City of Albuquerque
Red Light Camera Study
Final Report

Prepared by:
Paul Guerin Ph.D.
Institute for Social Research
University of New Mexico

The University of New Mexico

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Office of the Mayor

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INTRODUCTION

Red Light Cameras (RLC) have been in use in Albuquerque since October 2004 and until May 2010 were used at 20 intersections. In an agreement with the New Mexico Department of Transportation (NMDOT) in April 2010 three RLC systems were shut off and since May 2010 the City has 17 operational RLC systems. RLC systems are currently being used in approximately 480 communities in the U.S. (http://www.iihs.org/laws/auto_enforce_cities.aspx).

The overall goal of this study is to report on the safety impact of the RLC system in Albuquerque, New Mexico on traffic safety measured by changes in crashes, the type and severity of crashes, and changes in the cost of crashes.

The use of RLCs is one of several possible countermeasures available to impact the incidence of red light running related crashes. It is beyond the scope of this study to review the different countermeasures, their use at the RLC intersections, and their effectiveness. The literature review briefly describes the variety of countermeasures and their effectiveness but focuses on a review of RLC literature.

Information for this study was acquired from a number of sources. A survey was completed by the City of Albuquerque that provided much of the information that is used in the site description and provided the necessary context for the study. Additionally, City of Albuquerque staff was available to clarify survey responses and to provide additional information when necessary. The City of Albuquerque also provided us with a report completed in January 2008 by the Mayor's Automated Enforcement Study Group. Among other things the report included a review of crash data at the four longest operating intersections (Juan Tabo/Lomas, Paseo del Norte/Coors, Eubank/Montgomery, and San Mateo/Montgomery). Comparison intersections and traffic count data were not used. Analyses focused on a simple before and after analysis of crashes and looked at crashes inside the intersection (angle crashes) and crashes outside the intersection (rear-end crashes). The review of crash data found a statistically significant reduction in crashes inside the intersection at two intersections (Juan Tabo/Lomas and Paseo del Norte/Coors) a reduction in another intersection (Eubank/Montgomery) and an increase in the fourth intersection (San Mateo/Montgomery). The study found an overall reduction in average monthly crashes in the intersection (angle crashes) among the four intersections. The study also found a statistically significant increase in rear-end crashes in one intersection (Juan Tabo/Lomas), an increase in two other intersections (Paseo del Norte/Coors, and San Mateo/Montgomery) and a reduction in the fourth intersection (Eubank/Montgomery). An overall increase was found in average monthly rear-end crashes. The study also noted inconsistent quality control regarding accurate and thorough completion of crash reports. In conclusion, using a simple before and after method, average monthly angle crashes decreased and average monthly rear-end crashes increased from the before period to the after time period.

City of Albuquerque Municipal Development staff was very helpful in providing us official yellow light timings for the RLC intersections and the comparison intersections used in this study. We were also provided an electronic copy of a June 2007 report completed by *PB Americas, Inc*. that was designed to review and verify traffic signal timing data from the 20 RLC intersections. According to this report, the City of Albuquerque determines yellow light intervals based on the Institute of Transportation Engineers (ITE) Formula method and the posted speed limit. Through the use of this method citywide, the City has implemented a 'rule of thumb' practice for how yellow light intervals are timed. The report notes the City makes exceptions based on the geometry of the roadway and intersection. The study found:

- Consistency between the past and current yellow interval timings including before and after the RLCs were implemented at all 20 intersections with the exception of Lomas/Wyoming.
- The yellow intervals at 33 of the 39 intersection approaches exceeded the ITE Formula for the yellow interval time.
- The yellow intervals used at 5 of the 39 approaches were less than the ITE Formula due to the approach grade.
- The yellow interval for the southbound approach of the Lomas/Wyoming intersection was low and was corrected by the City.

To confirm the official yellow light timings provided by the city, ISR staff traveled to each RLC intersection, sometimes more than once, to collect yellow light timings as well as general information on each intersection (i.e. number of travel lanes by direction, presence of dedicated left turn lanes, pedestrian crossing signals, the presence of solid medians, presence of crosswalk, presence of red light camera signs, and rumble strips), and a general description of the intersection including a map of the intersection. Appendix A includes a copy of the intersection data collection instrument. The same instrument was used for the data collection at comparison intersections.

We were also able to obtain traffic volume count information from the Mid-Region Council of Governments of New Mexico (MRCOG). As one of its many tasks the MRCOG provides metropolitan and rural transportation planning for a four-county area, which includes the City of Albuquerque. This includes extensive data collection for traffic monitoring, analysis of current conditions, and traffic forecasts of future conditions. After receiving this information from MRCOG we were able to calculate average annual daily traffic (AADT) counts for each travel direction from calendar year 2000 through calendar year 2008. This information is used in the analyses to measure traffic flow and to calculate crash rates per million entering vehicles (MEV) in RLC and comparison group intersections. Following a national trend, during the study period traffic volume counts at both RLC and comparison group intersections declined. This is discussed in more detail later.

Crash data was provided by the New Mexico Department of Transportation (DOT) through the University of New Mexico's Division of Government Research (DGR). DGR maintains a comprehensive traffic crash database for the state of New Mexico. The database contains information on every crash that occurs in New Mexico with property damage over $500 and that occurs on public property. A copy of the Uniform Crash Report form is included as Appendix B. Information needed to complete this type of study is included in the database. This includes: the date and time of the accident, the severity of the accident, the type of accident (i.e. intersection, non-intersection, intersection related), the street name, contributing factors (i.e. excessive speed, failed to yield, improper overtaking, driver inattention, under influence of alcohol), the highest contributing factor, number of occupants, number killed, number of injuries by seriousness, and number not injured.

DGR staff was also instrumental in providing a list of potential comparison intersections. The list of potential comparison intersections was based on average total crashes, average total crash rate, average crashes by type (rear-end and angle), by type of injury (fatal, injury, and property damage only), and traffic volume. From this list various criteria were used to select comparison intersections including total crashes, the crash rate, and daily traffic. After extracting intersections that for a variety of reasons did not meet our criteria for inclusion as a comparison intersection we created a sample of 38 comparison intersections. We followed an identical process of collecting information at comparison group intersections.

LITERATURE REVIEW

Numerous countermeasures exist for impacting crashes at signalized intersections, which can generally be divided into either engineering or enforcement countermeasures. This section reviews existing research focused on enforcement countermeasures and more specifically RLC research.

In 2008 there were approximately 7,400 fatal crashes at intersections or that were intersection related (NHTSA, 2008). Approximately 2,600 of these fatal crashes were at signalized intersections. In addition, there were approximately 720,000 injury related crashes and approximately 1,550,000 property damage only crashes. Approximately 45 percent of all crashes are intersection-related (NHTSA, 2008). According to the Insurance Institute for Highway Safety, in 2008, 762 people were fatally injured and an estimated 137,000 people were injured in red light running crashes (www.iihs.org). A red light violation occurs when a vehicle enters an intersection some time after the signal light has turned red. Vehicles inadvertently in an intersection when the signal changes to red (i.e. waiting to turn left) are not red light runners (Q&As: Red Light Cameras http://www.iihs.org/research/qanda/rlr.html). A nationwide study of fatal crashes at traffic signals in 1999 and 2000 estimated that 20 percent of drivers fail to obey traffic signals (Q&As: Red Light Cameras http://www.iihs.org/research/qanda/rlr.html).

Red light running is complex and there is no single reason to explain why drivers run red lights. Broadly reasons fall into demographic, human behavioral, vehicle, and interaction characteristics categories (Burkey and Obeng, 2004). Demographic characteristics include age and gender. Drivers between 18 to 25 years of age and males are more likely to run red lights (FHWA, 2009). According to an Institute for Transportation Engineers (ITE) (2003) study red light runners tend to be less than 30 years old, have a record of moving violations, are driving without a valid license, and have consumed alcohol. Human behavioral factors include driver inattention that may be caused by numerous factors including: drowsiness, eating, using a cell phone or other hand held device, and talking with passengers. Speeding and aggressive driving are other factors. Intersection characteristics include traffic volumes, time of day (violations are higher during a.m. and p.m. peak travel hours) approach grade, and frequency of signal cycles. Motorists are more likely to be injured in urban crashes involving red light running than in other type of urban crashes. A study of urban crashes conducted by the Insurance Institute for Highway Safety found that running red lights and other traffic controls was the most common cause of all accidents (22 percent) and those injuries are prevalent within this category of crashes. According to the study, injuries occurred in 39 percent of crashes involving the running of a traffic control, the highest proportion of any type of crash (Retting et al., 1999). In general, red light running violations and crashes are negatively associated with approach flow rates, negatively associated with yellow indication duration, positively associated with approaching speeds, and negatively associated with clearance path length (i.e., the width of the intersection). A study by Bonneson and Zimmerman (2003) on the effect of yellow light interval timing on the frequency of red light running at urban intersections found that an increase of 0.5 to 1.5 seconds in the yellow light interval (as long as the total time did not exceed 5.5 seconds) decreased red light running by 50%. The authors also found that while drivers adjust to the longer yellow light interval, the increase in time did not 'undo' the benefit of an increased yellow interval.

Red light running countermeasures fall into one of two categories: enforcement countermeasures and engineering countermeasures (Bonneson, J. and Zimmerman, K. 2004). Enforcement countermeasures encourage compliance through the threat of a citation and a possible fine. These countermeasures require the use of either a police officer or an automated system to identify red light violators. Engineering countermeasures aim to reduce the incidences of red light running by improving driver awareness of the signal light or by reducing the number of incidences in which drivers are put in the position of having to decide whether or not to run the red light (Bonneson, J. and Zimmerman, K. 2004). Engineering countermeasures usually fall into four broad categories, including countermeasures that:

- Increase the visibility from a sufficient distance to capture the driver's attention (visibility and conspicuity).
- Increase the likelihood of stopping for the red signal when seen.
- Address intentional violators.
- Eliminate the need to stop altogether. (Institute of Transportation Engineers, 2003 and FHWA, 2009)

Some intersection characteristics including the design and configuration characteristics can increase the incidence of red light running. This includes the road grade approaching intersections, sight distance, roadside obstructions (i.e. trees, billboards, and traffic control devices), and approach traffic volumes,

Specific engineering countermeasures recommended by the Federal Highway Administration (2003) to reduce red light running include:

- Improve signal head visibility by increasing size or adding signal heads where one signal head is used for multiple lanes and may be blocked from view.
- Address east-west roads where sun angles silhouette the traffic sign head and add back plates to enhance visibility.
- Set appropriate yellow light time intervals that allow vehicles to clear the intersection or safely stop that is consistent with the speed limit, road grade and intersection width.
- Add a brief all-red light clearance interval to allow traffic in the intersection to clear prior to releasing cross traffic.
- Add intersection warning signs or advanced yellow flashing lights or reduce the approach speed to the intersection.
- Coordinate traffic signals to optimize traffic flow, eliminating interruptions.
- Remove on-site parking near intersections to increase visibility of pedestrians and cross traffic.
- Repair malfunctioning lights and avoid unnecessarily long cycle timings.

Several studies have shown that RLC programs reduce the number and rate of red light running violations (Retting et al., 1999). In short periods after RLC programs are implemented, violation rates drop dramatically. Some programs have seen reductions in violations of between 20 percent and 83 percent as drivers become accustomed to the presence of the cameras and are educated by the signs and public information campaigns that usually accompany RLC programs. In Greensboro, NC the violation rate declined by roughly 35 percent within several months. Some have suggested that reductions in violations translate into reduced crashes and improvements in safety.

History of Red Light Cameras:

The technology behind Red Light Cameras was developed in the 1960s. Red Light Cameras function by monitoring the status of the traffic signal by an electrical connection to the signal controller. Most Red Light Camera systems determine the vehicles presence by using electromagnetic sensors buried in the pavement near the entry point of the intersection. The cameras typically record images of an offending vehicle, recording the surrounding scene, date and time of the offense, vehicle speed, duration of the yellow signal, and how long after the red signal the vehicle began to enter the intersection (Retting, Ferguson, and Hakkert, 2003). Vehicles that enter an intersection on yellow and who are in the intersection when the signal turns red are not photographed. Typically two photos are taken to verify the vehicle actually proceeded through the intersection on the red signal. According to the Insurance Institute for Highway Safety, Highway Loss and Data Institute, violations occurring within 2/10ths of a second after the signal changes to red generally aren't recorded because of technical limitations of the recording equipment. In addition, some red light camera programs provide motorists with grace periods of up to 1/2 second. Tickets typically are mailed to owners of violating vehicles, based on the review of photographic evidence. In many states, it is standard practice for trained police officers or other officials to review every picture to verify that the vehicle is in violation. Tickets are mailed directly to the vehicle owners, based on the results of a review of the photographic evidence (Q&As: Red Light Cameras http://www.iihs.org/research/qanda/rlr.html).

Red light cameras are used in approximately 480 U.S. communities as well as several countries around the world. U.S. cities with red light cameras include: Albuquerque, Atlanta, Baltimore, Chicago, Denver, Houston, Los Angeles, New Orleans, New York City, Philadelphia, Phoenix, San Diego, San Francisco, Seattle, and Washington, DC, plus many smaller communities. Countries that use red light cameras include Australia, Austria, Belgium, Canada, Czech Republic, Germany, Greece, Israel, Italy, the Netherlands, Poland, Romania, Serbia, Singapore, Slovakia, South Africa, Spain, Sweden, Switzerland, Taiwan, and the United Kingdom (http://www.iihs.org/research/qanda/rlr.html).

The speed and safety effect of photo radar enforcement is based on general deterrence theory and the theories relating speeds and speed variance to collisions. General deterrence is described as: 'the effect of threatened punishment upon the population in general, influencing potential violators to refrain from a prohibited act through a desire to avoid the legal consequences' (Ross, H. 1982)

RLC Evaluations

Numerous evaluations have been conducted to examine the various effects of RLC on traffic safety. Evaluations have primarily addressed three major research questions (Washington and Shin 2007):

1. What is the impact of RLCs on safety at signalized intersection approaches that are equipped with cameras?
2. What is the impact of RLCs on safety at all signalized intersection approaches (testing for potential spillover at non RLC intersections)?
3. What are the economic effects of RLCs?

Generally studies indicate that red light cameras are effective at reducing both red light violations and associated crashes. However, there is a broad range of methods that have been used to examine the effects of red light cameras with varying results (Retting, Ferguson, and Hakkert, 2003). Studies conducted of red light camera efficacy vary according to several important regards including (Federal Highway Administration, 2005 B):

- The use and designation of comparison sites.
- Treatment type (cameras only, cameras plus warning signs, red-light-running and speed cameras).
- Area of study (treated intersections, treated approaches, jurisdiction-wide).
- Accident types (all, right-angle, those caused by red-light running).
- Accident severities (all, injury plus fatal, weighted).
- Sample sizes.

- Study methodology (simple before-and-after, before-and-after with comparison group, chi-squared tests, statistical modeling).

A meta-analysis of RLC literature (Federal Highway Administration, 2005 B), found that most studies: "…are tainted by methodological difficulties that raise questions about any conclusions from them". One of the most important difficulties with RLC studies is the failure to account for what is known as "regression to the mean", which can exaggerate positive effects of RLC enforcement. Additionally, many studies do not account for the possibility of "spill-over effects," or the expected effect of RLCs on intersections other than the ones that are actually treated resulting from jurisdiction-wide publicity and the general public's lack of knowledge of where RLCs are installed (Federal Highway Administration, 2005 B).

The meta-analysis identified a number of important lessons that are useful in designing studies of RLC enforcement. Among these lessons, researchers found it is important to (Federal Highway Administration, 2005 B):

- **Consider RLC effects on rear-end crashes:** There is a need to consider not only the crash type, but to account for the trade-off in severity between angle and rear-end types.
- **Consider RLC spillover effects:** Crashes could also be affected by RLC at control/comparison sites within the vicinity. This makes it difficult to determine the effect at treated locations versus all other locations in the same city.
- **Effectively Define "red-light-running crashes":** In previous studies there has been a lack of clarity between angle and turning crashes on police reports. "Legal" right on turn crashes could cloud the definition of the outcome variable.
- **Account for Regression to the mean effects:** RLCs tend to be placed at intersections with high incidence of crashes. In any particular year, there could be an extraordinary number of crashes, but over time these crashes could revert back to an average. This effect has the potential to overstate the positive effects on RLC related crashes.
- **Yellow interval improvements made at the time of RLC installation:** It is important to separate the effects of yellow light interval improvements because studies have shown that other treatments can be just as effective as RLCs.

According to the US Department of Transportation, to ensure statistical validity, it is important for researchers to have a sufficiently large sample of treatment sites to improve the ability of the study to show statistical significance of the results. The possibility of spillover effects should also be considered when designing a study and selecting comparison sites. A strong study would also reduce the reliance on the use of comparison sites and ensure a clear definition of the term "red light running crashes" is clear, consistent and local for the analysis (Federal Highway Administration, 2005 B). Another critical consideration is the duration of the yellow lights at the treatment and comparison intersections. Inconsistencies in signal operations and signing practices cannot be overlooked. Many studies failed to mention differences in the length of the yellow signal phase. In some cases yellow interval improvements may have been made concurrent or in close proximity to the installing of RLCs. Since longer yellow light times have been associated with reductions in crashes, it is important to separate the effects of these measures from that of RLC because some studies have shown that these other treatments can be just as effective as RLC (Decina et al., 2007).

Available research suggests that RLCs are associated with a decrease in the frequency of right-angle crashes and an increase in the frequency of rear-end crashes. Additionally, RLCs have been found to impact crash severity (Washington and Shin, 2007). Another study completed for the Federal Highway Administration (FHWA) (Council, Persaud, Eccles, Lyon, and Griffith, 2005) showed similar results. The study used an Empirical Bayes (EB) before-and-after approach with a large selection of signalized treatment intersection sites (132), signalized comparison intersection sites (408), and un-signalized comparison intersection sites (296) across 7 jurisdictions in the United States. The intent of the study was to aggregate the effects over all the RLC sites in the 7 jurisdictions. The authors found crash effects that were consistent with those found in many previous studies. That is, a decrease in right-angle crashes and an increase in rear-end crashes.

Calculating the Economic Benefit of RLCs

In past studies RLC systems have been shown to not only reduce the severities of accidents, but to reduce the overall costs of accidents in intersections where they are installed as well (Council et al., 2005; Washington and Shin, 2005). The most severe and costly accidents at intersections are right-angle crashes (Washington and Shin, 2005). At intersections where RLCs are installed, studies have revealed the number of angle and left turn crashes decrease, and the number of rear-end collisions increase. Rear-end crashes have been shown to be less severe and less costly than angle crashes (Council et al., 2005).

Calculating the cost of traffic crashes can be complex and generally two approaches are used to assign monetary costs. Economic costs, also called human capital costs, measure the cost of crashes that have occurred and don't measure the total cost to society that includes losses in the quality of life. The second approach is referred to as comprehensive costs and this approach includes the sum of economic costs plus an estimate of quality of life costs. Quality of life costs include physical and mental suffering, quality of life, and permanent cosmetic damage (Hanley, 2004).

The use of economic costs only is useful for measuring the cost of past motor vehicle crashes and should not be used to estimate the dollar value of future benefits due to traffic safety measures. The comprehensive cost approach which combines economic costs with quality of life costs can be used to estimate future benefits. The National Safety Council (NSC) (NSC, 2010) suggests that whenever possible this calculation should be used for cost benefit analyses.

This following briefly describes the two primary sources that have been used to estimate the costs of motor vehicle crashes (Hanley, 2004). First, the National Highway and Traffic Safety Administration (NHTSA) examined the cost of motor vehicle crashes in 1996 and 2000 (Blincoe et al., 2002). In both reports the Abbreviated Injury Scale (AIS) was used as the basis for stratifying costs by injury severity. AIS codes are mainly directed toward the immediate threat to life resulting from an injury and are estimated shortly after a crash occurs. The AIS, developed in 1969, ranks injuries on a scale of 1 (minor) to 6 (unsurviable). Because some motor vehicle crashes result in longer term injuries with more expensive outcomes, the AIS is not always an accurate predictor.

Various costs are associated with motor vehicle crashes including costs associated with programs designed to improve safety, in this study RLC systems. Economic costs are comprised of a number of separate categories including: medical costs, property damage costs, legal costs, workplace costs, insurance administration costs, household productivity costs, emergency services costs, household productivity costs, and travel delay costs. Other types of costs that are not economic such as physical pain and emotional anguish can be more difficult to estimate. NHTSA has focused on the economic impact of motor vehicle crashes and using these costs alone does not produce the most accurate cost-benefit ratio and so produces conservative estimates. The largest cost components are property damage, market productivity, and medical, which together accounted for approximately

66% of the cost of a motor vehicle crash. According to NHTSA (2002) the value of fatal risk reduction per life saved falls in the range of $2-5 million.

Second, the National Safety Council (NSC) publishes an annual bulletin (NSC, 2010) which estimates the costs of motor vehicle injuries. The NSC estimates includes wage and productivity losses, medical expenses, administrative expenses, vehicle damage, and employer's uninsured costs. The cost of all these items is calculated for each fatality, injury and property damage crash. The most recent NSC publication reflects 2008 data. NSC also calculates the comprehensive costs of motor vehicle crashes which focus on measures of the value of the lost quality of life. NSC reports crash severity using the KABCO injury scale established by the American National Standards Institute (ANSI). This injury scale is designed for law enforcement coding of motor vehicle crashes and is the scale used in the New Mexico Uniform Crash Report. The KABCO injury scale measures fatalities (K), incapacitating injuries (A), non-incapacitating injuries (B), possible injuries (C), and property damage only (O).

Tables 1 and 2 separately show the NHTSA 2001 and NSC 2008 estimated costs. Because the two reporting systems are different the values are not directly comparable. As noted above, NHTSA reports crash severity based on the Abbreviated Injury Scale (AIS) while the NSC reports crash severity using the KABCO injury scale.

Because NHTSA used the AIS which does not directly match the KABCO scale used by many law enforcement agencies in their crash reports it has been necessary to map AIS categories to traffic crash reports generated by law enforcement agencies (Council et al., 2005).

Table 1. NHTSA Cost per Person

Crash Type	2001 Dollars
Unsurvivable	$1,000,977
Critical	$1,122,824
Severe	$356,600
Serious	$190,624
Moderate	$68,445
Minor	$10,819
Property Damage Only	$2,593

Table 2. NSC Total Cost per Person

Crash Type	2008 Dollars	
	Economic Cost	Comprehensive Cost
Fatal (K)	$1,300,000	$4,200,000
Incapacitating (A)	$67,200	$214,200
Non-Incapacitating (B)	$21,800	$54,700
Possible (C)	$12,300	$26,000
Property Damage Only (O)	$2,400	$2,400

Due to the low frequency at which fatalities (K) and incapacitating injuries (A) occur, fatalities and incapacitating injuries are often combined into a single category - K+A (Council et al., 2005; Washington & Shin, 2005). In a number of previous studies when possible injuries (C) were compared to non-incapacitating injuries (B) the cost level of C was higher than B. Because injuries should have a higher cost than possible injuries this finding is counterintuitive. One possible reason why this may occur is that sometimes crash reports record minor injuries as C which later turns out to be more costly whiplash injuries (Council et al., 2005). Due to the high cost and infrequency of K+A, and the difficulty in coding non-incapacitating injuries and possible injuries all injuries have been grouped together in previous studies. Crashes with no injuries (Property Damage Only – PDO) become a second category, which creates cost groups: all injury related crashes K+A+B+C, and PDO crashes (Council et al., 2005; Washington & Shin, 2005). The analysis of injury related crashes and PDO crashes are important to measure the cost benefit of RLC systems.

Several studies have shown a reduction in both the injury severity and cost of crashes when comparing the results of the before and after installation period for RLCs has shown RLCs reduced the costs and severity of accidents. A study of RLCs across 7 U.S. jurisdictions showed a total reduction in right angle crashes of 24.6%, a reduction in right angle injury crashes of 15.7%, a total increase in rear-end crashes of 14.9%, an increase in rear-end injury crashes of 24.0%, and a total crash cost savings of $38,000 per RLC intersection per year (Council et al., 2005). A study in Phoenix, AZ by Washington and Shin (2005) found the installation of RLCs effectively reduced the total amount of right angle crashes by 12.2%, reduced the number of right angle injury crashes by 3.3%, increased the total amount of rear-end crashes by 12.2%, increased the total amount of rear-end injury crashes by 3.1%, and produced a net benefit crash cost savings of $143, 217 per year. A study on the effectiveness of RLCs in Scottsdale, AZ showed a total reduction in right angle crashes of 22.6%, a reduction in right angle injury crashes of 14.6%, a total increase in rear-end crashes of 22.6%, an increase in rear-end injury crashes of 17.8%, and produced a net benefit crash cost savings of $684,134 per year (Washington & Shin, 2005).

Researchers also found positive economic effects when both including and excluding property-only damage crashes. The analysis found a positive aggregate economic benefit of more than $18.5 million over approximately 370 site years, which translates into a crash reduction benefit of approximately $50,000 per site year. With property damage only (PDO) crashes included, the benefit is approximately $39,000 per site year. The implication of this finding is that less severe and generally lower unit costs for rear-end injury crashes together ensure that the increase in rear-end crash frequency does not negate the decrease in the right-angle crashes targeted by red-light-camera systems.

RESEARCH DESIGN

The design of this study is based upon methods commonly used in this type of study (Hauer, 1997 and Washington and Shin, 2007). The different methods described below are all designed to estimate the change in safety as a result of the use of RLCs. Some of the methods are more sophisticated and so tell us more about the actual differences in safety before and after the installation of RLCs. Many of the studies reviewed for this study have not been as rigorous or used multiple methods and so the findings in these studies are more questionable. Our research design incorporates best known practices for this type of study.

This study uses four methods to study the effectiveness of RLCs. These four methods are common in the traffic safety literature (Ozbay et al., 2009). Our study uses these four methods with some slight modifications. In the second and third method we calculate crashes per million entering vehicles (MEV). These methods are:

A simple before and after study. This method focuses on the comparison of the frequency and rate of crashes by total and type of crash (rear-end and right-angle) for a period of time before the installation of RLCs and for a similar period of time after the installation of RLCs. This method assumes no changes other than the installation of RLCs has occurred from the before to the after periods. This simple (or naïve) method assumes that if nothing has changed the crash frequency and rate before the installation of RLCs is a good estimate of what would have happened during the after period without the RLCs. The assumption of no change is questionable but this analysis serves as a starting point and a baseline measure for comparison. With this method, the effect of RLCs is determined by the difference between the crash rate before and the crash rate after RLCs were implemented.

Before and after study with a correction for traffic flow. This method adjusts the impact of RLC safety from the before to after study periods by correcting for traffic volumes. Traffic volume is an important factor that is influential on travel safety. Numerous factors may affect safety such as changes in traffic volume, changes in the geometry of the intersection (i.e. increase/decrease in the number of travel lanes, change in speed limits, the use of protected left turn lanes as compared to permitted left turn lanes, etc.), weather, surrounding land uses, and the driving population.

Before and after study using comparison intersections. This study uses comparison intersections in order to consider the effects of unrecognized factors. This type of study allows the comparison of intersections without RLCs with RLC intersections. Comparison intersections are defined as intersections that are similar in crash rates, traffic volume, and geographic characteristics. The crash data at the comparison group sites can be used to help estimate the crashes that would have occurred at the RLC sites if the RLCs had not been installed.

Before and after study with Empirical Bayes (EB) method. This method has been designed to adjust for the regression to the mean (RTM) problem, which is a serious problem associated with before and after traffic safety studies. Regression to the mean is a problem that occurs in this type of study because intersections are chosen for RLCs because they are thought to have a relatively high rate of crashes. They are 'hotspots' for crashes and sites that need to be treated to reduce the frequency and severity of crashes. Because these RLC intersections were chosen because they were 'hotspots' we could conclude the intersections would drop normally from previous high levels in spite of the introduction of treatments – high accident frequencies may tend to move to the average over the long term. As a result, the application of the comparison group method may tend to over-estimate the treatment effect, since it fails to correct the RTM problem.

Cost Analysis

This study includes a cost analysis that translates the estimated changes in the frequency of crashes to a dollar impact. This analysis is conducted using cost data available from the National Safety Council (NSC). Other studies have used cost data developed by the National Highway Traffic Safety Administration (NHTSA) (Council et al., 2005). The NSC estimate we use includes economic costs (i.e. wage and productivity losses, medical expenses, administrative expenses, vehicle damage, and employer's uninsured costs) and comprehensive costs that focus on lost quality of life.. The cost of all these items is calculated for each fatality, injury and property damage crash. NSC uses the KABCO injury scale established by the American National Standards Institute (ANSI). This injury scale is designed for law enforcement coding of motor vehicle crashes and is the scale used in the New Mexico Uniform Crash Report. The KABCO injury scale measures fatalities (K), incapacitating injuries (A), non-incapacitating injuries (B), possible injuries (C), and property damage only (O). Due to the high cost and infrequency of K+A, and the difficulty in coding non-incapacitating injuries and possible injuries all injuries have been grouped together in previous studies. Crashes with no injuries (Property Damage Only – PDO) become a second category, which creates cost groups: all injury related crashes K+A+B+C, and PDO crashes (Council et al., 2005; Washington & Shin, 2005). The analysis of injury related crashes and PDO crashes are important to measure the cost benefit of RLC systems. Using this method the estimated dollar impact is conservative. This occurs for several reasons. First, the NTHSA calculated costs for possible injuries which have been used in other studies (Council et al., 2005; Washington & Shin, 2005) uses a possible injury cost that is at least 25% higher than the NSC estimate of $26,000. Similarly, the NHTSA property damage only costs are higher by a minimum of 360%. Second, the estimated cost we use for injury crashes is for possible injury crashes. This means we include fatal injuries, incapacitating injuries, and non-incapacitating injuries, which have higher cost estimates into a lower cost estimate. This is done because fatal crashes and incapacitating injuries are relatively rare and it was not possible in this study because of time and cost considerations to separate out this level of detail. Third, our calculations are done by crash and not injury or number of vehicles involved in the crash. For example, some crashes involve multiple vehicles and multiple injuries. Again, because of time and cost considerations this study does not include this level of analysis.

SITE DESCRIPTION

Albuquerque, New Mexico is the largest city in New Mexico with a 2010 estimated population of 535,239 (http://www.cabq.gov/econdev/whyabqquickfacts.html). Albuquerque covers an area of 187.76 square miles and in early 2010 had 600 signalized intersections.

The City of Albuquerque has 20 RLC intersections with 40 monitored approaches total. All intersections have 2 cameras (approaches) with the exception of Eubank and Montgomery, which has one monitored approach, and Coors and Montano which has 3 monitored approaches. All cameras take only rear photographs and video and all 40 approaches record both red light running violations and speeding violations. Red light running citations and/or speeding citations are issued to the vehicle owner. The program officially began in May 2005 and the last RLC intersection was added in April 2007.

Table 4 provides a list of RLC intersections, the date each intersection went live by red light running and speeding, the monitored approaches, and the date of deactivation for three of the intersections. The first two intersection approaches were activated in October 2004 and the last two intersection approaches were activated 29 months later in April 2007. The staggered implementation of the RLCs at the 20 intersections over 29 months impacts the amount of exposure in years for each intersection in the after study period. Longer periods of time for the before and after time period are preferable because they allow for a longer period of time to test for effects and a larger pool of crashes. Exposure times for the 20 RLC intersections vary from 1.67 years (18 months) to 4.17 years (50 months).

Defining Intersection Crashes

Intersection crashes in this study are defined as either 'intersection' crashes or 'intersection related' crashes that occurred at an intersection that was controlled by an active traffic signal. According to NM State Statute (Section 66-7-209 NMSA 1978) New Mexico law enforcement agencies are required to use the New Mexico Uniform Crash Report form (Appendix B). The statute requires that written reports contain sufficiently detailed information to describe the cause, conditions, the persons, and vehicles involved. Reports are most frequently completed by law enforcement officers at the scene of accidents but may also be completed by citizens who complete reports at a local law enforcement agency (usually one of the six APD substations in Albuquerque) typically, but not always, when a local enforcement officer is not able to respond to an accident. While not known it is believed that less than 5% of all accident reports in this study were completed by citizens. Because citizens, unlike law enforcement officers, are not trained to complete crash reports data quality is more of an issue in citizen completed reports. By NM State Statute written reports are supposed to be forwarded to the NM Department of Transportation where they are entered into a statewide database.

The Uniform Crash Report form contains driver/occupant level, vehicle level, and crash level information. Information includes: the date and time of the accident, the severity of the accident, the type of accident (i.e. intersection, non-intersection, intersection related), a major street code and secondary street code, contributing factors (i.e. excessive speed, failed to yield, improper overtaking, driver inattention, under influence of alcohol), the highest contributing factor, number of occupants, number killed, number of injuries by seriousness, number not injured, distance from in intersection, and relation to intersection (i.e. intersection, intersection related, and non-intersection).

These reports are entered into a traffic crash database that is maintained by the University of New Mexico's Division of Government Research (DGR). The database contains information on every crash that occurs in New Mexico with property damage over $500 and that occurs on public property.

From these crashes alcohol involved crashes were extracted. These crashes were removed because they would have occurred regardless of the existence of the RLC system. It is important to note whether a crash is an intersection crash or intersection related crash or not is coded by the reporting officer and so accuracy of this information is a potential problem. This is particularly true of intersection related crashes. Currently there is no standard method or policy that defines intersection related for officers completing reports and so reporting officers subjectively determine whether a crash is intersection related. There is a field on the report that allows officers to note how many feet from the intersection in feet a crash occurred but this field is rarely completed by officers.

Traffic Volumes

The raw traffic volume data provided by the MRCOG was compiled to provide annual and total traffic volumes for each RLC and comparison group intersection for each respective pre-time period and post-time period. Using these data we calculated an average daily traffic count for each pre and post time period. Table 3 reports the total pre study traffic volume and post study traffic volume for all 20 RLC intersections and each intersection separately.

Traffic volume dropped 2.77% from the before time period to the after time period. This amounted to slightly over 96,000 vehicles a day. Changes in traffic volume varied by intersection; with 7 intersections experiencing increases from 0.7% to 18.8% and 13 intersections experiencing decreases from 1.6% to 23.3%. This overall decrease follows a national trend which has found that vehicle miles traveled (VMT) in urban areas have been decreasing (East-West Gateway Council of Governments, 2008). While in the past few decades there has been a large increase in VMT in the U.S. more recent evidence indicates that VMT is no longer increasing as rapidly and in some areas is decreasing (Traffic Volume Trends http://www.fhwa.dot.gov/ohim/tvtw/tvtpage.cfm).

Table 3. Traffic Volumes

Intersection	AADT Before Period	AADT After Period	Change in AADT	Percent Change
All RLC Intersections	3,491,079.70	3,394,473.92	-96,605.78	-2.77%
Academy and Wyoming	69,486.09	68,277.94	-1,208.14	+3.7%
Central and Coors	55,253.02	59,558.37	+4,305.35	+7.79%
Central and Eubank	61,388.82	60,419.97	-968.85	-1.58%
Central and Louisiana	54,436.3	52,022.60	-2,413.77	-4.43%
Ellison and Coors Bypass	67,267.14	70,750.12	+3,382.97	+5.02%
Lomas and Eubank	67,616.61	63,183.10	-4,433.52	-6.56%
Lomas and Juan Tabo	62,706.80	55,210.86	-7,495.95	-11.95%
Lomas and Wyoming	67,510.82	65,523.76	-1,987.06	-2.94%
Menaul and Carlisle	61,541.14	59,833.55	-1,707.59	-2.77%
Menaul and Louisiana	66,050.14	60,899.04	-5,151.10	-7.80%
Menaul and San Mateo	64,543.08	75,336.57	+10,793.49	+16.72%
Menaul and Wyoming	59,014.59	70,110.12	+11,095.52	+18.80
Montano and Coors	72,385.51	66,526.27	-5,859.24	-8.09%
Montgomery and Carlisle	62,404.54	64,172.18	+767.63	+1.21%
Montgomery and Eubank	75,372.04	70,307.41	-5,064.63	-6.72%
Montgomery and San Mateo	98,152.85	85,747.97	-12,404.88	-12.64%
Montgomery and Wyoming	99,487.76	96,376.80	-3,110.96	-3.13%
Paseo Del Norte and Coors	90,073.08	83,046.44	-7,026.64	-7.80%
Paseo Del Norte and Jefferson	77,281.37	77,846.78	+565.41	+0.73%
Quail and Coors	70,477.77	54,026.05	-16,451.72	-23.34%

RLC System Description

As noted in Table 4 the first two red light cameras were installed and activated in October 2004 and the last red light camera was installed and activated in April 2007. Nine red light camera intersections became active between January 2007 and April 2007. In an agreement with the New Mexico Department of Transportation (NMDOT) three RLC systems were shut off in May 2010.

For the majority of approaches the activation date was the same for the red light camera and speed camera. We had hoped to be able to explore the effects of the speed cameras and the red light cameras separately but because both systems were frequently activated simultaneously this was not possible. If the activation of the two systems had occurred in different time periods it may have been possible to study their effect.

Table 4. Red Light and Speed Camera Activation and De-Activation

Intersection	Direction	Date Red Light Camera Activated	Date Speed Camera Activated	Date De-activated
Academy and Wyoming	NB	1/31/2007	1/31/2007	
	SB	1/31/2007	1/31/2007	
Central and Coors	SB	12/31/2006	12/31/2006	
	WB	12/31/2006	12/31/2006	
Central and Eubank	NB	3/30/2007	3/30/2007	
	SB	3/30/2007	3/30/2007	
Central and Louisiana	EB	3/22/2007	3/22/2007	
	WB	3/22/2007	3/22/2007	
Ellison and Coors Bypass	NB	1/31/2007	1/31/2007	
	SB	1/31/2007	1/31/2007	
Lomas and Eubank	SB	2/28/2007	2/28/2007	
	WB	2/28/2007	2/28/2007	
Lomas and Juan Tabo	EB	2/17/2006	1/8/2007	
	SB	2/17/2006	1/8/2007	
Lomas and Wyoming	EB	4/25/2007	4/25/2007	
	SB	4/25/2007	4/25/2007	
Menaul and Carlisle	NB	1/25/2007	1/25/2007	
	SB	1/25/2007	1/25/2007	
Menaul and Louisiana	NB	3/31/2007	3/31/2007	
	EB	3/31/2007	3/31/2007	
Menaul and San Mateo	NB	6/30/2006	6/30/2006	
	WB	6/30/2006	6/30/2006	
Menaul and Wyoming	SB	6/30/2006	6/30/2006	
	WB	6/30/2006	6/30/2006	
Montano and Coors	EB	9/20/2006	9/20/2006	5/18/2010
	SB 1 & 2	9/20/2006	9/20/2006	5/18/2010
Montgomery and Carlisle	EB	10/5/2006	10/5/2006	
	WB	10/5/2006	10/5/2006	
Montgomery and Eubank	WB	10/22/2004	12/18/2006	
Montgomery and San Mateo	NB	10/18/2004	2/21/2007	
	EB	5/17/2006	5/17/2006	
Montgomery and Wyoming	NB	5/26/2006	5/26/2006	
	EB	5/29/2006	7/11/2008	
Paseo Del Norte and Coors	NB	2/10/2007	6/22/2007	5/18/2010
	SB	2/10/2007	6/22/2007	5/18/2010
Paseo Del Norte and Jefferson	EB	9/30/2006	9/30/2006	5/18/2010
	WB	9/30/2006	9/30/2006	5/18/2010
Quail and Coors	NB	11/30/2006	11/30/2006	
	SB	11/30/2006	11/30/2006	

In Albuquerque the standard definition for a red light running violation is based in New Mexico statute on the use of a stop bar instead of the curb line extension. There is an approximately 0.1 second forgiveness after the light turns red. The vehicle must be behind the stop bar when the light turns red to start the process for a violation.

Since August 2008, as defined in City of Albuquerque ordinance, the standard red light running and speeding violation is $75.00. Prior to August 2008, red light camera citations ranged from $100 for a first to $300 for a third. Speeding fines which began in approximately August 2006 ranged from $100 for speeding 10 miles over the speed limit to $400 for speeding 35 miles or more over the speed limit. Following an ordinance change in February 2008 and until August 2008 fines ranged from $74 for speeding 10 miles over the speed limit to $184 for speeding 26-30 miles over the speed limit.

Vehicle owners are responsible for the tickets and because the violation is defined in City of Albuquerque ordinance and not state criminal statute no points are applied to the point system that is used as a basis for suspending or revoking driving privileges in New Mexico.

According to City of Albuquerque staff the 20 intersections were chosen because they were 20 of the most dangerous intersections in New Mexico as measured by traffic crashes and fatalities. All 20 intersections appear on a list of the top 50 crash intersections in 2001-2003 and 19 of the 20 intersections appear on the 2003-2005 most dangerous intersection list. ISR staff confirmed this by a quick review of data published in reports that can be found on the University of New Mexico's Division of Government Research website (http://www.unm.edu/~dgrint/). It is not clear why the monitored approaches were chosen.

Table 5. Survey findings: General RLC enforcement program description

Questionnaire	City of Albuquerque
Number of intersections with RLCs	20 (3 intersections' cameras were turned off on 5/18/2010)
Total number of signalized intersections	600
Typical camera configuration	All intersections have 2 cameras (approaches) with the exception of Eubank and Montgomery, which only has one camera, and Coors and Montano has 3 cameras. All cameras take rear photographs and video.
RLR definition	Stop bar and 0.1 second forgiveness
Constant RLR definition over all intersections	Yes
RLR citation	Vehicle owner
RLR fine	$75 dollars
Speeding fine	$75 dollars
Points added to record	No
Standard for selecting RLC intersection	Intersections were chosen based upon New Mexico's most dangerous intersections list

Table 6 provides crash data information for the City of Albuquerque. For the study we were able to access 9 years of crash data from January 2000 through December 2008. This includes crash data for the 20 RLC intersections the comparison intersections and crash data for the City of Albuquerque. We do not have crash data for all othe the approximate 600 signalized intersections. Traffic crash reports can either be made by police or citizens and all reports that are marked as over $500 in property damage are included in the electronic crash data. Crashes on private property and crashes under $500 in property damage are not included in the electronic data.

Table 6. Survey findings: Crash data

Questionnaire	City of Albuquerque
Crash data of RLC intersection	Yes
Years of crash data	9
Crash data of non-RLC intersections	Yes
Reporting by	Police or Self (citizen made) Reports
Reporting cost of damage to vehicles and property	All reports marked as either under $500, or over $500
De-personalized copies of all crash reports	No

Table 7 provides some RLC site specific information. We have google earth maps of each intersection but do not have a record of improvements at RLC or comparison group intersections. We also obtained intersection layouts. As noted earlier, the Mid-Region Council of Governments provided us information on RLC and comparison group intersections for which we were able to calculate traffic volumes by travel direction at the relevant intersections from calendar year 2000 through calendar year 2008.

We were able to acquire speeding and red light running violations from the City of Albuquerque as well as vehicle counts from the inception of the program through January 2010. The City of Albuquerque, via Redflex, also provided us the lane coverage by monitored approach by intersection. As noted earlier not all approaches are monitored and not all monitored approach travel lanes are covered by the RLC system.

Table 7. Survey findings: Site specifics and signal phasing

Questionnaire	City of Albuquerque
Site drawing	Yes (City Aerial Photo System and Google Earth)
Other improvements when RLCs installed	Unknown
Record of any changes at signalized intersection	No
Traffic count on the RLC intersections	Yes
Traffic count on other signalized intersections	Yes
Traffic count on un-signalized intersections	No
Yellow interval of RLC intersection	Yes
Standard of Yellow interval	Rule of thumb
Use all-red interval on the RLC intersection	Yes
Use all-red interval on the non-treated intersection	Yes
Yellow interval change after installing RLCs	There were no physical or timing changes at the time of installation.

Table 8 provides a brief description of RLC publicity and information on enforcement. Warning signs with a traffic signal and the words "Photo Enforced" and rumble strips have been cut or placed on the pavement at each RLC intersection. They are typically placed before entering the intersection. The State of New Mexico began requiring these warnings and rumble strips were installed in July 2007.

Table 8. Survey findings: Site publicity and supplemental enforcement campaigns

Questionnaire	City of Albuquerque
Warning signs	Yes, posted on all approaches at the RLC intersections
Rumble strips	Yes, installed on all monitored directions
Level of public program	Low
Sign to show the number of ticketed violations	No
Supplemental enforcement at non-RLC sites	Yes, the City of Albuquerque has three speed vans which are stationed randomly throughout the city

Table 9 provides a record of the number of months each RLC intersection is available for the study in the before time period and after time period. The before period measures the number of months from January 2000 until the month before the RLC was installed and the after period measures the number of months from the month after the RLC was installed to December 2008.

The number of months in the before period ranged from a low of 57 months to a high of 87 months and the number of months in the after period ranged from a low of 20 months to a high of 50 months. In our study we use the number of months in the after period to balance the number of months in the before period. This is done to control for the amount of exposure for the before and after time period.

Nine intersections have 24 or fewer months of exposure time, nine intersections between 25 and 34 months, and two intersections have 50 months. For this type of study longer study periods are preferable to measure change.

Table 9. Study duration of each intersection

Intersection	Before Period (months)	After Period (months)
Academy and Wyoming	84	23
Central and Coors	83	24
Central and Eubank	86	21
Central and Louisiana	86	21
Ellison and Coors Bypass	84	23
Lomas and Eubank	85	22
Lomas and Juan Tabo	73	34
Lomas and Wyoming	87	20
Menaul and Carlisle	84	23
Menaul and Louisiana	86	21
Menaul and San Mateo	77	30
Menaul and Wyoming	77	30
Montano and Coors	80	27
Montgomery and Carlisle	81	26
Montgomery and Eubank	57	50
Montgomery and San Mateo	57	50
Montgomery and Wyoming	76	31
Paseo Del Norte and Coors	73	34
Paseo Del Norte and Jefferson	80	27
Quail and Coors	82	25

Yellow Light Timings

Because yellow light intervals have a large impact on crashes and because in our initial meetings with City of Albuquerque staff regarding this study this was mentioned as a particular area of interest, we have included this section. Both long intervals which can violate driver expectations and short intervals (shorter than Institute of Transportation Engineers suggested values) have resulted in a high number of RLR violations (FHWA 2009). As mentioned in the literature review, a study by Bonneson and Zimmerman (2003) on the effect of yellow light interval timing on the frequency of red light running at urban intersections found that an increase of 0.5 to 1.5 seconds in the yellow light interval, as long as the total time did not exceed 5.5 seconds, decreased red light running by 50%. The authors also found that while drivers adjust to the longer yellow light interval the increase in time did not negate the benefit of an increased yellow interval.

Each yellow light at the 20 RLC and 38 comparison intersections was simultaneously timed twice by two different researchers. The four timings for each yellow light were averaged and compared against the timings provided by the City of Albuquerque. If an averaged timing taken was plus or minus 0.20 seconds, a researcher was sent to the intersection to re-time the specific yellow light in question. In a previous study, it was found that a technician timing yellow lights had a reaction time of approximately 0.16 seconds (PB Americas Inc., 2007). Due to this slight lag in reaction time, yellow lights with a timing difference of < 0.20 seconds were considered to be correct.

There were originally 4 RLC intersections containing 17 yellow lights with timing differences greater than plus or minus 0.20 seconds. Four yellow lights were running under the time at which the City said they were set and 13 yellow lights were running longer than the City stated timing. After a third researcher was sent to the intersections showing timing discrepancies, 2 of the 4 yellow lights that were running shorter than the city stated they should be set appeared to be running at the correct timing. We determined one of the yellow lights running shorter was timed incorrectly by one of the original timers, and the third timer's findings corrected the timing. It appears the other short yellow light was corrected by the City during the original timing and the final timing. The remaining yellow lights continued to run at the original timing, making the total count: 2 timed at less than the City timing and 13 timed longer than the City timing. The City was provided this information.

Using the identical process used for the RLC intersections the 38 comparison intersections were reviewed. After concluding the review we determined 8 yellow lights were running under and 8 yellow lights were running for longer than the times indicated by the City. The City was also provided this information.

Selection of Comparison Intersections

For this study comparison intersections were selected using a number of available criteria. First, intersections must have been a signalized intersection in Albuquerque, New Mexico and must have had been signalized for the entire study period from January 2000 through December 2008. Using this broad criterion, potential study group signalized intersection, were selected based on average daily traffic, average total crashes, average fatal and injury crashes, and average total crash rate. The 5^{th} and 95^{th} percentiles were used to select potential comparison signalized intersections. These criteria produced 53 potential comparison intersections where at least one of the criteria was met. Following this each intersection was reviewed by study group staff and some intersections were excluded. Excluded intersections included those with two or fewer total traffic lanes for a travel direction, intersections that include frontage road lanes and most intersections with less than four travel directions (one intersection included a residential street as a travel direction). This left us with 38 potential comparison group intersections. Study group staff using a reduced version of the RLC intersection data collection instrument then traveled to each intersection. Based on this review we decided to include the 38 intersections as comparison intersections. In addition to meeting the criteria noted above (average daily traffic, crashes by type and total crash rate) the comparison intersections have similar speed limits, number of travel lanes, yellow light interval timings, and other similar geographic characteristics (i.e. mixed land use, cross walks, median, curbs and left turn lanes). We did not have all the different variables that would have been useful to compare intersections like road grade.

Using available information we completed a direct match with RLC intersections. In general, we matched two comparison intersections to each RLC intersection. Because the RLC intersection of Paseo del Norte and Coors is a freeway off ramp there was no comparable intersection and so no match occurred. RLC intersections were originally chosen because they experienced high crash rates and so finding comparable comparison intersection could only be done very generally. As a group, RLC intersections had more total travel lanes, more left turn lanes, much higher crash rates, a much larger number of total crashes for the study period, and larger traffic volumes. With this in mind we matched intersections as well as possible using the available criteria. We also used general information on the geographic characteristics of the two groups of intersections combined with our knowledge of the City of Albuquerque to broadly match intersections on geography. In constructing the comparison group of intersections we were not able to account for the potential spillover effect from the RLC intersections. Spillover effects refer to the potential crash migration or general deterrent effect to all signalized intersections, not just RLC intersections, especially if drivers are not generally aware of the location of RLC intersections. We were not able to achieve the ideal of constructing a comparison group that is unaffected by the RLC system and it is an unreasonable to think this could be done. For this study we were not able to measure the spillover effects to comparison intersections. We believe this may lead to an underestimation of RLC effects.

Red Light Running Citations and Speeding Citations

This section briefly describes the red light running and speeding citations. As noted earlier the RLC system at each monitored approach at each intersection includes both a system that issues citations for red light running and for speeding.

As noted in the literature review several studies have shown that RLC programs reduce the number and rate of red light running violations (Retting et al., 1999). In short periods after RLC programs are implemented, violation rates drop dramatically. Some programs have seen reductions in violations between 20 percent and 83 percent as drivers become accustomed to the presence of the cameras and are educated by the signs and public information campaigns that usually accompany RLC programs. In Greensboro NC, the violation rate declined by roughly 35 percent within several months. Some have suggested that reductions in violations translate into reduced crashes and improvements in safety. In our review of the literature we found RLC intersection systems generally only issue red light running citations and do not include a speeding citation component. Although the relationship between red light violations and crashes at an intersection has not been well quantified, McGee and Eccles (2003) in a review of available literature found several studies that concluded that red light running cameras reduce signal violations at intersections.

The next table (Table 10) shows the total number of citations issued by type from January 2005 through January 2010. In the 61 months from January 2005 through January 2010 532,372 citations were issued. By type of citation, 47% were speeding citations, 33.5% were red light running citations and 19.5% were issued by the three vans used by the City primarily in school zones and construction zones. The table also shows the average number of tickets issued by each of the 40 red light cameras. As mentioned earlier one RLC intersection (Eubank and Montgomery) has one camera, one RLC intersections has three cameras (Coors and Montano), and the remaining 18 RLC intersections had 2 cameras each. The average for the speeding van citations is very high because there are only three vans. The average number of citations issued monthly by camera is also provided. On average, 73.1 red light running citations and 102.7 speeding citations are issued by each camera monthly.

Table 10. Citations: Number, Percent, Average Issued by Camera, and Average Issued by Camera by Month

	Frequency	Percent	Average Issued by Camera or Van	Average Issued by Camera by Month
Total Citations	532,372	100.0%	13,309.3	218.21
Red Light Running Citations	178,342	33.5%	4,458.6	73.1
Speeding Citations	250,474	47.0%	6,261.9	102.7
Speeding Van Citations	103,555	19.5%	34,518.3	565.9

The following charts separately show the average number of red light running and speeding violation citations issued by each camera by month since the activation of the first RLC. As indicated in the charts (Chart 1 and Chart 2) the average number of citations (both red light running and speeding) has remained relatively stable since January 2007 at around 100 red light running citations a month per camera and approximately 200 speeding citations a month pre camera.

Chart 1. Average Number of Red Light Running Citations Issued by Active Camera

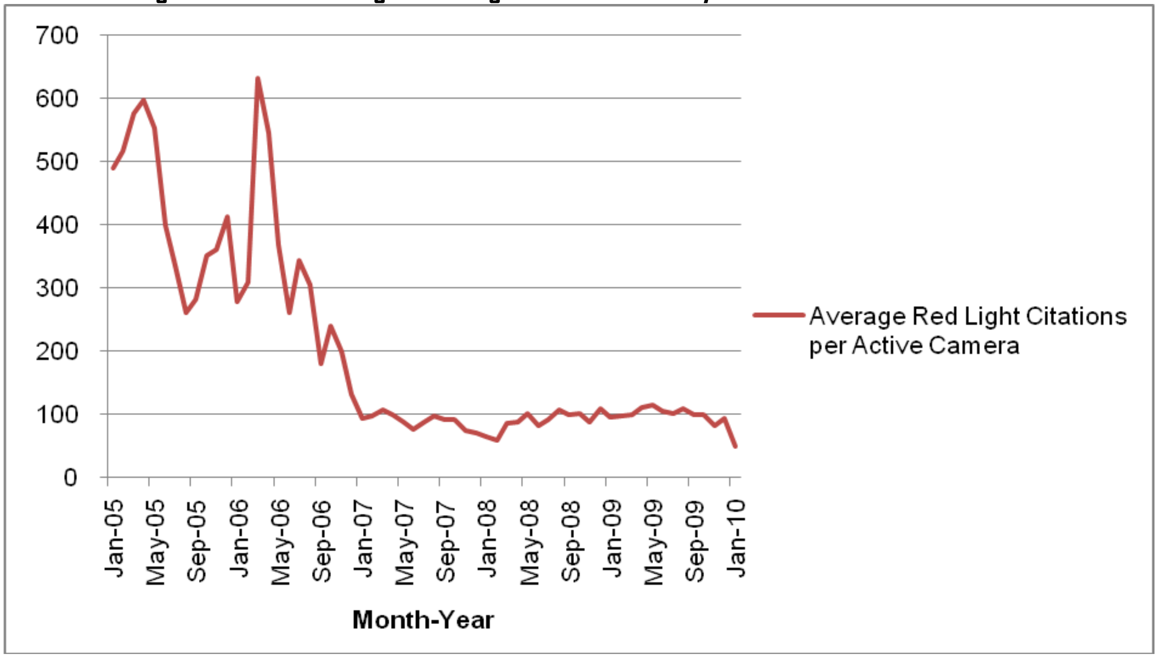
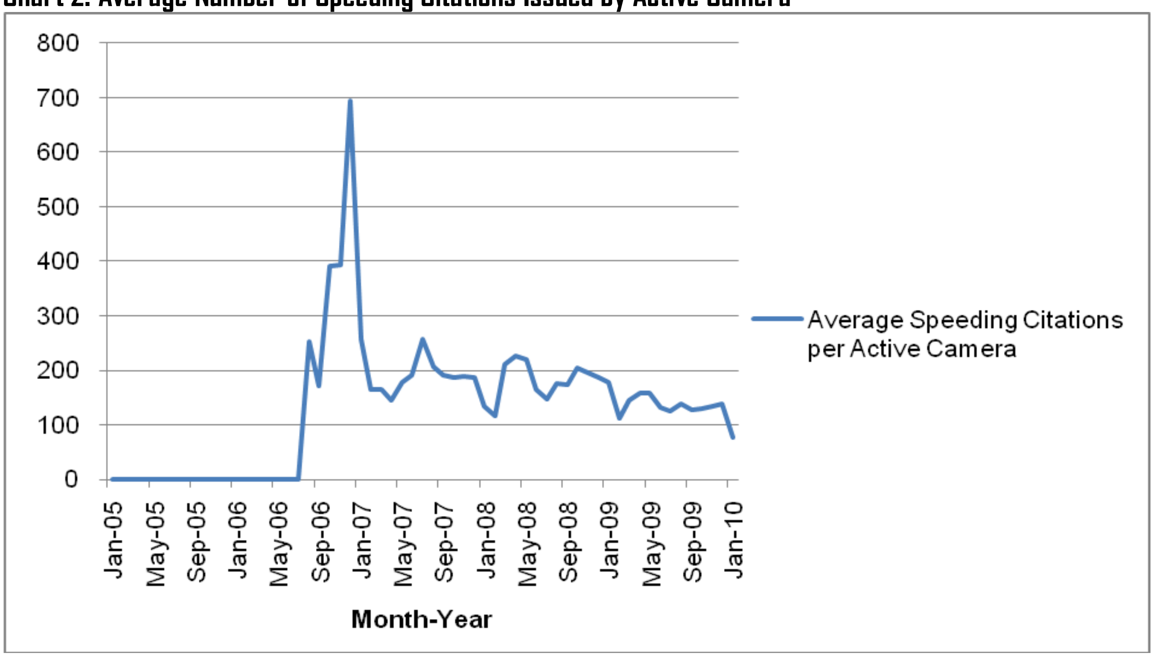


Chart 2. Average Number of Speeding Citations Issued by Active Camera



ANALYSIS

This section first provides a general description of Albuquerque crash data followed by the four different analyses described earlier.

Albuquerque Crash Data

This section provides a general description of crash data for Albuquerque, for the RLC intersections, and the comparison intersections. Crashes are represented in two distinct ways. Crashes are reported by type of crash, either angle crashes (right angle crashes and left turn crashes) or rear-end crashes and by crash severity (fatal/injury and property damage only). It is important to note angle crashes and rear-end crashes can either be fatal/injury or property damage only. It is also important to remember that angle crashes + rear-end crashes = total crashes and fatal/injury crashes + property damage only crashes = total crashes.

Table 12 presents crash data for all Albuquerque signalized intersections, the 20 RLC intersections and the 38 non-RLC comparison intersections. Between January 2000 and December 2008 there was 44,474 crashes at signalized intersections in Albuquerque, 7,174 crashes at the 38 comparison intersections, and 6,331 crashes at the 20 RLC intersections.

The average number of crashes of 65.6 for all signalized intersections between January 2000 and December 2008 was much lower compared to both RLC (316.55) and comparison intersections (188.79). The 20 RLC intersections accounted for 14.2% of all intersection crashes during the nine year study time period and the 38 comparison intersections accounted for 16.1% of all intersection crashes.

As expected, fatal injury crashes accounted for a very small percent of all crashes at signalized intersections. During the study period there were 39 fatal crashes at all signalized intersections or 4.9 fatal crashes a year. There were 6 fatal crashes at the 38 comparison intersections and 2 fatal crashes occurred at RLC intersections. There were more rear-end crashes and PDO crashes in all three groups when compared to angle crashes and injury crashes. Injury crashes made up approximately 36.5% of all signalized intersection crashes and 32.6% of RLC intersection crashes. Property damage only crashes accounted for the largest number and percent of all crashes at both signalized intersections (63.4%) and RLC intersections (67.3%).

In the review of types of crashes we found rear-end crashes accounted for 53.6% of signalized crashes, 72.8% of RLC intersection crashes and 61.7% of non-RLC comparison intersections. Angle crashes accounted for the lowest percent of crashes at RLC intersections (27.2%), 38.3% of all crashes in comparison intersections, and 46.4% of all crashes citywide.

Table 12. Summary Statistics of Crashes for the City of Albuquerque, RLC Intersections and Comparison Intersections 2000 - 2008

Variable	Crashes Citywide in Intersections		Crashes in comparison intersections		Crashes in RLC intersections	
Count of Intersections	~600		38		20	
Count of Crashes	44,474		7,174		6,331	
Average Number of Crashes per Intersection	65.60		188.79		316.55	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Fatal	39	0.1	6	0.1	2	0.03
Injury	16229	36.5	2498	34.8	2067	32.6
PDO	28206	63.4	4670	65.1	4262	67.3
Angle	20656	46.4	2747	38.3	1720	27.2
Rear-end	23818	53.6	4427	61.7	4611	72.8

The next table (Table 13) provides a count of citywide crashes, RLC crashes, and comparison group crashes for each year of the study period. During the nine year study period, total citywide intersection crashes were lowest in 2008, the last year of the study period. Crashes at RLC intersections and comparison intersections remained relatively unchanged from the first year (2000) to the last year (2008) but the overall trend in the nine-year study period was a reduction in crashes.

Table 13. Citywide Intersection, RLC, and Non-RLC crashes by Year

Year	Citywide Crashes		RLC Crashes		Non-RLC Comparison Crashes	
	Count	Percent	Count	Percent	Count	Percent
2000	4864	10.9%	631	10.0%	770	10.7%
2001	5278	11.9%	708	11.2%	822	11.5%
2002	5022	11.3%	742	11.7%	801	11.2%
2003	4680	10.5%	665	10.5%	761	10.6%
2004	5020	11.3%	708	11.2%	863	12.0%
2005	5182	11.7%	703	11.1%	819	11.4%
2006	5306	11.9%	763	12.1%	887	12.4%
2007	4905	11.0%	760	12.0%	777	10.8%
2008	4217	9.5%	651	10.3%	674	9.4%
Total	44474	100.0%	7174	100.0%	6331	100.0%

Table 14 provides summary statistic information on crashes at RLC intersections by crash type. Rear-end crashes occurred on average more frequently than angle crashes. Additionally, the median number of crashes was also higher for rear-end crashes compared to angle crashes. The median measures the point at which half of the crashes are below this number and half of the crashes are higher than this number.

Table 14. Average Number of Crashes Yearly at RLC intersections by Crash Type

Statistics	Angle Crashes	Rear-end Crashes
Average	9.59	25.62
Median	10.22	22.22

Table 15 reports the average number of crashes yearly for the entire reporting period of January 2000 through December 2008 for each RLC intersection by total crashes and type of crash. For every intersection the average number of rear-end crashes was greater than the average number of angle crashes.

Table 15. Count and Average Number of Yearly RLC Crashes by Crash Type by Intersection

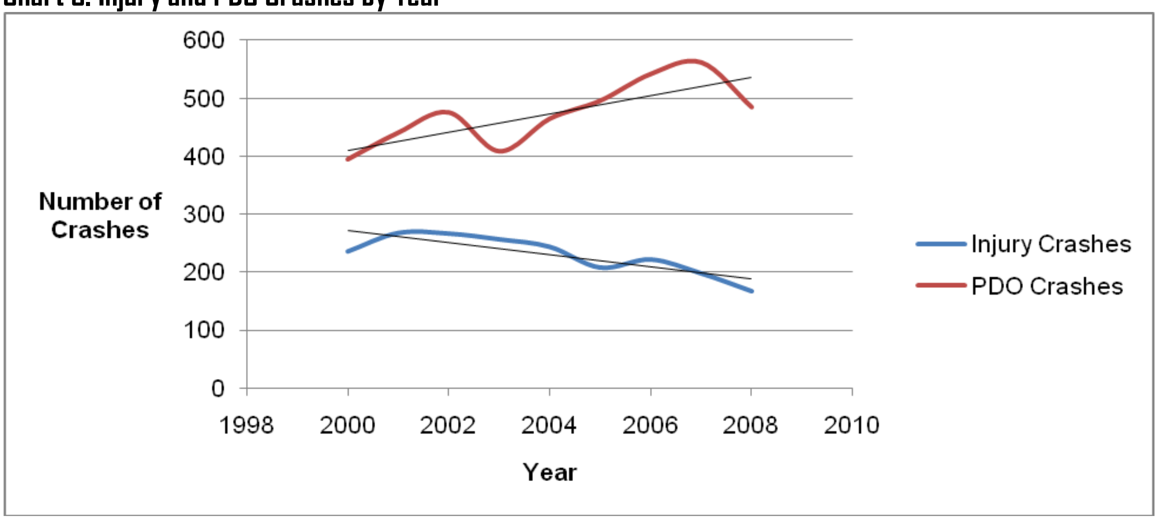
Intersection	Count of Crashes	Total Crashes	Angle Crashes	Rear-end Crashes
Academy & Wyoming	301	33.44	11.89	21.56
Coors & Central	466	51.78	15.44	36.33
Central & Louisiana	222	24.67	10.44	14.22
Central & Eubank	245	27.22	11.22	16.00
Coors & Ellison	349	38.78	6.00	33.44
Lomas & Wyoming	207	23.00	5.22	17.78
Lomas & Eubank	204	22.67	6.00	16.67
Lomas & Juan Tabo	254	28.22	10.00	18.22
Menaul & Carlisle	206	22.89	7.11	15.78
Menaul & San Mateo	267	29.67	6.78	22.89
Menaul & Louisiana	214	23.78	7.22	16.56
Menaul & Wyoming	232	25.78	7.00	18.78
Coors & Montano	414	46.00	7.00	39.00
Montgomery & Carlisle	256	28.44	11.78	16.67
Montgomery & San Mateo	477	53.00	15.33	37.67
Montgomery & Wyoming	438	48.67	10.89	37.78
Montgomery & Eubank	340	37.78	14.33	23.44
Coors & Paseo	459	51.00	6.00	45.00
Jefferson & Paseo	441	49.00	10.44	38.56
Coors & Quail	339	37.67	11.67	26

Table 16 reports the frequency and percent of crashes by crash type and crash severity by year. Chart 3 displays the number of injury and PDO crashes by year. Both the number and percent of angle crashes and injury crashes decreased from January 2000 through December 2008 while the number and percent of rear-end and property damage only crashes increased.

Table 16. RLC Angle, Rear-End, Injury, and PDO Crashes by Year

Year	RLC	Angle		Rear-End		Injury		PDO	
	Count	Count	Percent	Count	Percent	Count	Percent	Count	Percent
2000	631	206	12.0%	425	9.2%	236	11.4%	394	9.2%
2001	708	219	12.7%	489	10.6%	268	13.0%	440	10.3%
2002	742	185	10.8%	557	12.1%	267	12.9%	475	11.1%
2003	665	206	12.0%	459	10.0%	257	12.4%	408	9.6%
2004	708	224	13.0%	484	10.5%	244	11.8%	464	10.9%
2005	703	194	11.3%	509	11.0%	208	10.1%	495	11.6%
2006	763	194	11.3%	569	12.3%	222	10.7%	541	12.7%
2007	760	143	8.3%	617	13.4%	198	9.6%	561	13.2%
2008	651	149	8.7%	502	10.9%	167	8.1%	484	11.4%
Total	6,331	1720	100.0%	4611	100.0%	2067	100.0%	4262	100.0%

Chart 3. Injury and PDO Crashes by Year



The next table (Table 17) documents summary statistics at RLC intersections by crash severity measured as fatal crashes, injury crashes, and property damage only (PDO) crashes. Between January 2000 and December 2008 there were a total of two fatal crashes making the average number of yearly fatal crashes extremely small. The average number of injury crashes is slightly less than 50% of the average number of PDO crashes.

Table 17. Average Number of Crashes Yearly at RLC intersections by Crash Severity

Statistics	Fatal Crashes	Injury Crashes	PDO Crashes
Average	0.01	11.48	23.68
Median	0.00	11.00	20.56

Table 18 reports the average number of crashes by intersection per year by severity of crash. The average number of crashes was greater for each intersection for property damage only crashes compared to injury and fatal crashes. As shown in the table, only two intersections had a fatal crash during the nine year study period.

Table 18. Average Number of Crashes Yearly by Severity by Intersection

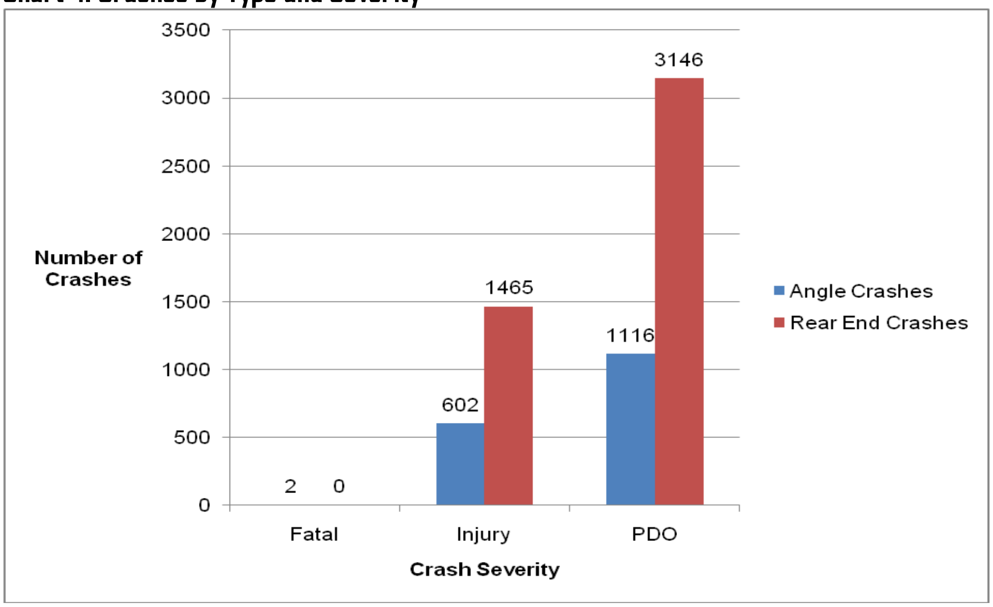
Intersection	Fatal Crashes	Injury Crashes	PDO Crashes
Academy & Wyoming	0.00	13.11	20.33
Coors & Central	0.00	18.67	33.11
Central & Louisiana	0.00	8.89	15.78
Central & Eubank	0.00	9.67	17.56
Coors & Ellison	0.00	12.33	26.44
Lomas & Wyoming	0.00	7.00	16.78
Lomas & Eubank	0.00	6.33	16.33
Lomas & Juan Tabo	0.00	8.44	19.78
Menaul & Carlisle	0.00	7.67	15.22
Menaul & San Mateo	0.00	8.89	20.78
Menaul & Louisiana	0.00	7.11	16.67
Menaul & Wyoming	0.00	7.89	17.89
Coors & Montano	0.11	15.67	30.22
Montgomery & Carlisle	0.00	8.44	20.00
Montgomery & San Mateo	0.00	17.78	35.22
Montgomery & Wyoming	0.00	12.33	36.33
Montgomery & Eubank	0.11	13.22	24.44
Coors & Paseo	0.00	19.11	31.89
Jefferson & Paseo	0.00	14.89	34.11
Coors & Quail	0.00	13.00	24.67

Table 19 and Chart 4 report RLC crashes by crash type by crash severity. Both fatal crashes were angle crashes, 35% of angle crashes had injuries, and 64.9% were property damage only crashes. Almost 32% of all rear-end crashes were injury crashes and 68.2% were property damage only crashes.

Table 19. Number of crashes by crash type and crash severity

Severity/Type	Angle Crashes		Rear-End Crashes	
	Count	Percent	Count	Percent
Fatal	2	0.1	0	0.0
Injury	602	35.0	1465	31.8
PDO	1116	64.9	3146	68.2
Total	1720		4611	

Chart 4. Crashes by Type and Severity



This section focused on describing crashes at RLC camera intersections with some limited information on crashes at all signalized intersections from January 2000 through December 2008. This description included information on types of crashes (rear-end and angle) and crash injuries (fatalities, injuries, and property damage only).

During the study period there were 39 fatal crashes at City signalized intersections, 2 fatal crashes at RLC intersections, and 6 fatal crashes at comparison intersections. There were more rear-end crashes and PDO crashes in all three groups when compared to angle crashes and injury crashes.

While the 20 RLC intersections accounted for approximately 3.3% of the City's approximately 600 signalized intersections the RLC intersections accounted for 14.2% of all intersection crashes during the study time period. The 38 comparison intersections accounted for 6.3% of all signalized intersections and for 16.1% of all intersection crashes. The average number of RLC intersection crashes per intersection during the nine year study period of 316.55 crashes was 67.7% higher than the 188.79 average number of crashes for comparison group intersections and 482.5% higher than the 65.6 average number of crashes for citywide intersections.

Analysis 1: Simple Before and After Study

This analysis focuses on the comparison of the frequency and rate of crashes by total, crash severity (injury and property damage only) and crash type (rear-end and right-angle) for a period of time before the installation of RLCs and for a similar period of time after the installation of RLCs.

Table 20 shows the observed count of crashes in the before period, the observed number of crashes in the after period for all approaches at the RLC intersections and the monitored approaches. The table also provides the monthly average crashes in the before and after periods and the average difference. A positive average difference indicates an increase in the average crashes from the pre to post time period and a negative difference indicates a decrease in the average number of crashes from the pre to post time periods.

At all approaches at the 20 RLC intersections there were 18 (1.0%) more crashes in the post-time period compared to the pre-time period. This accounted for the very slight but not statistically significant increase in the average monthly number of crashes of 0.08 per RLC intersection. There were large statistically significant percentage decreases in injury crashes (25.6%) and angle crashes (28.8%) and smaller more moderate statistically significant increases in rear-end (8.8%) and PDO (9.9%) crashes.

At the monitored approaches only there were 56 (5.5%) more crashes in the post-time period compared to the pre time period. Similar to the all approaches analysis, there were larger percent decreases in injury crashes and angle crashes compared to PDO crashes and rear-end crashes. While the trend was similar the differences were smaller and not as statistically significant.

Table 20. Crashes at RLC Intersections Before and After Controlling for Exposure

	Pre-Count	Post-Count	Count Increase / Decrease	Percent Increase / Decrease	After RLC Monthly Average	Before RLC Monthly Average	Difference
All Approaches							
Total Crashes	1740	1769	+19	+1.1	3.37	3.34	0.03
Injury Crashes	579	459	-120	-26.1	0.88	1.11	***-0.23
PDO Crashes	1161	1308	+147	+12.7	2.50	2.23	** 0.27
Rear-End Crashes	1256	1386	+130	+10.4	2.65	2.41	* 0.24
Angle Crashes	328	213	-115	-54.0	0.41	0.63	***-0.22
Monitored Approaches							
Total Crashes	951	1,000	+49	+5.2	2.30	2.18	0.12
Injury Crashes	329	270	-59	-21.9	0.62	0.75	* -0.13
PDO Crashes	622	729	+107	+17.2	1.68	1.42	*** 0.26
Rear-End Crashes	716	814	+98	+13.7	1.88	1.64	* 0.24
Angle Crashes	164	103	-61	-59.2	0.43	0.54	* -0.11

Note: #p<0.10, *p<0.05, **p<0.01, ***p<0.001

The next table (Table 21) provides similar information as Table 20 but for each RLC intersection. A table of all monitored approaches is included in Appendix E. The total average difference for all crashes, injury type of crash (injury and PDO), and crash type (rear-end and angle) is included. The average difference in crashes varied by crash type and injury type. As noted before, positive differences indicate an increase in crashes, while negative differences indicate a decrease in crashes. Statistically significant differences are noted.

Table 21. RLC Intersection Differences of Averages at Intersections Before and After Controlling for Exposure

	Differences in Averages for Each Type of Crash (RLC Years – Pre-RLC Years)						
Intersection	Pre Count	Post Count	Total	Injury	PDO	Rear-End	Angle
Academy & Wyoming	66	76	0.45	0.05	0.41	0.45	-0.32
Coors & Central	113	107	-0.45	-0.66	0.20	-0.61	-0.08
Central & Louisiana	48	39	-0.83	-0.15	# -0.68	-0.19	-0.49
Central & Eubank	40	58	* 1.00	0.22	# 0.78	0.61	0.33
Coors & Ellison	76	71	-0.53	-0.17	-0.36	-0.49	-0.13
Lomas & Wyoming	42	41	-0.52	-0.38	-0.14	-0.61	0.19
Lomas & Eubank	51	42	-0.43	0.00	-0.43	0.29	-0.24
Lomas & Juan Tabo	72	77	0.32	-0.16	0.47	# 0.53	# -0.36
Menaul & Carlisle	43	40	0.20	0.11	0.09	0.48	-0.05
Menaul & San Mateo	76	76	-0.19	# -0.38	0.18	-0.01	-0.06
Menaul & Louisiana	56	38	# -0.80	* -0.58	-0.22	-0.53	-0.24
Menaul & Wyoming	54	56	0.08	-0.16	0.24	0.28	# -0.32
Coors & Montano	109	137	0.53	0.19	0.34	0.60	-0.13
Montgomery & Carlisle	53	53	0.40	0.04	0.37	# 0.66	# -0.39
Montgomery & San Mateo	215	236	0.33	* -0.62	** 0.95	0.18	-0.10
Montgomery & Wyoming	117	101	-0.52	-0.26	-0.26	-0.35	-0.06
Montgomery & Eubank	175	135	* -0.72	** -0.65	-0.10	-0.32	* -0.40
Coors & Paseo	130	177	* 1.38	-0.03	** 1.41	** 1.50	# -0.26
Jefferson & Paseo	106	139	# 1.07	-0.05	* 1.12	* 1.17	-0.21
Coors & Quail	98	69	* -1.16	-0.40	* -0.76	0.08	***-0.88

Note: #>.1, *>.05, **>.01, ***>.001

In general Analysis 1 which is a simple before and after study indicates very little change (18 crashes or 1.0% increase) from the pre time period to the post time period in the count of total crashes for all 20 RLC intersections. While there is little change in the count of total crashes there are larger and statistically significant differences between crash type and injury type.

At the monitored approaches only there were 56 (5.5%) more crashes in the post-time period compared to the pre time period. Similar to the all approaches analysis, there were larger percent decreases in injury crashes and angle crashes compared to PDO crashes and rear-end crashes. While the trend was similar the differences were smaller and not as statistically significant.

This finding generally supports the literature which notes that at intersections where RLC systems are installed PDO and rear-end crashes increase and the more costly injury and angle crashes decrease. These findings serve as a baseline finding for the remaining methods.

Analysis 2: Simple Before and After Study with a Correction for Traffic Flow

This analysis adjusts the impact of RLC safety from the before to after study period by correcting for traffic volumes. Numerous factors may affect safety such as changes in traffic volume, changes in the geometry of the intersection (i.e. increase/decrease in the number of travel lanes), weather, surrounding land uses, and the driving population. In this analysis we use calculated crash rates to standardize the crashes by traffic volume. Intersection crash rates and monitored approach crash rates are calculated separately.

For each intersection and approach we used average annual daily traffic (AADT) counts for each approach to arrive at the number of vehicles daily in a given year that enter each intersection. This number is then multiplied by 365 (number of days in a year) to arrive at the number of estimated vehicles that enter each intersection in each year of the study period. For the pre study period and post study period we then summed the traffic volume yearly (or portion of a year) to arrive at the number of vehicles that enter each intersection and each monitored approach for each time period. These estimated counts of vehicles are used in the calculations in this analysis. Additionally, because we need to calculate a single crash rate each for the pre period and post period we sum the number of crashes for the pre period and post period separately. Using a specific formula we calculated the crash rate per million entering vehicles (MEV) for all 20 RLC intersections, each intersection separately, and each monitored approach. The information for all 20 RLC intersections and each intersection separately is provided in the following tables.

Table 22 describes crashes per million entering vehicles by injury type and crash type for RLC intersections and for the monitored approaches. Overall crashes increased from the pre-period to the post-period and there was a slight increase in crashes per MEV. This change was not statistically significant for all approaches or monitored approaches only. Both injury crashes and angle crashes decreased from the pre-period to the post-period and the decrease in MEV was slightly statistically significant for injury crashes and moderately statistically significant for angle crashes. From the pre-period to the post-period PDO and rear-end crashes increased both in frequency and crashes per MEV for both all approaches and monitored approaches.

These differences in MEV were slightly statistically significant for all approaches and weakly statistically significant for monitored approaches.

Table 22. Differences in Crashes per MEV by Type of Injury and Type of Crash Pre to Post

	Pre-period Crash Count	Post-period Crash Count	Count Increase / Decrease	Percent Increase / Decrease	Pre-period Crashes per MEV	Post-period Crashes per MEV	Difference in Crashes per MEV
All Approaches							
Total Crashes	1740	1769	+19	+1.1	1.42	1.48	+0.06
Injury Crashes	579	459	-120	-26.1	0.45	0.39	*-0.06
PDO Crashes	1161	1308	+147	+12.7	0.98	1.09	*+0.11
Rear- End Crashes	1256	1386	+130	+10.4	1.02	1.16	*+0.14
Angle Crashes	328	213	-115	-54.0	0.27	0.18	**-0.09
Monitored Approaches							
Total Crashes	951	1,000	+49	+5.2	1.64	1.74	+0.10
Injury Crashes	329	270	-59	-21.9	0.55	0.46	*-0.09
PDO Crashes	622	729	+107	+17.2	1.09	1.25	#+0.16
Rear-End Crashes	716	814	+98	+13.7	1.23	1.39	#+0.16
Angle Crashes	164	103	-61	-59.2	0.29	0.18	**-0.11

Note: #.1 *>.05, **>.01, ***>.001

The next table (Table 23) further describes changes from the pre-period to the post-period by type of crash and type of injury per MEV by intersection. Six intersections (Academy & Wyoming, Lomas & Juan Tabo, Coors & Montano, Montgomery & San Mateo, Coors & Paseo, and Jefferson & Paseo) experienced overall increases in crashes per MEV and 14 intersections experienced decreases. In general there were decreases in injury crashes and angle crashes at intersections and increases in PDO crashes and rear-end crashes.

Table 23. Differences in Crashes per MEV by Intersection, Type of Injury and Type of Crash Pre to Post by RLC Intersection

Intersection	Total	Injury	PDO	Rear-End	Angle
Academy & Wyoming	+0.58	+0.07	+0.47	+0.44	-0.04
Coors & Central	-0.84	-0.39	0.00	-0.31	-0.22
Central & Louisiana	-0.15	-0.05	-0.18	+0.09	-0.23
Central & Eubank	+0.69	+0.22	+0.49	+0.55	+0.16
Coors & Ellison	-0.19	+0.14	-0.29	-0.18	0.00
Lomas & Wyoming	+0.07	0.00	+0.09	0.00	+0.04
Lomas & Eubank	-0.23	+0.09	-0.37	+0.05	-0.14
Lomas & Juan Tabo	+0.11	-0.32	+0.37	+0.50	-0.41
Menaul & Carlisle	-0.10	-0.19	-0.09	-0.19	-0.05
Menaul & San Mateo	-0.22	-0.42	+0.23	+0.04	-0.08
Menaul & Louisiana	-0.07	-0.24	+.09	-0.14	0.00
Menaul & Wyoming	+0.56	-0.13	+0.50	+0.42	-0.13
Coors & Montano	+0.46	-0.04	+0.62	+0.44	+0.04
Montgomery & Carlisle	-0.06	-0.03	-0.13	-0.03	-0.23
Montgomery & San Mateo	+0.22	-0.23	+0.23	-0.07	-0.04
Montgomery & Wyoming	-0.56	-0.19	-0.42	-0.39	-0.15
Montgomery & Eubank	-0.21	-0.18	-0.12	-0.24	0.00
Coors & Paseo	+0.96	+0.13	+0.74	+0.89	-0.05
Jefferson & Paseo	+0.17	-0.11	0.00	+0.34	-0.31
Coors & Quail	-0.05	-0.17	-0.30	+0.11	-0.59

The findings in this section support the findings of the simple before and after analysis. This analysis found statistically significant differences in MEV from the pre time period to the post time period for injury, angle, PDO and rear-end crashes. While injury and angle crashes decreased, PDO and rear-end crashes increased.

Analysis Three: Before and After Study Using Comparison Intersections

This analysis uses comparison intersections in order to consider the effects of unrecognized factors. This type of study allows the comparison of intersections without RLCs with RLC intersections. Comparison intersections are defined as intersections that are similar in crash rates, traffic volume, and geographic characteristics. Using available information described earlier we selected 38 intersections in Albuquerque as comparison intersections. We had originally hoped to conduct analyses between matched individual RLC intersections or groups of similar RLC intersections with individual or groups of comparison intersections but this turned out to not be possible. This level of analysis would have allowed us to compare individual RLC intersections with comparison intersections. Because of the individual uniqueness of intersections a close match was difficult. For example, there is no match to the RLC intersection of Coors and Paseo del Norte. This intersection is an off ramp and there are not similar comparison intersections. In addition, the number of crashes at some intersections, both RLC and comparison, is not large enough to conduct intersection to intersection analyses. Further, the statistical technique Empirical Bayesian is not designed to be used in this manner. For these reasons we focus on a comparison in this section and the next section of RLC intersections with comparison intersections. With this in mind we still report on RLC intersections to provide information on the RLC intersection level differences.

Table 24 provides the total number of crashes, the average number of crashes, and the median number of crashes at comparison intersections by crash type and injury type. Similar to the RLC intersections the most common type of crash was rear-end and the most common type of injury was PDO.

Table 24. Average Number of Crashes at Comparison Intersections by Crash Type and Type of Injury

Statistics	Angle Crashes	Rear-End Crashes	Fatal Crashes	Injury Crashes	PDO Crashes
Total Count	2747	4427	6	2498	4670
Average	8.0	12.9	0.02	7.3	13.7
Median	8.0	12.0	0.00	7.0	13.0

Table 25 documents the average number of yearly crashes at comparison intersections by crash type and type of injury. At all but 5 comparison intersections rear-end crashes were the most frequent type of crash and PDO crashes were the most common type of injury at all 38 comparison intersections.

Table 25. Average Number of Crashes Yearly by Comparison Intersection by Crash Type and Type of Injury

Intersection	Total Crashes	Angle Crashes	Rear-End Crashes	Injury Crashes	PDO Crashes
Academy and Eubank	15.9	4.8	11.1	4.7	11.2
Academy and San Mateo	25.1	9.3	15.8	9.1	16.0
Candelaria and Carlisle	18.7	8.0	10.7	6.8	11.9
Candelaria and Juan Tabo	18.6	10.0	8.6	6.9	11.7
Candelaria and San Mateo	23.0	9.9	13.1	8.4	14.6
Candelaria and Wyoming	18.7	9.0	9.7	6.3	12.3
Central and Juan Tabo	21.3	10.4	10.9	7.4	13.9
Central and Rio Grande	16.9	6.4	10.4	4.2	12.7
Central and San Mateo	24.1	6.8	17.3	9.9	14.2
Central and University	18.4	6.2	12.2	5.6	12.9
Central and Wyoming	23.4	8.7	14.8	7.9	15.4
Constitution and Eubank	16.9	8.9	8.0	6.2	10.7
Constitution and Wyoming	15.7	8.2	7.4	5.9	9.7
Corrales and NM 528	25.1	6.1	19.0	6.6	19.1
Cutler and San Mateo	21.4	8.3	13.1	5.3	16.1
Ellison and NM 528	22.2	6.4	15.8	7.1	15.1
Gibson and Yale	21.8	8.7	13.1	8.0	13.7
Indian School and Louisiana	19.6	6.4	13.1	6.9	12.7
Indian School and San Mateo	19.9	10.1	9.8	7.3	12.4
Irving and Coors	32.8	5.7	27.1	11.8	21.0
Lomas and Louisiana	25.3	12.1	13.2	8.9	16.3
Lomas and San Mateo	24.8	6.9	17.9	8.2	16.6
Lomas and San Pedro	17.1	10.0	7.1	6.1	11.0
Lomas and University	23.1	9.2	13.9	8.0	15.1
Menaul and Eubank	26.8	10.3	16.4	10.0	16.8
Menaul and Juan Tabo	21.6	10.8	10.8	7.1	14.4
Menaul and San Pedro	15.9	4.3	11.6	5.6	10.3
Montgomery and Juan Tabo	25.2	12.2	13.0	9.2	16.0
Montgomery and Louisiana	21.4	9.1	12.3	8.1	13.3
Montgomery and Morris	16.1	9.8	6.3	7.4	8.7
Montgomery and San Pedro	19.9	8.0	11.9	7.3	12.6
Montgomery and Tramway	16.7	6.2	10.4	6.6	10.1
Osuna and Wyoming	18.6	6.2	12.3	6.0	12.6
Paradise and Golf Course	18.4	7.7	10.8	6.9	11.6
Paseo Del Norte and Eagle Ranch	15.8	6.6	9.2	5.3	10.4
Paseo Del Norte and San Pedro	22.1	6.8	15.3	7.3	14.8
Paseo Del Norte and Wyoming	29.4	6.1	23.3	9.3	20.1
St. Josephs and Coors	19.4	4.4	15.0	8.4	11.0

Table 26 reports on the differences in crashes by frequency and percent increase/decrease and MEV crash rates by type of injury and type of crash from the before time period to the after time period. While there was a very slight increase of 1.1% in total crashes for the RLC intersections there was a 9.4% decrease in comparison intersection crashes. For both RLC intersections and comparison intersections there were large decreases in injury crashes (RLC intersections -26.1% and comparison intersections -37.3%) and smaller increases in PDO crashes (RLC intersections +12.7% and comparison intersections +1.7%). There were large decreases (-54.0%) in angle crashes at RLC intersections, a smaller decrease in angle crashes at comparison intersections (-29.3%), a 10.4% increase in RLC rear-end crashes, and rear-end crashes for comparison intersection decreased by 3.6%.

Differences in crashes per MEV for RLC intersections and comparison intersections followed the same pattern as the percent increase/decrease by type of injury and type of crash from the pre period to the post period. There were statistically significantly fewer injury crashes and angle crashes at RLC intersections. The reduction in angle crashes was moderately statistically significant. At RLC intersections there were statistically significantly more PDO and rear-end crashes. At comparison intersections there were statistically significantly fewer total crashes, injury crashes, and angle crashes. The reduction in injury crashes and angle crashes at comparison intersections was highly statistically significant.

The reduction at comparison intersections in injury crashes and angle crashes was more statistically significant than the reduction of injury and angles crashes at RLC intersections.

Table 26. Differences in Crashes per MEV by Type of Injury and Type of Crash Before Period to After Period

	Pre-period Crash Count	Post-period Crash Count	Count Increase / Decrease	Percent Increase / Decrease	Pre-period Crashes per MEV	Post-period Crashes per MEV	Difference in Crashes per MEV
RLC Intersections							
Total Crashes	1740	1769	+19	+1.1	1.42	1.48	+0.06
Injury Crashes	579	459	-120	-26.1	0.45	0.39	*-0.06
PDO Crashes	1161	1308	+147	+12.7	0.98	1.09	*+0.11
Rear-End Crashes	1256	1386	+130	+10.4	1.02	1.16	*+0.14
Angle Crashes	328	213	-115	-54.0	0.27	0.18	**-0.09
Comparison Intersections							
Total Crashes	1954	1787	-167	-9.4	1.14	1.04	**-0.10
Injury Crashes	681	496	-185	-37.3	0.39	0.29	***-0.10
PDO Crashes	1269	1290	+21	+1.7	0.76	0.75	+0.01
Rear-End Crashes	1244	1201	-43	-3.6	0.72	0.68	-0.04
Angle Crashes	490	379	-111	-29.3	0..30	0.23	***-0.07

Note: *>.05, **>.01, ***>.001

Analysis Four: Before and After Study with Empirical Bayes (EB) Method

This method is the most sophisticated of the four methods and has been designed to adjust for the regression to the mean (RTM) problem, which as noted earlier is a serious problem associated with before and after traffic safety studies. Regression to the mean is a problem that occurs in this type of study because intersections are chosen for RLCs because they are thought to have a relatively high rate of crashes. As a result, the application of the comparison group method (Analysis 3) may tend to over-estimate the treatment effect, since it fails to correct the RTM problem. This method is considered to be the standard in professional practice.

According to Persaud and Lyon (2007) based on evidence from actual studies, the EB methodology, if done correctly produces results that are substantially different, and more valid, than those produced by more traditional methods like a simple before and after study. Hauer (1997) notes that all simple before and after studies need to have an appropriate disclaimer that states that any changes cannot be attributed to the treatment, in this case RLCs, and what part is due to all the other factors that changed (i.e. traffic volume, number of travel lanes, speed limits, etc). It is therefore worth the investment in data collection and analysis, to undertake such evaluations. On the other hand, quick and dirty conventional evaluations, often done as a compromise of convenience, will produce questionable results, and should generally be avoided (Persaud and Lyon, 2007).

Completing an Empirical Bayes analysis requires a number of steps that have been detailed in numerous studies (Hauer 1997, Persaud and Lyon 2007, and Powers and Carson, 2004). In this study we do not provide a detailed explanation of the steps and how these steps are completed. Following the generally accepted practice, we first calculated a unique Safety Performance Function (SPF) for each intersection (RLC and comparison) using a multiple linear regression model. In this model we included AADT (average annual daily traffic), the total number of travel lanes per intersection (this included left turn lanes and any dedicated right turn lanes), and the highest speed limit by intersection (some intersections had more than one speed limit). Second, after determining the unique SPF for each intersection we calculated a unique over-dispersion parameter using a negative binomial model. Third, to adjust for varying degrees of over-dispersion we developed a relative weight which was applied to each RLC and comparison intersection. Fourth, using these measures we calculated an estimate of the expected crashes for each intersection for the post time period.

For this analysis we only include crashes by severity (injury and PDO) and not by crash type (rear-end and angle). This was done because crash severity is more important in terms of measuring changes in safety and economic benefits (reported in the next section). In the future it may be useful to report on both crash severity and crash type so that, for example, rear-end injury and rear-end PDO crashes could be reported. While the total change in crashes is important the differential impact of RLC systems on the type and severity of crash would also be useful.

The results from the Empirical Bayes analysis allow us to determine the impact of the RLCs on safety. This is done by comparing actual crashes in the after study period to predicted crashes in the after period. The essence of the comparison is that it compares crashes that did occur at RLC intersections (the actual crashes) and the crashes that would have occurred had no camera been installed (the predicted crashes generated by the EB analysis). The ratio of observed crashes to estimated crashes is described as an index of effectiveness, where a value of less than 1.0 indicates the RLC improved safety and a value of greater than 1.0 indicates safety was not improved.

The next table (Table 27) reports the findings from the Empirical Bayes analysis. The EB crash estimate is provided in the column labeled 'EB Post-Period Crash Count Estimate' and the actual crash count is in the column labeled 'Actual Post-Period Crash Count'. For a safety improvement to have been experienced the number of crashes *expected* (EB estimate) must exceed the *actual* number of crashes (actual crash count) that occurred in the after time period.

The column labeled 'Percent Change in Crash Frequency' measures the percent lower than expected or higher than expected. A '+' indicates an increase in the percent of expected crashes and a '-' indicates a reduction in the percent of expected crashes. There was a change of +3.5% in the number of actual crashes compared to the expected, a 18.2% decrease in the number of actual injury crashes compared to the expected injury crashes, and an increase of 13.2% in the number of actual PDO crashes compared to the expected number of PDO crashes. The index of effectiveness included in the last column notes the RLC system improved safety overall for all crashes, injury crashes, and PDO crashes.

The count of expected to actual crashes at the comparison intersections decreased 9.9% for all crashes, decreased 29% for injury crashes and increased 0.3% for PDO crashes. The index of effectiveness shows improved safety at comparison intersections. Because separate analyses were completed for total crashes, injury crashes, and PDO crashes the sum of the injury crashes and PDO crashes do not equal the total crashes.

Other studies have noted that in some cases a particular traffic treatment to improve safety may affect the logical comparison group (Persaud and Lyon, 2007). The general assumption is that the comparison group remains unaffected by the RLC system while the hope is that a general deterrent effect spills over to all signalized intersections, not just RLC intersections. We believe the general deterrent effect is occurring in this study but we were not able to test for this effect in this study. Potentially additional analyses could be performed to test for spillover. Because the majority of comparison intersections were in the same area of the city as the RLC and in many cases either adjacent intersections or in very close proximity this seems reasonable.

Table 27. Empirical Bayes Estimate

	Pre-Period Crash Count	EB Post-Period Crash Count Expected	Actual Post-Period Crash Count	Percent Change In Crash Frequency	Actual Post-Period Crash Count – EB Post-Period Crash Count Estimate	Average Change in Number of Crashes by Intersection from Pre to Post Time	Index of Effectiveness
Red Light Camera Intersections							
Total Crashes	1740	1707	1769	+3.5%	+62	+3.1	0.98
Injury Crashes	579	561	459	-18.2%	-102	-5.1	0.94
PDO Crashes	1161	1142	1308	+13.2%	+166	+8.3	0.97
Comparison Group Intersections							
Total Crashes	1954	1984	1787	-9.9%	-59	-1.6	0.94
Injury Crashes	681	699	496	-29.0%	-203	-5.3	0.88
PDO Crashes	1269	1286	1290	+0.3%	+4	+0.1	0.93

The next Table (Table 28) and Chart (Chart 5) report on changes in expected crashes and actual crashes by RLC intersection. The complete tables that show the number of expected and actual crash counts can be found in Appendix F.

While overall there was a small increase in total crashes, an 18.2% decrease in injury crashes and a 13.2% increase in PDO crashes these changes varied by RLC intersection. Analyzing the differences by intersection is useful for better understanding how the system has impacted the targeted intersections. Further analyses would be useful to document these changes by monitored approach compared to non-monitored approaches and major arterials (the travel directions with the largest AADT) compared to minor arterials. This type of analysis was beyond the scope of this study.

For all crashes, injury crashes, and PDO crashes the frequency change in the number of expected crashes to the number of actual crashes is included, as well as the annual change in the number of expected to actual crashes, and the percent change in the number of expected to actual crashes.

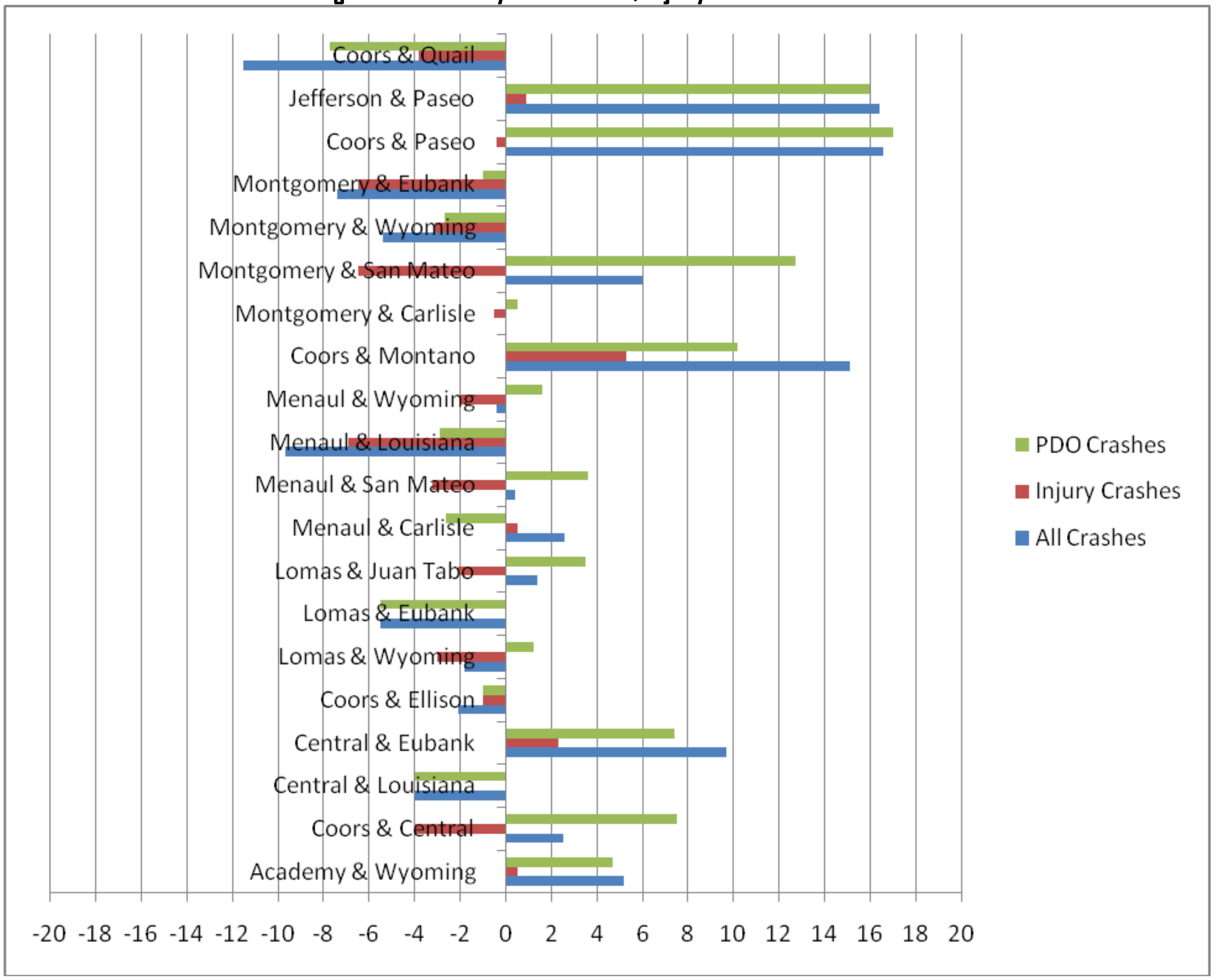
Four intersections (Jefferson and Paseo del Norte, Coors and Montano, Central and Eubank, and Academy and Wyoming) had increases in both injury and PDO crashes. These intersections deserve further assessment to understand why this occurred. Montgomery and San Mateo was a particularly interesting intersection because it experienced a large decrease in injury crashes and a large increase in PDO crashes.

Like the previous table, because of the differential impact of injury and PDO crashes on traffic safety at intersections and because RLC intersections have been found to increase the frequency of rear-end crashes and reduce the frequency of angle crashes, it is important to assess crash severity.

Table 28. EB Analysis by Intersection: Expected to Actual Crashes for All Crashes, Injury Crashes and PDO Crashes

	All Crashes			Injury Crashes			PDO Crashes		
RLC Intersection	Frequency Change	Annual Change	Percent Change	Frequency Change	Annual Change	Percent Change	Frequency Change	Annual Change	Percent Change
Academy & Wyoming	+10	+5.2	+13.1	+1	0.5	+3.7	+9	+4.7	+18.4
Coors & Central	+5	+2.5	+4.6	-8	-4.0	-22.2	+15	+7.5	+19.0
Central & Louisiana	-7	-4.0	-15.2	0	0	0	-7	-4.0	-21.2
Central & Eubank	+17	+9.7	+29.3	+4	+2.3	+33.3	+13	+7.4	+28.3
Coors & Ellison	-4	-2.1	-5.3	-2	-1.0	-9.5	-2	-1.0	-3.7
Lomas & Wyoming	-3	-1.8	-6.8	-5	-3.0	-55.6	+2	+1.2	+5.4
Lomas & Eubank	-10	-5.5	-19.2	0	0	0	-10	-5.5	-25.6
Lomas & Juan Tabo	+4	+1.4	+5.2	-6	-2.1	-28.6	+10	+3.5	+16.1
Menaul & Carlisle	+5	+2.6	+11.1	+1	+0.5	+7.6	-5	-2.6	-15.6
Menaul & San Mateo	+1	+0.4	+1.3	-8	-3.2	-32.0	+9	+3.6	+15.3
Menaul & Louisiana	-17	-9.7	-30.9	-12	-6.9	-60.0	-5	-2.9	-14.3
Menaul & Wyoming	-1	-0.4	-1.8	-5	-2.0	-29.4	+4	+1.6	+9.1
Coors & Montano	+34	+15.1	24.8	+12	+5.3	+30.0	+23	+10.2	+23.7
Montgomery & Carlisle	0	0	0	-1	-0.5	-9.1	+1	+0.5	+2.3
Montgomery & San Mateo	+25	+6.0	+10.6	-27	-6.5	-30.7	+53	+12.7	+30.2
Montgomery & Wyoming	-14	-5.4	-12.2	-8	-3.1	-27.6	-7	-2.7	-8.0
Montgomery & Eubank	-31	-7.4	-18.7	-27	-6.5	-42.2	-4	-1.0	-4.0
Coors & Paseo	+47	+16.6	+26.6	-1	-0.4	-2.0	+48	+17.0	+37.8
Jefferson & Paseo	+37	+16.4	+26.7	+2	+0.9	+5.6	+36	+16.0	+35.0
Coors & Quail	-24	-11.5	-25.8	-8	-3.8	-25.8	-16	-7.7	-25.8

Chart 5. Estimated Annual Change in Crashes by All Crashes, Injury Crashes and PDO Crashes



Cost Analysis

In past studies RLCs have been shown to not only reduce the severity of accidents, but to reduce the overall costs of accidents in intersections where they are installed (Council et al., 2005; Washington and Shin, 2005). Research has shown the most severe and costly accidents at intersections are right-angle crashes and at intersections where RLCs are installed, past studies revealed the number of angle and left turn crashes decrease, and the number of rear-end collisions increase. Rear-end collisions have shown to be less severe and less costly (Council et al., 2005 and Washington and Shin, 2005).

This section calculates the cost of RLC intersection crashes through December 2008 and relies on NSC cost estimates of the comprehensive costs of crashes. This is done for two reasons. First, the NSC cost estimate is directly comparable to NM Uniform Crash report injury severity coding because both use the KABCO injury severity scale. Second, the NSC cost estimate is completed annually making the estimate more recent. As proposed in the literature review we collapse injury severity to two codes – injury and property damage only. This means that whether a crash resulted in a possible injury or an incapacitating injury, the same cost was applied to each injury crash. This section also relies on the information generated in analysis four to estimate the costs.

For this study we use the possible injury comprehensive cost ($26,000) and the property damage only comprehensive cost ($2,400) to report injury crash costs and property damage only crash costs. We use these costs to estimate the cost increase or cost reduction of the RLC system. As indicated in Table 29 there was a cost savings of $2,652,000 based on a predicted reduction of 102 injury crashes through December 2008 and an increase of $398,400 based on a predicted increase of 166 PDO crashes for the same time period. The RLC system has experienced a moderate aggregate crash cost benefit of $2,253,600 ($2,652,000 - $398,400) since the activation of the first RLC system in October 2004 through December 2008. Because the RLC intersections were activated between October 2004 and March 2007 it is difficult to annualize the cost benefit. Additional analyses, which are beyond the scope of this study, could be completed to report the annual cost benefit based on the number of active intersections by year and the changes in crashes by severity for those intersections.

This cost estimate does not include calculations involving the cost to install, operate and maintain the RLC system. For the benefit of the reader we have included as Appendix G information provided by the City of Albuquerque that provides information on issued citations that were paid as well as expenditures.

Table 29. Estimated Costs

Severity	EB Estimated After Crashes	Actual After Crashes	Change	Cost per Crash	Calculated Cost
Injury (K+A+B+C)	561	459	-102	$26,000	$2,652,000
Possible Injury (O)	1142	1308	+166	$2,400	-$398,400

This cost estimate varies by intersection and Table 30 provides a preliminary analysis of the cost benefit by intersection. This table uses information reported in Table 28 to provide the count of crashes used to generate the cost benefit and the cost per crash noted above in Table 29. Chart 6 graphically displays the same information.

Two intersections experienced no increase or decrease in crash costs, 6 intersections experienced increases in injury crash costs, and 12 intersections had decreases in injury crash costs. Twelve intersections experienced increased PDO crash costs and 8 intersections experienced decreased PDO crash costs. Intersections that experienced at least a moderate cost reduction per year (~$50,000) are highlighted in yellow. Intersections that experienced at least a moderate cost increase per year (~$50,000) are highlighted in light green. The remaining intersections that are not highlighted are those that experienced either small annual reductions or increases in cost. Three of the four intersections (Coors and Montano, Coors and Paseo del Norte, and Jefferson and Paseo del Norte) that had at least moderate annual increases in cost were deactivated in May 2010.

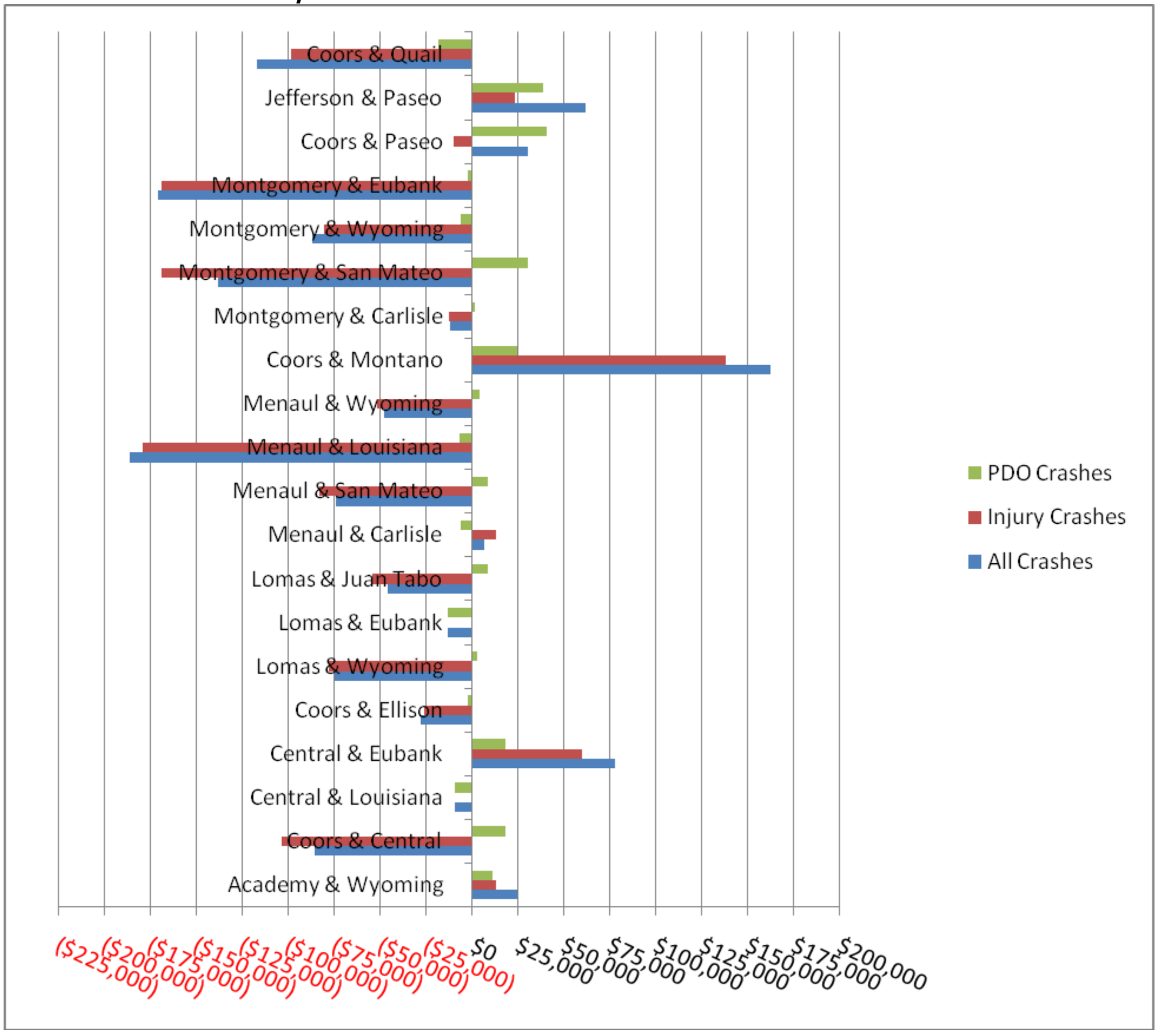
Chart 6 displays the same information described above. Intersections with bars on the left side are those that experienced reductions in crashes and costs. Most intersections with cost reductions experienced large reductions in injury crashes relative to PDO crashes. Two intersections (Coors and Montano and Central and Eubank) experienced relatively large cost increases in injury crashes which was unexpected.

Coors and Montano experienced the largest annual increase in costs at $162,280 per year and Menaul and Louisiana experienced the largest annual decrease at $186,360.

Table 30. Estimated Total Costs and Annual Costs by Intersection

	All Crashes		Injury Crashes		PDO Crashes	
RLC Intersection	Total Cost	Annual Cost	Total Cost	Annual Cost	Total Cost	Annual Cost
Academy & Wyoming	$47,600	$24,280	$26,000	$13,000	$21,600	$11,280
Coors & Central	-$172,000	-$86,000	-$208,000	-$104,000	$36,000	$18,000
Central & Louisiana	-$16,800	-$9,600	$0	$0	-$16,800	-$9,600
Central & Eubank	$135,200	$77,560	$104,000	$59,800	$31,200	$17,760
Coors & Ellison	-$56,800	-$28,400	-$52,000	-$26,000	-$4,800	-$2,400
Lomas & Wyoming	-$125,200	-$75,120	-$130,000	-$78,000	$4,800	$2,880
Lomas & Eubank	-$24,000	-$13,200	$0	$0	-$24,000	-$13,200
Lomas & Juan Tabo	-$132,000	-$46,200	-$156,000	-$54,600	$24,000	$8,400
Menaul & Carlisle	$14,000	$6,760	$26,000	$13,000	-$12,000	-$6,240
Menaul & San Mateo	-$186,400	-$74,560	-$208,000	-$83,200	$21,600	$8,640
Menaul & Louisiana	-$324,000	-$186,360	-$312,000	-$179,400	-$12,000	-$6,960
Menaul & Wyoming	-$120,400	-$48,160	-$130,000	-$52,000	$9,600	$3,840
Coors & Montano	$367,200	$162,280	$312,000	$137,800	$55,200	$24,480
Montgomery & Carlisle	-$23,600	-$11,800	-$26,000	-$13,000	$2,400	$1,200
Montgomery & San Mateo	-$574,800	-$138,520	-$702,000	-$169,000	$127,200	$30,480
Montgomery & Wyoming	-$224,800	-$87,080	-$208,000	-$80,600	-$16,800	-$6,480
Montgomery & Eubank	-$711,600	-$171,400	-$702,000	-$169,000	-$9,600	-$2,400
Coors & Paseo	$89,200	$30,400	-$26,000	-$10,400	$115,200	$40,800
Jefferson & Paseo	$138,400	$61,800	$52,000	$23,400	$86,400	$38,400
Coors & Quail	-$246,400	-$117,280	-$208,000	-$98,800	-$38,400	-$18,480

Chart 6. Estimated Costs by Intersection



DISCUSSION AND CONCLUSION

This section discusses the study findings based on the use of the four methods to measure the overall goal of this study which was to report on whether the use of RLCs in Albuquerque, New Mexico has improved traffic safety as measured by a reduction in crashes and crash severity at RLC intersections and changes in the cost of crashes. To complete this study we first conducted a review of relevant traffic safety literature with an emphasis on RLC research to better understand the use of RLC systems and current best practices to study the effectiveness of RLC systems. In conjunction with the literature review we compiled intersection crash information for the 20 RLC intersections, a comparison group of intersections, and aggregate crash information on all signalized intersections in Albuquerque, New Mexico from January 2000 through December 2008. We also collected other necessary information including traffic volume data and information on each intersection in the study.

Based on the literature review and what we considered to be practical we determined to use a variety of different methods to analyze the collected data. We believe the use of the four methods we chose is beneficial because succeeding methods build upon the knowledge of the previous and in total the four methods tell a more complete story. While the Empirical Bayesian analysis is the most sophisticated of the four methods the simple before and after analysis, the simple before and after analysis with the addition of traffic volume, and the analysis of RLC intersections with a matched comparison group of intersections provide useful information. All the analyses support the finding that the RLC system reduced injury crashes and increased rear-end crashes with intersection level differences. Importantly there were no inconsistencies in the trend of the findings across the four methods. This statistically defensible study found crash effects that were consistent with those found in other studies.

The Empirical Bayesian analysis overcomes the limitations of many other evaluations of RLC systems by properly accounting for regression to the mean. One difficulty we faced in this study was not properly accounting for possible spillover effects to comparison intersections, which we believe leads to an underestimation of RLC benefits. As noted earlier, further analyses could be completed to account for spillover effects. We believe the spillover effect is evidenced in the large reductions in injury crashes at some of the comparison intersections, many of which are in very close proximity to the RLC intersections.

Analysis 1 which is a simple before and after study showed very little change (18 crashes or 1.0% increase) from the before time period to the after time period in the count of total crashes for all 20 RLC intersections. While there was very little change in the count of total crashes there were larger and statistically significant differences between crash type and injury type. Angle crashes and injury crashes statistically significantly reduced from the before time period to the after time period. The monitored approach only analysis paralleled the intersection analysis with smaller and not as statistically significant differences. These findings generally support the literature which notes that at intersections where RLC systems are installed PDO and rear-end crashes increase and the more costly injury and angle crashes decrease. These findings serve as a baseline finding for the remaining methods.

The findings in Analysis 2 support the findings of the simple before and after analysis. This analysis found statistically significant differences in crashes per MEV from the before time period to the after time period for injury, angle, PDO and rear-end crashes. While injury and angle crashes decreased, PDO and rear-end crashes increased.

Analysis 3 was similar to Analysis 2 but included a comparison group of intersections. Differences in crashes per MEV for RLC intersections and comparison intersections followed the same pattern by type of injury and type of crash from the before time period to the after time period. There were statistically significantly fewer injury crashes and angle crashes at RLC intersections. At RLC intersections there were statistically significantly more PDO and rear-end crashes. At comparison intersections there were statistically significantly fewer total crashes, injury crashes, and angle crashes. The reduction in injury crashes and angle crashes at comparison intersections was highly statistically significant. The reduction at comparison intersections in injury crashes and angle crashes was more statistically significant than the reduction of injury and angles crashes at RLC intersections.

Findings from Analysis 4 were consistent with the findings from the other three analyses. Injury crashes were reduced while PDO crashes increased at RLC intersections. Injury crashes and PDO crashes followed the same pattern at comparison intersections, but with larger increases and decreases. This finding followed the pattern of differences found in Analysis 3, which focused on crash changes per MEV.

In Analysis 4 certain RLC intersections were shown to be associated with beneficial effects and some RLC intersections were shown to be associated with a reduction in safety. This is similar to what has been found in other studies (Garber et al., 2005).

The cost analysis used the information generated in Analysis 4 to estimate the cost benefit of the RLC system in Albuquerque and the cost benefit of each RLC intersection. An overall moderate cost benefit was found based on the decrease in injury crashes relative to the increase in PDO crashes and the cost associated with each. We also found differences by RLC intersection with some intersections experiencing increases and some intersections experiencing reductions. We believe the method used to measure the cost benefit produces a conservative estimate

The opposing effects for the two crash types implies that RLC systems would be most beneficial at intersections where there are relatively fewer rear-end crashes and more angle crashes. While we did not specifically analyze the type of crash (rear-end and angle) by crash severity (injury and PDO) the consistent finding of a reduction in angle crashes and rear-end crashes across the different analyses provides evidence that this occurs. Additional analyses could be completed to clarify this finding.

The indications of a spillover effect point to a need for more study of this issue. Importantly, we were also not able to account for all the other programs and treatments that may have affected crash frequencies at both the RLC intersections and comparison intersections study sites. This is not unusual in this type of study. This includes enforcement countermeasures and engineering countermeasures changes. The estimation of the cost benefit does not take into account potential spillover benefits derived from a general deterrent effect to other intersections and so the cost benefit estimate could be conservative.

Specific engineering countermeasures recommended by the Federal Highway Administration (2003) to reduce red light running should be reviewed at current RLC intersections. Many of these countermeasures including appropriate yellow light time intervals that allow vehicles to clear the intersection or safely, improved signal head visibility, brief all-red light clearance intervals, protected left turns, and additional warning signs may already be in place. Where appropriate, additional countermeasures could be implemented to improve safety.

Any future red light cameras should not be implemented without an intersection-specific study of the intersection's crash patterns and geometric characteristics. It may be possible to increase the effectiveness of RLCs through careful selection of the sites to be treated (e.g., sites with a high ratio of right-angle to rear-end crashes as compared to other intersections) and program design (e.g., high publicity and signing at intersections). It may be beneficial to conduct this type of assessment at existing RLC intersections.

The findings in this study have policy implications for the use of RLCs in Albuquerque at signalized intersections and suggest several courses of action.

- The primary finding of a moderate net cost benefit supports the continued use of RLCs in Albuquerque. The moderate net cost benefit primarily derives from the reduction in the number of injury crashes relative to the increase in PDO crashes.

- The finding that this benefit varies by intersection suggests a more targeted approach to the use of RLC systems. This is further supported by the finding that the mix of injury and PDO crashes also varies considerably by intersection.

- The reduction of red light running citations and speeding citations provides evidence and parallels the findings of other studies that RLC programs reduce the number and rate of red light running violations.

Our study was not intended to address this issue and so the findings presented in this report are only preliminary.

- Because of the variation in the change in traffic safety at RLC intersections an assessment of current RLC intersections focused on a review of the specific engineering countermeasures recommended by the Federal Highway Administration to reduce red light running should be considered.

- The evidence of a general deterrent spillover effect that was found in the comparison intersections is important and deserves further study. Considering this effect in the impact of the RLC system would produce an increased benefit in traffic safety.

- As changes are made to the current RLC system it would be useful to study how these changes impact traffic safety at RLC intersections and in Albuquerque.

As noted by Washington and Shinn (2007) RLC systems are not a complete remedy to address red light running problems that include crashes at intersections. RLC systems are one of several possible countermeasures that can be utilized to address crash problems at intersections.

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APPENDICES

Appendix A Intersection Data Collection Instrument

CITY OF ALBUQUERQUE RED LIGHT CAMERA STUDY
INTERSECTION DATA COLLECTION FORM

GENERAL INFORMATION

Date of Visit:_____/_____/________ Time of Visit Begin::___________________
End::______________________
mm/dd/yyyy

Intersection Name:____

Name:____

Last *First*

	Northbound	**Southbound**	**Eastbound**	**Westbound**
Pedestrian crossing signal	Yes______ No______	Yes______ No______	Yes______ No______	Yes______ No______
Presence of solid median	Yes______ No______	Yes______ No______	Yes______ No______	Yes______ No______
Painted crosswalk	Yes______ No______	Yes______ No______	Yes______ No______	Yes______ No______

Notes on general description of surrounding land uses for entire intersection. Please map the following features of the intersection. Check off each feature as you map it. Write "N/A" to any feature that does that not apply to the intersection.

_____ RED LIGHT CAMERAS

_____RED LIGHT CAMERA SIGNS

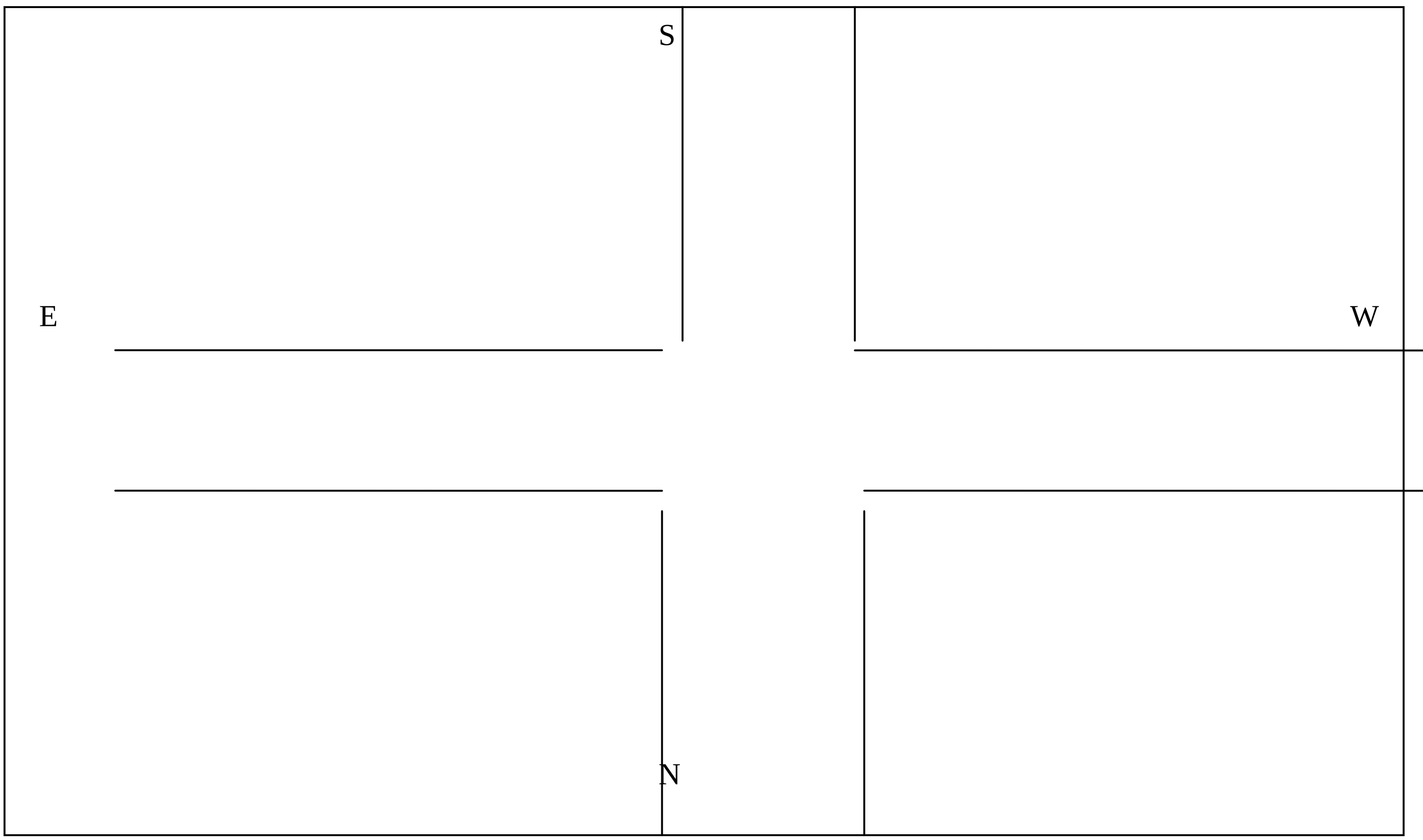
_____RUMBLE STRIPS

_____DRIVEWAYS WITHIN 100 FT OF INTERSECTION

_____COMMERCIAL BUSINESSES

_____RESIDENTIAL PROPERTIES

_____ VACANT LOTS



NORTHBOUND TRAFFIC INFORMATION

Yellow Light Timing **(straight lane)**

Time 1:____________ Time 2:_____________

Green Light Timing **(straight lane)**

Time 1:____________ Time 2:_____________

Number of travel lanes: ______________ Number of left turn lanes:______________ Speed limit:________________

Number of right turn lanes: _____________ Presence of sidewalk: Yes______ No______ Presence of Stop Bar: Yes______ No______

Light Timing

Yellow Light Timing **(left lane)**

Time 1:____________ Time 2:_____________

Green Light Timing **(left lane)**

Time 1:____________ Time 2:_____________

Light Timing

Yellow Light Timing **(right lane)**

Time 1:____________ Time 2:_____________

Green Light Timing **(right lane)**

Time 1:____________ Time 2:_____________

EASTBOUND STREET INFORMATION

Light Timing

Yellow Light Timing **(straight lane)**

Time 1:____________ Time 2:_____________

Green Light Timing **(straight lane)**

Time 1:____________ Time 2:_____________

Number of travel lanes:______________ Number of left turn lanes:______________ Speed limit:________________

Number of right turn lanes:_____________ Presence of sidewalk: Yes______ No______ Presence of Stop Bar: Yes______ No______

Light Timing

Yellow Light Timing **(left lane)**

Time 1:____________ Time 2:_____________

Green Light Timing **(left lane)**

Time 1:____________ Time 2:_____________

Light Timing

Yellow Light Timing **(right lane)**

Time 1:____________ Time 2:_____________

Green Light Timing **(right lane)**

Time 1:____________ Time 2:_____________

SOUTHBOUND TRAFFIC INFORMATION

Yellow Light Timing **(straight lane)**

Time 1:____________ Time 2:_____________

Green Light Timing **(straight lane)**

Time 1:____________ Time 2:_____________

Number of travel lanes: ______________ Number of left turn lanes:______________ Speed limit:________________

Number of right turn lanes: _____________ Presence of sidewalk: Yes______ No______ Presence of Stop Bar: Yes______ No______

Light Timing

Yellow Light Timing **(left lane)**

Time 1:____________ Time 2:_____________

Green Light Timing **(left lane)**

Time 1:____________ Time 2:_____________

Light Timing

Yellow Light Timing **(right lane)**

Time 1:____________ Time 2:_____________

Green Light Timing **(right lane)**

Time 1:____________ Time 2:_____________

WESTBOUND TRAFFIC INFORMATION

Yellow Light Timing **(straight lane)**

Time 1:____________ Time 2:_____________

Green Light Timing **(straight lane)**

Time 1:____________ Time 2:_____________

Number of travel lanes: ______________ Number of left turn lanes:______________ Speed limit:________________

Number of right turn lanes: _____________ Presence of sidewalk: Yes______ No______ Presence of Stop Bar: Yes______ No______

Light Timing

Yellow Light Timing **(left lane)**

Time 1:____________ Time 2:_____________

Green Light Timing **(left lane)**

Time 1:____________ Time 2:_____________

Light Timing

Yellow Light Timing **(right lane)**

Time 1:____________ Time 2:_____________

Green Light Timing **(right lane)**

Time 1:____________ Time 2:_____________

Notes on signage for red light camera (notes should be by travel direction)

Eastbound: West bound: North bound: South Bound:

Notes on signage (i.e. left turn must yield on green, no right turn on red, no U turn, left turn on green arrow only, etc.)

East bound: Westbound: Northbound: Southbound:

Other general observations and reviewer notes

Appendix B State of New Mexico Uniform Crash Report Form

STATE OF NEW MEXICO UNIFORM CRASH REPORT

0000000000

REPORTING DEPARTMENT

☐ ON PRIVATE PROPERTY | ☐ FATAL ☐ INJURY | PROPERTY DAMAGE ONLY ☐ UNDER $500 ☐ $500 OR MORE | ☐ HIT AND RUN | Case Number: | NMDOT: | CAD Num:

CRASH DATE (MM/DD/YY) | MILITARY TIME | CITY OCCURRED IN | COUNTY

Sun ☐ M ☐ Tu ☐ W ☐ Th ☐ F ☐ S ☐ | OCCURRED ON: (Route No. or Name) | AT INTERSECTION WITH: | TRIBAL LAND? ☐ Yes ☐ No

OTHER LOCATION | ☐ FEET ☐ MILES | N ☐ NE ☐ NW ☐ S ☐ SE ☐ SW ☐ E ☐ W ☐ | PERMANENT LANDMARK - COUNTY LINE – INTERSECTION - MILEPOST | LAT: LONG:

CRASH OCCURRED ☐ On Roadway ☐ Off Roadway | CRASH CLASSIFICATION ☐ Overturned ☐ Rollover ☐ Other N-Col ☐ R. R. Train ☐ Pedestrian ☐ Pedalcyclist ☐ Other Vehicle ☐ Animal ☐ Vehicle on Other Rdwy ☐ Fixed Object ☐ Parked Vehicle ☐ Other Object | ANALYSIS CODE:

Vehicle No. 0

VEHICLE NO. HEADED | N NE NW S SE SW E W | On: | Left Scene of Crash | Posted Speed | Safe Speed

Drivers Full Name (Last, First, Middle) | Address

Driver's License Number | State | Type | Status | Restrictions | Endorsements | Expires | City/State | Zip Code | Phone

Date of Birth - M/D/YR | Occupation | Seat Pos. | Age | Sex (M/F) | Race | Injury Code | OP Code | OP Used Property | Airbag Deploy | Ejected | EMS# | Med Trans

Seat Pos.	Occupant's Name (Last, First, Middle)	Occupant's Address (City, State, Zip)

Vehicle Yr. | Vehicle Make | Color | Body Style | Cargo Body Type | Vehicle Use (1) | Vehicle Use (2) | Towed? ☐ Yes ☐ No | Damage Severity ☐ Heavy ☐ Moderate ☐ Slight ☐ None ☐ Unknown ☐ All Areas | Extent ☐ Disabled ☐ Functional ☐ Appearance ☐ Property ☐ Fire ☐ None | ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ Top ☐ Undercarriage

License Yr. | State | License Plate Number | VIN | Towed due to disabling damage? ☐ Yes ☐ No

DOT # | Interstate Carrier Code | Towed By | Towed To

Number of Axles | Vehicle Weight Rating/Gross Combination Weight Rating ☐ 10,000 lbs. or less ☐ 10,001 lbs. to 26,000 lbs. ☐ Greater than 26,000 lbs. | HazMat Placard | Hazmat Placard 4 digit # | OR | Hazmat Name | AND | 1 digit # | Hazmat Released?

Carrier's Name | Carrier's Address | Carrier'sZip

Owner's Name | Owner's Company Name | Owner's Address | Owner's Zip | Owner's Telephone

Insured By: (Name of Company) | Policy Number | Trailer or Towed Vehicles (1) | Type | Year | Make | License Yr. | License State | License Number

Trailer or Towed vehicles (2) | Type | Year | Make | License Yr. | License State | License Number | Trailer or Towed Vehicles (3) | Type | Year | Make | License Yr. | License State | License Number

Vehicle No. 1 or PEDESTRIAN - OTHER

Vehicle No. HEADED | N NE NW S SE SW E W | On: | Left Scene of Crash | Posted Speed | Safe Speed

Drivers Full Name (Last, First, Middle) | Address

Driver's License Number | State | Type | Status | Restrictions | Endorsements | Expires | City/State | Zip Code | Phone

Date of Birth - M/D/YR | Occupation | Seat Pos. | Age | Sex (M/F) | Race | Injury Code | OP Code | OP Used Property | Airbag Deploy | Ejected | EMS # | Med Trans

Seat Pos.	Occupant's Name (Last, First, Middle)	Occupant's Address (City, State, Zip)

Vehicle Yr. | Vehicle Make | Color | Body Style | Cargo Body Type | Vehicle Use (1) | Vehicle Use (2) | Towed? ☐ Yes ☐ No | Damage Severity ☐ Heavy ☐ Moderate ☐ Slight ☐ None ☐ Unknown ☐ All Areas | Extent ☐ Disabled ☐ Functional ☐ Appearance ☐ Property ☐ Fire ☐ None | ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 RR ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 LR ☐ 12 ☐ Top ☐ Undercarriage

License Yr. | State | License Plate Number | VIN | Towed due to disabling damage? ☐ Yes ☐ No

DOT # | Interstate Carrier Code | Towed By | Towed To

Number of Axles | Vehicle Weight Ratings/Gross Combination Weight Rating ☐ 10,000 lbs. or less ☐ 10,001 lbs. to 26,000 lbs. ☐ Greater than 26,000 lbs. | HazMat Placard | Hazmat Placard 4 digit # | OR | Hazmat Name | AND | 1 digit # | Hazmat Released?

Carrier's Name | Carrier's Address | Carrier'sZip

Owner's Name | Owner's Company Name | Owner's Address | Owner's Zip | Owner's Telephone

Insured By: (Name of Company) | Policy Number | Trailer or Towed Vehicles (1) | Type | Year | Make | License Yr. | License State | License Number

Trailer or Towed Vehicles (2) | Type | Year | Make | License Yr. | License State | License Number | Trailer or Towed Vehicles (3) | Type | Year | Make | License Yr. | License State | License Number

Crash Report Number 0000000000 | **STATE OF NEW MEXICO UNIFORM CRASH REPORT** **NM Statute 66-7-209** | SHEET

Case Number 0 | OF SHEETS

ROAD – WEATHER

LIGHTING (Check 1)	WEATHER (Check 1)	ROAD COND (Check 1 for each)	ROAD SURFACE (Check 1 for each)	TRAFFIC CONTROL (Check 1 for each)	ROAD CHARACTER (Check 1)
		V O V O	V O V O	V O V O	
☐ Daylight	☐ Clear	☐ ☐ Dry	☐ ☐ Paved	☐ ☐ No Passing Zone	☐ Straight
☐ Dawn	☐ Raining	☐ ☐ Wet	☐ ☐ Paved	☐ ☐ Stop Sign	☐ Curve
☐ Dusk	☐ Snowing	☐ ☐ Snow	☐ ☐ Paved Center & Edgeline	☐ ☐ Traffic Signals	GRADE (Check 1)
☐ Dark - Lighted	☐ Fog	☐ ☐ Ice	☐ ☐ Unpaved	☐ ☐ Yield Sign	☐ Level
☐ Dark - Not Lighted	☐ Dust	☐ ☐ Loose		☐ ☐ R.R. Gate	☐ Hillcrest
☐ Other and not stated	☐ Wind	☐ ☐ Other		☐ ☐ 4 Way Stop	☐ On Grade
	☐ Other	☐ ☐ Standing or Moving Water		☐ ☐ Flashers	☐ Dip
	☐ Sleet or Hail	☐ ☐ Slush		☐ ☐ No Controls	
				☐ ☐ Other	

Crash Report Number 0000000000

Case Number 0

ROAD DESIGN (Check 1 OR more for each)	
V V	V O V
☐ ☐ 1 Lane	☐ ☐ One Way
☐ ☐ 2 Lanes	☐ ☐ Ramp
☐ ☐ 3 Lanes	☐ ☐ Full Access Control
☐ ☐ 4 + Lanes	☐ ☐ Undeveloped
☐ ☐ Undivided	☐ ☐ Alley
☐ ☐ Physical Divider	☐ ☐ Other
☐ ☐ Painted Divider	☐ ☐ Constr. Zone

EVENT

APPARENT CONTRIBUTING FACTORS (Check 1 or more for each)

V O V O	V O V O	V O V O
☐ ☐ Excessive Speed	☐ ☐ Following too closely	☐ ☐ Defective steering
☐ ☐ Speed too fast for conditions	☐ ☐ Made improper turn	☐ ☐ Defective tires
☐ ☐ Failed to yield right of way	☐ ☐ Driver inattention	☐ ☐ Other mech. defect
☐ ☐ Passed stop sign	☐ ☐ Under influence of alcohol	☐ ☐ Road defect
☐ ☐ Disregarded traffic signal	☐ ☐ Other improper driving	☐ ☐ Other No driver error
☐ ☐ Drove left of center	☐ ☐ Pedestrian error	☐ ☐ Traffic control not functioning
☐ ☐ Improper overtaking	☐ ☐ Inadequate brakes	☐ ☐ Improp lane change
☐ ☐ Avoid no contact vehicle	☐ ☐ Driverless moving vehicle	☐ ☐ Improper backing
☐ ☐ Avoid no contact -other	☐ ☐ Failed to yield - Police Veh(s)	☐ ☐ None
☐ ☐ Cell phone	☐ ☐ Failed to yield – Emrgcy Veh(s)	☐ ☐ Vehicle Skidded Before Brake
☐ ☐ Low Visibility due to smoke	☐ ☐ Under the influence of Drugs or Medication	
	☐ ☐ High speed pursuit	

DRIVERS' ACTIONS (Check 1 or more for each)

V O V O	V O V O
☐ ☐ Going Straight	☐ ☐ Stopped for traffic
☐ ☐ Overtaking /Passing	☐ ☐ Stopped for sign/signal
☐ ☐ Right Turn	☐ ☐ Start in traffic lane
☐ ☐ Left Turn	☐ ☐ Start from park
☐ ☐ U Turn	☐ ☐ Parked
☐ ☐ Slowing	☐ ☐ Other
☐ ☐ Backing	

SEQUENCE OF EVENTS (See event codes)

V O	V O	
		FIRST EVENT
		SECOND
		THIRD
		FOURTH EVENT

DRIVER

DRIVER/PED/PEDALCYCLIST SOBRIETY (Check 1 or more for each with X)

D1 D2
- ☐ ☐ Consumed Alcohol
- ☐ ☐ Consumed a Controlled Substance
- ☐ ☐ Had Not Consumed Alcohol
- ☐ ☐ Sobriety Unknown
- ☐ ☐ Consumed Medication
- ☐ ☐ Tested by Instrument
- ☐ ☐ Breath Test Administered

_______ gms/210L _______ gms/210L
- ☐ ☐ Blood Test Administered
- ☐ ☐ Standard Field Sobriety Test Administered
- ☐ ☐ Refused Test

DRIVER/PED/PEDALCYCLIST PHYSICAL COND. (Mark 1 or more for each with X)

D0 D0	D0 D0
☐ ☐ Fatigue-Asleep	☐ ☐ Medication
☐ ☐ Eyesight Imp.	☐ ☐ Amputee
☐ ☐ Hearing Imp.	☐ ☐ No App. Defects
☐ ☐ Illness	☐ ☐ *Other Physical Impairment
	☐ ☐ Unknown

*SPECIFY:

PEDESTRIAN

PEDESTRIAN/PEDALCYCLIST ACTION

At Intersection	Not at Intersection	
P O P O	P O P O	P O P O
☐ ☐ With Signal	☐ ☐ From Behind Obstruction	☐ ☐ Walking Against Traffic
☐ ☐ Against Signal	☐ ☐ No Crosswalk	☐ ☐ Standing
☐ ☐ No Signal	☐ ☐ Crosswalk	☐ ☐ Pushing or Working on Vehicle
☐ ☐ Crossing Diagonally	☐ ☐ Walking W/Traffic	☐ ☐ Playing in Road
	☐ ☐ *Other	

*SPECIFY:

NARRATIVE

Describe what happened – refer to vehicles by number.

Use Diagram/Narrative Sheet for additional information

OTHER PROPERTY INVOLVED

Property Type	DESCRIPTION OF PROPERTY AND DAMAGE		
Owner's Name	Owner's Addres	Owner's Zip Code	Owner's Telephone

WITNESS

NAME	AGE	ADDRESS	TELEPHONE

ENFORCEMENT ACTION

VEH. NO.	NAME	VIOLATION (COMMON NAME)	ACTION
			☐ Booked ☐ Cited ☐ Pending
			☐ Booked ☐ Cited ☐ Pending
			☐ Booked ☐ Cited ☐ Pending

Time Notified	Time Arrived	Notified By	Supervisor at Scene	Checked By		
Officer's Signature	Printed Officers Name	Rank	ID No.	District	Date of Report	

Crash Report Number 0000000000

Case Number 0

STATE OF NEW MEXICO UNIFORM CRASH REPORT
NM Statute 66-7-209

0

SHEET

OF SHEETS

DIAGRAM/NARRATIVE

Use Additional Sheets As Necessary

CRASH REPORT NUMBER: 0000000000

CASE NUMBER: 0

DIAGRAM DRAWING BY:

MEASUREMENTS TAKEN BY:

Indicate North By Arrow

Crash Report Number 0000000000 Case Number 0	STATE OF NEW MEXICO UNIFORM CRASH REPORT NM Statute 66-7-209 0	SHEET OF SHEETS

Appendix C: RLC Intersections and Monitored Approaches

Survey of Red Light Camera Intersections

Intersection Name	Direction	2008 ADT	Speed Limit	No. of lanes	CABQ Straight Yellow Interval (sec)	ISR Straight Yellow Interval (sec)	Straight Yellow Interval Difference	CABQ Left Turn Yellow Interval (sec)	ISR Left Turn Yellow Interval (sec)	Left Turn Yellow Interval Difference
Academy and Wyoming	NB	21955	40	6	4.00	3.91	-0.09	3.50	3.41	-0.09
	EB	11944	45	4	4.00	3.91	-0.09	3.50	3.41	-0.09
	SB	19602	40	5	4.00	3.98	-0.02	3.00	2.99	-0.01
	WB	12923	40	4	4.00	3.92	-0.08	3.00	2.89	-0.11
Central and Coors	NB	8914	45	5	4.30	4.37	0.07	3.00	2.91	-0.09
	EB	10925	45	3	4.30	4.38	0.08	3.00	2.99	-0.01
	SB	16428	45	4	4.30	4.36	0.06	3.00	2.97	-0.03
	WB	12131	40	3	4.30	4.36	0.06	3.00	2.93	-0.07
Central and Eubank	NB	13643	40	4	4.00	3.89	-0.11	3.00	2.87	-0.13
	EB	16546	40	5	4.00	3.90	-0.10	3.00	2.87	-0.13
	SB	16303	40	5	4.00	3.89	-0.11	3.00	2.91	-0.09
	WB	13354	40	4	4.00	3.92	-0.08	3.00	2.95	-0.05
Central and Louisiana	NB	9741	35	4	4.00	3.89	-0.11	3.00	2.95	-0.05
	EB	12338	35	4	4.00	3.93	-0.07	3.00	2.93	-0.07
	SB	9352	35	4	4.00	3.91	-0.09	3.00	2.99	-0.01
	WB	18954	35	4	4.00	3.92	-0.08	3.00	2.87	-0.13
Ellison and Coors Bypass	NB	21615	45	6	4.50	4.43	-0.07	3.00	3.06	0.06
	EB	14941	40	5	3.80	3.86	0.06	3.00	2.94	-0.06
	SB	21047	45	6	4.50	4.33	-0.17	3.00	2.85	-0.15
	WB	10321	35	5	3.80	3.86	0.06	3.00	2.87	-0.13
Lomas and Eubank	NB	19375	40	6	4.00	3.86	-0.14	3.00	2.89	-0.11
	EB	9461	40	5	4.00	3.87	-0.13	3.00	2.90	-0.10
	SB	18962	40	5	4.00	3.95	-0.05	3.00	2.93	-0.07
	WB	13115	40	5	4.00	3.90	-0.10	3.00	2.95	-0.05
Lomas and Juan Tabo	NB	14032	40	5	4.00	3.96	-0.04	3.00	2.97	-0.03
	EB	10855	40	4	4.00	3.89	-0.11	3.00	2.96	-0.04
	SB	21846	40	4	4.00	3.92	-0.08	3.00	2.96	-0.04
	WB	9002	40	5	4.00	3.88	-0.12	3.00	2.94	-0.06
Lomas and Wyoming	NB	17413	40	6	4.00	3.43	-0.57	3.00	3.00	0.00
	EB	16364	40	5	4.00	4.39	0.39	3.00	2.98	-0.02
	SB	20815	40	5	4.00	3.43	-0.57	3.00	2.91	-0.09
	WB	9627	40	5	4.00	4.40	0.40	3.00	2.92	-0.08
Menaul and Carlisle	NB	14462	35	5	4.00	3.87	-0.13	3.00	2.92	-0.08
	EB	13356	40	5	4.00	3.87	-0.13	3.00	3.02	0.02
	SB	12599	35	5	4.00	3.86	-0.14	3.00	2.92	-0.08
	WB	14870	35	5	4.00	3.88	-0.12	3.00	2.95	-0.05
Menaul and Louisiana	NB	15005	35	6	4.00	3.89	-0.11	3.00	2.96	-0.04
	EB	15964	35	6	4.00	3.88	-0.12	3.00	2.94	-0.06
	SB	8601	35	3	4.00	3.95	-0.05	3.00	2.93	-0.07
	WB	17729	35	6	4.00	3.85	-0.15	3.00	2.96	-0.04
Menaul and	NB	21833	35	6	3.50	3.87	0.37	3.00	2.96	-0.04

San Mateo	EB	14372	35	5	3.50	3.89	0.39	3.00	2.96	-0.04
	SB	16062	35	5	3.50	3.88	0.38	3.00	3.39	0.39
	WB	21387	35	5	3.50	3.84	0.34	3.00	3.47	0.47
Menaul and Wyoming	NB	15189	40	5	4.00	3.90	-0.10	3.00	2.98	-0.02
	EB	17827	35	5	4.00	3.84	-0.16	3.00	2.92	-0.08
	SB	18793	40	5	4.00	3.92	-0.08	3.00	2.92	-0.08
	WB	12637	35	5	4.00	3.91	-0.09	3.00	2.88	-0.12
Montano and Coors	NB	25122	45	7	4.50	4.38	-0.12	3.50	3.45	-0.05
	EB	14490	40	5	4.00	3.88	-0.12	3.50	3.42	-0.08
	SB	22469	40	6	4.50	4.37	-0.13	3.50	3.45	-0.05
	WB	13329	40	2	4.00	3.90	-0.10	3.50	3.42	-0.08
Montgomery and Carlisle	NB	12357	35	4	4.00	3.95	-0.05	3.00	2.96	-0.04
	EB	17790	35	5	4.00	3.92	-0.08	3.00	2.93	-0.07
	SB	12357	25	3	4.00	3.80	-0.20	3.00	2.93	-0.07
	WB	21994	35	5	4.00	3.91	-0.09	3.00	2.95	-0.05
Montgomery and Eubank	NB	12671	40	4	4.00	3.93	-0.07	3.00	3.02	0.02
	EB	14733	40	4	4.00	3.92	-0.08	3.00	2.99	-0.01
	SB	16040	40	4	4.00	3.87	-0.13	3.00	2.95	-0.05
	WB	17952	40	3	4.00	3.87	-0.13	3.00	2.97	-0.03
Montgomery and San Mateo	NB	18122	40	6	4.00	3.84	-0.16	3.00	2.96	-0.04
	EB	22787	35	6	4.00	3.88	-0.12	3.00	2.96	-0.04
	SB	18122	40	6	4.00	3.91	-0.09	3.00	2.96	-0.04
	WB	19930	35	6	4.00	3.91	-0.09	3.00	2.93	-0.07
Montgomery and Wyoming	NB	18716	40	5	4.00	3.91	-0.09	3.00	2.98	-0.02
	EB	19251	40	5	4.00	3.96	-0.04	3.00	2.96	-0.04
	SB	35172	40	5	4.00	3.96	-0.04	3.00	2.97	-0.03
	WB	18944	40	5	4.00	3.90	-0.10	3.00	2.97	-0.03
Paseo Del Norte and Coors	NB	19292	45	5	4.50	4.45	-0.05	4.00	3.93	-0.07
	EB	17337	45	3	Light does not exist			4.00	3.96	-0.04
	SB	36025	45	6	4.50	4.43	-0.07	4.00	3.82	-0.18
	WB	17225	55	4	Light does not exist			4.00	3.92	-0.08
Paseo Del Norte and Jefferson	NB	11371	35	4	4.00	3.92	-0.08	3.00	2.92	-0.08
	EB	24471	45	6	5.00	4.91	-0.09	3.00	2.92	-0.08
	SB	6848	40	6	4.00	3.88	-0.12	3.00	2.92	-0.08
	WB	28218	45	3	5.00	4.87	-0.13	3.00	2.99	-0.01
Quail and Coors	NB	23959	45	6	4.50	4.37	-0.13	3.00	3.48	0.48
	EB	6207	25	3	3.50	3.89	0.39	3.50	3.35	-0.15
	SB	23959	45	6	4.50	4.45	-0.05	3.00	3.37	0.37
	WB	6207	25	4	3.50	3.92	0.42	3.00	3.44	0.44

Appendix D: Non-RLC Comparison Intersections

Survey of Comparison Intersections

Intersection Name	Direction	2008 ADT	Speed Limit	No. of lanes	CABQ Straight Yellow Interval (sec)	ISR Straight Yellow Interval (sec)	Straight Yellow Interval Difference	CABQ Left Turn Yellow Interval (sec)	ISR Left Turn Yellow Interval (sec)	Left Turn Yellow Interval Difference
Academy and Eubank	NB	13158	40	4	4.00	3.93	-0.07	3.50	3.44	-0.06
	EB	9793	40	4	4.00	3.91	-0.09	3.50	3.48	-0.02
	SB	9289	40	4	4.00	3.88	-0.12	3.50	3.50	0.00
	WB	7755	40	4	4.00	3.95	-0.05	3.50	3.32	-0.18
Academy and San Mateo	NB	16171	40	5	4.00	3.89	-0.11	3.00	2.97	-0.03
	EB	16668	40	3	3.50	3.41	-0.09	3.00	2.95	-0.05
	SB	21178	40	5	4.00	3.87	-0.13	3.00	2.98	-0.02
	WB	16668	40	5	3.50	3.47	-0.03	3.00	2.93	-0.07
Candelaria and Carlisle	NB	12746	35	4	4.00	3.83	-0.17	3.00	2.95	-0.05
	EB	8531	35	3	4.00	3.87	-0.13	3.00	2.97	-0.03
	SB	12756	35	4	4.00	3.88	-0.12	3.00	2.96	-0.04
	WB	10740	35	3	4.00	3.93	-0.07	3.00	2.94	-0.06
Candelaria and Juan Tabo	NB	14508	40	4	4.00	3.90	-0.10	3.00	2.98	-0.02
	EB	4091	35	3	4.00	3.93	-0.07	3.00	2.95	-0.05
	SB	13283	40	4	4.00	3.85	-0.15	3.00	3.03	0.03
	WB	6321	35	3	4.00	3.90	-0.10	3.00	3.04	0.04
Candelaria and San Mateo	NB	18017	40	4	4.00	3.97	-0.03	3.00	3.00	0.00
	EB	9056	35	3	4.00	3.93	-0.07	3.00	2.98	-0.02
	SB	17729	40	4	4.00	3.87	-0.13	3.00	2.98	-0.02
	WB	7579	40	3	4.00	3.89	-0.11	3.00	2.95	-0.05
Candelaria and Wyoming	NB	16455	40	4	4.00	3.93	-0.07	3.00	2.96	-0.04
	EB	9595	35	3	4.00	3.93	-0.07	3.00	2.99	-0.01
	SB	20918	40	4	4.00	3.86	-0.14	3.00	2.92	-0.08
	WB	9730	35	3	4.00	3.91	-0.09	3.00	3.00	0.00
Central and Juan Tabo	NB	7657	35	4	4.00	3.85	-0.15	3.00	3.02	0.02
	EB	11793	40	4	4.30	4.20	-0.10	3.00	3.01	0.01
	SB	13113	40	4	4.00	3.90	-0.10	3.00	2.97	-0.03
	WB	12846	40	4	4.30	4.22	-0.08	3.00	2.93	-0.07
Central and Rio Grande	NB	13947	25	2	4.00	3.95	-0.05	Light does not exist		
	EB	16775	35	4	4.00	3.85	-0.15	3.00	2.89	-0.11
	SB	13947	35	4	4.00	3.89	-0.11	3.00	2.99	-0.01
	WB	13917	30	4	4.00	3.92	-0.08	Light does not exist		
Central and San Mateo	NB	13746	40	5	4.00	3.87	-0.13	3.00	2.99	-0.01
	EB	12412	35	4	4.00	3.88	-0.12	3.00	2.95	-0.05
	SB	16607	40	5	4.00	3.91	-0.09	3.00	2.93	-0.07
	WB	14756	35	3	4.00	3.91	-0.09	3.00	3.00	0.00
Central and University	NB	6420	30	4	4.00	3.87	-0.13	3.00	2.98	-0.02
	EB	12063	30	3	4.00	3.96	-0.04	3.00	2.98	-0.02
	SB	11638	30	4	4.00	3.93	-0.07	3.00	2.96	-0.04
	WB	15815	30	4	4.00	3.96	-0.04	3.00	2.95	-0.05
Central and	NB	10966	35	4	4.00	3.86	-0.14	3.00	2.90	-0.10

Wyoming	EB	14538	35	4	4.00	3.82	-0.18	3.00	3.04	0.04
	SB	13297	40	4	4.00	3.89	-0.11	3.00	2.92	-0.08
	WB	14589	40	4	4.00	3.82	-0.18	3.00	2.93	-0.07
Constitution and Eubank	NB	18000	40	4	4.00	3.89	-0.11	3.00	2.96	-0.04
	EB	4057	35	2	4.00	3.81	-0.19	3.00	2.95	-0.05
	SB	15953	40	4	4.00	3.84	-0.16	3.00	2.88	-0.12
	WB	4540	30	2	4.00	3.91	-0.09	3.00	2.95	-0.05
Constitution and Wyoming	NB	18365	40	4	4.00	3.84	-0.16	3.00	3.01	0.01
	EB	3743	30	2	4.00	3.86	-0.14	3.00	2.95	-0.05
	SB	18111	40	4	4.00	3.82	-0.18	3.00	2.97	-0.03
	WB	4783	35	3	4.00	3.86	-0.14	3.00	2.93	-0.07
Corrales and NM 528	NB	9325	35	5	4.00	3.86	-0.14	3.50	3.39	-0.11
	EB	17183	35	4	4.00	3.90	-0.10	3.50	3.42	-0.08
	SB	2275	35	4	4.00	3.93	-0.07	3.50	3.42	-0.08
	WB	26048	40	5	4.00	3.93	-0.07	3.50	3.42	-0.08
Cutler and San Mateo	NB	24681	35	5	4.00	3.87	-0.13	3.00	2.98	-0.02
	EB	5663	30	3	Light does not exist			3.00	2.89	-0.11
	SB	24681	35	4	4.00	3.87	-0.13	Light does not exist		
	WB	5663	30	4	4.00	3.89	-0.11	3.00	2.90	-0.10
Ellison and NM 528	NB	16031	35	4	4.00	3.89	-0.11	3.00	2.98	-0.02
	EB	10913	35	4	4.00	3.95	-0.05	3.00	3.02	0.02
	SB	18166	25	3	4.00	3.94	-0.06	3.00	3.03	0.03
	WB	3899	40	4	4.00	3.90	-0.10	3.00	2.92	-0.08
Gibson and Yale	NB	1652	35	5	4.00	3.45	-0.55	3.00	2.90	-0.10
	EB	16172	45	5	4.50	4.40	-0.10	3.00	2.97	-0.03
	SB	1693	40	3	4.00	3.47	-0.53	3.00	3.02	0.02
	WB	17950	45	5	4.50	4.41	-0.09	3.00	2.96	-0.04
Indian School and Louisiana	NB	18287	35	7	4.00	3.88	-0.12	3.00	3.91	0.91
	EB	5143	35	4	4.00	3.90	-0.10	3.00	3.41	0.41
	SB	20460	35	7	4.00	3.93	-0.07	3.00	3.91	0.91
	WB	8049	35	4	4.00	3.88	-0.12	3.00	3.44	0.44
Indian School and San Mateo	NB	21796	40	4	4.00	3.86	-0.14	3.00	2.88	-0.12
	EB	5310	40	3	3.50	3.44	-0.06	3.00	2.94	-0.06
	SB	23464	35	5	4.00	3.87	-0.13	3.00	2.93	-0.07
	WB	3433	35	4	3.50	3.34	-0.16	3.00	2.95	-0.05
Irving and Coors	NB	34815	45	5	4.50	4.89	0.39	3.00	2.91	-0.09
	EB	5143	40	3	4.30	3.37	-0.93	3.00	2.96	-0.04
	SB	20460	45	5	4.50	4.89	0.39	3.00	2.98	-0.02
	WB	8049	40	4	4.30	3.44	-0.86	3.00	2.96	-0.04
Lomas and Louisiana	NB	11307	40	4	4.00	3.87	-0.13	3.00	2.97	-0.03
	EB	12471	40	4	4.00	3.91	-0.09	3.00	2.90	-0.10
	SB	12383	40	4	4.00	3.89	-0.11	3.00	2.91	-0.09
	WB	13607	40	4	4.00	3.94	-0.06	3.00	2.97	-0.03
Lomas and San Mateo	NB	13309	40	4	4.00	3.89	-0.11	3.00	2.98	-0.02
	EB	13133	35	4	4.00	3.96	-0.04	3.00	2.97	-0.03
	SB	22247	40	4	4.00	3.88	-0.12	3.00	2.92	-0.08
	WB	13212	35	4	4.00	3.93	-0.07	3.00	2.94	-0.06
Lomas and San Pedro	NB	6213	35	4	4.00	3.89	-0.11	3.00	2.93	-0.07
	EB	12899	40	4	4.00	3.96	-0.04	3.00	2.92	-0.08

	SB	6794	35	3	4.00	3.89	-0.11	3.00	2.95	-0.05
	WB	13503	40	4	4.00	3.92	-0.08	3.00	2.95	-0.05
Lomas and University	NB	11109	30	4	4.00	3.90	-0.10	3.00	2.97	-0.03
	EB	20717	35	4	4.00	3.95	-0.05	3.00	2.95	-0.05
	SB	9665	35	3	4.00	3.92	-0.08	3.00	2.98	-0.02
	WB	15249	35	4	4.00	3.90	-0.10	3.00	2.98	-0.02
Menaul and Eubank	NB	17881	40	4	4.00	3.90	-0.10	3.50	3.38	-0.12
	EB	11335	40	3	4.00	3.88	-0.12	3.50	3.40	-0.10
	SB	16148	40	4	4.00	3.89	-0.11	3.50	3.46	-0.04
	WB	10640	40	4	4.00	3.88	-0.12	3.50	3.44	-0.06
Menaul and Juan Tabo	NB	20382	40	4	4.00	3.85	-0.15	3.00	2.89	-0.11
	EB	9987	40	3	4.00	3.88	-0.12	3.00	2.97	-0.03
	SB	14114	40	4	4.00	3.89	-0.11	3.00	2.84	-0.16
	WB	6989	40	3	4.00	3.92	-0.08	2.85	2.97	0.12
Menaul and San Pedro	NB	9275	35	5	4.00	3.84	-0.16	3.00	3.02	0.02
	EB	9987	35	5	4.00	3.89	-0.11	3.00	2.93	-0.07
	SB	7156	35	4	4.00	3.85	-0.15	3.00	3.45	0.45
	WB	18405	35	5	4.00	3.89	-0.11	3.00	3.46	0.46
Montgomery and Juan Tabo	NB	20066	40	4	4.00	3.90	-0.10	3.00	2.91	-0.09
	EB	11725	40	4	4.30	4.13	-0.17	3.00	2.96	-0.04
	SB	10004	40	4	4.00	3.91	-0.09	3.00	2.96	-0.04
	WB	8449	40	4	4.30	4.12	-0.18	3.00	2.88	-0.12
Montgomery and Louisiana	NB	11465	35	3	4.00	3.94	-0.06	3.00	2.87	-0.13
	EB	33969	40	4	4.00	3.82	-0.18	3.00	2.94	-0.06
	SB	4388	35	3	4.00	3.88	-0.12	3.00	2.94	-0.06
	WB	19697	40	4	4.00	3.84	-0.16	3.00	2.95	-0.05
Montgomery and Morris	NB	3617	35	2	4.00	3.85	-0.15	3.00	2.93	-0.07
	EB	14733	40	4	4.00	3.94	-0.06	3.00	2.91	-0.09
	SB	3089	30	3	4.00	3.91	-0.09	3.00	2.97	-0.03
	WB	12936	40	5	4.00	3.83	-0.17	3.00	2.87	-0.13
Montgomery and San Pedro	NB	6959	30	3	4.00	3.86	-0.14	3.00	2.86	-0.14
	EB	20348	35	4	4.00	3.93	-0.07	3.00	2.96	-0.04
	SB	7756	35	3	4.00	2.96	-1.04	3.00	2.94	-0.06
	WB	16002	40	4	4.00	2.91	-1.09	3.00	2.96	-0.04
Montgomery and Tramway	NB	13201	50	5	4.50	4.48	-0.02	3.50	3.39	-0.11
	EB	7968	40	3	4.00	3.91	-0.09	3.50	3.38	-0.12
	SB	12761	50	5	4.50	4.36	-0.14	3.50	3.45	-0.05
	WB	3211	30	4	4.00	3.91	-0.09	3.50	3.41	-0.09
Osuna and Wyoming	NB	24259	40	4	4.00	3.88	-0.12	3.00	2.86	-0.14
	EB	5879	35	3	4.00	3.89	-0.11	3.00	2.94	-0.06
	SB	22836	40	4	4.00	3.86	-0.14	3.00	2.97	-0.03
	WB	2814	35	2	4.00	3.96	-0.04	3.00	2.99	-0.01
Paradise and Golf Course	NB	10871	40	4	4.00	3.86	-0.14	3.00	2.94	-0.06
	EB	9871	35	3	4.00	3.86	-0.14	3.00	2.84	-0.16
	SB	10421	30	3	4.00	3.87	-0.13	3.00	2.93	-0.07
	WB	11093	40	3	4.00	3.89	-0.11	3.00	2.98	-0.02
Paseo Del Norte and Eagle Ranch	NB	4475	35	3	4.00	3.88	-0.12	3.00	2.95	-0.05
	EB	14149	45	4	4.00	3.89	-0.11	3.00	2.99	-0.01
	SB	13326	35	4	4.00	3.92	-0.08	3.00	2.95	-0.05

	WB	14714	45	4	4.00	3.85	-0.15	3.00	2.94	-0.06
Paseo Del Norte and San Pedro	NB	6693	35	4	4.00	3.91	-0.09	3.00	2.86	-0.14
	EB	11307	45	6	5.00	4.83	-0.17	3.00	2.95	-0.05
	SB	5805	35	4	4.00	3.92	-0.08	3.00	2.98	-0.02
	WB	20637	45	6	5.00	4.90	-0.10	3.00	2.94	-0.06
Paseo Del Norte and Wyoming	NB	13763	40	5	4.00	4.00	0.00	3.00	2.82	-0.18
	EB	10238	55	6	5.00	4.84	-0.16	3.00	2.96	-0.04
	SB	9537	40	4	4.00	3.94	-0.06	3.00	2.87	-0.13
	WB	15252	55	5	5.00	4.96	-0.04	3.00	2.92	-0.08
St. Josephs and Coors	NB	37033	45	5	4.50	4.35	-0.15	3.00	2.90	-0.10
	EB	4067	35	4	4.00	3.36	-0.64	3.00	2.84	-0.16
	SB	23505	45	5	4.50	4.49	-0.01	3.00	2.92	-0.08
	WB	4067	25	3	4.00	3.35	-0.65	3.00	2.89	-0.11

Appendix E RLC Monitored Approaches

RLC Intersection Monitored Approaches Differences of Means at Intersections Before and After Controlling for Exposure

Intersection Name	Direction	Total	Injury	PDO	Rear-end	Angle
Academy and Wyoming	NB	0.36	0.20	0.15	0.22	0.14
	SB	0.19	-0.48	0.67	0.31	-0.12
Central and Coors	SB	-0.03	-0.15	0.12	-0.17	0.15
	WB	-0.17	-0.23	0.06	0.02	-0.19
Central and Eubank	NB	0.14	-0.09	0.22	0.36	-0.23
	SB	0.30	-0.02	0.32	0.24	0.06
Central and Louisiana	EB	0.00	0.20	-0.20	0.18	-0.18
	WB	-0.33	-0.17	-0.16	0.11	-0.44
Ellison and Coors Bypass	NB	0.22	0.20	0.01	0.01	0.20
	SB	-0.33	0.04	-0.37	-0.12	-0.21
Lomas and Eubank	SB	-0.33	-0.08	-0.25	0.08	-0.42
	WB	-0.13	0.50	-0.63	0.00	-0.13
Lomas and Juan Tabo	EB	0.56	-0.23	0.79	0.55	0.02
	SB	-0.33	-0.67	0.33	0.22	-0.56
Lomas and Wyoming	EB	0.22	0.36	-0.14	0.09	0.13
	SB	-0.02	-0.44	0.42	-0.20	0.18
Menaul and Carlisle	NB	0.00	0.08	-0.08	-0.25	0.25
	SB	0.22	-0.26	0.49	0.50	-0.28
Menaul and Louisiana	NB	-0.09	0.00	-0.09	-0.27	0.18
	EB	-0.22	-0.44	0.22	0.15	-0.37
Menaul and San Mateo	NB	0.20	-0.20	0.40	0.40	-0.20
	WB	0.40	-0.25	0.65	0.50	-0.10
Menaul and Wyoming	SB	0.51	0.02	0.49	0.56	-0.04
	WB	0.07	-0.27	0.33	0.23	-0.17
Montano and Coors	EB	-0.14	0.09	-0.23	-0.27	0.13
	SB	0.45	-0.17	0.62	0.43	0.01
Montgomery and Carlisle	EB	0.28	0.08	0.20	0.66	-0.38
	WB	-0.20	-0.6	-0.14	-0.25	0.05
Montgomery and Eubank	WB	-0.05	-0.16	0.07	-0.15	0.11
Montgomery and San Mateo	NB	-0.15	-0.35	0.21	-0.23	0.08
	EB	0.08	-0.17	0.25	0.03	0.05
Montgomery and Wyoming	NB	0.21	0.17	0.05	0.13	0.09
	EB	-0.17	-0.08	-0.09	-0.03	-0.15
Paseo Del Norte and Coors	NB	0.12	0.16	-0.04	0.25	-0.12
	SB	0.35	-0.44	0.79	0.44	-0.10
Paseo Del Norte and Jefferson	EB	0.68	-0.04	0.72	0.86	-0.18
	WB	0.18	0.05	0.13	0.09	0.09
Quail and Coors	NB	-0.50	-0.21	-0.29	0.17	-0.67
	SB	0.19	-0.06	0.25	0.37	-0.18

Appendix F: Empirical Bayesian Analysis

RLC Empirical Bayes Estimate – Total Crashes

RLC Intersection	EB Post-Period Total Crash Total EB Count Estimate	Actual Post-Period Total Actual Crash Count	Change	Annual Change	Percent Change
Academy & Wyoming	66	76	+10	+5.2	+13.1
Coors & Central	102	107	+5	+2.5	+4.6
Central & Louisiana	46	39	-7	-4.0	-15.2
Central & Eubank	41	58	+17	+9.7	+29.3
Coors & Ellison	75	71	-4	-2.1	-5.3
Lomas & Wyoming	44	41	-3	-1.8	-6.8
Lomas & Eubank	52	42	-10	-5.5	-19.2
Lomas & Juan Tabo	73	77	+4	+1.4	+5.2
Menaul & Carlisle	45	40	+5	+2.6	+11.1
Menaul & San Mateo	75	76	+1	+0.4	+1.3
Menaul & Louisiana	55	38	-17	-9.7	-30.9
Menaul & Wyoming	57	56	-1	-0.4	-1.8
Coors & Montano	103	137	+34	+15.1	24.8
Montgomery & Carlisle	53	53	0	0	0
Montgomery & San Mateo	211	236	+25	+8.3	+10.6
Montgomery & Wyoming	115	101	-14	-5.4	-12.2
Montgomery & Eubank	166	135	-31	-7.4	-18.7
Coors & Paseo	130	177	+47	+16.6	+26.6
Jefferson & Paseo	102	139	+37	+16.4	+26.7
Coors & Quail	93	69	-24	-11.5	-25.8

RLC Empirical Bayes Estimate – Injury Crashes

RLC Intersection	EB Post-Period Injury Total EB Injury Crash Count Estimate	Actual Post-Period Injury Crash Count	Change	Annual Change	Percent Change
Academy & Wyoming	26	27	+1	+0.5	+3.7
Coors & Central	36	28	-8	-4.0	-22.2
Central & Louisiana	13	13	0	0	0
Central & Eubank	8	12	+4	+2.3	+33.3
Coors & Ellison	21	19	-2	-1.0	-9.5
Lomas & Wyoming	9	4	-5	-3.0	-55.6
Lomas & Eubank	13	13	0	0	0
Lomas & Juan Tabo	21	15	-6	-2.1	-28.6
Menaul & Carlisle	12	13	+1	+0.5	+7.6
Menaul & San Mateo	25	17	-8	-3.2	-32.0
Menaul & Louisiana	20	8	-12	-6.9	-60.0
Menaul & Wyoming	17	12	-5	-2.0	-29.4
Coors & Montano	28	40	+12	+5.3	+30.0
Montgomery & Carlisle	11	10	-1	-0.5	-9.1
Montgomery & San Mateo	88	61	-27	-6.5	-30.7
Montgomery & Wyoming	29	21	-8	-3.1	-27.6
Montgomery & Eubank	64	37	-27	-6.5	-42.2
Coors & Paseo	51	50	-1	-0.4	-2.0
Jefferson & Paseo	34	36	+2	+0.9	+5.6
Coors & Quail	31	23	-8	-3.8	-25.8

RLC Empirical Bayes Estimate – PDO Crashes

RLC Intersection	EB Post-Period PDO Total EB PDO Crash Count Estimate	Actual Post-Period PDO Crash Count	Change	Annual Change	Percent Change
Academy & Wyoming	40	49	+9	+4.7	+18.4
Coors & Central	64	79	+15	+7.5	+19.0
Central & Louisiana	33	26	-7	-4.0	-21.2
Central & Eubank	33	46	+13	+7.4	+28.3
Coors & Ellison	54	52	-2	-1.0	-3.7
Lomas & Wyoming	35	37	+2	+1.2	+5.4
Lomas & Eubank	39	29	-10	-5.5	-25.6
Lomas & Juan Tabo	52	62	+10	+3.5	+16.1
Menaul & Carlisle	32	27	-5	-2.6	-15.6
Menaul & San Mateo	50	59	+9	+3.6	+15.3
Menaul & Louisiana	35	30	-5	-2.9	-14.3
Menaul & Wyoming	40	44	+4	+1.6	+9.1
Coors & Montano	74	97	+23	+10.2	+23.7
Montgomery & Carlisle	42	43	+1	+0.5	+2.3
Montgomery & San Mateo	122	175	+53	+12.7	+30.2
Montgomery & Wyoming	87	80	-7	-2.7	-8.0
Montgomery & Eubank	101	97	-4	-1.0	-4.0
Coors & Paseo	79	127	+48	+17.0	+37.8
Jefferson & Paseo	67	103	+36	+16.0	+35.0
Coors & Quail	62	46	-16	-7.7	-25.8

Appendix G: City of Albuquerque RLC Revenue and Expenditure Information

City of Albuquerque
History of Photo Enforcement Revenues

	FY/2005	FY/2006	FY/2007	FY/2008	Unaudited FY/2009	Unaudited FY/2010	TOTALS	Estimated FY/2011
REVENUE								
Speeding Fixed *	$ -	$ -	$ 4,799,000	$ 6,469,000	$ 3,888,000	$ 2,834,000	$ 17,990,000	$ 2,398,000
Red Light *	61,000	1,338,000	2,988,000	3,003,000	2,404,000	2,229,000	12,023,000	1,884,000
Total Fixed Cameras	$ 61,000	$ 1,338,000	$ 7,787,000	$ 9,472,000	$ 6,292,000	$ 5,063,000	$ 30,013,000	$ 4,282,000
Speeding Vans *		157,000	1,268,000	2,043,000	2,278,000	1,618,000	7,364,000	1,369,000
Total Fines	$ 61,000	$ 1,495,000	$ 9,055,000	$ 11,515,000	$ 8,570,000	$ 6,681,000	$ 37,377,000	$ 5,651,000
*Number of Intersections***	*2*	*6*	*20*	*20*	*20*	*20*		*17*
Interest Revenue				79,000	325,000	150,000	554,000	25,000
Total Revenue	$ 61,000	$ 1,495,000	$ 9,055,000	$ 11,594,000	$ 8,895,000	$ 6,831,000	$ 37,931,000	$ 5,676,000
EXPENDITURES								
Labor	$ 40,000	$ 122,000	$ 304,000	$ 259,000	$ 208,000	$ 234,000	$ 1,167,000	$ 388,000
Operating	8,000	48,000	820,000	217,000	18,000	280,000	1,391,000	150,000
Admin Hearing (70%) / Staff Support ***			732,000	841,000	995,000	848,000	3,416,000	942,000
Total City Costs	$ 48,000	$ 170,000	$ 1,856,000	$ 1,317,000	$ 1,221,000	$ 1,362,000	$ 5,974,000	$ 1,480,000
Redflex	78,000	310,000	3,170,000	4,321,000	4,248,000	3,820,000	15,947,000	3,498,000
State of NM					4,065,000	1,430,000	5,495,000	1,076,000
Total Expenditures	$ 126,000	$ 480,000	$ 5,026,000	$ 5,638,000	$ 9,534,000	$ 6,612,000	$ 27,416,000	$ 6,054,000
Net City Gain	$ (65,000)	$ 1,015,000	$ 4,029,000	$ 5,956,000	$ (639,000)	$ 219,000	$ 10,515,000	$ (378,000)
How the City Spent the Profits								
Fire Department Capital and Equipment ****						2,696,000		
Police Department vehicles						5,550,000		
Police Department traffic support						767,000		
Police Department party patrol overtime						80,000		
Total						$ 9,093,000	$ 9,093,000	
Adjusted Net Gain							$ 1,422,000	

* Allocated based on total fines paid; FY/07 is allocated based on graduated scale for fines in place at that time.

** The number of intersections with camera's changed to 17 on 5/18/2010.

*** Includes 70% of costs for administrative hearing office (11 FTE) and two support staff within APD (Fiscal/Sergeant).

**** One time appropriations:

Fire Station 2	$ 1,200,000
Fire Station 7	1,000,000
Fire Rescue 8	346,000
SCBA Equipment for firefighters	150,000
	$ 2,696,000

Total Fines Paid	FY/2005	FY/2006	FY/2007	FY/2008	FY/2009	FY/2010	Totals
Red Light	397	9,739	29,113	23,853	31,488	30,150	124,740
Speeding Vans		1,142	9,152	16,227	29,857	21,890	78,268
Speeding Fixed			32,916	51,377	50,954	38,349	173,596
Total Fines Printed							
Red Light	1,893	19,031	29,113	34,148	45,143	43,066	172,394
Speeding Vans		1,753	14,040	22,412	43,028	22,034	103,267
Speeding Fixed			52,759	75,378	70,257	53,195	251,589