28
	20	31	2.7	2.7	89.9	21.99
	21	38	3.3	3.3	93.2	25.31
	22	40	3.5	3.5	96.7	28.80
	23	36	3.1	3.1	99.8	31.94
	24	2	.2	.2	100.0	32.11
	Total	1144	99.8	100.0		
Missing	System	2	.2			
Total		1146	100.0			



Statistics

Hour_24HrClock

N	Valid	1144
	Missing	2
Mean		12.95
Median		13.00
Std. Deviation		5.738
Skewness		-.344
Std. Error of Skewness		.072
Kurtosis		-.387
Std. Error of Kurtosis		.145
Minimum		0
Maximum		24

Ci = calibration factor for intersection i, assume 1.0 if no knowledge.

From Srinivasan et al. (2008) for North Carolina:
3-year averages from 2007, 2008, 2009.

Piedmont Region	Intersection Type 3SG	4SG
Ci	2.86	4.10
n	10 ints	40 ints

Statewide	Intersection Type 3SG	4SG
Ci	2.47	2.79
n	31 ints	122 ints

Table 12-27 CMF_5i

	p_ni
3SG/4	0.235

<< default value, can replace w local data

CMF_5i = 1-0.38*p_ni

p_ni = Proportion of Crashes that Occur at Night

OUTPUT FROM SPSS: All crash data looked at for the frequency values of daytime/nighttime.

AmbientLight

		Frequenc	Percent	Valid Percent	Cumulative Percent
Valid	1	809	70.6	70.6	70.6
	2	26	2.3	2.3	72.9
	3	8	.7	.7	73.6
	4	282	24.6	24.6	98.2
	5	18	1.6	1.6	99.7
	6	3	.3	.3	100.0
	Total	1146	100.0	100.0	

Values 4, 5, and 6 are for "Dark" conditions, with and without lighting.
Therefore, the sum of these percentages can approximate the percent of nighttime crashes.

Dark	26.440%

CMF_6i = 1 - p_ra*(1-0.74) - p_re*(1-1.18)

0.74 = Persaud et al. CMF for right-angle collisions

1.18 = Persaud et al. CMF for rear-end collisions

p_ra = $[p_{ramv(FI)} * N_{bimv(FI)} + p_{ramv(PDO)} * N_{bimv(PDO)}] / [N_{bimv(FI)} + N_{bimv(PDO)} + N_{bisv}]$

p_re = $[p_{ramv(FI)} * N_{bimv(FI)} + p_{ramv(PDO)} * N_{bimv(PDO)}] / [N_{bimv(FI)} + N_{bimv(PDO)} + N_{bisv}]$

Nbisv = exp[a + b*ln(AADTmaj) + c*ln(AADTmin)]

Table 12-12 **Safety Performance Functions (N) with coefficients a, b, c, and overdispersion parameter k. (HSM, Table 12-12)**

Formula	$N_{bisv-3SG}$	$N_{bisv-4SG}$
a	-9.02	-10.21
b	0.42	0.68
c	0.40	0.27
k	0.36	0.36

CMF_1i	Intersection Left-Turn Lanes (HSM Table 12-24)
CMF_2i	Intersection Left-Turn Signal Phasing (HSM Table 12-25)
CMF_3i	Intersection Right-Turn Lanes (HSM Table 12-26)
CMF_4i	Right-Turn-on-Red (HSM Equation 12-35)
CMF_5i	Lighting (HSM Equation 12-36, Table 12-27)
CMF_6i	Red-Light Cameras (HSM Equations 12-37, 12-38, and 12-39)
Ci	Calibration Factor

Meaning of CMF Values

<1	Lower crash frequency than base condition
1	Base condition of SPFs
>1	Higher crash frequency than base condition

Table 12-24 CMF_1i

		Approaches with Left-Turn Lanes				
		0	1	2	3	4
3-leg	3SG	1	0.93	0.86	0.80	
4-leg	4SG	1	0.90	0.81	0.73	0.66

Table 12-25 CMF_2i

	Type of Left-Turn Phasing		
	Perm	PP	Prot
CMF	1	0.99	0.94

careful with this one. Multiply these together if there are multiple approaches with left phasing

Table 12-26 CMF_3i

		Approaches with Right-Turn Lanes				
		0	1	2	3	4
3-leg	3SG	1	0.96	0.92		
4-leg	4SG	1	0.96	0.92	0.88	0.85

CMF_4i =0.98^n_prohib

n_prohib = number of approaches with RTOR prohibited

Safety Performance Functions (N) with coefficients a, b, c, and overdispersion parameter k. (HSM, Table 12-10)

Formula	$N_{bimv\text{-}3SG}$	$N'_{bimv(FI)\text{-}3SG}$	$N'_{bimv(PDO)\text{-}3SG}$	$N_{bimv\text{-}4SG}$	$N'_{bimv(FI)\text{-}4SG}$	$N'_{bimv(PDO)\text{-}4SG}$
a	-12.13	-11.58	-13.24	-10.99	-13.14	-11.02
b	1.11	1.02	1.14	1.07	1.18	1.02
c	0.26	0.17	0.3	0.23	0.22	0.24
k	0.33	0.3	0.36	0.39	0.33	0.44

N_{bimv}= predicted number of multiple-vehicle crashes for intersection per year for base conditions;

N_{bisv} = predicted number of single-vehicle crashes for intersection per year for base conditions.

$N_{bimv\text{-}3SG}$ = exp[-12.13+1.11Ln(ADT_{maj})+0.26Ln(ADT_{min})] **(3.54)**

$N_{bimv\text{-}4SG}$ = exp[-10.99+1.07Ln(ADT_{maj})+0.23Ln(ADT_{min})] **(3.56)**

Safety performance functions for "FI" crashes are shown in Equations 3.57 through 3.60:

$N'_{bimv(FI)\text{-}3SG}$ = exp[-11.58+1.02Ln(ADT_{maj})+0.17Ln(ADT_{min})] **(3.58)**

$N'_{bimv(FI)\text{-}4SG}$ = exp[-13.14+1.18Ln(ADT_{maj})+0.22Ln(ADT_{min})] **(3.60)**

Safety performance functions for "PDO" crashes are shown in Equations 3.61 through 3.64:

$N'_{bimv(PDO)\text{-}3SG}$ = exp[-13.24+1.14Ln(ADT_{maj})+0.30Ln(ADT_{min})] **(3.62)**

$N'_{bimv(PDO)\text{-}4SG}$ = exp[-11.02+1.02Ln(ADT_{maj})+0.24Ln(ADT_{min})] **(3.64)**

where:

$N_{bimv\text{-}3SG}$, $N_{bimv\text{-}4SG}$= baseline total multi-vehicle intersection-related crashes per year for intersections of types 3SG and 4SG, respectively.

$N'_{bimv(FI)\text{-}3SG}$, $N'_{bimv(FI)\text{-}4SG}$= baseline "FI" multi-vehicle intersection-related crashes per year for intersections of types 3SG and 4SG, respectively.

$N'_{bimv(PDO)\text{-}3SG}$, $N'_{bimv(PDO)\text{-}4SG}$= baseline "PDO" multi-vehicle intersection-related crashes per year for intersections of types 3SG and 4SG, respectively.

ADT_{maj} = average daily traffic volume (veh/day) for major road (both directions of travel combined)

ADT_{min} = average daily traffic volume (veh/day) for minor road (both directions of travel combined)

p_ra = proportion of crashes that are multiple-vehicle, right-angle collisions

p_re = proportion of crashes that are multiple-vehicle, rear-end collisions

$p_{ramv(FI)}$ = proportion of crashes that are multiple-vehicle, right-angle collisions (fatalities & injuries only)

$p_{ramv(PDO)}$ = proportion of crashes that are multiple-vehicle, right-angle collisions (property damage only)

$p_{remv(FI)}$ = proportion of crashes that are multiple-vehicle, rear-end collisions (fatalities & injuries only)

$p_{remv(PDO)}$ = proportion of crashes that are multiple-vehicle, rear-end collisions (property damage only)

N_{bisv} = number of single-vehicle crashes at intersection i

CASE 2: BASE + ALL CMF; C = 1.00

pulled from sheet 2-Intersections_prepped

Step 1b Determine Crash Modification Factors (CMFs) and Calibration Factors (Ci) for each intersection for each year

vlookup column >>		5	6	296	299	300	297	301														
				for CMF_1i	for CMF_2i		for CMF_3i	n_prohib			N_{bisv}											
R_SiteType		Approaches	Legs	AppsWLeftLns	AppsWLeftProt	LeftProtPerm	AppsWRgtLns	AppsRTORprohib	Bef3Yr	Bef2Yr	Bef1Yr	Aft1Yr	Aft2Yr	Aft3Yr	RLC	CMF_1i	CMF_2i	CMF_3i	CMF_4i	CMF_5i	CMF_6i	Ci
0 IntNum	3	2	4	0	0	0	1	0	0.34	0.35	0.35	0.34	0.32	0.32	0	1.00	1.00	0.96	1.00	0.91		1
	9	4	4	0	4	0	4	0	0.96	1.00	1.02	1.03	0.97	0.89	0	1.00	0.78	0.85	1.00	0.91		1
	17	2	4	0	0	0	0	0	0.23	0.22	0.22	0.22	0.21	0.21	0	1.00	1.00	1.00	1.00	0.91		1
	18	4	4	0	0	0	2	0	0.32	0.30	0.26	0.25	0.25	0.25	0	1.00	1.00	0.92	1.00	0.91		1
	19	3	4	0	0	0	0	0	0.25	0.23	0.22	0.22	0.20	0.20	0	1.00	1.00	1.00	1.00	0.91		1
	20	4	4	0	0	0	4	0	0.23	0.23	0.23	0.22	0.22	0.22	0	1.00	1.00	0.85	1.00	0.91		1
	21	4	4	0	0	2	4	0	0.43	0.44	0.44	0.40	0.36	0.36	0	1.00	0.98	0.85	1.00	0.91		1
	22	3	4	0	0	1	2	0	1.11	1.15	1.19	1.28	1.36	1.37	0	1.00	0.99	0.92	1.00	0.91		1
	23	2	4	0	0	0	1	0	0.22	0.21	0.19	0.19	0.20	0.20	0	1.00	1.00	0.96	1.00	0.91		1
	24	4	4	0	2	0	3	0	0.28	0.29	0.28	0.27	0.27	0.27	0	1.00	0.88	0.88	1.00	0.91		1
	25	3	4	0	0	0	1	0	0.41	0.44	0.46	0.44	0.41	0.42	0	1.00	1.00	0.96	1.00	0.91		1
	26	2	4	0	0	0	0	0	0.19	0.19	0.19	0.18	0.19	0.19	0	1.00	1.00	1.00	1.00	0.91		1
	27	4	4	1	2	2	4	0	0.52	0.52	0.51	0.49	0.50	0.51	0	0.90	0.87	0.85	1.00	0.91		1
	28	4	4	0	0	2	4	0	0.36	0.37	0.37	0.37	0.38	0.39	0	1.00	0.98	0.85	1.00	0.91		1
	29	4	4	0	0	0	4	1	0.40	0.41	0.39	0.38	0.38	0.39	0	1.00	1.00	0.85	0.98	0.91		1
	122	3	4	0	0	1	2	0	1.37	1.38	1.36	1.33	1.36	1.39	0	1.00	0.99	0.92	1.00	0.91		1
1 IntNum	1	2	4	0	0	0	0	1	0.41	0.42	0.42	0.40	0.38	0.37	1	1.00	1.00	1.00	0.98	0.91		1
	2	2	4	0	0	0	1	0	0.30	0.31	0.32	0.32	0.32	0.32	1	1.00	1.00	0.96	1.00	0.91		1
	4	4	4	0	0	1	3	1	0.52	0.52	0.52	0.49	0.56	0.62	1	1.00	0.99	0.88	0.98	0.91		1
	5	4	4	1	4	0	4	0	0.44	0.43	0.42	0.40	0.40	0.40	1	0.90	0.78	0.85	1.00	0.91		1
	6	4	4	0	2	0	4	0	0.28	0.30	0.33	0.31	0.30	0.30	1	1.00	0.88	0.85	1.00	0.91		1
	7	3	3	0	1	0	2	0	0.53	0.54	0.54	0.54	0.54	0.54	1	1.00	0.94	0.92	1.00	0.91		1
	8	4	4	0	4	0	4	0	0.82	0.87	0.82	0.77	0.77	0.76	1	1.00	0.78	0.85	1.00	0.91		1
	10	4	4	0	2	2	3	0	0.30	0.31	0.33	0.32	0.31	0.31	1	1.00	0.87	0.88	1.00	0.91		1
	11	4	4	0	1	0	3	1	0.36	0.36	0.35	0.34	0.33	0.33	1	1.00	0.94	0.88	0.98	0.91		1
	12	4	4	1	2	0	4	0	0.59	0.57	0.58	0.63	0.64	0.66	1	0.90	0.88	0.85	1.00	0.91		1
	13	4	4	0	2	0	4	0	0.37	0.38	0.40	0.38	0.37	0.38	1	1.00	0.88	0.85	1.00	0.91		1
	14	3	4	0	1	0	1	0	0.26	0.25	0.24	0.24	0.24	0.25	1	1.00	0.94	0.96	1.00	0.91		1
	15	2	3	0	1	0	0	0	1.05	1.03	1.02	1.01	1.01	1.01	1	1.00	0.94	1.00	1.00	0.91		1
	16	2	3	0	1	0	1	0	1.12	1.07	1.06	1.05	1.04	1.02	1	1.00	0.94	0.96	1.00	0.91		1
	103	2	4	0	0	0	1	0	0.32	0.32	0.32	0.31	0.32	0.32	1	1.00	1.00	0.96	1.00	0.91		1
	109	4	4	0	4	0	4	0	0.97	0.89	0.93	0.94	0.90	0.87	1	1.00	0.78	0.85	1.00	0.91		1

ESTIMATION OF MEAN TREATMENT EFFECTIVENESS

CASE 2: BASE + ALL CMF; C = 1.00

STEPS 1b & 2b CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR BEFORE TREATMENT

Step 2.b.1 Calculate Safety Performance Functions for each COMPARISON intersection for each BEFORE year

Step 1.b.1 Calculate Safety Performance Functions for each TREATMENT intersection for each BEFORE year

				Bef3Yr					Bef2Yr					Bef1Yr				
R_SiteType			FormulaApplied	$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$	$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$	$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$
0	IntNum	3	4SG	5.17	1.64	3.34	1.70	3.47	5.29	1.67	3.42	1.74	3.55	5.39	1.71	3.49	1.77	3.62
		9	4SG	22.49	8.05	13.81	8.28	14.21	24.11	8.69	14.76	8.94	15.17	24.80	8.97	15.16	9.22	15.58
		17	4SG	2.62	0.76	1.76	0.79	1.82	2.54	0.74	1.71	0.77	1.77	2.47	0.72	1.66	0.75	1.72
		18	4SG	5.46	1.78	3.48	1.85	3.62	4.86	1.56	3.11	1.62	3.23	4.09	1.30	2.63	1.35	2.74
		19	4SG	2.95	0.87	1.97	0.91	2.05	2.68	0.78	1.80	0.81	1.87	2.40	0.70	1.62	0.72	1.68
		20	4SG	2.93	0.88	1.94	0.91	2.02	2.86	0.85	1.90	0.88	1.97	2.78	0.83	1.85	0.86	1.92
		21	4SG	7.13	2.31	4.57	2.39	4.74	7.28	2.36	4.66	2.45	4.83	7.43	2.42	4.76	2.50	4.93
		22	4SG	25.28	8.97	15.64	9.21	16.07	26.64	9.50	16.45	9.75	16.89	28.02	10.04	17.27	10.30	17.72
		23	4SG	2.57	0.75	1.73	0.78	1.79	2.29	0.66	1.55	0.69	1.60	2.01	0.57	1.37	0.60	1.42
		24	4SG	3.92	1.21	2.56	1.25	2.66	4.06	1.26	2.65	1.30	2.76	3.88	1.20	2.54	1.24	2.63
		25	4SG	6.08	1.91	3.95	1.98	4.10	6.73	2.14	4.36	2.22	4.51	7.40	2.38	4.77	2.46	4.94
		26	4SG	1.96	0.56	1.34	0.58	1.39	1.97	0.56	1.35	0.58	1.39	1.90	0.54	1.30	0.56	1.35
		27	4SG	8.36	2.69	5.40	2.78	5.58	8.36	2.69	5.40	2.78	5.58	8.08	2.59	5.22	2.68	5.40
		28	4SG	5.31	1.67	3.45	1.73	3.58	5.61	1.77	3.64	1.84	3.78	5.61	1.77	3.64	1.84	3.78
		29	4SG	7.22	2.39	4.57	2.48	4.74	7.45	2.48	4.71	2.57	4.88	7.01	2.32	4.43	2.40	4.60
		122	4SG	35.42	13.04	21.55	13.36	22.07	35.85	13.22	21.80	13.53	22.32	35.14	12.94	21.37	13.26	21.88
1	IntNum	1	4SG	7.13	2.34	4.54	2.42	4.71	7.14	2.33	4.56	2.42	4.72	7.14	2.32	4.56	2.41	4.73
		2	4SG	4.79	1.53	3.07	1.60	3.19	4.95	1.59	3.17	1.65	3.30	5.12	1.65	3.28	1.71	3.41
		4	4SG	10.69	3.69	6.63	3.82	6.87	10.99	3.81	6.80	3.95	7.04	11.26	3.93	6.95	4.07	7.19
		5	4SG	9.16	3.17	5.66	3.29	5.87	9.26	3.22	5.70	3.34	5.91	8.92	3.11	5.49	3.22	5.70
		6	4SG	4.48	1.44	2.87	1.50	2.98	5.00	1.62	3.19	1.68	3.32	5.53	1.80	3.52	1.87	3.66
		7	3SG	13.51	3.74	9.00	3.96	9.54	14.19	3.91	9.47	4.15	10.04	14.87	4.08	9.94	4.33	10.54
		8	4SG	16.35	5.60	10.27	5.77	10.58	17.48	5.99	10.99	6.16	11.32	16.26	5.55	10.23	5.71	10.54
		10	4SG	4.67	1.49	3.00	1.54	3.12	5.05	1.62	3.23	1.68	3.36	5.43	1.75	3.47	1.82	3.60
		11	4SG	6.28	2.06	3.99	2.13	4.14	6.12	2.00	3.89	2.08	4.04	5.96	1.94	3.79	2.02	3.94
		12	4SG	13.74	4.90	8.40	5.06	8.68	13.00	4.61	7.96	4.77	8.23	13.57	4.84	8.28	5.00	8.57
		13	4SG	5.55	1.75	3.60	1.82	3.73	5.88	1.87	3.80	1.94	3.94	6.22	1.98	4.01	2.06	4.16
		14	4SG	3.25	0.97	2.16	1.01	2.24	3.08	0.91	2.05	0.95	2.13	2.90	0.86	1.94	0.89	2.01
		15	3SG	27.54	6.53	19.59	6.89	20.65	25.91	6.16	18.43	6.50	19.42	25.50	6.08	18.12	6.41	19.09
		16	3SG	28.77	6.72	20.61	7.08	21.69	26.49	6.25	18.90	6.59	19.91	26.08	6.17	18.59	6.50	19.58
		103	4SG	4.80	1.51	3.11	1.57	3.23	4.76	1.50	3.08	1.56	3.20	4.75	1.50	3.07	1.56	3.19
		109	4SG	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90	21.54	7.69	13.25	7.91	13.63

CASE 2: BASE + ALL CMF; C = 1.00

STEPS 1a & 2a CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR AFTER TREATMENT

Step 2.a.1 Calculate Safety Performance Functions for each COMPARISON intersection for each AFTER year

Step 1.a.1 Calculate Safety Performance Functions for each TREATMENT intersection for each AFTER year

1 TREAT | b before | 1 by year
2 COMP | a after | 2 all years

Aft1Yr					Aft2Yr					Aft3Yr				
$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$
5.12	1.62	3.32	1.68	3.44	4.85	1.53	3.14	1.59	3.26	4.80	1.51	3.11	1.57	3.23
25.50	9.25	15.57	9.51	15.99	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90
2.42	0.70	1.63	0.73	1.69	2.37	0.69	1.60	0.71	1.66	2.36	0.68	1.59	0.71	1.65
3.90	1.24	2.50	1.29	2.61	3.90	1.24	2.50	1.29	2.61	4.01	1.28	2.57	1.33	2.68
2.40	0.69	1.62	0.72	1.68	2.23	0.65	1.50	0.67	1.56	2.19	0.64	1.47	0.66	1.53
2.71	0.80	1.81	0.83	1.88	2.64	0.78	1.76	0.81	1.83	2.64	0.78	1.76	0.81	1.83
6.34	2.03	4.09	2.10	4.24	5.28	1.66	3.43	1.72	3.56	5.29	1.66	3.44	1.72	3.57
31.55	11.46	19.31	11.75	19.80	35.00	12.87	21.30	13.18	21.82	35.42	13.04	21.55	13.36	22.07
2.06	0.59	1.39	0.61	1.45	2.10	0.60	1.42	0.62	1.47	2.12	0.61	1.44	0.63	1.49
3.70	1.14	2.42	1.18	2.52	3.72	1.14	2.44	1.19	2.53	3.75	1.15	2.46	1.20	2.55
6.76	2.15	4.38	2.22	4.53	6.11	1.92	3.98	1.99	4.12	6.29	1.98	4.09	2.05	4.23
1.83	0.52	1.25	0.53	1.30	1.91	0.54	1.30	0.56	1.35	1.98	0.56	1.35	0.58	1.40
7.81	2.50	5.05	2.59	5.22	7.95	2.55	5.15	2.63	5.32	8.09	2.59	5.24	2.68	5.42
5.61	1.77	3.64	1.84	3.78	5.64	1.77	3.67	1.84	3.80	5.64	1.77	3.68	1.83	3.81
6.57	2.16	4.17	2.24	4.33	6.80	2.24	4.30	2.33	4.47	7.02	2.33	4.44	2.42	4.61
34.43	12.67	20.94	12.98	21.45	35.35	13.03	21.49	13.34	22.01	36.28	13.39	22.04	13.71	22.57
6.68	2.17	4.27	2.25	4.43	6.22	2.01	3.98	2.09	4.13	6.03	1.95	3.86	2.02	4.01
5.10	1.63	3.27	1.70	3.40	5.07	1.62	3.26	1.68	3.38	5.05	1.62	3.25	1.68	3.37
10.46	3.64	6.46	3.77	6.69	11.42	3.93	7.11	4.06	7.36	12.44	4.26	7.78	4.41	8.04
8.57	2.99	5.27	3.10	5.47	8.43	2.92	5.20	3.03	5.40	8.26	2.85	5.11	2.96	5.30
5.19	1.68	3.31	1.75	3.44	4.85	1.56	3.10	1.63	3.22	4.83	1.55	3.09	1.61	3.21
14.87	4.08	9.94	4.33	10.54	14.87	4.08	9.94	4.33	10.54	14.42	3.97	9.63	4.21	10.21
15.04	5.11	9.48	5.27	9.77	14.85	5.04	9.36	5.19	9.65	14.65	4.97	9.25	5.12	9.53
5.05	1.62	3.24	1.69	3.37	4.84	1.54	3.12	1.60	3.24	4.71	1.49	3.04	1.55	3.16
5.76	1.88	3.67	1.95	3.81	5.56	1.81	3.54	1.88	3.68	5.57	1.81	3.55	1.88	3.69
14.77	5.28	9.01	5.46	9.31	14.97	5.34	9.16	5.51	9.46	15.11	5.37	9.26	5.55	9.57
5.91	1.88	3.83	1.95	3.97	5.61	1.77	3.64	1.84	3.78	5.91	1.88	3.83	1.95	3.97
2.92	0.86	1.95	0.90	2.02	2.93	0.87	1.95	0.90	2.03	2.94	0.87	1.97	0.90	2.04
25.09	5.99	17.81	6.32	18.77	25.44	6.08	18.06	6.41	19.03	25.78	6.17	18.29	6.50	19.28
25.66	6.08	18.28	6.41	19.26	25.82	6.14	18.36	6.47	19.35	25.94	6.19	18.42	6.53	19.42
4.74	1.50	3.07	1.55	3.19	4.76	1.50	3.08	1.56	3.20	4.78	1.51	3.09	1.57	3.21
22.40	8.05	13.73	8.28	14.12	21.08	7.55	12.93	7.77	13.31	20.21	7.20	12.42	7.42	12.79

CASE 2: BASE + ALL CMF; C = 1.00

$N_{pred,bi} = N_{bimv} * (CMF_{1i} * \ldots * CMF_{6i}) * C_i$

Note: if CMF or C unknown, assume 1.00.

STEPS 1b & 2b CALCULATE PREDICTED CRASH FREQUENCY BY SITE FOR ENTIRE BEFORE PERIOD

Step 2.b.2 Calculate SPFs for each COMPARISON intersection for entire BEFORE period

Step 1.b.2 Calculate SPFs for each TREATMENT intersection for entire BEFORE period

RESULTS OF STEPS 1b & 2b

R_SiteType			Formula Applied	BefAllYrs $N_{bimv\text{-}nSG}$	$N_{bimv(FI)\text{-}nSG}$	$N_{bimv(PDO)\text{-}nSG}$	BefAllYrs $N_{pred,bi}$	$N_{pred,bi(FI)}$	$N_{pred,bi(PDO)}$
0	IntNum	3	4SG	15.85	5.21	10.64	13.86	4.55	9.30
		9	4SG	71.40	26.44	44.96	43.15	15.98	27.17
		17	4SG	7.63	2.31	5.32	6.95	2.10	4.85
		18	4SG	14.41	4.83	9.59	12.08	4.04	8.03
		19	4SG	8.03	2.44	5.59	7.32	2.22	5.09
		20	4SG	8.57	2.65	5.91	6.63	2.05	4.58
		21	4SG	21.84	7.34	14.50	16.57	5.57	11.00
		22	4SG	79.95	29.27	50.68	66.31	24.28	42.04
		23	4SG	6.88	2.06	4.81	6.01	1.80	4.21
		24	4SG	11.85	3.80	8.05	8.39	2.69	5.70
		25	4SG	20.21	6.66	13.55	17.67	5.82	11.85
		26	4SG	5.84	1.71	4.13	5.32	1.56	3.76
		27	4SG	24.80	8.24	16.56	14.96	4.97	9.99
		28	4SG	16.54	5.41	11.13	12.55	4.10	8.45
		29	4SG	21.68	7.45	14.22	16.45	5.66	10.79
		122	4SG	106.41	40.14	66.27	88.27	33.30	54.97
1	IntNum	1	4SG	21.41	7.25	14.16	19.11	6.47	12.64
		2	4SG	14.86	4.96	9.90	12.99	4.34	8.66
		4	4SG	32.94	11.84	21.11	25.61	9.20	16.41
		5	4SG	27.34	9.86	17.48	14.87	5.36	9.51
		6	4SG	15.01	5.05	9.96	10.27	3.45	6.81
		7	3SG	42.57	12.44	30.13	33.53	9.80	23.73
		8	4SG	50.09	17.64	32.45	30.27	10.66	19.61
		10	4SG	15.14	5.05	10.09	10.51	3.51	7.00
		11	4SG	18.36	6.23	12.13	13.55	4.60	8.95
		12	4SG	40.31	14.83	25.48	24.81	9.13	15.68
		13	4SG	17.64	5.81	11.83	12.07	3.97	8.09
		14	4SG	9.23	2.85	6.38	7.59	2.34	5.25
		15	3SG	78.95	19.79	59.16	67.58	16.94	50.64
		16	3SG	81.34	20.16	61.18	66.85	16.57	50.28
		103	4SG	14.32	4.69	9.62	12.52	4.10	8.41
		109	4SG	64.75	23.78	40.97	39.13	14.37	24.76

CASE 2: BASE + ALL CMF; C = 1.00

STEPS 1a & 2a CALCULATE PREDICTED CRASH FREQUENCY BY SITE IN PERIOD AFTER TREATMENT

Step 2.a.2 Calculate SPFs for each COMPARISON intersection for entire AFTER period

Step 1.a.2 Calculate SPFs for each TREATMENT intersection for entire AFTER period

RESULTS OF STEPS 1a & 2a

R_SiteType			Formula Applied	AftAllYrs $N_{aimv\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	AftAllYrs $N_{pred,ai}$	$N_{pred,ai(FI)}$	$N_{pred,ai(PDO)}$
0	IntNum	3	4SG	14.77	4.84	9.93	12.91	4.23	8.68
		9	4SG	68.70	25.37	43.33	41.52	15.33	26.19
		17	4SG	7.15	2.15	5.00	6.52	1.96	4.55
		18	4SG	11.81	3.92	7.89	9.90	3.29	6.61
		19	4SG	6.82	2.05	4.77	6.21	1.87	4.34
		20	4SG	7.98	2.45	5.53	6.18	1.90	4.28
		21	4SG	16.92	5.55	11.37	12.83	4.21	8.62
		22	4SG	101.97	38.28	63.69	84.58	31.76	52.82
		23	4SG	6.28	1.86	4.41	5.49	1.63	3.86
		24	4SG	11.17	3.57	7.60	7.91	2.53	5.38
		25	4SG	19.15	6.27	12.89	16.75	5.48	11.27
		26	4SG	5.72	1.68	4.05	5.21	1.53	3.69
		27	4SG	23.86	7.90	15.96	14.39	4.76	9.63
		28	4SG	16.90	5.51	11.39	12.82	4.18	8.64
		29	4SG	20.39	6.99	13.40	15.46	5.30	10.16
		122	4SG	106.06	40.03	66.03	87.97	33.20	54.77
1	IntNum	1	4SG	18.93	6.36	12.57	16.90	5.68	11.22
		2	4SG	15.22	5.06	10.16	13.30	4.42	8.88
		4	4SG	34.32	12.24	22.08	26.69	9.51	17.17
		5	4SG	25.27	9.09	16.18	13.74	4.94	8.80
		6	4SG	14.86	4.99	9.87	10.16	3.41	6.75
		7	3SG	44.17	12.87	31.29	34.78	10.14	24.65
		8	4SG	44.54	15.58	28.95	26.92	9.42	17.50
		10	4SG	14.60	4.83	9.76	10.13	3.35	6.78
		11	4SG	16.89	5.71	11.18	12.47	4.22	8.25
		12	4SG	44.85	16.51	28.34	27.61	10.17	17.44
		13	4SG	17.44	5.73	11.71	11.93	3.92	8.01
		14	4SG	8.78	2.70	6.09	7.22	2.22	5.00
		15	3SG	76.31	19.23	57.09	65.33	16.46	48.87
		16	3SG	77.42	19.40	58.02	63.63	15.94	47.68
		103	4SG	14.28	4.68	9.60	12.48	4.09	8.39
		109	4SG	63.69	23.47	40.22	38.49	14.18	24.31

CASE 2: BASE + ALL CMF; C = 1.00

STEP 3 CALCULATE ADJUSTMENT FACTOR FOR EACH COMBINATION OF TREATMENT & COMPARISON SITE, SEPARATELY FOR BEFORE & AFTER PERIODS

	DO NOT SORT	DO NOT SORT
R_SiteType	1	0
Pairings	Treatment IntNum	Comparison IntNum
	1	23
	2	17
	4	**3**
	5	24
	6	21
	7	22
	8	**9**
	10	20
	11	18
	12	27
	13	19
	14	25
	15	29
	16	**122**
	103	26
	109	28

Note: each color represents a different three-year span of time since cameras were installed at various times. The colors will have to be referred to for the next steps when adjustments are made because they should only use other intersections from the same time period for the calculations to be valid.

Adj_{ijb}		$N_{pred,Tbi}$	19.11	12.99	25.61	33.53	13.55	12.07	14.87	10.27	30.27	10.51	7.59	24.81	67.58	66.85	12.52	39.13
		Y_{BT}	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	**103**	**109**
$N_{pred,Cbj}$	Y_{BC}	CIntNum																
13.86	3	**3**	1.379	0.938	1.848	2.419	0.978	0.871										
6.95	3	17	2.750	1.870	3.686	4.825	1.950	1.737										
12.08	3	18	1.582	1.076	2.121	2.776	1.122	0.999										
7.32	3	19	2.612	1.776	3.501	4.582	1.852	1.649										
66.31	3	22	0.288	0.196	0.386	0.506	0.204	0.182										
6.01	3	23	3.179	2.162	4.261	5.578	2.255	2.008										
43.15	3	**9**							0.345	0.238	0.702	0.244	0.176					
6.63	3	20							2.242	1.548	4.565	1.585	1.144					
16.57	3	21							0.898	0.620	1.827	0.634	0.458					
8.39	3	24							1.772	1.223	3.607	1.252	0.904					
17.67	3	25							0.842	0.581	1.714	0.595	0.429					
5.32	3	26												4.666	12.708	12.570	2.353	7.358
14.96	3	27												1.658	4.516	4.467	0.836	2.615
12.55	3	28												1.977	5.386	5.327	0.997	3.118
16.45	3	29												1.509	4.110	4.065	0.761	2.379
88.27	3	**122**												0.281	0.766	0.757	0.142	0.443

Adj_{ijb} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during BEFORE perio

$= (N_{pred,Tbi} / N_{pred, Cbj})*(Y_{BT} / Y_{BC})$

Adj_{ija}		$N_{pred,Tai}$	16.90	13.30	26.69	34.78	12.47	11.93	13.74	10.16	26.92	10.13	7.22	27.61	65.33	63.63	12.48	38.49
		Y_{AT}	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	**103**	**109**
$N_{pred,Caj}$	Y_{AC}	CIntNum																
12.91	3	**3**	1.309	1.030	2.067	2.694	0.966	0.924										
6.52	3	17	2.594	2.042	4.096	5.339	1.914	1.831										
9.90	3	18	1.707	1.344	2.696	3.514	1.260	1.205										
6.21	3	19	2.721	2.142	4.297	5.601	2.008	1.921										
84.58	3	22	0.200	0.157	0.316	0.411	0.147	0.141										
5.49	3	23	3.080	2.425	4.864	6.340	2.273	2.174										
41.52	3	**9**							0.331	0.245	0.648	0.244	0.174					
6.18	3	20							2.224	1.645	4.357	1.640	1.168					
12.83	3	21							1.071	0.792	2.097	0.789	0.563					
7.91	3	24							1.737	1.285	3.403	1.281	0.913					
16.75	3	25							0.821	0.607	1.607	0.605	0.431					
5.21	3	26												5.296	12.532	12.205	2.395	7.384
14.39	3	27												1.918	4.539	4.420	0.867	2.674
12.82	3	28												2.154	5.095	4.963	0.974	3.002
15.46	3	29												1.785	4.224	4.114	0.807	2.489
87.97	3	**122**												0.314	0.743	0.723	0.142	0.438

Adj_{ija} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during AFTER period (

$= (N_{pred,Tai} / N_{pred, Caj})*(Y_{AT} / Y_{AC})$

CASE 2: BASE + ALL CMF; C = 1.00

STEP 4 CALCULATE EXPECTED AVERAGE CRASH FREQUENCY (ADJUSTED CRASH FREQUENCY) FOR EACH COMBINATION, SEPARATELY FOR BEFORE & AFTER PERIODS

STEP 5 CALCULATE TOTAL COMPARISON GROUP ADJUSTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN BEFORE PERIOD

STEP 6 CALCULATE TOTAL COMPARISON GROUP ADJUSTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN AFTER PERIOD

R_SiteType			BefAllYrs $N_{observed,B}$	AftAllYrs $N_{observedA}$
0	IntNum	3	16	19
		9	14	16
		17	28	24
		18	25	19
		19	19	23
		20	7	8
		21	12	13
		22	9	7
		23	12	13
		24	13	7
		25	17	12
		26	8	26
		27	13	11
		28	13	14
		29	18	10
		122	14	9
d (b1	IntNum	1	27	3
		2	26	26
		4	12	5
		5	7	2
		6	7	6
		7	19	23
		8	18	7
		10	9	3
		11	7	1
		12	12	5
		13	23	7
		14	8	10
		15	9	4
		16	13	3
		103	25	14
		109	13	8

(a)

$N_{exptd,CB}$	$N_{pred,Tbi}$ / Y_{BT} / TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
$N_{obsvd,Cbj}$	CIntNum																
16	3	22.07	15.00	29.58	38.71	15.65	13.93										
28	17	77.00	52.36	103.21	135.09	54.61	48.63										
25	18	39.56	26.90	53.02	69.40	28.06	24.98										
19	19	49.62	33.74	66.51	87.06	35.19	31.34										
9	22	2.59	1.76	3.48	4.55	1.84	1.64										
12	23	38.15	25.94	51.14	66.93	27.06	24.09										
14	9							4.82	3.33	9.82	3.41	2.46					
7	20							15.70	10.84	31.95	11.09	8.01					
12	21							10.77	7.44	21.92	7.61	5.49					
13	24							23.03	15.90	46.88	16.28	11.75					
17	25							14.31	9.88	29.13	10.11	7.30					
8	26												37.32	101.66	100.56	18.83	58.86
13	27												21.56	58.71	58.07	10.87	34.00
13	28												25.70	70.02	69.25	12.97	40.54
18	29												27.16	73.97	73.16	13.70	42.83
14	122												3.94	10.72	10.60	1.99	6.21
	$N_{exptd,CB,total}$	**229.00**	**155.72**	**306.93**	**401.74**	**162.41**	**144.61**	**68.64**	**47.39**	**139.71**	**48.50**	**35.01**	**115.68**	**315.09**	**311.65**	**58.35**	**182.43**

Adj_{ijb} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during BEFORE perio

$= (N_{pred,Tbi} / N_{pred,Cbj})*(Y_{BT} / Y_{BC})$

$N_{exptd,CA}$		$N_{pred,Tai}$ / Y_{AT} / TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
$N_{obsvd,Caj}$	Y_{AC}	CIntNum																
19	3	3	24.86	19.57	39.26	51.18	18.35	17.55										
24	3	17	62.25	49.01	98.30	128.13	45.93	43.94										
19	3	18	32.44	25.54	51.23	66.77	23.94	22.90										
23	3	19	62.58	49.27	98.83	128.81	46.18	44.18										
7	3	22	1.40	1.10	2.21	2.88	1.03	0.99										
13	3	23	40.04	31.52	63.23	82.41	29.54	28.27										
16	3	9							5.30	3.92	10.37	3.90	2.78					
8	3	20							17.79	13.16	34.85	13.12	9.35					
13	3	21							13.92	10.30	27.27	10.26	7.31					
7	3	24							12.16	9.00	23.82	8.97	6.39					
12	3	25							9.85	7.28	19.29	7.26	5.17					
26	3	26												137.70	325.82	317.33	62.27	191.98
11	3	27												21.10	49.93	48.63	9.54	29.42
14	3	28												30.15	71.34	69.48	13.63	42.03
10	3	29												17.85	42.24	41.14	8.07	24.89
9	3	122												2.82	6.68	6.51	1.28	3.94
		$N_{exptd,CA,total}$	**223.55**	**176.01**	**353.06**	**460.19**	**164.96**	**157.83**	**59.02**	**43.65**	**115.60**	**43.51**	**31.00**	**209.63**	**496.01**	**483.09**	**94.79**	**292.26**

Adj_{ija} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during AFTER period

$= (N_{pred,Tai} / N_{pred,Caj})*(Y_{AT} / Y_{AC})$

CASE 2: BASE + ALL CMF; C = 1.00

STEP 7 CALCULATE COMPARISON RATIO FOR EACH TREATMENT SITE
STEP 8 CALCULATE EXPECTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN THE AFTER PERIOD, HAD NO TREATMENT BEEN IMPLEMENTED
STEP 9 CALCULATE SAFETY EFFECTIVENESS EXPRESSED AS AN ODDS RATIO AT AN INDIVIDUAL TREATMENT SITE
STEP 10 CALCULATE LOG ODDS RATIO FOR EACH TREATMENT SITE
STEP 11 CALCULATE WEIGHT FOR EACH TREATMENT SITE

	TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	**103**	**109**	Totals
STEP 6	$N_{exptd,CA,total}$	223.55	176.01	353.06	460.19	164.96	157.83	59.02	43.65	115.60	43.51	31.00	209.63	496.01	483.09	94.79	292.26	
STEP 5	$N_{exptd,CB,total}$	229.00	155.72	306.93	401.74	162.41	144.61	68.64	47.39	139.71	48.50	35.01	115.68	315.09	311.65	58.35	182.43	
STEP 7	$r_{i,C}$	0.9762	1.1303	1.1503	1.1455	1.0157	1.0914	0.8599	0.9213	0.8274	0.8971	0.8856	1.8122	1.5742	1.5501	1.6246	1.602	
	$N_{observedTB}$	27	26	12	19	7	23	7	7	18	9	8	12	9	13	25	13	
STEP 8	$N_{exptd,TA}$	26.36	29.39	13.80	21.76	7.11	25.10	6.02	6.45	14.89	8.07	7.09	21.75	14.17	20.15	40.61	20.83	
	$N_{observedTA}$	3	26	5	23	1	7	2	6	7	3	10	5	4	3	14	8	
STEP 9	$omega_i$	0.114	0.885	0.362	1.057	0.141	0.279	0.332	0.930	0.470	0.372	1.411	0.230	0.282	0.149	0.345	0.384	
	omega check:	0.114	0.885	0.362	1.057	0.141	0.279	0.332	0.930	0.470	0.372	1.411	0.230	0.282	0.149	0.345	0.384	
STEP 10	R_i	-2.173	-0.123	-1.015	0.0552	-1.962	-1.277	-1.102	-0.072	-0.755	-0.99	0.3446	-1.47	-1.265	-1.905	-1.065	-0.957	
	$R_{i(SE)}^2$	0.3792	0.089	0.2894	0.1008	1.1551	0.1996	0.6744	0.3535	0.2142	0.488	0.2858	0.2967	0.3663	0.4155	0.1391	0.2108	Totals
STEP 11	w_i	2.637	11.233	3.455	9.923	0.866	5.010	1.483	2.829	4.668	2.049	3.499	3.370	2.730	2.407	7.188	4.743	**68.089**
	w_iR_i	-5.731	-1.376	-3.509	0.5481	-1.698	-6.399	-1.634	-0.204	-3.524	-2.028	1.2056	-4.954	-3.453	-4.584	-7.656	-4.538	**-49.533**

$r_{i,C} = N_{exptd,C,A,total} / N_{exptd,C,B,total}$

$N_{exptd,TA} = sum(N_{obsvd,T,B} * r_{iC})$ over all sites

$omega_i = sum(N_{observed,T,A} / N_{expected,T,A})$ over all sites

$= (N_{observed,T,A,total} / N_{observed,T,B,total}) * (N_{expected,C,B,total} / N_{expected,C,A,total})$

d (b)

$R_{i(SE)}^2 = (1/N_{observed,T,A,total}) + (1/ N_{observed,T,B,total}) + (1/N_{expected,C,B,total}) + (1/N_{expected,C,A,total})$

$w_i = 1/R_{i(SE)}^2$

(a)

CASE 2: BASE + ALL CMF; C = 1.00

STEP 12 CALCULATE WEIGHTED AVERAGE LOG ODDS RATIO ACROSS ALL TREATMENT SITES

$sum(w_i*R_i)$ -49.533

$sum(w_i)$ 68.089

-0.727 = R =sum(wi*Ri)/sum(wi)

STEP 13 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT EXPRESSED AS AN ODDS RATIO

0.48 = OR = exp(R)

STEP 14 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT EXPRESSED AS A PERCENTAGE CHANGE IN CRASH FREQUENCY

51.69 = Safety Effectiveness = 100 * (1 - R)

51.69% = Safety Effectiveness

ESTIMATION OF PRECISION OF TREATMENT EFFECTIVENESS

STEP 15 CALCULATE STANDARD ERROR OF TREATMENT EFFECTIVENESS

5.85 = SE(Safety Effectiveness) = 100 * OR / sqrt(sum(wi))

STEP 16 ASSESS STATISTICAL SIGNIFICANCE OF ESTIMATED SAFETY EFFECTIVENESS

8.83 = Performance Measure = ABS[Safety Effectiveness / SE(Safety Effectiveness)]

PM < 1.7 Treatment Effect NOT significant at the (approx.) 90% confidence interval

PM >= 1.7 Treatment Effect IS significant at the (approx.) 90% confidence interval

PM >= 2.0 Treatment Effect IS significant at the (approx.) 95% confidence interval

CASE 3: BASE + ALL CMF + Ci_forNC

pulled from sheet 2-Intersections_prepped

Step 1b Determine Crash Modification Factors (CMFs) and Calibration Factors (Ci) for each intersection for each year

vlookup column >>		5	6	296	299	300	297	301							
				for CMF_1i	for CMF_2i		for CMF_3i	n_prohib			N_{bisv}				
R_SiteType		Approaches	Legs	AppsWLeftLns	AppsWLeftProt	LeftProtPerm	AppsWRgtLns	AppsRTORprohib	Bef3Yr	Bef2Yr	Bef1Yr	Aft1Yr	Aft2Yr	Aft3Yr	RLC
0	IntNum 3	2	4	0	0	0	1	0	0.34	0.35	0.35	0.34	0.32	0.32	0
	9	4	4	0	4	0	4	0	0.96	1.00	1.02	1.03	0.97	0.89	0
	17	2	4	0	0	0	0	0	0.23	0.22	0.22	0.22	0.21	0.21	0
	18	4	4	0	0	0	2	0	0.32	0.30	0.26	0.25	0.25	0.25	0
	19	3	4	0	0	0	0	0	0.25	0.23	0.22	0.22	0.20	0.20	0
	20	4	4	0	0	0	4	0	0.23	0.23	0.23	0.22	0.22	0.22	0
	21	4	4	0	0	2	4	0	0.43	0.44	0.44	0.40	0.36	0.36	0
	22	3	4	0	0	1	2	0	1.11	1.15	1.19	1.28	1.36	1.37	0
	23	2	4	0	0	0	1	0	0.22	0.21	0.19	0.19	0.20	0.20	0
	24	4	4	0	2	0	3	0	0.28	0.29	0.28	0.27	0.27	0.27	0
	25	3	4	0	0	0	1	0	0.41	0.44	0.46	0.44	0.41	0.42	0
	26	2	4	0	0	0	0	0	0.19	0.19	0.19	0.18	0.19	0.19	0
	27	4	4	1	2	2	4	0	0.52	0.52	0.51	0.49	0.50	0.51	0
	28	4	4	0	0	2	4	0	0.36	0.37	0.37	0.37	0.38	0.39	0
	29	4	4	0	0	0	4	1	0.40	0.41	0.39	0.38	0.38	0.39	0
	122	3	4	0	0	1	2	0	1.37	1.38	1.36	1.33	1.36	1.39	0
1	IntNum 1	2	4	0	0	0	0	1	0.41	0.42	0.42	0.40	0.38	0.37	1
	2	2	4	0	0	0	1	0	0.30	0.31	0.32	0.32	0.32	0.32	1
	4	4	4	0	0	1	3	1	0.52	0.52	0.52	0.49	0.56	0.62	1
	5	4	4	1	4	0	4	0	0.44	0.43	0.42	0.40	0.40	0.40	1
	6	4	4	0	2	0	4	0	0.28	0.30	0.33	0.31	0.30	0.30	1
	7	3	3	0	1	0	2	0	0.53	0.54	0.54	0.54	0.54	0.54	1
	8	4	4	0	4	0	4	0	0.82	0.87	0.82	0.77	0.77	0.76	1
	10	4	4	0	2	2	3	0	0.30	0.31	0.33	0.32	0.31	0.31	1
	11	4	4	0	1	0	3	1	0.36	0.36	0.35	0.34	0.33	0.33	1
	12	4	4	1	2	0	4	0	0.59	0.57	0.58	0.63	0.64	0.66	1
	13	4	4	0	2	0	4	0	0.37	0.38	0.40	0.38	0.37	0.38	1
	14	3	4	0	1	0	1	0	0.26	0.25	0.24	0.24	0.24	0.25	1
	15	2	3	0	1	0	0	0	1.05	1.03	1.02	1.01	1.01	1.01	1
	16	2	3	0	1	0	1	0	1.12	1.07	1.06	1.05	1.04	1.02	1
	103	2	4	0	0	0	1	0	0.32	0.32	0.32	0.31	0.32	0.32	1
	109	4	4	0	4	0	4	0	0.97	0.89	0.93	0.94	0.90	0.87	1

R_SiteType		CMF_1i	CMF_2i	CMF_3i	CMF_4i	CMF_5i	CMF_6i	Ci
0	IntNum 3	1.00	1.00	0.96	1.00	0.91		2.79
	9	1.00	0.78	0.85	1.00	0.91		2.79
	17	1.00	1.00	1.00	1.00	0.91		2.79
	18	1.00	1.00	0.92	1.00	0.91		2.79
	19	1.00	1.00	1.00	1.00	0.91		2.79
	20	1.00	1.00	0.85	1.00	0.91		2.79
	21	1.00	0.98	0.85	1.00	0.91		2.79
	22	1.00	0.99	0.92	1.00	0.91		2.79
	23	1.00	1.00	0.96	1.00	0.91		2.79
	24	1.00	0.88	0.88	1.00	0.91		2.79
	25	1.00	1.00	0.96	1.00	0.91		2.79
	26	1.00	1.00	1.00	1.00	0.91		2.79
	27	0.90	0.87	0.85	1.00	0.91		2.79
	28	1.00	0.98	0.85	1.00	0.91		2.79
	29	1.00	1.00	0.85	0.98	0.91		2.79
	122	1.00	0.99	0.92	1.00	0.91		2.79
1	IntNum 1	1.00	1.00	1.00	0.98	0.91		2.79
	2	1.00	1.00	0.96	1.00	0.91		2.79
	4	1.00	0.99	0.88	0.98	0.91		2.79
	5	0.90	0.78	0.85	1.00	0.91		2.79
	6	1.00	0.88	0.85	1.00	0.91		2.79
	7	1.00	0.94	0.92	1.00	0.91		2.47
	8	1.00	0.78	0.85	1.00	0.91		2.79
	10	1.00	0.87	0.88	1.00	0.91		2.79
	11	1.00	0.94	0.88	0.98	0.91		2.79
	12	0.90	0.88	0.85	1.00	0.91		2.79
	13	1.00	0.88	0.85	1.00	0.91		2.79
	14	1.00	0.94	0.96	1.00	0.91		2.79
	15	1.00	0.94	1.00	1.00	0.91		2.47
	16	1.00	0.94	0.96	1.00	0.91		2.47
	103	1.00	1.00	0.96	1.00	0.91		2.79
	109	1.00	0.78	0.85	1.00	0.91		2.79

ESTIMATION OF MEAN TREATMENT EFFECTIVENESS

CASE 3: BASE + ALL CMF + Ci_forNC

STEPS 1b & 2b CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR BEFORE TREATMENT

Step 2.b.1 Calculate Safety Performance Functions for each COMPARISON intersection for each BEFORE year

Step 1.b.1 Calculate Safety Performance Functions for each TREATMENT intersection for each BEFORE year

R_SiteType			FormulaApplied	Bef3Yr					Bef2Yr					Bef1Yr				
				$N_{bimv\text{-}nSG}$	$N'_{bimv(FI)\text{-}nSG}$	$N'_{bimv(PDO)\text{-}nSG}$	$N_{bimv(FI)\text{-}nSG}$	$N_{bimv(PDO)\text{-}nSG}$	$N_{bimv\text{-}nSG}$	$N'_{bimv(FI)\text{-}nSG}$	$N'_{bimv(PDO)\text{-}nSG}$	$N_{bimv(FI)\text{-}nSG}$	$N_{bimv(PDO)\text{-}nSG}$	$N_{bimv\text{-}nSG}$	$N'_{bimv(FI)\text{-}nSG}$	$N'_{bimv(PDO)\text{-}nSG}$	$N_{bimv(FI)\text{-}nSG}$	$N_{bimv(PDO)\text{-}nSG}$
0	IntNum	3	4SG	5.17	1.64	3.34	1.70	3.47	5.29	1.67	3.42	1.74	3.55	5.39	1.71	3.49	1.77	3.62
		9	4SG	22.49	8.05	13.81	8.28	14.21	24.11	8.69	14.76	8.94	15.17	24.80	8.97	15.16	9.22	15.58
		17	4SG	2.62	0.76	1.76	0.79	1.82	2.54	0.74	1.71	0.77	1.77	2.47	0.72	1.66	0.75	1.72
		18	4SG	5.46	1.78	3.48	1.85	3.62	4.86	1.56	3.11	1.62	3.23	4.09	1.30	2.63	1.35	2.74
		19	4SG	2.95	0.87	1.97	0.91	2.05	2.68	0.78	1.80	0.81	1.87	2.40	0.70	1.62	0.72	1.68
		20	4SG	2.93	0.88	1.94	0.91	2.02	2.86	0.85	1.90	0.88	1.97	2.78	0.83	1.85	0.86	1.92
		21	4SG	7.13	2.31	4.57	2.39	4.74	7.28	2.36	4.66	2.45	4.83	7.43	2.42	4.76	2.50	4.93
		22	4SG	25.28	8.97	15.64	9.21	16.07	26.64	9.50	16.45	9.75	16.89	28.02	10.04	17.27	10.30	17.72
		23	4SG	2.57	0.75	1.73	0.78	1.79	2.29	0.66	1.55	0.69	1.60	2.01	0.57	1.37	0.60	1.42
		24	4SG	3.92	1.21	2.56	1.25	2.66	4.06	1.26	2.65	1.30	2.76	3.88	1.20	2.54	1.24	2.63
		25	4SG	6.08	1.91	3.95	1.98	4.10	6.73	2.14	4.36	2.22	4.51	7.40	2.38	4.77	2.46	4.94
		26	4SG	1.96	0.56	1.34	0.58	1.39	1.97	0.56	1.35	0.58	1.39	1.90	0.54	1.30	0.56	1.35
		27	4SG	8.36	2.69	5.40	2.78	5.58	8.36	2.69	5.40	2.78	5.58	8.08	2.59	5.22	2.68	5.40
		28	4SG	5.31	1.67	3.45	1.73	3.58	5.61	1.77	3.64	1.84	3.78	5.61	1.77	3.64	1.84	3.78
		29	4SG	7.22	2.39	4.57	2.48	4.74	7.45	2.48	4.71	2.57	4.88	7.01	2.32	4.43	2.40	4.60
		122	4SG	35.42	13.04	21.55	13.36	22.07	35.85	13.22	21.80	13.53	22.32	35.14	12.94	21.37	13.26	21.88
1	IntNum	1	4SG	7.13	2.34	4.54	2.42	4.71	7.14	2.33	4.56	2.42	4.72	7.14	2.32	4.56	2.41	4.73
		2	4SG	4.79	1.53	3.07	1.60	3.19	4.95	1.59	3.17	1.65	3.30	5.12	1.65	3.28	1.71	3.41
		4	4SG	10.69	3.69	6.63	3.82	6.87	10.99	3.81	6.80	3.95	7.04	11.26	3.93	6.95	4.07	7.19
		5	4SG	9.16	3.17	5.66	3.29	5.87	9.26	3.22	5.70	3.34	5.91	8.92	3.11	5.49	3.22	5.70
		6	4SG	4.48	1.44	2.87	1.50	2.98	5.00	1.62	3.19	1.68	3.32	5.53	1.80	3.52	1.87	3.66
		7	3SG	13.51	3.74	9.00	3.96	9.54	14.19	3.91	9.47	4.15	10.04	14.87	4.08	9.94	4.33	10.54
		8	4SG	16.35	5.60	10.27	5.77	10.58	17.48	5.99	10.99	6.16	11.32	16.26	5.55	10.23	5.71	10.54
		10	4SG	4.67	1.49	3.00	1.54	3.12	5.05	1.62	3.23	1.68	3.36	5.43	1.75	3.47	1.82	3.60
		11	4SG	6.28	2.06	3.99	2.13	4.14	6.12	2.00	3.89	2.08	4.04	5.96	1.94	3.79	2.02	3.94
		12	4SG	13.74	4.90	8.40	5.06	8.68	13.00	4.61	7.96	4.77	8.23	13.57	4.84	8.28	5.00	8.57
		13	4SG	5.55	1.75	3.60	1.82	3.73	5.88	1.87	3.80	1.94	3.94	6.22	1.98	4.01	2.06	4.16
		14	4SG	3.25	0.97	2.16	1.01	2.24	3.08	0.91	2.05	0.95	2.13	2.90	0.86	1.94	0.89	2.01
		15	3SG	27.54	6.53	19.59	6.89	20.65	25.91	6.16	18.43	6.50	19.42	25.50	6.08	18.12	6.41	19.09
		16	3SG	28.77	6.72	20.61	7.08	21.69	26.49	6.25	18.90	6.59	19.91	26.08	6.17	18.59	6.50	19.58
		103	4SG	4.80	1.51	3.11	1.57	3.23	4.76	1.50	3.08	1.56	3.20	4.75	1.50	3.07	1.56	3.19
		109	4SG	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90	21.54	7.69	13.25	7.91	13.63

CASE 3: BASE + ALL CMF + Ci_forNC

STEPS 1a & 2a CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR AFTER TREATMENT

1 TREAT	b before	1 by year
2 COMP	a after	2 all years

Step 2.a.1 Calculate Safety Performance Functions for each COMPARISON intersection for each AFTER year

Step 1.a.1 Calculate Safety Performance Functions for each TREATMENT intersection for each AFTER year

Aft1Yr					Aft2Yr					Aft3Yr				
$N_{aimv-nSG}$	$N'_{aimv(FI)-nSG}$	$N'_{aimv(PDO)-nSG}$	$N_{aimv(FI)-nSG}$	$N_{aimv(PDO)-nSG}$	$N_{aimv-nSG}$	$N'_{aimv(FI)-nSG}$	$N'_{aimv(PDO)-nSG}$	$N_{aimv(FI)-nSG}$	$N_{aimv(PDO)-nSG}$	$N_{aimv-nSG}$	$N'_{aimv(FI)-nSG}$	$N'_{aimv(PDO)-nSG}$	$N_{aimv(FI)-nSG}$	$N_{aimv(PDO)-nSG}$
5.12	1.62	3.32	1.68	3.44	4.85	1.53	3.14	1.59	3.26	4.80	1.51	3.11	1.57	3.23
25.50	9.25	15.57	9.51	15.99	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90
2.42	0.70	1.63	0.73	1.69	2.37	0.69	1.60	0.71	1.66	2.36	0.68	1.59	0.71	1.65
3.90	1.24	2.50	1.29	2.61	3.90	1.24	2.50	1.29	2.61	4.01	1.28	2.57	1.33	2.68
2.40	0.69	1.62	0.72	1.68	2.23	0.65	1.50	0.67	1.56	2.19	0.64	1.47	0.66	1.53
2.71	0.80	1.81	0.83	1.88	2.64	0.78	1.76	0.81	1.83	2.64	0.78	1.76	0.81	1.83
6.34	2.03	4.09	2.10	4.24	5.28	1.66	3.43	1.72	3.56	5.29	1.66	3.44	1.72	3.57
31.55	11.46	19.31	11.75	19.80	35.00	12.87	21.30	13.18	21.82	35.42	13.04	21.55	13.36	22.07
2.06	0.59	1.39	0.61	1.45	2.10	0.60	1.42	0.62	1.47	2.12	0.61	1.44	0.63	1.49
3.70	1.14	2.42	1.18	2.52	3.72	1.14	2.44	1.19	2.53	3.75	1.15	2.46	1.20	2.55
6.76	2.15	4.38	2.22	4.53	6.11	1.92	3.98	1.99	4.12	6.29	1.98	4.09	2.05	4.23
1.83	0.52	1.25	0.53	1.30	1.91	0.54	1.30	0.56	1.35	1.98	0.56	1.35	0.58	1.40
7.81	2.50	5.05	2.59	5.22	7.95	2.55	5.15	2.63	5.32	8.09	2.59	5.24	2.68	5.42
5.61	1.77	3.64	1.84	3.78	5.64	1.77	3.67	1.84	3.80	5.64	1.77	3.68	1.83	3.81
6.57	2.16	4.17	2.24	4.33	6.80	2.24	4.30	2.33	4.47	7.02	2.33	4.44	2.42	4.61
34.43	12.67	20.94	12.98	21.45	35.35	13.03	21.49	13.34	22.01	36.28	13.39	22.04	13.71	22.57
6.68	2.17	4.27	2.25	4.43	6.22	2.01	3.98	2.09	4.13	6.03	1.95	3.86	2.02	4.01
5.10	1.63	3.27	1.70	3.40	5.07	1.62	3.26	1.68	3.38	5.05	1.62	3.25	1.68	3.37
10.46	3.64	6.46	3.77	6.69	11.42	3.93	7.11	4.06	7.36	12.44	4.26	7.78	4.41	8.04
8.57	2.99	5.27	3.10	5.47	8.43	2.92	5.20	3.03	5.40	8.26	2.85	5.11	2.96	5.30
5.19	1.68	3.31	1.75	3.44	4.85	1.56	3.10	1.63	3.22	4.83	1.55	3.09	1.61	3.21
14.87	4.08	9.94	4.33	10.54	14.87	4.08	9.94	4.33	10.54	14.42	3.97	9.63	4.21	10.21
15.04	5.11	9.48	5.27	9.77	14.85	5.04	9.36	5.19	9.65	14.65	4.97	9.25	5.12	9.53
5.05	1.62	3.24	1.69	3.37	4.84	1.54	3.12	1.60	3.24	4.71	1.49	3.04	1.55	3.16
5.76	1.88	3.67	1.95	3.81	5.56	1.81	3.54	1.88	3.68	5.57	1.81	3.55	1.88	3.69
14.77	5.28	9.01	5.46	9.31	14.97	5.34	9.16	5.51	9.46	15.11	5.37	9.26	5.55	9.57
5.91	1.88	3.83	1.95	3.97	5.61	1.77	3.64	1.84	3.78	5.91	1.88	3.83	1.95	3.97
2.92	0.86	1.95	0.90	2.02	2.93	0.87	1.95	0.90	2.03	2.94	0.87	1.97	0.90	2.04
25.09	5.99	17.81	6.32	18.77	25.44	6.08	18.06	6.41	19.03	25.78	6.17	18.29	6.50	19.28
25.66	6.08	18.28	6.41	19.26	25.82	6.14	18.36	6.47	19.35	25.94	6.19	18.42	6.53	19.42
4.74	1.50	3.07	1.55	3.19	4.76	1.50	3.08	1.56	3.20	4.78	1.51	3.09	1.57	3.21
22.40	8.05	13.73	8.28	14.12	21.08	7.55	12.93	7.77	13.31	20.21	7.20	12.42	7.42	12.79

CASE 3: BASE + ALL CMF + Ci_forNC

$N_{pred,bi} = N_{bimv} * (CMF_{1i} * \ldots * CMF_{6i}) * C_i$

Note: if CMF or C unknown, assume 1.00.

STEPS 1b & 2b CALCULATE PREDICTED CRASH FREQUENCY BY SITE FOR ENTIRE BEFORE PERIOD

Step 2.b.2 Calculate SPFs for each COMPARISON intersection for entire BEFORE period

Step 1.b.2 Calculate SPFs for each TREATMENT intersection for entire BEFORE period

RESULTS OF STEPS 1b & 2b

R_SiteType			FormulaApplied	BefAllYrs			BefAllYrs		
				$N_{bimv\text{-}nSG}$	$N_{bimv(FI)\text{-}nSG}$	$N_{bimv(PDO)\text{-}nSG}$	$N_{pred,bi}$	$N_{pred,bi(FI)}$	$N_{pred,bi(PDO)}$
0	IntNum	3	4SG	15.85	5.21	10.64	38.66	12.70	25.95
		9	4SG	71.40	26.44	44.96	120.39	44.58	75.82
		17	4SG	7.63	2.31	5.32	19.39	5.87	13.52
		18	4SG	14.41	4.83	9.59	33.69	11.28	22.41
		19	4SG	8.03	2.44	5.59	20.41	6.20	14.21
		20	4SG	8.57	2.65	5.91	18.50	5.73	12.77
		21	4SG	21.84	7.34	14.50	46.23	15.54	30.69
		22	4SG	79.95	29.27	50.68	185.01	67.73	117.28
		23	4SG	6.88	2.06	4.81	16.77	5.03	11.74
		24	4SG	11.85	3.80	8.05	23.42	7.51	15.91
		25	4SG	20.21	6.66	13.55	49.29	16.24	33.05
		26	4SG	5.84	1.71	4.13	14.84	4.35	10.48
		27	4SG	24.80	8.24	16.56	41.75	13.87	27.88
		28	4SG	16.54	5.41	11.13	35.01	11.44	23.57
		29	4SG	21.68	7.45	14.22	45.88	15.78	30.11
		122	4SG	106.41	40.14	66.27	246.27	92.90	153.36
1	IntNum	1	4SG	21.41	7.25	14.16	53.32	18.06	35.26
		2	4SG	14.86	4.96	9.90	36.26	12.11	24.15
		4	4SG	32.94	11.84	21.11	71.46	25.68	45.79
		5	4SG	27.34	9.86	17.48	41.49	14.96	26.53
		6	4SG	15.01	5.05	9.96	28.65	9.64	19.01
		7	3SG	42.57	12.44	30.13	82.81	24.20	58.61
		8	4SG	50.09	17.64	32.45	84.46	29.75	54.71
		10	4SG	15.14	5.05	10.09	29.32	9.78	19.54
		11	4SG	18.36	6.23	12.13	37.81	12.84	24.98
		12	4SG	40.31	14.83	25.48	69.22	25.47	43.75
		13	4SG	17.64	5.81	11.83	33.67	11.09	22.58
		14	4SG	9.23	2.85	6.38	21.16	6.53	14.63
		15	3SG	78.95	19.79	59.16	166.93	41.84	125.09
		16	3SG	81.34	20.16	61.18	165.11	40.92	124.19
		103	4SG	14.32	4.69	9.62	34.92	11.44	23.47
		109	4SG	64.75	23.78	40.97	109.17	40.09	69.08

CASE 3: BASE + ALL CMF + Ci_forNC

STEPS 1a & 2a CALCULATE PREDICTED CRASH FREQUENCY BY SITE IN PERIOD AFTER TREATMENT

Step 2.a.2 Calculate SPFs for each COMPARISON intersection for entire AFTER period

Step 1.a.2 Calculate SPFs for each TREATMENT intersection for entire AFTER period

RESULTS OF STEPS 1a & 2a

R_SiteType			FormulaApplied	AftAllYrs			AftAllYrs		
				$N_{aimv\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	$N_{pred,ai}$	$N_{pred,ai(FI)}$	$N_{pred,ai(PDO)}$
0	IntNum	3	4SG	14.77	4.84	9.93	36.03	11.80	24.23
		9	4SG	68.70	25.37	43.33	115.85	42.78	73.07
		17	4SG	7.15	2.15	5.00	18.18	5.47	12.71
		18	4SG	11.81	3.92	7.89	27.62	9.17	18.45
		19	4SG	6.82	2.05	4.77	17.33	5.22	12.11
		20	4SG	7.98	2.45	5.53	17.24	5.30	11.94
		21	4SG	16.92	5.55	11.37	35.81	11.74	24.06
		22	4SG	101.97	38.28	63.69	235.98	88.60	147.38
		23	4SG	6.28	1.86	4.41	15.31	4.54	10.77
		24	4SG	11.17	3.57	7.60	22.07	7.05	15.02
		25	4SG	19.15	6.27	12.89	46.72	15.29	31.43
		26	4SG	5.72	1.68	4.05	14.54	4.26	10.29
		27	4SG	23.86	7.90	15.96	40.16	13.29	26.87
		28	4SG	16.90	5.51	11.39	35.77	11.66	24.11
		29	4SG	20.39	6.99	13.40	43.15	14.79	28.36
		122	4SG	106.06	40.03	66.03	245.44	92.64	152.80
1	IntNum	1	4SG	18.93	6.36	12.57	47.14	15.83	31.31
		2	4SG	15.22	5.06	10.16	37.12	12.35	24.77
		4	4SG	34.32	12.24	22.08	74.45	26.55	47.91
		5	4SG	25.27	9.09	16.18	38.34	13.79	24.55
		6	4SG	14.86	4.99	9.87	28.36	9.52	18.84
		7	3SG	44.17	12.87	31.29	85.92	25.04	60.88
		8	4SG	44.54	15.58	28.95	75.10	26.28	48.82
		10	4SG	14.60	4.83	9.76	28.27	9.36	18.91
		11	4SG	16.89	5.71	11.18	34.79	11.76	23.03
		12	4SG	44.85	16.51	28.34	77.03	28.36	48.67
		13	4SG	17.44	5.73	11.71	33.28	10.94	22.35
		14	4SG	8.78	2.70	6.09	20.14	6.18	13.96
		15	3SG	76.31	19.23	57.09	161.36	40.65	120.71
		16	3SG	77.42	19.40	58.02	157.16	39.38	117.78
		103	4SG	14.28	4.68	9.60	34.83	11.42	23.42
		109	4SG	63.69	23.47	40.22	107.40	39.57	67.83

CASE 3: BASE + ALL CMF + Ci_forNC

STEP 3 CALCULATE ADJUSTMENT FACTOR FOR EACH COMBINATION OF TREATMENT & COMPARISON SITE, SEPARATELY FOR BEFORE & AFTER PERIODS

	DO NOT SORT	DO NOT SORT
R_SiteType	1	0
Pairings	Treatment IntNum	Comparison IntNum
	1	23
	2	17
	4	3
	5	24
	6	21
	7	22
	8	9
	10	20
	11	18
	12	27
	13	19
	14	25
	15	29
	16	122
	103	26
	109	28

Note: each color represents a different three-year span of time since cameras were installed at various times. The colors will have to be referred to for the next steps when adjustments are made because they should only use other intersections from the same time period for the calculations to be valid.

Adj_{ijb}		$N_{pred,Tbi}$	53.32	36.26	71.46	82.81	37.81	33.67	41.49	28.65	84.46	29.32	21.16	69.22	166.93	165.11	34.92	109.17
		Y_{BT}	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
$N_{pred,Cbj}$	Y_{BC}	CIntNum																
38.66	3	3	1.379	0.938	1.848	2.142	0.978	0.871										
19.39	3	17	2.750	1.870	3.686	4.271	1.950	1.737										
33.69	3	18	1.582	1.076	2.121	2.458	1.122	0.999										
20.41	3	19	2.612	1.776	3.501	4.056	1.852	1.649										
185.01	3	22	0.288	0.196	0.386	0.448	0.204	0.182										
16.77	3	23	3.179	2.162	4.261	4.938	2.255	2.008										
120.39	3	9							0.345	0.238	0.702	0.244	0.176					
18.50	3	20							2.242	1.548	4.565	1.585	1.144					
46.23	3	21							0.898	0.620	1.827	0.634	0.458					
23.42	3	24							1.772	1.223	3.607	1.252	0.904					
49.29	3	25							0.842	0.581	1.714	0.595	0.429					
14.84	3	26												4.666	11.251	11.128	2.353	7.358
41.75	3	27												1.658	3.998	3.955	0.836	2.615
35.01	3	28												1.977	4.768	4.716	0.997	3.118
45.88	3	29												1.509	3.638	3.599	0.761	2.379
246.27	3	122												0.281	0.678	0.670	0.142	0.443

Adj_{ijb} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during BEFORE period (

$= (N_{pred,Tbi} / N_{pred, Cbj})*(Y_{BT} / Y_{BC})$

Adj_{ija}		$N_{pred,Tai}$	47.14	37.12	74.45	85.92	34.79	33.28	38.34	28.36	75.10	28.27	20.14	77.03	161.36	157.16	34.83	107.40
		Y_{AT}	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
$N_{pred,Caj}$	Y_{AC}	CIntNum																
36.03	3	3	1.309	1.030	2.067	2.385	0.966	0.924										
18.18	3	17	2.594	2.042	4.096	4.727	1.914	1.831										
27.62	3	18	1.707	1.344	2.696	3.111	1.260	1.205										
17.33	3	19	2.721	2.142	4.297	4.958	2.008	1.921										
235.98	3	22	0.200	0.157	0.316	0.364	0.147	0.141										
15.31	3	23	3.080	2.425	4.864	5.612	2.273	2.174										
115.85	3	9							0.331	0.245	0.648	0.244	0.174					
17.24	3	20							2.224	1.645	4.357	1.640	1.168					
35.81	3	21							1.071	0.792	2.097	0.789	0.563					
22.07	3	24							1.737	1.285	3.403	1.281	0.913					
46.72	3	25							0.821	0.607	1.607	0.605	0.431					
14.54	3	26												5.296	11.094	10.805	2.395	7.384
40.16	3	27												1.918	4.018	3.913	0.867	2.674
35.77	3	28												2.154	4.511	4.394	0.974	3.002
43.15	3	29												1.785	3.740	3.642	0.807	2.489
245.44	3	122												0.314	0.657	0.640	0.142	0.438

Adj_{ija} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during AFTER period (a)

$= (N_{pred,Tai} / N_{pred, Caj})*(Y_{AT} / Y_{AC})$

CASE 3: BASE + ALL CMF + Ci_forNC

STEP 4 CALCULATE EXPECTED AVERAGE CRASH FREQUENCY (ADJUSTED CRASH FREQUENCY) FOR EACH COMBINATION, SEPARATELY FOR BEFORE & AFTER PERIODS

STEP 5 CALCULATE TOTAL COMPARISON GROUP ADJUSTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN BEFORE PERIOD

STEP 6 CALCULATE TOTAL COMPARISON GROUP ADJUSTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN AFTER PERIOD

R_SiteType		IntNum	BefAllYrs $N_{observed,B}$	AftAllYrs $N_{observedA}$
0	IntNum	3	16	19
		9	14	16
		17	28	24
		18	25	19
		19	19	23
		20	7	8
		21	12	13
		22	9	7
		23	12	13
		24	13	7
		25	17	12
		26	8	26
		27	13	11
		28	13	14
		29	18	10
		122	14	9
b) 1	IntNum	1	27	3
		2	26	26
		4	12	5
		5	7	2
		6	7	6
		7	19	23
		8	18	7
		10	9	3
		11	7	1
		12	12	5
		13	23	7
		14	8	10
		15	9	4
		16	13	3
		103	25	14
		109	13	8

$N_{exptd,CB}$ ($N_{pred,Tbi}$, Y_{BT})

$N_{obsvd,Cbj}$	CIntNum \ TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
16	3	22.07	15.00	29.58	34.27	15.65	13.93										
28	17	77.00	52.36	103.21	119.59	54.61	48.63										
25	18	39.56	26.90	53.02	61.44	28.06	24.98										
19	19	49.62	33.74	66.51	77.07	35.19	31.34										
9	22	2.59	1.76	3.48	4.03	1.84	1.64										
12	23	38.15	25.94	51.14	59.25	27.06	24.09										
14	9							4.82	3.33	9.82	3.41	2.46					
7	20							15.70	10.84	31.95	11.09	8.01					
12	21							10.77	7.44	21.92	7.61	5.49					
13	24							23.03	15.90	46.88	16.28	11.75					
17	25							14.31	9.88	29.13	10.11	7.30					
8	26												37.32	90.00	89.02	18.83	58.86
13	27												21.56	51.98	51.41	10.87	34.00
13	28												25.70	61.98	61.31	12.97	40.54
18	29												27.16	65.49	64.77	13.70	42.83
14	122												3.94	9.49	9.39	1.99	6.21
$N_{exptd,CB,total}$		**229.00**	**155.72**	**306.93**	**355.66**	**162.41**	**144.61**	**68.64**	**47.39**	**139.71**	**48.50**	**35.01**	**115.68**	**278.95**	**275.90**	**58.35**	**182.43**

Adj_{ijb} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during BEFORE period (

$= (N_{pred,Tbi} / N_{pred,Cbj})*(Y_{BT} / Y_{BC})$

$N_{exptd,CA}$ ($N_{pred,Tai}$, Y_{AT})

$N_{obsvd,Caj}$	Y_{AC}	CIntNum \ TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
19	3	3	24.86	19.57	39.26	45.31	18.35	17.55										
24	3	17	62.25	49.01	98.30	113.44	45.93	43.94										
19	3	18	32.44	25.54	51.23	59.11	23.94	22.90										
23	3	19	62.58	49.27	98.83	114.04	46.18	44.18										
7	3	22	1.40	1.10	2.21	2.55	1.03	0.99										
13	3	23	40.04	31.52	63.23	72.96	29.54	28.27										
16	3	9							5.30	3.92	10.37	3.90	2.78					
8	3	20							17.79	13.16	34.85	13.12	9.35					
13	3	21							13.92	10.30	27.27	10.26	7.31					
7	3	24							12.16	9.00	23.82	8.97	6.39					
12	3	25							9.85	7.28	19.29	7.26	5.17					
26	3	26												137.70	288.45	280.94	62.27	191.98
11	3	27												21.10	44.20	43.05	9.54	29.42
14	3	28												30.15	63.15	61.51	13.63	42.03
10	3	29												17.85	37.40	36.42	8.07	24.89
9	3	122												2.82	5.92	5.76	1.28	3.94
$N_{exptd,CA,total}$			**223.55**	**176.01**	**353.06**	**407.41**	**164.96**	**157.83**	**59.02**	**43.65**	**115.60**	**43.51**	**31.00**	**209.63**	**439.12**	**427.68**	**94.79**	**292.26**

Adj_{ija} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during AFTER period (a)

$= (N_{pred,Tai} / N_{pred,Caj})*(Y_{AT} / Y_{AC})$

CASE 3: BASE + ALL CMF + Ci_forNC

STEP 7 CALCULATE COMPARISON RATIO FOR EACH TREATMENT SITE
STEP 8 CALCULATE EXPECTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN THE AFTER PERIOD, HAD NO TREATMENT BEEN IMPLEMENTED
STEP 9 CALCULATE SAFETY EFFECTIVENESS EXPRESSED AS AN ODDS RATIO AT AN INDIVIDUAL TREATMENT SITE
STEP 10 CALCULATE LOG ODDS RATIO FOR EACH TREATMENT SITE
STEP 11 CALCULATE WEIGHT FOR EACH TREATMENT SITE

	TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	**103**	**109**	
STEP 6	$N_{exptd,CA,total}$	223.55	176.01	353.06	407.41	164.96	157.83	59.02	43.65	115.60	43.51	31.00	209.63	439.12	427.68	94.79	292.26	
STEP 5	$N_{exptd,CB,total}$	229.00	155.72	306.93	355.66	162.41	144.61	68.64	47.39	139.71	48.50	35.01	115.68	278.95	275.90	58.35	182.43	
STEP 7	$r_{i,C}$	0.9762	1.1303	1.1503	1.1455	1.0157	1.0914	0.8599	0.9213	0.8274	0.8971	0.8856	1.8122	1.5742	1.5501	1.6246	1.602	
	$N_{observedTB}$	27	26	12	19	7	23	7	7	18	9	8	12	9	13	25	13	
STEP 8	$N_{exptd,TA}$	26.36	29.39	13.80	21.76	7.11	25.10	6.02	6.45	14.89	8.07	7.09	21.75	14.17	20.15	40.61	20.83	
	$N_{observedTA}$	3	26	5	23	1	7	2	6	7	3	10	5	4	3	14	8	
STEP 9	$omega_i$	0.114	0.885	0.362	1.057	0.141	0.279	0.332	0.930	0.470	0.372	1.411	0.230	0.282	0.149	0.345	0.384	
	omega check:	0.114	0.885	0.362	1.057	0.141	0.279	0.332	0.930	0.470	0.372	1.411	0.230	0.282	0.149	0.345	0.384	
STEP 10	R_i	-2.173	-0.123	-1.015	0.0552	-1.962	-1.277	-1.102	-0.072	-0.755	-0.99	0.3446	-1.47	-1.265	-1.905	-1.065	-0.957	
	$R_{i(SE)}^2$	0.3792	0.089	0.2894	0.1014	1.1551	0.1996	0.6744	0.3535	0.2142	0.488	0.2858	0.2967	0.367	0.4162	0.1391	0.2108	Totals
STEP 11	w_i	2.637	11.233	3.455	9.864	0.866	5.010	1.483	2.829	4.668	2.049	3.499	3.370	2.725	2.403	7.188	4.743	**68.021**
	w_iR_i	-5.731	-1.376	-3.509	0.5448	-1.698	-6.399	-1.634	-0.204	-3.524	-2.028	1.2056	-4.954	-3.446	-4.576	-7.656	-4.538	**-49.523**

$r_{i,C} = N_{exptd,C,A,total} / N_{exptd,C,B,total}$

$N_{exptd,TA} = sum(N_{obsvd,T,B} * r_{iC})$ over all sites

$omega_i = sum(N_{observed,T,A} / N_{expected,T,A})$ over all sites

$= (N_{observed,T,A,total} / N_{observed,T,B,total}) * (N_{expected,C,B,total} / N_{expected,C,A,total})$

b)

$R_{i(SE)}^2 = (1/N_{observed,T,A,total}) + (1/ N_{observed,T,B,total}) + (1/N_{expected,C,B,total}) + (1/N_{expected,C,A,total})$

$w_i = 1/R_{i(SE)}^2$

CASE 3: BASE + ALL CMF + Ci_forNC

STEP 12 CALCULATE WEIGHTED AVERAGE LOG ODDS RATIO ACROSS ALL TREATMENT SITES

$sum(w_i*R_i)$ -49.523

$sum(w_i)$ 68.021

-0.728 = R =sum(wi*Ri)/sum(wi)

STEP 13 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT EXPRESSED AS AN ODDS RATIO

0.48 = OR = exp(R)

STEP 14 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT EXPRESSED AS A PERCENTAGE CHANGE IN CRASH FREQUENCY

51.71 = Safety Effectiveness = 100 * (1 - R)

51.71% = Safety Effectiveness

ESTIMATION OF PRECISION OF TREATMENT EFFECTIVENESS

STEP 15 CALCULATE STANDARD ERROR OF TREATMENT EFFECTIVENESS

5.85 = SE(Safety Effectiveness) = 100 * OR / sqrt(sum(wi))

STEP 16 ASSESS STATISTICAL SIGNIFICANCE OF ESTIMATED SAFETY EFFECTIVENESS

8.83 = Performance Measure = ABS[Safety Effectiveness / SE(Safety Effectiveness)]

PM < 1.7 Treatment Effect NOT significant at the (approx.) 90% confidence interval
PM >= 1.7 Treatment Effect IS significant at the (approx.) 90% confidence interval
PM >= 2.0 Treatment Effect IS significant at the (approx.) 95% confidence interval

CASE 4: BASE + ALL CMF + Ci_forPiedmont

pulled from sheet 2-Intersections_prepped

Step 1b Determine Crash Modification Factors (CMFs) and Calibration Factors (Ci) for each intersection for each year

vlookup column >>		5	6	296	299	300	297	301														
				for CMF_1i	for CMF_2i		for CMF_3i	n_prohib			N_{bisv}											
R_SiteType		Approaches	Legs	AppsWLeftLns	AppsWLeftProt	LeftProtPerm	AppsWRgtLns	AppsRTORprohib	Bef3Yr	Bef2Yr	Bef1Yr	Aft1Yr	Aft2Yr	Aft3Yr	RLC	CMF_1i	CMF_2i	CMF_3i	CMF_4i	CMF_5i	CMF_6i	Ci
0 IntNum	3	2	4	0	0	0	1	0	0.34	0.35	0.35	0.34	0.32	0.32	0	1.00	1.00	0.96	1.00	0.91		4.10
	9	4	4	0	4	0	4	0	0.96	1.00	1.02	1.03	0.97	0.89	0	1.00	0.78	0.85	1.00	0.91		4.10
	17	2	4	0	0	0	0	0	0.23	0.22	0.22	0.22	0.21	0.21	0	1.00	1.00	1.00	1.00	0.91		4.10
	18	4	4	0	0	0	2	0	0.32	0.30	0.26	0.25	0.25	0.25	0	1.00	1.00	0.92	1.00	0.91		4.10
	19	3	4	0	0	0	0	0	0.25	0.23	0.22	0.22	0.20	0.20	0	1.00	1.00	1.00	1.00	0.91		4.10
	20	4	4	0	0	0	4	0	0.23	0.23	0.23	0.22	0.22	0.22	0	1.00	1.00	0.85	1.00	0.91		4.10
	21	4	4	0	0	2	4	0	0.43	0.44	0.44	0.40	0.36	0.36	0	1.00	0.98	0.85	1.00	0.91		4.10
	22	3	4	0	0	1	2	0	1.11	1.15	1.19	1.28	1.36	1.37	0	1.00	0.99	0.92	1.00	0.91		4.10
	23	2	4	0	0	0	1	0	0.22	0.21	0.19	0.19	0.20	0.20	0	1.00	1.00	0.96	1.00	0.91		4.10
	24	4	4	0	2	0	3	0	0.28	0.29	0.28	0.27	0.27	0.27	0	1.00	0.88	0.88	1.00	0.91		4.10
	25	3	4	0	0	0	1	0	0.41	0.44	0.46	0.44	0.41	0.42	0	1.00	1.00	0.96	1.00	0.91		4.10
	26	2	4	0	0	0	0	0	0.19	0.19	0.19	0.18	0.19	0.19	0	1.00	1.00	1.00	1.00	0.91		4.10
	27	4	4	1	2	2	4	0	0.52	0.52	0.51	0.49	0.50	0.51	0	0.90	0.87	0.85	1.00	0.91		4.10
	28	4	4	0	0	2	4	0	0.36	0.37	0.37	0.37	0.38	0.39	0	1.00	0.98	0.85	1.00	0.91		4.10
	29	4	4	0	0	0	4	1	0.40	0.41	0.39	0.38	0.38	0.39	0	1.00	1.00	0.85	0.98	0.91		4.10
	122	3	4	0	0	1	2	0	1.37	1.38	1.36	1.33	1.36	1.39	0	1.00	0.99	0.92	1.00	0.91		4.10
1 IntNum	1	2	4	0	0	0	0	1	0.41	0.42	0.42	0.40	0.38	0.37	1	1.00	1.00	1.00	0.98	0.91		4.10
	2	2	4	0	0	0	1	0	0.30	0.31	0.32	0.32	0.32	0.32	1	1.00	1.00	0.96	1.00	0.91		4.10
	4	4	4	0	0	1	3	1	0.52	0.52	0.52	0.49	0.56	0.62	1	1.00	0.99	0.88	0.98	0.91		4.10
	5	4	4	1	4	0	4	0	0.44	0.43	0.42	0.40	0.40	0.40	1	0.90	0.78	0.85	1.00	0.91		4.10
	6	4	4	0	2	0	4	0	0.28	0.30	0.33	0.31	0.30	0.30	1	1.00	0.88	0.85	1.00	0.91		4.10
	7	3	3	0	1	0	2	0	0.53	0.54	0.54	0.54	0.54	0.54	1	1.00	0.94	0.92	1.00	0.91		2.86
	8	4	4	0	4	0	4	0	0.82	0.87	0.82	0.77	0.77	0.76	1	1.00	0.78	0.85	1.00	0.91		4.10
	10	4	4	0	2	2	3	0	0.30	0.31	0.33	0.32	0.31	0.31	1	1.00	0.87	0.88	1.00	0.91		4.10
	11	4	4	0	1	0	3	1	0.36	0.36	0.35	0.34	0.33	0.33	1	1.00	0.94	0.88	0.98	0.91		4.10
	12	4	4	1	2	0	4	0	0.59	0.57	0.58	0.63	0.64	0.66	1	0.90	0.88	0.85	1.00	0.91		4.10
	13	4	4	0	2	0	4	0	0.37	0.38	0.40	0.38	0.37	0.38	1	1.00	0.88	0.85	1.00	0.91		4.10
	14	3	4	0	1	0	1	0	0.26	0.25	0.24	0.24	0.24	0.25	1	1.00	0.94	0.96	1.00	0.91		4.10
	15	2	3	0	1	0	0	0	1.05	1.03	1.02	1.01	1.01	1.01	1	1.00	0.94	1.00	1.00	0.91		2.86
	16	2	3	0	1	0	1	0	1.12	1.07	1.06	1.05	1.04	1.02	1	1.00	0.94	0.96	1.00	0.91		2.86
	103	2	4	0	0	0	1	0	0.32	0.32	0.32	0.31	0.32	0.32	1	1.00	1.00	0.96	1.00	0.91		4.10
	109	4	4	0	4	0	4	0	0.97	0.89	0.93	0.94	0.90	0.87	1	1.00	0.78	0.85	1.00	0.91		4.10

ESTIMATION OF MEAN TREATMENT EFFECTIVENESS

CASE 4: BASE + ALL CMF + Ci_forPiedmont

STEPS 1b & 2b CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR BEFORE TREATMENT

Step 2.b.1 Calculate Safety Performance Functions for each COMPARISON intersection for each BEFORE year

Step 1.b.1 Calculate Safety Performance Functions for each TREATMENT intersection for each BEFORE year

R_SiteType			FormulaApplied	Bef3Yr					Bef2Yr					Bef1Yr				
				$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$	$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$	$N_{bimv-nSG}$	$N'_{bimv(FI)-nSG}$	$N'_{bimv(PDO)-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$
0	IntNum	3	4SG	5.17	1.64	3.34	1.70	3.47	5.29	1.67	3.42	1.74	3.55	5.39	1.71	3.49	1.77	3.62
		9	4SG	22.49	8.05	13.81	8.28	14.21	24.11	8.69	14.76	8.94	15.17	24.80	8.97	15.16	9.22	15.58
		17	4SG	2.62	0.76	1.76	0.79	1.82	2.54	0.74	1.71	0.77	1.77	2.47	0.72	1.66	0.75	1.72
		18	4SG	5.46	1.78	3.48	1.85	3.62	4.86	1.56	3.11	1.62	3.23	4.09	1.30	2.63	1.35	2.74
		19	4SG	2.95	0.87	1.97	0.91	2.05	2.68	0.78	1.80	0.81	1.87	2.40	0.70	1.62	0.72	1.68
		20	4SG	2.93	0.88	1.94	0.91	2.02	2.86	0.85	1.90	0.88	1.97	2.78	0.83	1.85	0.86	1.92
		21	4SG	7.13	2.31	4.57	2.39	4.74	7.28	2.36	4.66	2.45	4.83	7.43	2.42	4.76	2.50	4.93
		22	4SG	25.28	8.97	15.64	9.21	16.07	26.64	9.50	16.45	9.75	16.89	28.02	10.04	17.27	10.30	17.72
		23	4SG	2.57	0.75	1.73	0.78	1.79	2.29	0.66	1.55	0.69	1.60	2.01	0.57	1.37	0.60	1.42
		24	4SG	3.92	1.21	2.56	1.25	2.66	4.06	1.26	2.65	1.30	2.76	3.88	1.20	2.54	1.24	2.63
		25	4SG	6.08	1.91	3.95	1.98	4.10	6.73	2.14	4.36	2.22	4.51	7.40	2.38	4.77	2.46	4.94
		26	4SG	1.96	0.56	1.34	0.58	1.39	1.97	0.56	1.35	0.58	1.39	1.90	0.54	1.30	0.56	1.35
		27	4SG	8.36	2.69	5.40	2.78	5.58	8.36	2.69	5.40	2.78	5.58	8.08	2.59	5.22	2.68	5.40
		28	4SG	5.31	1.67	3.45	1.73	3.58	5.61	1.77	3.64	1.84	3.78	5.61	1.77	3.64	1.84	3.78
		29	4SG	7.22	2.39	4.57	2.48	4.74	7.45	2.48	4.71	2.57	4.88	7.01	2.32	4.43	2.40	4.60
		122	4SG	35.42	13.04	21.55	13.36	22.07	35.85	13.22	21.80	13.53	22.32	35.14	12.94	21.37	13.26	21.88
1	IntNum	1	4SG	7.13	2.34	4.54	2.42	4.71	7.14	2.33	4.56	2.42	4.72	7.14	2.32	4.56	2.41	4.73
		2	4SG	4.79	1.53	3.07	1.60	3.19	4.95	1.59	3.17	1.65	3.30	5.12	1.65	3.28	1.71	3.41
		4	4SG	10.69	3.69	6.63	3.82	6.87	10.99	3.81	6.80	3.95	7.04	11.26	3.93	6.95	4.07	7.19
		5	4SG	9.16	3.17	5.66	3.29	5.87	9.26	3.22	5.70	3.34	5.91	8.92	3.11	5.49	3.22	5.70
		6	4SG	4.48	1.44	2.87	1.50	2.98	5.00	1.62	3.19	1.68	3.32	5.53	1.80	3.52	1.87	3.66
		7	3SG	13.51	3.74	9.00	3.96	9.54	14.19	3.91	9.47	4.15	10.04	14.87	4.08	9.94	4.33	10.54
		8	4SG	16.35	5.60	10.27	5.77	10.58	17.48	5.99	10.99	6.16	11.32	16.26	5.55	10.23	5.71	10.54
		10	4SG	4.67	1.49	3.00	1.54	3.12	5.05	1.62	3.23	1.68	3.36	5.43	1.75	3.47	1.82	3.60
		11	4SG	6.28	2.06	3.99	2.13	4.14	6.12	2.00	3.89	2.08	4.04	5.96	1.94	3.79	2.02	3.94
		12	4SG	13.74	4.90	8.40	5.06	8.68	13.00	4.61	7.96	4.77	8.23	13.57	4.84	8.28	5.00	8.57
		13	4SG	5.55	1.75	3.60	1.82	3.73	5.88	1.87	3.80	1.94	3.94	6.22	1.98	4.01	2.06	4.16
		14	4SG	3.25	0.97	2.16	1.01	2.24	3.08	0.91	2.05	0.95	2.13	2.90	0.86	1.94	0.89	2.01
		15	3SG	27.54	6.53	19.59	6.89	20.65	25.91	6.16	18.43	6.50	19.42	25.50	6.08	18.12	6.41	19.09
		16	3SG	28.77	6.72	20.61	7.08	21.69	26.49	6.25	18.90	6.59	19.91	26.08	6.17	18.59	6.50	19.58
		103	4SG	4.80	1.51	3.11	1.57	3.23	4.76	1.50	3.08	1.56	3.20	4.75	1.50	3.07	1.56	3.19
		109	4SG	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90	21.54	7.69	13.25	7.91	13.63

CASE 4: BASE + ALL CMF + Ci_forPiedmont

STEPS 1a & 2a CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR AFTER TREATMENT

Step 2.a.1 Calculate Safety Performance Functions for each COMPARISON intersection for each AFTER year

Step 1.a.1 Calculate Safety Performance Functions for each TREATMENT intersection for each AFTER year

1 TREAT	b before	1 by year
2 COMP	a after	2 all years

Aft1Yr					Aft2Yr					Aft3Yr				
$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$
5.12	1.62	3.32	1.68	3.44	4.85	1.53	3.14	1.59	3.26	4.80	1.51	3.11	1.57	3.23
25.50	9.25	15.57	9.51	15.99	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90
2.42	0.70	1.63	0.73	1.69	2.37	0.69	1.60	0.71	1.66	2.36	0.68	1.59	0.71	1.65
3.90	1.24	2.50	1.29	2.61	3.90	1.24	2.50	1.29	2.61	4.01	1.28	2.57	1.33	2.68
2.40	0.69	1.62	0.72	1.68	2.23	0.65	1.50	0.67	1.56	2.19	0.64	1.47	0.66	1.53
2.71	0.80	1.81	0.83	1.88	2.64	0.78	1.76	0.81	1.83	2.64	0.78	1.76	0.81	1.83
6.34	2.03	4.09	2.10	4.24	5.28	1.66	3.43	1.72	3.56	5.29	1.66	3.44	1.72	3.57
31.55	11.46	19.31	11.75	19.80	35.00	12.87	21.30	13.18	21.82	35.42	13.04	21.55	13.36	22.07
2.06	0.59	1.39	0.61	1.45	2.10	0.60	1.42	0.62	1.47	2.12	0.61	1.44	0.63	1.49
3.70	1.14	2.42	1.18	2.52	3.72	1.14	2.44	1.19	2.53	3.75	1.15	2.46	1.20	2.55
6.76	2.15	4.38	2.22	4.53	6.11	1.92	3.98	1.99	4.12	6.29	1.98	4.09	2.05	4.23
1.83	0.52	1.25	0.53	1.30	1.91	0.54	1.30	0.56	1.35	1.98	0.56	1.35	0.58	1.40
7.81	2.50	5.05	2.59	5.22	7.95	2.55	5.15	2.63	5.32	8.09	2.59	5.24	2.68	5.42
5.61	1.77	3.64	1.84	3.78	5.64	1.77	3.67	1.84	3.80	5.64	1.77	3.68	1.83	3.81
6.57	2.16	4.17	2.24	4.33	6.80	2.24	4.30	2.33	4.47	7.02	2.33	4.44	2.42	4.61
34.43	12.67	20.94	12.98	21.45	35.35	13.03	21.49	13.34	22.01	36.28	13.39	22.04	13.71	22.57
6.68	2.17	4.27	2.25	4.43	6.22	2.01	3.98	2.09	4.13	6.03	1.95	3.86	2.02	4.01
5.10	1.63	3.27	1.70	3.40	5.07	1.62	3.26	1.68	3.38	5.05	1.62	3.25	1.68	3.37
10.46	3.64	6.46	3.77	6.69	11.42	3.93	7.11	4.06	7.36	12.44	4.26	7.78	4.41	8.04
8.57	2.99	5.27	3.10	5.47	8.43	2.92	5.20	3.03	5.40	8.26	2.85	5.11	2.96	5.30
5.19	1.68	3.31	1.75	3.44	4.85	1.56	3.10	1.63	3.22	4.83	1.55	3.09	1.61	3.21
14.87	4.08	9.94	4.33	10.54	14.87	4.08	9.94	4.33	10.54	14.42	3.97	9.63	4.21	10.21
15.04	5.11	9.48	5.27	9.77	14.85	5.04	9.36	5.19	9.65	14.65	4.97	9.25	5.12	9.53
5.05	1.62	3.24	1.69	3.37	4.84	1.54	3.12	1.60	3.24	4.71	1.49	3.04	1.55	3.16
5.76	1.88	3.67	1.95	3.81	5.56	1.81	3.54	1.88	3.68	5.57	1.81	3.55	1.88	3.69
14.77	5.28	9.01	5.46	9.31	14.97	5.34	9.16	5.51	9.46	15.11	5.37	9.26	5.55	9.57
5.91	1.88	3.83	1.95	3.97	5.61	1.77	3.64	1.84	3.78	5.91	1.88	3.83	1.95	3.97
2.92	0.86	1.95	0.90	2.02	2.93	0.87	1.95	0.90	2.03	2.94	0.87	1.97	0.90	2.04
25.09	5.99	17.81	6.32	18.77	25.44	6.08	18.06	6.41	19.03	25.78	6.17	18.29	6.50	19.28
25.66	6.08	18.28	6.41	19.26	25.82	6.14	18.36	6.47	19.35	25.94	6.19	18.42	6.53	19.42
4.74	1.50	3.07	1.55	3.19	4.76	1.50	3.08	1.56	3.20	4.78	1.51	3.09	1.57	3.21
22.40	8.05	13.73	8.28	14.12	21.08	7.55	12.93	7.77	13.31	20.21	7.20	12.42	7.42	12.79

CASE 4: BASE + ALL CMF + Ci_forPiedmont

$N_{pred,bi} = N_{bimv}*(CMF_{1i}*\ldots*CMF_{6i})*C_i$

Note: if CMF or C unknown, assume 1.00.

STEPS 1b & 2b CALCULATE PREDICTED CRASH FREQUENCY BY SITE FOR ENTIRE BEFORE PERIOD

Step 2.b.2 Calculate SPFs for each COMPARISON intersection for entire BEFORE period

Step 1.b.2 Calculate SPFs for each TREATMENT intersection for entire BEFORE period

RESULTS OF STEPS 1b & 2b

R_SiteType		FormulaApplied	BefAllYrs $N_{bimv-nSG}$	$N_{bimv(FI)-nSG}$	$N_{bimv(PDO)-nSG}$	BefAllYrs $N_{pred,bi}$	$N_{pred,bi(FI)}$	$N_{pred,bi(PDO)}$
0 IntNum	3	4SG	15.85	5.21	10.64	56.81	18.67	38.14
	9	4SG	71.40	26.44	44.96	176.92	65.51	111.42
	17	4SG	7.63	2.31	5.32	28.49	8.62	19.87
	18	4SG	14.41	4.83	9.59	49.51	16.57	32.94
	19	4SG	8.03	2.44	5.59	30.00	9.12	20.88
	20	4SG	8.57	2.65	5.91	27.19	8.42	18.77
	21	4SG	21.84	7.34	14.50	67.93	22.83	45.10
	22	4SG	79.95	29.27	50.68	271.88	99.53	172.35
	23	4SG	6.88	2.06	4.81	24.64	7.39	17.26
	24	4SG	11.85	3.80	8.05	34.41	11.03	23.38
	25	4SG	20.21	6.66	13.55	72.43	23.86	48.57
	26	4SG	5.84	1.71	4.13	21.80	6.40	15.41
	27	4SG	24.80	8.24	16.56	61.35	20.38	40.97
	28	4SG	16.54	5.41	11.13	51.45	16.82	34.63
	29	4SG	21.68	7.45	14.22	67.43	23.19	44.24
	122	4SG	106.41	40.14	66.27	361.90	136.52	225.37
1 IntNum	1	4SG	21.41	7.25	14.16	78.35	26.53	51.82
	2	4SG	14.86	4.96	9.90	53.28	17.79	35.49
	4	4SG	32.94	11.84	21.11	105.02	37.73	67.28
	5	4SG	27.34	9.86	17.48	60.97	21.98	38.99
	6	4SG	15.01	5.05	9.96	42.10	14.16	27.93
	7	3SG	42.57	12.44	30.13	95.88	28.02	67.86
	8	4SG	50.09	17.64	32.45	124.12	43.72	80.40
	10	4SG	15.14	5.05	10.09	43.09	14.38	28.71
	11	4SG	18.36	6.23	12.13	55.57	18.86	36.70
	12	4SG	40.31	14.83	25.48	101.73	37.43	64.30
	13	4SG	17.64	5.81	11.83	49.48	16.29	33.18
	14	4SG	9.23	2.85	6.38	31.10	9.59	21.51
	15	3SG	78.95	19.79	59.16	193.29	48.45	144.84
	16	3SG	81.34	20.16	61.18	191.18	47.39	143.79
	103	4SG	14.32	4.69	9.62	51.31	16.82	34.50
	109	4SG	64.75	23.78	40.97	160.44	58.91	101.52

CASE 4: BASE + ALL CMF + Ci_forPiedmont

STEPS 1a & 2a CALCULATE PREDICTED CRASH FREQUENCY BY SITE IN PERIOD AFTER TREATMENT

Step 2.a.2 Calculate SPFs for each COMPARISON intersection for entire AFTER period

Step 1.a.2 Calculate SPFs for each TREATMENT intersection for entire AFTER period

RESULTS OF STEPS 1a & 2a

R_SiteType		FormulaApplied	AftAllYrs $N_{aimv-nSG}$	$N_{aimv(FI)-nSG}$	$N_{aimv(PDO)-nSG}$	AftAllYrs $N_{pred,ai}$	$N_{pred,ai(FI)}$	$N_{pred,ai(PDO)}$
0 IntNum	3	4SG	14.77	4.84	9.93	52.95	17.35	35.60
	9	4SG	68.70	25.37	43.33	170.24	62.87	107.37
	17	4SG	7.15	2.15	5.00	26.71	8.04	18.67
	18	4SG	11.81	3.92	7.89	40.58	13.47	27.11
	19	4SG	6.82	2.05	4.77	25.46	7.67	17.79
	20	4SG	7.98	2.45	5.53	25.33	7.78	17.55
	21	4SG	16.92	5.55	11.37	52.62	17.26	35.36
	22	4SG	101.97	38.28	63.69	346.78	130.20	216.58
	23	4SG	6.28	1.86	4.41	22.50	6.67	15.82
	24	4SG	11.17	3.57	7.60	32.43	10.36	22.07
	25	4SG	19.15	6.27	12.89	68.66	22.47	46.19
	26	4SG	5.72	1.68	4.05	21.37	6.26	15.12
	27	4SG	23.86	7.90	15.96	59.01	19.53	39.48
	28	4SG	16.90	5.51	11.39	52.57	17.14	35.43
	29	4SG	20.39	6.99	13.40	63.40	21.73	41.67
	122	4SG	106.06	40.03	66.03	360.68	136.13	224.54
1 IntNum	1	4SG	18.93	6.36	12.57	69.28	23.27	46.01
	2	4SG	15.22	5.06	10.16	54.55	18.14	36.41
	4	4SG	34.32	12.24	22.08	109.41	39.01	70.40
	5	4SG	25.27	9.09	16.18	56.34	20.27	36.07
	6	4SG	14.86	4.99	9.87	41.68	13.99	27.69
	7	3SG	44.17	12.87	31.29	99.48	28.99	70.49
	8	4SG	44.54	15.58	28.95	110.36	38.62	71.75
	10	4SG	14.60	4.83	9.76	41.54	13.76	27.78
	11	4SG	16.89	5.71	11.18	51.12	17.28	33.84
	12	4SG	44.85	16.51	28.34	113.20	41.68	71.52
	13	4SG	17.44	5.73	11.71	48.91	16.07	32.84
	14	4SG	8.78	2.70	6.09	29.60	9.09	20.51
	15	3SG	76.31	19.23	57.09	186.84	47.07	139.77
	16	3SG	77.42	19.40	58.02	181.97	45.60	136.37
	103	4SG	14.28	4.68	9.60	51.19	16.78	34.41
	109	4SG	63.69	23.47	40.22	157.82	58.15	99.67

CASE 4: BASE + ALL CMF + Ci_forPiedmont

STEP 3 CALCULATE ADJUSTMENT FACTOR FOR EACH COMBINATION OF TREATMENT & COMPARISON SITE, SEPARATELY FOR BEFORE & AFTER PERIODS

	DO NOT SORT	DO NOT SORT
R_SiteType	1	0
Pairings	Treatment IntNum	Comparison IntNum
	1	23
	2	17
	4	**3**
	5	24
	6	21
	7	22
	8	**9**
	10	20
	11	18
	12	27
	13	19
	14	25
	15	29
	16	**122**
	103	26
	109	28

Adj_{ijb}		$N_{pred,Tbi}$	78.35	53.28	105.02	95.88	55.57	49.48	60.97	42.10	124.12	43.09	31.10	101.73	193.29	191.18	51.31	160.44
		Y_{BT}	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	**103**	**109**
$N_{pred,Cbj}$	Y_{BC}	CIntNum																
56.81	3	**3**	1.379	0.938	1.848	1.688	0.978	0.871										
28.49	3	17	2.750	1.870	3.686	3.365	1.950	1.737										
49.51	3	18	1.582	1.076	2.121	1.937	1.122	0.999										
30.00	3	19	2.612	1.776	3.501	3.196	1.852	1.649										
271.88	3	22	0.288	0.196	0.386	0.353	0.204	0.182										
24.64	3	23	3.179	2.162	4.261	3.891	2.255	2.008										
176.92	3	**9**							0.345	0.238	0.702	0.244	0.176					
27.19	3	20							2.242	1.548	4.565	1.585	1.144					
67.93	3	21							0.898	0.620	1.827	0.634	0.458					
34.41	3	24							1.772	1.223	3.607	1.252	0.904					
72.43	3	25							0.842	0.581	1.714	0.595	0.429					
21.80	3	26												4.666	8.865	8.768	2.353	7.358
61.35	3	27												1.658	3.151	3.116	0.836	2.615
51.45	3	28												1.977	3.757	3.716	0.997	3.118
67.43	3	29												1.509	2.867	2.835	0.761	2.379
361.90	3	**122**												0.281	0.534	0.528	0.142	0.443

Note: each color represents a different three-year span of time since cameras were installed at various times. The colors will have to be referred to for the next steps when adjustments are made because they should only use other intersections from the same time period for the calculations to be valid.

Adj_{ijb} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during BEFORE period (

$= (N_{pred,Tbi} / N_{pred,Cbj})*(Y_{BT} / Y_{BC})$

Adj_{ija}		$N_{pred,Tai}$	69.28	54.55	109.41	99.48	51.12	48.91	56.34	41.68	110.36	41.54	29.60	113.20	186.84	181.97	51.19	157.82
		Y_{AT}	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	**103**	**109**
$N_{pred,Caj}$	Y_{AC}	CIntNum																
52.95	3	**3**	1.309	1.030	2.067	1.879	0.966	0.924										
26.71	3	17	2.594	2.042	4.096	3.724	1.914	1.831										
40.58	3	18	1.707	1.344	2.696	2.451	1.260	1.205										
25.46	3	19	2.721	2.142	4.297	3.907	2.008	1.921										
346.78	3	22	0.200	0.157	0.316	0.287	0.147	0.141										
22.50	3	23	3.080	2.425	4.864	4.422	2.273	2.174										
170.24	3	**9**							0.331	0.245	0.648	0.244	0.174					
25.33	3	20							2.224	1.645	4.357	1.640	1.168					
52.62	3	21							1.071	0.792	2.097	0.789	0.563					
32.43	3	24							1.737	1.285	3.403	1.281	0.913					
68.66	3	25							0.821	0.607	1.607	0.605	0.431					
21.37	3	26												5.296	8.741	8.514	2.395	7.384
59.01	3	27												1.918	3.166	3.084	0.867	2.674
52.57	3	28												2.154	3.554	3.462	0.974	3.002
63.40	3	29												1.785	2.947	2.870	0.807	2.489
360.68	3	**122**												0.314	0.518	0.505	0.142	0.438

Adj_{ija} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during AFTER period (a)

$= (N_{pred,Tai} / N_{pred,Caj})*(Y_{AT} / Y_{AC})$

CASE 4: BASE + ALL CMF + Ci_forPiedmont

STEP 4 CALCULATE EXPECTED AVERAGE CRASH FREQUENCY (ADJUSTED CRASH FREQUENCY) FOR EACH COMBINATION, SEPARATELY FOR BEFORE & AFTER PERIODS

STEP 5 CALCULATE TOTAL COMPARISON GROUP ADJUSTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN BEFORE PERIOD

STEP 6 CALCULATE TOTAL COMPARISON GROUP ADJUSTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN AFTER PERIOD

R_SiteType			BefAllYrs $N_{observed,B}$	AftAllYrs $N_{observedA}$
0	IntNum	3	16	19
		9	14	16
		17	28	24
		18	25	19
		19	19	23
		20	7	8
		21	12	13
		22	9	7
		23	12	13
		24	13	7
		25	17	12
		26	8	26
		27	13	11
		28	13	14
		29	18	10
		122	14	9
b) 1	IntNum	1	27	3
		2	26	26
		4	12	5
		5	7	2
		6	7	6
		7	19	23
		8	18	7
		10	9	3
		11	7	1
		12	12	5
		13	23	7
		14	8	10
		15	9	4
		16	13	3
		103	25	14
		109	13	8

$N_{exptd,CB}$

$N_{obsvd,Cbj}$	$N_{pred,Tbi}$ / Y_{BT} / TIntNum → CIntNum ↓	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
16	3	22.07	15.00	29.58	27.00	15.65	13.93										
28	17	77.00	52.36	103.21	94.23	54.61	48.63										
25	18	39.56	26.90	53.02	48.41	28.06	24.98										
19	19	49.62	33.74	66.51	60.73	35.19	31.34										
9	22	2.59	1.76	3.48	3.17	1.84	1.64										
12	23	38.15	25.94	51.14	46.69	27.06	24.09										
14	9							4.82	3.33	9.82	3.41	2.46					
7	20							15.70	10.84	31.95	11.09	8.01					
12	21							10.77	7.44	21.92	7.61	5.49					
13	24							23.03	15.90	46.88	16.28	11.75					
17	25							14.31	9.88	29.13	10.11	7.30					
8	26												37.32	70.92	70.14	18.83	58.86
13	27												21.56	40.96	40.51	10.87	34.00
13	28												25.70	48.84	48.31	12.97	40.54
18	29												27.16	51.60	51.04	13.70	42.83
14	122												3.94	7.48	7.40	1.99	6.21
	$N_{exptd,CB,total}$	**229.00**	**155.72**	**306.93**	**280.24**	**162.41**	**144.61**	**68.64**	**47.39**	**139.71**	**48.50**	**35.01**	**115.68**	**219.79**	**217.39**	**58.35**	**182.43**

Adj_{ijb} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during BEFORE period (

$= (N_{pred,Tbi} / N_{pred,Cbj})*(Y_{BT} / Y_{BC})$

$N_{exptd,CA}$

$N_{obsvd,Caj}$	Y_{AC}	$N_{pred,Tai}$ / Y_{AT} / TIntNum → CIntNum ↓	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
19	3	3	24.86	19.57	39.26	35.70	18.35	17.55										
24	3	17	62.25	49.01	98.30	89.38	45.93	43.94										
19	3	18	32.44	25.54	51.23	46.58	23.94	22.90										
23	3	19	62.58	49.27	98.83	89.86	46.18	44.18										
7	3	22	1.40	1.10	2.21	2.01	1.03	0.99										
13	3	23	40.04	31.52	63.23	57.49	29.54	28.27										
16	3	9							5.30	3.92	10.37	3.90	2.78					
8	3	20							17.79	13.16	34.85	13.12	9.35					
13	3	21							13.92	10.30	27.27	10.26	7.31					
7	3	24							12.16	9.00	23.82	8.97	6.39					
12	3	25							9.85	7.28	19.29	7.26	5.17					
26	3	26												137.70	227.28	221.36	62.27	191.98
11	3	27												21.10	34.83	33.92	9.54	29.42
14	3	28												30.15	49.76	48.47	13.63	42.03
10	3	29												17.85	29.47	28.70	8.07	24.89
9	3	122												2.82	4.66	4.54	1.28	3.94
		$N_{exptd,CA,total}$	**223.55**	**176.01**	**353.06**	**321.01**	**164.96**	**157.83**	**59.02**	**43.65**	**115.60**	**43.51**	**31.00**	**209.63**	**346.00**	**336.98**	**94.79**	**292.26**

Adj_{ija} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during AFTER period (a)

$= (N_{pred,Tai} / N_{pred,Caj})*(Y_{AT} / Y_{AC})$

CASE 4: BASE + ALL CMF + Ci_forPiedmont

STEP 7 CALCULATE COMPARISON RATIO FOR EACH TREATMENT SITE

STEP 8 CALCULATE EXPECTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN THE AFTER PERIOD, HAD NO TREATMENT BEEN IMPLEMENTED

STEP 9 CALCULATE SAFETY EFFECTIVENESS EXPRESSED AS AN ODDS RATIO AT AN INDIVIDUAL TREATMENT SITE

STEP 10 CALCULATE LOG ODDS RATIO FOR EACH TREATMENT SITE

STEP 11 CALCULATE WEIGHT FOR EACH TREATMENT SITE

Step	TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109	
STEP 6	$N_{exptd,CA,total}$	223.55	176.01	353.06	321.01	164.96	157.83	59.02	43.65	115.60	43.51	31.00	209.63	346.00	336.98	94.79	292.26	
STEP 5	$N_{exptd,CB,total}$	229.00	155.72	306.93	280.24	162.41	144.61	68.64	47.39	139.71	48.50	35.01	115.68	219.79	217.39	58.35	182.43	
STEP 7	$r_{i,C}$	0.9762	1.1303	1.1503	1.1455	1.0157	1.0914	0.8599	0.9213	0.8274	0.8971	0.8856	1.8122	1.5742	1.5501	1.6246	1.602	
	$N_{observedTB}$	27	26	12	19	7	23	7	7	18	9	8	12	9	13	25	13	
STEP 8	$N_{exptd,TA}$	26.36	29.39	13.80	21.76	7.11	25.10	6.02	6.45	14.89	8.07	7.09	21.75	14.17	20.15	40.61	20.83	
	$N_{observedTA}$	3	26	5	23	1	7	2	6	7	3	10	5	4	3	14	8	
STEP 9	$omega_i$	0.114	0.885	0.362	1.057	0.141	0.279	0.332	0.930	0.470	0.372	1.411	0.230	0.282	0.149	0.345	0.384	
	omega check:	0.114	0.885	0.362	1.057	0.141	0.279	0.332	0.930	0.470	0.372	1.411	0.230	0.282	0.149	0.345	0.384	
STEP 10	R_i	-2.173	-0.123	-1.015	0.0552	-1.962	-1.277	-1.102	-0.072	-0.755	-0.99	0.3446	-1.47	-1.265	-1.905	-1.065	-0.957	
	$R_{i(SE)}^2$	0.3792	0.089	0.2894	0.1028	1.1551	0.1996	0.6744	0.3535	0.2142	0.488	0.2858	0.2967	0.3686	0.4178	0.1391	0.2108	Totals
STEP 11	w_i	2.637	11.233	3.455	9.728	0.866	5.010	1.483	2.829	4.668	2.049	3.499	3.370	2.713	2.393	7.188	4.743	**67.864**
	w_iR_i	-5.731	-1.376	-3.509	0.5373	-1.698	-6.399	-1.634	-0.204	-3.524	-2.028	1.2056	-4.954	-3.431	-4.559	-7.656	-4.538	**-49.498**

$r_{i,C} = N_{exptd,C,A,total} / N_{exptd,C,B,total}$

$N_{exptd,TA} = sum(N_{obsvd,T,B} * r_{iC})$ over all sites

$omega_i = sum(N_{observed,T,A} / N_{expected,T,A})$ over all sites

$= (N_{observed,T,A,total} / N_{observed,T,B,total}) * (N_{expected,C,B,total} / N_{expected,C,A,total})$

b)

$R_{i(SE)}^2 = (1/N_{observed,T,A,total}) + (1/ N_{observed,T,B,total}) + (1/N_{expected,C,B,total}) + (1/N_{expected,C,A,total})$

$w_i = 1/R_{i(SE)}^2$

CASE 4: BASE + ALL CMF + Ci_forPiedmont

STEP 12 CALCULATE WEIGHTED AVERAGE LOG ODDS RATIO ACROSS ALL TREATMENT SITES

$sum(w_i*R_i)$ -49.498

$sum(w_i)$ 67.864

-0.729 = R =sum(wi*Ri)/sum(wi)

STEP 13 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT EXPRESSED AS AN ODDS RATIO

0.48 = OR = exp(R)

STEP 14 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT EXPRESSED AS A PERCENTAGE CHANGE IN CRASH FREQUENCY

51.78 = Safety Effectiveness = 100 * (1 - R)

51.78% = Safety Effectiveness

ESTIMATION OF PRECISION OF TREATMENT EFFECTIVENESS

STEP 15 CALCULATE STANDARD ERROR OF TREATMENT EFFECTIVENESS

5.85 = SE(Safety Effectiveness) = 100 * OR / sqrt(sum(wi))

STEP 16 ASSESS STATISTICAL SIGNIFICANCE OF ESTIMATED SAFETY EFFECTIVENESS

8.85 = Performance Measure = ABS[Safety Effectiveness / SE(Safety Effectiveness)]

PM < 1.7 Treatment Effect NOT significant at the (approx.) 90% confidence interval

PM >= 1.7 Treatment Effect IS significant at the (approx.) 90% confidence interval

PM >= 2.0 Treatment Effect IS significant at the (approx.) 95% confidence interval

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiec

pulled from sheet 2-Intersections_prepped

Step 1b Determine Crash Modification Factors (CMFs) and Calibration Factors (Ci) for each intersection for each year

vlookup column >>			5	6	296	299	300	297	301							
					for CMF_1i	for CMF_2i		for CMF_3i	n_prohib			N_{bisv}				
R_SiteType			Approaches	Legs	AppsWLeftLns	AppsWLeftProt	LeftProtPerm	AppsWRgtLns	AppsRTORprohib	Bef3Yr	Bef2Yr	Bef1Yr	Aft1Yr	Aft2Yr	Aft3Yr	RLC
0	IntNum	3	2	4	0	0	0	1	0	0.34	0.35	0.35	0.34	0.32	0.32	0
		9	4	4	0	4	0	4	0	0.96	1.00	1.02	1.03	0.97	0.89	0
		17	2	4	0	0	0	0	0	0.23	0.22	0.22	0.22	0.21	0.21	0
		18	4	4	0	0	0	2	0	0.32	0.30	0.26	0.25	0.25	0.25	0
		19	3	4	0	0	0	0	0	0.25	0.23	0.22	0.22	0.20	0.20	0
		20	4	4	0	0	0	4	0	0.23	0.23	0.23	0.22	0.22	0.22	0
		21	4	4	0	0	2	4	0	0.43	0.44	0.44	0.40	0.36	0.36	0
		22	3	4	0	0	1	2	0	1.11	1.15	1.19	1.28	1.36	1.37	0
		23	2	4	0	0	0	1	0	0.22	0.21	0.19	0.19	0.20	0.20	0
		24	4	4	0	2	0	3	0	0.28	0.29	0.28	0.27	0.27	0.27	0
		25	3	4	0	0	0	1	0	0.41	0.44	0.46	0.44	0.41	0.42	0
		26	2	4	0	0	0	0	0	0.19	0.19	0.19	0.18	0.19	0.19	0
		27	4	4	1	2	2	4	0	0.52	0.52	0.51	0.49	0.50	0.51	0
		28	4	4	0	0	2	4	0	0.36	0.37	0.37	0.37	0.38	0.39	0
		29	4	4	0	0	0	4	1	0.40	0.41	0.39	0.38	0.38	0.39	0
		122	3	4	0	0	1	2	0	1.37	1.38	1.36	1.33	1.36	1.39	0
1	IntNum	1	2	4	0	0	0	0	1	0.41	0.42	0.42	0.40	0.38	0.37	1
		2	2	4	0	0	0	1	0	0.30	0.31	0.32	0.32	0.32	0.32	1
		4	4	4	0	0	1	3	1	0.52	0.52	0.52	0.49	0.56	0.62	1
		5	4	4	1	4	0	4	0	0.44	0.43	0.42	0.40	0.40	0.40	1
		6	4	4	0	2	0	4	0	0.28	0.30	0.33	0.31	0.30	0.30	1
		7	3	3	0	1	0	2	0	0.53	0.54	0.54	0.54	0.54	0.54	1
		8	4	4	0	4	0	4	0	0.82	0.87	0.82	0.77	0.77	0.76	1
		10	4	4	0	2	2	3	0	0.30	0.31	0.33	0.32	0.31	0.31	1
		11	4	4	0	1	0	3	1	0.36	0.36	0.35	0.34	0.33	0.33	1
		12	4	4	1	2	0	4	0	0.59	0.57	0.58	0.63	0.64	0.66	1
		13	4	4	0	2	0	4	0	0.37	0.38	0.40	0.38	0.37	0.38	1
		14	3	4	0	1	0	1	0	0.26	0.25	0.24	0.24	0.24	0.25	1
		15	2	3	0	1	0	0	0	1.05	1.03	1.02	1.01	1.01	1.01	1
		16	2	3	0	1	0	1	0	1.12	1.07	1.06	1.05	1.04	1.02	1
		103	2	4	0	0	0	1	0	0.32	0.32	0.32	0.31	0.32	0.32	1
		109	4	4	0	4	0	4	0	0.97	0.89	0.93	0.94	0.90	0.87	1

CMF_1i	CMF_2i	CMF_3i	CMF_4i	CMF_5i	CMF_6i	Ci
1.00	1.00	0.96	1.00	0.8995		4.10
1.00	0.78	0.85	1.00	0.8995		4.10
1.00	1.00	1.00	1.00	0.8995		4.10
1.00	1.00	0.92	1.00	0.8995		4.10
1.00	1.00	1.00	1.00	0.8995		4.10
1.00	1.00	0.85	1.00	0.8995		4.10
1.00	0.98	0.85	1.00	0.8995		4.10
1.00	0.99	0.92	1.00	0.8995		4.10
1.00	1.00	0.96	1.00	0.8995		4.10
1.00	0.88	0.88	1.00	0.8995		4.10
1.00	1.00	0.96	1.00	0.8995		4.10
1.00	1.00	1.00	1.00	0.8995		4.10
0.90	0.87	0.85	1.00	0.8995		4.10
1.00	0.98	0.85	1.00	0.8995		4.10
1.00	1.00	0.85	0.98	0.8995		4.10
1.00	0.99	0.92	1.00	0.8995		4.10
1.00	1.00	1.00	0.98	0.8995		4.10
1.00	1.00	0.96	1.00	0.8995		4.10
1.00	0.99	0.88	0.98	0.8995		4.10
0.90	0.78	0.85	1.00	0.8995		4.10
1.00	0.88	0.85	1.00	0.8995		4.10
1.00	0.94	0.92	1.00	0.8995		2.86
1.00	0.78	0.85	1.00	0.8995		4.10
1.00	0.87	0.88	1.00	0.8995		4.10
1.00	0.94	0.88	0.98	0.8995		4.10
0.90	0.88	0.85	1.00	0.8995		4.10
1.00	0.88	0.85	1.00	0.8995		4.10
1.00	0.94	0.96	1.00	0.8995		4.10
1.00	0.94	1.00	1.00	0.8995		2.86
1.00	0.94	0.96	1.00	0.8995		2.86
1.00	1.00	0.96	1.00	0.8995		4.10
1.00	0.78	0.85	1.00	0.8995		4.10

ESTIMATION OF MEAN TREATMENT EFFECTIVENESS

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

STEPS 1b & 2b CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR BEFORE TREATMENT

Step 2.b.1 Calculate Safety Performance Functions for each COMPARISON intersection for each BEFORE year

Step 1.b.1 Calculate Safety Performance Functions for each TREATMENT intersection for each BEFORE year

R_SiteType			FormulaApplied	Bef3Yr $N_{bimv\text{-}nSG}$	Bef3Yr $N'_{bimv(FI)\text{-}nSG}$	Bef3Yr $N'_{bimv(PDO)\text{-}nSG}$	Bef3Yr $N_{bimv(FI)\text{-}nSG}$	Bef3Yr $N_{bimv(PDO)\text{-}nSG}$	Bef2Yr $N_{bimv\text{-}nSG}$	Bef2Yr $N'_{bimv(FI)\text{-}nSG}$	Bef2Yr $N'_{bimv(PDO)\text{-}nSG}$	Bef2Yr $N_{bimv(FI)\text{-}nSG}$	Bef2Yr $N_{bimv(PDO)\text{-}nSG}$	Bef1Yr $N_{bimv\text{-}nSG}$	Bef1Yr $N'_{bimv(FI)\text{-}nSG}$	Bef1Yr $N'_{bimv(PDO)\text{-}nSG}$	Bef1Yr $N_{bimv(FI)\text{-}nSG}$	Bef1Yr $N_{bimv(PDO)\text{-}nSG}$
0	IntNum	3	4SG	5.17	1.64	3.34	1.70	3.47	5.29	1.67	3.42	1.74	3.55	5.39	1.71	3.49	1.77	3.62
		9	4SG	22.49	8.05	13.81	8.28	14.21	24.11	8.69	14.76	8.94	15.17	24.80	8.97	15.16	9.22	15.58
		17	4SG	2.62	0.76	1.76	0.79	1.82	2.54	0.74	1.71	0.77	1.77	2.47	0.72	1.66	0.75	1.72
		18	4SG	5.46	1.78	3.48	1.85	3.62	4.86	1.56	3.11	1.62	3.23	4.09	1.30	2.63	1.35	2.74
		19	4SG	2.95	0.87	1.97	0.91	2.05	2.68	0.78	1.80	0.81	1.87	2.40	0.70	1.62	0.72	1.68
		20	4SG	2.93	0.88	1.94	0.91	2.02	2.86	0.85	1.90	0.88	1.97	2.78	0.83	1.85	0.86	1.92
		21	4SG	7.13	2.31	4.57	2.39	4.74	7.28	2.36	4.66	2.45	4.83	7.43	2.42	4.76	2.50	4.93
		22	4SG	25.28	8.97	15.64	9.21	16.07	26.64	9.50	16.45	9.75	16.89	28.02	10.04	17.27	10.30	17.72
		23	4SG	2.57	0.75	1.73	0.78	1.79	2.29	0.66	1.55	0.69	1.60	2.01	0.57	1.37	0.60	1.42
		24	4SG	3.92	1.21	2.56	1.25	2.66	4.06	1.26	2.65	1.30	2.76	3.88	1.20	2.54	1.24	2.63
		25	4SG	6.08	1.91	3.95	1.98	4.10	6.73	2.14	4.36	2.22	4.51	7.40	2.38	4.77	2.46	4.94
		26	4SG	1.96	0.56	1.34	0.58	1.39	1.97	0.56	1.35	0.58	1.39	1.90	0.54	1.30	0.56	1.35
		27	4SG	8.36	2.69	5.40	2.78	5.58	8.36	2.69	5.40	2.78	5.58	8.08	2.59	5.22	2.68	5.40
		28	4SG	5.31	1.67	3.45	1.73	3.58	5.61	1.77	3.64	1.84	3.78	5.61	1.77	3.64	1.84	3.78
		29	4SG	7.22	2.39	4.57	2.48	4.74	7.45	2.48	4.71	2.57	4.88	7.01	2.32	4.43	2.40	4.60
		122	4SG	35.42	13.04	21.55	13.36	22.07	35.85	13.22	21.80	13.53	22.32	35.14	12.94	21.37	13.26	21.88
1	IntNum	1	4SG	7.13	2.34	4.54	2.42	4.71	7.14	2.33	4.56	2.42	4.72	7.14	2.32	4.56	2.41	4.73
		2	4SG	4.79	1.53	3.07	1.60	3.19	4.95	1.59	3.17	1.65	3.30	5.12	1.65	3.28	1.71	3.41
		4	4SG	10.69	3.69	6.63	3.82	6.87	10.99	3.81	6.80	3.95	7.04	11.26	3.93	6.95	4.07	7.19
		5	4SG	9.16	3.17	5.66	3.29	5.87	9.26	3.22	5.70	3.34	5.91	8.92	3.11	5.49	3.22	5.70
		6	4SG	4.48	1.44	2.87	1.50	2.98	5.00	1.62	3.19	1.68	3.32	5.53	1.80	3.52	1.87	3.66
		7	3SG	13.51	3.74	9.00	3.96	9.54	14.19	3.91	9.47	4.15	10.04	14.87	4.08	9.94	4.33	10.54
		8	4SG	16.35	5.60	10.27	5.77	10.58	17.48	5.99	10.99	6.16	11.32	16.26	5.55	10.23	5.71	10.54
		10	4SG	4.67	1.49	3.00	1.54	3.12	5.05	1.62	3.23	1.68	3.36	5.43	1.75	3.47	1.82	3.60
		11	4SG	6.28	2.06	3.99	2.13	4.14	6.12	2.00	3.89	2.08	4.04	5.96	1.94	3.79	2.02	3.94
		12	4SG	13.74	4.90	8.40	5.06	8.68	13.00	4.61	7.96	4.77	8.23	13.57	4.84	8.28	5.00	8.57
		13	4SG	5.55	1.75	3.60	1.82	3.73	5.88	1.87	3.80	1.94	3.94	6.22	1.98	4.01	2.06	4.16
		14	4SG	3.25	0.97	2.16	1.01	2.24	3.08	0.91	2.05	0.95	2.13	2.90	0.86	1.94	0.89	2.01
		15	3SG	27.54	6.53	19.59	6.89	20.65	25.91	6.16	18.43	6.50	19.42	25.50	6.08	18.12	6.41	19.09
		16	3SG	28.77	6.72	20.61	7.08	21.69	26.49	6.25	18.90	6.59	19.91	26.08	6.17	18.59	6.50	19.58
		103	4SG	4.80	1.51	3.11	1.57	3.23	4.76	1.50	3.08	1.56	3.20	4.75	1.50	3.07	1.56	3.19
		109	4SG	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90	21.54	7.69	13.25	7.91	13.63

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

STEPS 1a & 2a CALCULATE PREDICTED CRASH FREQUENCY BY SITE BY YEAR AFTER TREATMENT

Step 2.a.1	Calculate Safety Performance Functions for each COMPARISON intersection for each AFTER year	
Step 1.a.1	Calculate Safety Performance Functions for each TREATMENT intersection for each AFTER year	

1 TREAT	b before	1 by year
2 COMP	a after	2 all years

Aft1Yr					Aft2Yr					Aft3Yr				
$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	$N_{aimv\text{-}nSG}$	$N'_{aimv(FI)\text{-}nSG}$	$N'_{aimv(PDO)\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$
5.12	1.62	3.32	1.68	3.44	4.85	1.53	3.14	1.59	3.26	4.80	1.51	3.11	1.57	3.23
25.50	9.25	15.57	9.51	15.99	22.89	8.22	14.04	8.45	14.44	20.31	7.20	12.53	7.41	12.90
2.42	0.70	1.63	0.73	1.69	2.37	0.69	1.60	0.71	1.66	2.36	0.68	1.59	0.71	1.65
3.90	1.24	2.50	1.29	2.61	3.90	1.24	2.50	1.29	2.61	4.01	1.28	2.57	1.33	2.68
2.40	0.69	1.62	0.72	1.68	2.23	0.65	1.50	0.67	1.56	2.19	0.64	1.47	0.66	1.53
2.71	0.80	1.81	0.83	1.88	2.64	0.78	1.76	0.81	1.83	2.64	0.78	1.76	0.81	1.83
6.34	2.03	4.09	2.10	4.24	5.28	1.66	3.43	1.72	3.56	5.29	1.66	3.44	1.72	3.57
31.55	11.46	19.31	11.75	19.80	35.00	12.87	21.30	13.18	21.82	35.42	13.04	21.55	13.36	22.07
2.06	0.59	1.39	0.61	1.45	2.10	0.60	1.42	0.62	1.47	2.12	0.61	1.44	0.63	1.49
3.70	1.14	2.42	1.18	2.52	3.72	1.14	2.44	1.19	2.53	3.75	1.15	2.46	1.20	2.55
6.76	2.15	4.38	2.22	4.53	6.11	1.92	3.98	1.99	4.12	6.29	1.98	4.09	2.05	4.23
1.83	0.52	1.25	0.53	1.30	1.91	0.54	1.30	0.56	1.35	1.98	0.56	1.35	0.58	1.40
7.81	2.50	5.05	2.59	5.22	7.95	2.55	5.15	2.63	5.32	8.09	2.59	5.24	2.68	5.42
5.61	1.77	3.64	1.84	3.78	5.64	1.77	3.67	1.84	3.80	5.64	1.77	3.68	1.83	3.81
6.57	2.16	4.17	2.24	4.33	6.80	2.24	4.30	2.33	4.47	7.02	2.33	4.44	2.42	4.61
34.43	12.67	20.94	12.98	21.45	35.35	13.03	21.49	13.34	22.01	36.28	13.39	22.04	13.71	22.57
6.68	2.17	4.27	2.25	4.43	6.22	2.01	3.98	2.09	4.13	6.03	1.95	3.86	2.02	4.01
5.10	1.63	3.27	1.70	3.40	5.07	1.62	3.26	1.68	3.38	5.05	1.62	3.25	1.68	3.37
10.46	3.64	6.46	3.77	6.69	11.42	3.93	7.11	4.06	7.36	12.44	4.26	7.78	4.41	8.04
8.57	2.99	5.27	3.10	5.47	8.43	2.92	5.20	3.03	5.40	8.26	2.85	5.11	2.96	5.30
5.19	1.68	3.31	1.75	3.44	4.85	1.56	3.10	1.63	3.22	4.83	1.55	3.09	1.61	3.21
14.87	4.08	9.94	4.33	10.54	14.87	4.08	9.94	4.33	10.54	14.42	3.97	9.63	4.21	10.21
15.04	5.11	9.48	5.27	9.77	14.85	5.04	9.36	5.19	9.65	14.65	4.97	9.25	5.12	9.53
5.05	1.62	3.24	1.69	3.37	4.84	1.54	3.12	1.60	3.24	4.71	1.49	3.04	1.55	3.16
5.76	1.88	3.67	1.95	3.81	5.56	1.81	3.54	1.88	3.68	5.57	1.81	3.55	1.88	3.69
14.77	5.28	9.01	5.46	9.31	14.97	5.34	9.16	5.51	9.46	15.11	5.37	9.26	5.55	9.57
5.91	1.88	3.83	1.95	3.97	5.61	1.77	3.64	1.84	3.78	5.91	1.88	3.83	1.95	3.97
2.92	0.86	1.95	0.90	2.02	2.93	0.87	1.95	0.90	2.03	2.94	0.87	1.97	0.90	2.04
25.09	5.99	17.81	6.32	18.77	25.44	6.08	18.06	6.41	19.03	25.78	6.17	18.29	6.50	19.28
25.66	6.08	18.28	6.41	19.26	25.82	6.14	18.36	6.47	19.35	25.94	6.19	18.42	6.53	19.42
4.74	1.50	3.07	1.55	3.19	4.76	1.50	3.08	1.56	3.20	4.78	1.51	3.09	1.57	3.21
22.40	8.05	13.73	8.28	14.12	21.08	7.55	12.93	7.77	13.31	20.21	7.20	12.42	7.42	12.79

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

$N_{pred,bi} = N_{bimv}*(CMF_{1i}*\ldots*CMF_{6i})*C_i$

Note: if CMF or C unknown, assume 1.00.

STEPS 1b & 2b CALCULATE PREDICTED CRASH FREQUENCY BY SITE FOR ENTIRE BEFORE PERIOD

Step 2.b.2 Calculate SPFs for each COMPARISON intersection for entire BEFORE period

Step 1.b.2 Calculate SPFs for each TREATMENT intersection for entire BEFORE period

RESULTS OF STEPS 1b & 2b

R_SiteType			FormulaApplied	BefAllYrs $N_{bimv\text{-}nSG}$	$N_{bimv(FI)\text{-}nSG}$	$N_{bimv(PDO)\text{-}nSG}$	BefAllYrs $N_{pred,bi}$	$N_{pred,bi(FI)}$	$N_{pred,bi(PDO)}$
0	IntNum	3	4SG	15.85	5.21	10.64	56.11	18.44	37.67
		9	4SG	71.40	26.44	44.96	174.75	64.70	110.05
		17	4SG	7.63	2.31	5.32	28.14	8.51	19.63
		18	4SG	14.41	4.83	9.59	48.90	16.37	32.53
		19	4SG	8.03	2.44	5.59	29.63	9.00	20.63
		20	4SG	8.57	2.65	5.91	26.86	8.32	18.54
		21	4SG	21.84	7.34	14.50	67.10	22.55	44.55
		22	4SG	79.95	29.27	50.68	268.55	98.31	170.24
		23	4SG	6.88	2.06	4.81	24.34	7.30	17.05
		24	4SG	11.85	3.80	8.05	33.99	10.90	23.09
		25	4SG	20.21	6.66	13.55	71.54	23.57	47.97
		26	4SG	5.84	1.71	4.13	21.54	6.32	15.22
		27	4SG	24.80	8.24	16.56	60.60	20.13	40.47
		28	4SG	16.54	5.41	11.13	50.82	16.61	34.21
		29	4SG	21.68	7.45	14.22	66.60	22.90	43.70
		122	4SG	106.41	40.14	66.27	357.46	134.85	222.61
1	IntNum	1	4SG	21.41	7.25	14.16	77.39	26.21	51.18
		2	4SG	14.86	4.96	9.90	52.62	17.57	35.05
		4	4SG	32.94	11.84	21.11	103.73	37.27	66.46
		5	4SG	27.34	9.86	17.48	60.22	21.71	38.51
		6	4SG	15.01	5.05	9.96	41.58	13.99	27.59
		7	3SG	42.57	12.44	30.13	94.71	27.68	67.03
		8	4SG	50.09	17.64	32.45	122.59	43.18	79.41
		10	4SG	15.14	5.05	10.09	42.56	14.20	28.36
		11	4SG	18.36	6.23	12.13	54.89	18.63	36.25
		12	4SG	40.31	14.83	25.48	100.48	36.97	63.51
		13	4SG	17.64	5.81	11.83	48.87	16.09	32.77
		14	4SG	9.23	2.85	6.38	30.72	9.48	21.24
		15	3SG	78.95	19.79	59.16	190.92	47.86	143.06
		16	3SG	81.34	20.16	61.18	188.84	46.81	142.03
		103	4SG	14.32	4.69	9.62	50.68	16.61	34.07
		109	4SG	64.75	23.78	40.97	158.47	58.19	100.28

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

STEPS 1a & 2a CALCULATE PREDICTED CRASH FREQUENCY BY SITE IN PERIOD AFTER TREATMENT

Step 2.a.2 Calculate SPFs for each COMPARISON intersection for entire AFTER period

Step 1.a.2 Calculate SPFs for each TREATMENT intersection for entire AFTER period

RESULTS OF STEPS 1a & 2a

R_SiteType			FormulaApplied	AftAllYrs $N_{aimv\text{-}nSG}$	$N_{aimv(FI)\text{-}nSG}$	$N_{aimv(PDO)\text{-}nSG}$	AftAllYrs $N_{pred,ai}$	$N_{pred,ai(FI)}$	$N_{pred,ai(PDO)}$
0	IntNum	3	4SG	14.77	4.84	9.93	52.30	17.13	35.16
		9	4SG	68.70	25.37	43.33	168.15	62.10	106.06
		17	4SG	7.15	2.15	5.00	26.38	7.94	18.44
		18	4SG	11.81	3.92	7.89	40.08	13.30	26.78
		19	4SG	6.82	2.05	4.77	25.15	7.57	17.58
		20	4SG	7.98	2.45	5.53	25.02	7.69	17.33
		21	4SG	16.92	5.55	11.37	51.97	17.05	34.93
		22	4SG	101.97	38.28	63.69	342.53	128.60	213.92
		23	4SG	6.28	1.86	4.41	22.22	6.59	15.63
		24	4SG	11.17	3.57	7.60	32.03	10.23	21.80
		25	4SG	19.15	6.27	12.89	67.82	22.20	45.62
		26	4SG	5.72	1.68	4.05	21.11	6.18	14.93
		27	4SG	23.86	7.90	15.96	58.29	19.29	39.00
		28	4SG	16.90	5.51	11.39	51.92	16.93	35.00
		29	4SG	20.39	6.99	13.40	62.63	21.47	41.16
		122	4SG	106.06	40.03	66.03	356.25	134.46	221.79
1	IntNum	1	4SG	18.93	6.36	12.57	68.43	22.98	45.45
		2	4SG	15.22	5.06	10.16	53.88	17.92	35.96
		4	4SG	34.32	12.24	22.08	108.07	38.53	69.54
		5	4SG	25.27	9.09	16.18	55.65	20.02	35.63
		6	4SG	14.86	4.99	9.87	41.16	13.82	27.35
		7	3SG	44.17	12.87	31.29	98.26	28.64	69.63
		8	4SG	44.54	15.58	28.95	109.01	38.14	70.87
		10	4SG	14.60	4.83	9.76	41.03	13.59	27.44
		11	4SG	16.89	5.71	11.18	50.50	17.07	33.43
		12	4SG	44.85	16.51	28.34	111.81	41.17	70.64
		13	4SG	17.44	5.73	11.71	48.31	15.88	32.43
		14	4SG	8.78	2.70	6.09	29.24	8.97	20.26
		15	3SG	76.31	19.23	57.09	184.55	46.50	138.05
		16	3SG	77.42	19.40	58.02	179.74	45.04	134.70
		103	4SG	14.28	4.68	9.60	50.56	16.57	33.99
		109	4SG	63.69	23.47	40.22	155.89	57.43	98.45

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

STEP 3 CALCULATE ADJUSTMENT FACTOR FOR EACH COMBINATION OF TREATMENT & COMPARISON SITE, SEPARATELY FOR BEFORE & AFTER PERIODS

	DO NOT SORT	DO NOT SORT
R_SiteType	1	0
Pairings	Treatment IntNum	Comparison IntNum
	1	23
	2	17
	4	3
	5	24
	6	21
	7	22
	8	9
	10	20
	11	18
	12	27
	13	19
	14	25
	15	29
	16	122
	103	26
	109	28

Note: each color represents a different three-year span of time since cameras were installed at various times. The colors will have to be referred to for the next steps when adjustments are made because they should only use other intersections from the same time period for the calculations to be valid.

Adj_{ijb}		$N_{pred,Tbi}$	77.39	52.62	103.73	94.71	54.89	48.87	60.22	41.58	122.59	42.56	30.72	100.48	190.92	188.84	50.68	158.47
		Y_{BT}	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
$N_{pred,Cbj}$	Y_{BC}	CIntNum																
56.11	3	3	1.379	0.938	1.848	1.688	0.978	0.871										
28.14	3	17	2.750	1.870	3.686	3.365	1.950	1.737										
48.90	3	18	1.582	1.076	2.121	1.937	1.122	0.999										
29.63	3	19	2.612	1.776	3.501	3.196	1.852	1.649										
268.55	3	22	0.288	0.196	0.386	0.353	0.204	0.182										
24.34	3	23	3.179	2.162	4.261	3.891	2.255	2.008										
174.75	3	9							0.345	0.238	0.702	0.244	0.176					
26.86	3	20							2.242	1.548	4.565	1.585	1.144					
67.10	3	21							0.898	0.620	1.827	0.634	0.458					
33.99	3	24							1.772	1.223	3.607	1.252	0.904					
71.54	3	25							0.842	0.581	1.714	0.595	0.429					
21.54	3	26												4.666	8.865	8.768	2.353	7.358
60.60	3	27												1.658	3.151	3.116	0.836	2.615
50.82	3	28												1.977	3.757	3.716	0.997	3.118
66.60	3	29												1.509	2.867	2.835	0.761	2.379
357.46	3	122												0.281	0.534	0.528	0.142	0.443

Adj_{ijb} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during BEFORE period (

$= (N_{pred,Tbi} / N_{pred,Cbj})*(Y_{BT} / Y_{BC})$

Adj_{ija}		$N_{pred,Tai}$	68.43	53.88	108.07	98.26	50.50	48.31	55.65	41.16	109.01	41.03	29.24	111.81	184.55	179.74	50.56	155.89
		Y_{AT}	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
$N_{pred,Caj}$	Y_{AC}	CIntNum																
52.30	3	3	1.309	1.030	2.067	1.879	0.966	0.924										
26.38	3	17	2.594	2.042	4.096	3.724	1.914	1.831										
40.08	3	18	1.707	1.344	2.696	2.451	1.260	1.205										
25.15	3	19	2.721	2.142	4.297	3.907	2.008	1.921										
342.53	3	22	0.200	0.157	0.316	0.287	0.147	0.141										
22.22	3	23	3.080	2.425	4.864	4.422	2.273	2.174										
168.15	3	9							0.331	0.245	0.648	0.244	0.174					
25.02	3	20							2.224	1.645	4.357	1.640	1.168					
51.97	3	21							1.071	0.792	2.097	0.789	0.563					
32.03	3	24							1.737	1.285	3.403	1.281	0.913					
67.82	3	25							0.821	0.607	1.607	0.605	0.431					
21.11	3	26												5.296	8.741	8.514	2.395	7.384
58.29	3	27												1.918	3.166	3.084	0.867	2.674
51.92	3	28												2.154	3.554	3.462	0.974	3.002
62.63	3	29												1.785	2.947	2.870	0.807	2.489
356.25	3	122												0.314	0.518	0.505	0.142	0.438

Adj_{ija} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during AFTER period (a)

$= (N_{pred,Tai} / N_{pred,Caj})*(Y_{AT} / Y_{AC})$

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

STEP 4 CALCULATE EXPECTED AVERAGE CRASH FREQUENCY (ADJUSTED CRASH FREQUENCY) FOR EACH COMBINATION, SEPARATELY FOR BEFORE & AFTER PERIODS

STEP 5 CALCULATE TOTAL COMPARISON GROUP ADJUSTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN BEFORE PERIOD

STEP 6 CALCULATE TOTAL COMPARISON GROUP ADJUSTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN AFTER PERIOD

R_SiteType		IntNum	BefAllYrs $N_{observed,B}$	AftAllYrs $N_{observedA}$
0	IntNum	3	16	19
		9	14	16
		17	28	24
		18	25	19
		19	19	23
		20	7	8
		21	12	13
		22	9	7
		23	12	13
		24	13	7
		25	17	12
		26	8	26
		27	13	11
		28	13	14
		29	18	10
		122	14	9
b) 1	IntNum	1	27	3
		2	26	26
		4	12	5
		5	7	2
		6	7	6
		7	19	23
		8	18	7
		10	9	3
		11	7	1
		12	12	5
		13	23	7
		14	8	10
		15	9	4
		16	13	3
		103	25	14
		109	13	8

$N_{exptd,CB}$ ($N_{pred,Tbi}$, Y_{BT})

$N_{obsvd,Cbj}$	CIntNum \ TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
16	3	22.07	15.00	29.58	27.00	15.65	13.93										
28	17	77.00	52.36	103.21	94.23	54.61	48.63										
25	18	39.56	26.90	53.02	48.41	28.06	24.98										
19	19	49.62	33.74	66.51	60.73	35.19	31.34										
9	22	2.59	1.76	3.48	3.17	1.84	1.64										
12	23	38.15	25.94	51.14	46.69	27.06	24.09										
14	9							4.82	3.33	9.82	3.41	2.46					
7	20							15.70	10.84	31.95	11.09	8.01					
12	21							10.77	7.44	21.92	7.61	5.49					
13	24							23.03	15.90	46.88	16.28	11.75					
17	25							14.31	9.88	29.13	10.11	7.30					
8	26												37.32	70.92	70.14	18.83	58.86
13	27												21.56	40.96	40.51	10.87	34.00
13	28												25.70	48.84	48.31	12.97	40.54
18	29												27.16	51.60	51.04	13.70	42.83
14	122												3.94	7.48	7.40	1.99	6.21
	$N_{exptd,CB,total}$	**229.00**	**155.72**	**306.93**	**280.24**	**162.41**	**144.61**	**68.64**	**47.39**	**139.71**	**48.50**	**35.01**	**115.68**	**219.79**	**217.39**	**58.35**	**182.43**

Adj_{ijb} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during BEFORE period (

$= (N_{pred,Tbi} / N_{pred,Cbj}) * (Y_{BT} / Y_{BC})$

$N_{exptd,CA}$ ($N_{pred,Tai}$, Y_{AT})

$N_{obsvd,Caj}$	Y_{AC}	CIntNum \ TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109
19	3	3	24.86	19.57	39.26	35.70	18.35	17.55										
24	3	17	62.25	49.01	98.30	89.38	45.93	43.94										
19	3	18	32.44	25.54	51.23	46.58	23.94	22.90										
23	3	19	62.58	49.27	98.83	89.86	46.18	44.18										
7	3	22	1.40	1.10	2.21	2.01	1.03	0.99										
13	3	23	40.04	31.52	63.23	57.49	29.54	28.27										
16	3	9							5.30	3.92	10.37	3.90	2.78					
8	3	20							17.79	13.16	34.85	13.12	9.35					
13	3	21							13.92	10.30	27.27	10.26	7.31					
7	3	24							12.16	9.00	23.82	8.97	6.39					
12	3	25							9.85	7.28	19.29	7.26	5.17					
26	3	26												137.70	227.28	221.36	62.27	191.98
11	3	27												21.10	34.83	33.92	9.54	29.42
14	3	28												30.15	49.76	48.47	13.63	42.03
10	3	29												17.85	29.47	28.70	8.07	24.89
9	3	122												2.82	4.66	4.54	1.28	3.94
		$N_{exptd,CA,total}$	**223.55**	**176.01**	**353.06**	**321.01**	**164.96**	**157.83**	**59.02**	**43.65**	**115.60**	**43.51**	**31.00**	**209.63**	**346.00**	**336.98**	**94.79**	**292.26**

Adj_{ija} =adjustment factor to account for differences in traffic volumes and number of years between treatment site (i) and comparison site (j) during AFTER period (a)

$= (N_{pred,Tai} / N_{pred,Caj}) * (Y_{AT} / Y_{AC})$

CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

STEP 7 CALCULATE COMPARISON RATIO FOR EACH TREATMENT SITE
STEP 8 CALCULATE EXPECTED CRASH FREQUENCY FOR EACH TREATMENT SITE IN THE AFTER PERIOD, HAD NO TREATMENT BEEN IMPLEMENTED
STEP 9 CALCULATE SAFETY EFFECTIVENESS EXPRESSED AS AN ODDS RATIO AT AN INDIVIDUAL TREATMENT SITE
STEP 10 CALCULATE LOG ODDS RATIO FOR EACH TREATMENT SITE
STEP 11 CALCULATE WEIGHT FOR EACH TREATMENT SITE

	TIntNum	1	2	4	7	11	13	5	6	8	10	14	12	15	16	103	109	
STEP 6	$N_{exptd,CA,total}$	223.55	176.01	353.06	321.01	164.96	157.83	59.02	43.65	115.60	43.51	31.00	209.63	346.00	336.98	94.79	292.26	
STEP 5	$N_{exptd,CB,total}$	229.00	155.72	306.93	280.24	162.41	144.61	68.64	47.39	139.71	48.50	35.01	115.68	219.79	217.39	58.35	182.43	
STEP 7	$r_{i,C}$	0.9762	1.1303	1.1503	1.1455	1.0157	1.0914	0.8599	0.9213	0.8274	0.8971	0.8856	1.8122	1.5742	1.5501	1.6246	1.602	
	$N_{observedTB}$	27	26	12	19	7	23	7	7	18	9	8	12	9	13	25	13	
STEP 8	$N_{exptd,TA}$	26.36	29.39	13.80	21.76	7.11	25.10	6.02	6.45	14.89	8.07	7.09	21.75	14.17	20.15	40.61	20.83	
	$N_{observedTA}$	3	26	5	23	1	7	2	6	7	3	10	5	4	3	14	8	
STEP 9	$theta_i$	0.114	0.885	0.362	1.057	0.141	0.279	0.332	0.930	0.470	0.372	1.411	0.230	0.282	0.149	0.345	0.384	
	theta check:	0.114	0.885	0.362	1.057	0.141	0.279	0.332	0.930	0.470	0.372	1.411	0.230	0.282	0.149	0.345	0.384	
STEP 10	R_i	-2.173	-0.123	-1.015	0.0552	-1.962	-1.277	-1.102	-0.072	-0.755	-0.99	0.3446	-1.47	-1.265	-1.905	-1.065	-0.957	
	$R_{i(SE)}^2$	0.3792	0.089	0.2894	0.1028	1.1551	0.1996	0.6744	0.3535	0.2142	0.488	0.2858	0.2967	0.3686	0.4178	0.1391	0.2108	Totals
STEP 11	w_i	2.637	11.233	3.455	9.728	0.866	5.010	1.483	2.829	4.668	2.049	3.499	3.370	2.713	2.393	7.188	4.743	**67.864**
	w_iR_i	-5.731	-1.376	-3.509	0.5373	-1.698	-6.399	-1.634	-0.204	-3.524	-2.028	1.2056	-4.954	-3.431	-4.559	-7.656	-4.538	**-49.498**

$r_{i,C} = N_{exptd,C,A,total} / N_{exptd,C,B,total}$

$N_{exptd,TA} = sum(N_{obsvd,T,B} * r_{iC})$ over all sites

$theta_i = sum(N_{observed,T,A} / N_{expected,T,A})$ over all sites

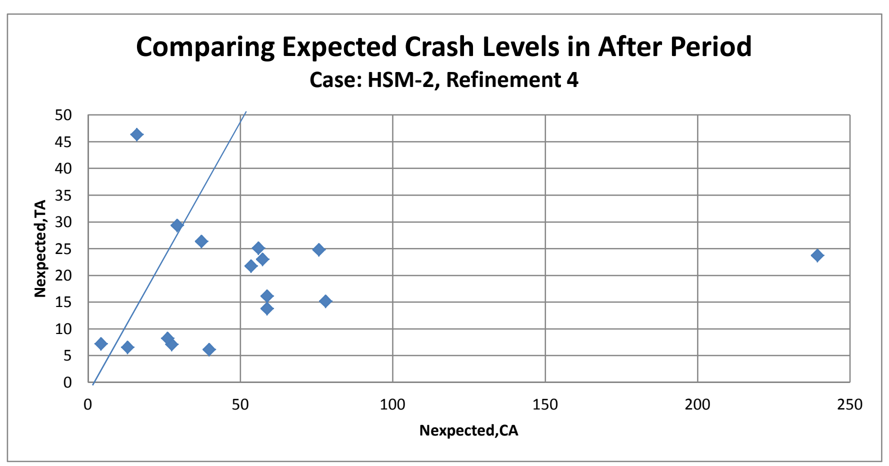
$= (N_{observed,T,A,total} / N_{observed,T,B,total}) * (N_{expected,C,B,total} / N_{expected,C,A,total})$

b)

$R_{i(SE)}^2 = (1/N_{observed,T,A,total}) + (1/ N_{observed,T,B,total}) + (1/N_{expected,C,B,total}) + (1/N_{expected,C,A,total})$

$w_i = 1/R_{i(SE)}^2$

TIntNum	CA,total	l,CA,avg	xptd,TA
1	223.6	37.3	26.4
2	176.0	29.3	29.4
4	353.1	58.8	13.8
7	321.0	53.5	21.8
11	165.0	27.5	7.1
13	335.8	56.0	25.1
5	199.1	39.8	6.1
6	65.1	13.0	6.6
8	390.0	78.0	15.2
10	131.0	26.2	8.2
14	21.7	4.3	7.2
12	379.2	75.8	24.8
15	294.1	58.8	16.2
16	286.5	57.3	23.0
103	80.6	16.1	46.4
109	1196.6	239.3	23.8



CASE 5: BASE + ALL CMF (CMF5 w Raleigh Data) + Ci_forPiedmont

STEP 12 CALCULATE WEIGHTED AVERAGE LOG ODDS RATIO ACROSS ALL TREATMENT SITES

$sum(w_i*R_i)$ -49.498

$sum(w_i)$ 67.864

-0.729 = R =sum(wi*Ri)/sum(wi)

STEP 13 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT EXPRESSED AS AN ODDS RATIO

0.48 = OR = exp(R)

STEP 14 CALCULATE OVERALL EFFECTIVENESS OF TREATMENT EXPRESSED AS A PERCENTAGE CHANGE IN CRASH FREQUENCY

51.78 = Safety Effectiveness = 100 * (1 - R)

51.78% = Safety Effectiveness

ESTIMATION OF PRECISION OF TREATMENT EFFECTIVENESS

STEP 15 CALCULATE STANDARD ERROR OF TREATMENT EFFECTIVENESS

5.85 = SE(Safety Effectiveness)

= 100 * OR / sqrt(sum(wi))

STEP 16 ASSESS STATISTICAL SIGNIFICANCE OF ESTIMATED SAFETY EFFECTIVENESS

8.85 = Performance Measure

= ABS[Safety Effectiveness / SE(Safety Effectiveness)]

PM < 1.7 Treatment Effect NOT significant at the (approx.) 90% confidence interval

PM >= 1.7 Treatment Effect IS significant at the (approx.) 90% confidence interval

PM >= 2.0 Treatment Effect IS significant at the (approx.) 95% confidence interval

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