TRAFFIC OPERATIONAL EVALUATION OF TRAFFIC IMPACT ANALYSIS (TIA) CASE SITES

Final Report # 2009-09

Submitted to

North Carolina Department of Transportation
Research and Analysis Group
1 South Wilmington Street
Raleigh, NC 27601

By

Srinivas S. Pulugurtha, Ph.D., P.E.
Rakesh Mora, M.S.

Department of Civil & Environmental Engineering
The University of North Carolina at Charlotte
9201 University City Boulevard
Charlotte, NC 28223-0001

September 22, 2010

Technical Report Documentation Page

1. Report No. FHWA/NC/2009-09	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Traffic Operational Evaluation of Traffic Impact Analysis (TIA) Case Sites		5. Report Date September 22, 2010 6. Performing Organization Code
7. Author(s) Srinivas S. Pulugurtha		8. Performing Organization Report No.
9. Performing Organization Name and Address Department of Civil & Environmental Engineering The University of North Carolina at Charlotte 9201 University City Boulevard Charlotte, NC 28223 – 0001 Telephone: 704-687-6660 Fax: 704-687-6953 Email: sspulugurtha@uncc.edu		10. Work Unit No. (TRAIS) 11. Contract or Grant No. 2009 – 09
12. Sponsoring Agency Name and Address North Carolina Department of Transportation Research and Analysis Group 1 South Wilmington Street Raleigh, North Carolina 27601		13. Type of Report and Period Covered Final Report August 16, 2008 – December 31, 2009 14. Sponsoring Agency Code
Supplementary Notes:		

16. Abstract

This report summarizes traffic operational evaluation of six select traffic impact analysis (TIA) case sites and the effectiveness of forecasting methods used in TIA studies. Six TIA case sites comprising 15 signalized intersections and 2 unsignalized intersections in North Carolina (four sites in the Charlotte region and two sites in the Raleigh region) were considered for comparison. Data collected during morning peak hours (7 AM – 9 AM) and evening peak hours (4 PM – 6 PM) on a typical weekday were used for evaluation. The measures of effectiveness (MOEs) considered for the evaluation of data are total number of hourly stops, 50th percentile queue length, average intersection delay, and level-of-service (LOS).

The comparison of operational performance and forecasting methods was conducted using three different methods. The first method was used to compare the operational performance at selected intersections before and after the construction of the new development proposed in the TIA study using Synchro® traffic simulation software. The second method was used to compare "what was forecasted to happen after the development?" with "what is happening after the development?" using Synchro® traffic simulation software. The third method was used to compare outcomes obtained using Synchro® traffic simulation software with field observations after the development.

Results obtained from the evaluations indicate that new developments naturally have a considerable effect on operational performance at intersections near the development. The build-out year forecasted traffic volumes and traffic conditions had not been reached for the six reviewed TIA reports. This difference can at least in part be attributed to economic conditions and the fact that several of the site's still had vacant parcels / outlots and additional unconstructed development. Recognizing that seasonal traffic fluctuations can have a significant impact on the magnitude of commercial site traffic, improved forecasts and traffic operational condition modeling could be achieved with improved regional traffic growth rates, conservative peak hour factors (PHF) and use of representative heavy vehicle percentages. Given the variability and significance of the build out of complex mixed use sites a five year build out horizon may be more appropriate for determination of needed improvements and acceptable levels of service since a three year window often only allows completion of the construction of the primary anchors.

17. Key Words Traffic impact analysis, Operational performance, evaluation, delay, queue length, stops		18. Distribution Statement	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 170	22. Price

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

DISCLAIMER

ACKNOWLEDGEMENTS

The authors acknowledge the North Carolina Department of Transportation (NCDOT) for providing financial support for this project. Special thanks are extended to Tony Wyatt, Kevin Lacy, Michael Reese, Jay Bennett, Louis Mitchell, Scott Cole, and Neal Galehouse of NCDOT for providing excellent support, guidance and valuable inputs for successful completion of the project. The authors also thank Doman Cecilia of City of Charlotte Department of Transportation (CDOT) for providing signal timing data for sites in the Charlotte region, and TIA consultants (Kubilins Transportation Group, Inc. and Ramey Kemp & Associates, Inc.) for providing required data. In addition, data collection efforts by the graduate students in transportation engineering of the Department of Civil & Environmental Engineering at the University of North Carolina at Charlotte are also recognized.

EXECUTIVE SUMMARY

This report summarizes traffic operational evaluation of six select traffic impact analysis (TIA) case sites and the effectiveness of forecasting methods used in TIA studies. Six TIA case sites comprising 15 signalized intersections and 2 unsignalized intersections in North Carolina (four sites in the Charlotte region and two sites in the Raleigh region) were considered for comparison. Data collected during morning peak hours (7 AM – 9 AM) and evening peak hours (4 PM – 6 PM) on a typical weekday were used for evaluation. The measures of effectiveness (MOEs) considered for the evaluation of data are total number of hourly stops, 50th percentile queue length, average intersection delay, and level-of-service (LOS).

The comparison of operational performance and forecasting methods was conducted using three different methods. The first method was used to compare the operational performance at selected intersections before and after the construction of the new development proposed in the TIA study using Synchro® traffic simulation software. The second method was used to compare "what was forecasted to happen after the development?" with "what is happening after the development?" using Synchro® traffic simulation software. The third method was used to compare outcomes obtained using Synchro® traffic simulation software with field observations after the development.

Results obtained from the evaluations indicate that new developments naturally have a considerable effect on operational performance at intersections near the development. The build-out year forecasted traffic volumes and traffic conditions had not been reached for the six reviewed TIA reports. This difference can at least in part be attributed to economic conditions and the fact that several of the site's still had vacant parcels / outlots and additional unconstructed development. Recognizing that seasonal traffic fluctuations can have a significant impact on the magnitude of commercial site traffic, improved forecasts and traffic operational condition modeling could be achieved with improved regional traffic growth rates, conservative peak hour factors (PHF) and use of representative heavy vehicle percentages. Given the variability and significance of the build out of complex mixed use sites a five year build out horizon may be more appropriate for determination of needed improvements and acceptable levels of service

since a three year window often only allows completion of the construction of the primary anchors.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

1.1 Introduction

Meteoric growth in population and travel demand such as that experienced along the I-85 and I-77 corridors, and numerous other locations has rapidly exceeded the designed capabilities of North Carolina roads, bridges, and traffic control devices. Performance measures (such as travel time, travel delay, emissions, fuel consumption, human quality of life and safety) and economy (unsustainable unbalanced growth, sprawl, excessive accumulation of infrastructure needs) suffered as a result of this unexpected growth. Longer term projections indicate that this is expected to resume, continue and worsen. Agencies such as North Carolina Department of Transportation (NCDOT), Charlotte Department of Transportation (CDOT) and others have realized the need to improve mobility and safety at such locations and have been using access management and improved alternative design configurations as a set of control strategies.

1.2 Background and Need

Far too many of our emerging congestion and safety problems are the result of "new" developments that utilized "old" access designs, spacing, and philosophies rather than established and proven management methods.

Past studies primarily focused on the benefits of treatments pertaining to operational and safety performances of roadway near new developments (Levinson et al., 1996; Vargas and Reddy, 1996; Parsonson et al., 2000; Bared and Kaisar, 2002; Dissanayake and Lu, 2003; Eisele et al., 2004; Frawley and Eisele, 2004). However, literature documents no formal evaluation process for determining if the improvements and access scenario for new major developments provided the traffic operational and safety outcomes that had been forecasted in traffic impact analysis (TIA) studies before implementation. Also, little research was done to study/analyze and evaluate the effectiveness of the methods used in TIA and suggest measures for better forecasts.

The number of stops, queue length and delay are most critical parameters to assess and evaluate the operational performance of transportation systems. In general, a majority of crashes and traffic delays are due to turning movements (left turns and right turns) into and out of median openings and driveway locations. Access management treatments such as directional crossovers, channelization, driveway throat protection, coordinated traffic signals, auxiliary lanes and internal cross access connections are used to reduce delays and crash risk by reducing the number of conflict points on roadways ensuring a smooth flow of traffic. Though there is an improvement in traffic operation at intersections with such implemented treatments, it could affect the operational performance at adjacent intersections along the corridor. Literature documents no research on examining the effect of TIA recommendations at intersections adjacent to the new developments.

The forecasted level of service outcomes from the TIA reports are often the sole basis for driveway (and even rezoning and site plan) approvals. Consequently, NCDOT and other agencies in North Carolina continue to authorize and conduct business on a preliminary study without detailed knowledge concerning the interim or ultimate performance of the development that accessed the road network. This often results in agencies re-engaging themselves in a defensive and re-active posture investing limited funds to fix operational and safety problems following the opening of a major development (shopping centers, activity centers, power centers, schools, and other traffic generators) or a subsequent phase of a major development. Examples of two recent high profile cases include Briar Creek in Raleigh, North Carolina and the US 401 corridor in Fuquay Varina (southern Wake County, North Carolina).

While responsible agencies have been looking at the use of operational and safety improvement treatments in their recommendations to improve operational performance on North Carolina roads, not much has been done to assertively state that these treatments achieved the desired goals and objectives. Therefore, there is a need to research and evaluate the effectiveness of operational and safety improvement treatments such as driveway/intersection spacing, median openings/restrictions, new traffic signals, and additional turn lanes that are typically recommended in the TIA study. The outcomes will be useful in addressing operational and safety problems not only at “new” residential and commercial developments but also in retrofitting existing locations based on identified issues.

1.3 Research Objectives

The objectives of the proposed research are thus derived as: 1) to conduct an operational evaluation of selected TIA case sites, and, 2) recommend a framework procedure that could be adopted by NCDOT to conduct similar review assessments for flagged or random sites in the future so as to improve operational performance on North Carolina streets and highways. The emphasis of the proposed research will be more on finding answers to questions such as:

1. What was required and what was built?
2. How do the TIA recommendations affect operational performances at intersections near and adjacent to the development?
3. What was expected to happen and what is happening now?
4. Which evaluation methods need to be adopted so as to yield better forecasts?
5. What are the most/least effective treatments that would help improve traffic operations at TIA sites?

Finding answers to these questions through the proposed research will help NCDOT use accurate methods and implement evaluations methods and treatments that would benefit everyone.

1.4 Organization of the Report

This report presents traffic operational evaluation of TIA case sites in the State of North Carolina. The measures of effectiveness (MOEs) used in evaluation of data collected "before" and "after" implementing treatments identified in the TIA report include total number of hourly stops, 50th percentile queue length in feet, average vehicle delay, and level-of-service (LOS). The outcomes obtained from data collection and analyses of data are discussed in this report.

The remainder of this report comprises 6 chapters. A review of existing literature on TIA, and, methods, tools and treatments to improve traffic operations at intersections with new developments are discussed in Chapter 2. The research methodology and analytical methods adopted to evaluate the MOEs are explained in Chapter 3. Chapter 4 describes the selected TIA case sites and Chapter 5 discusses the data collection. Implementation of evaluation methods and results obtained are discussed in Chapter 6. Conclusions of this research are discussed in Chapter 7.

CHAPTER 2: LITERATURE REVIEW

A review of existing literature on TIA, and, methods, tools and treatments to improve traffic operations at intersections with new developments are discussed next.

2.1 Traffic Impact Analysis (TIA)

A TIA study assesses the impact of a proposed development on its adjacent street network depending on the characteristics of the development. The study provides recommendations to mitigate the negative impact of the development and also to enhance the performance of the road network surrounding the development. The benefits of a TIA study are (Edwards, Year Unknown):

1. Forecast additional traffic and distribution/assignment associated with the new development based on acceptable local practices.
2. Determine the improvements/modifications/restrictions that are necessary to accommodate the new development.
3. Assist communities in land use decision making and in allocating scarce resources to areas which need improvement.
4. Identify potential problems with the proposed development which may influence a developer’s decision to pursue it.
5. Allow the community to assess the impacts that a proposed development may have and help to ensure safe and reasonable traffic conditions on streets after the development is complete.
6. Reduce the negative impacts created by developments by helping to ensure that the transportation network can accommodate the development.
7. Provide direction to community decision makers and developers of expected impacts and protect the community investment in the street system.

If a TIA study is not performed it may lead to failure in estimating the impacts of development, which in turn can increase the number of conflicts, delay and reduce the

LOS on the roads. Increases in crash rates, poor traffic flow and congestion, numerous brake light activations by drivers in the through lanes, unsightly strip development, neighborhood disrupted by traffic and pressures to signalize more locations, widen an existing street or build bypass are some of the ill-effects observed in absence of a TIA study.

The guidelines to conduct a TIA study in the State of North Carolina are based on capacity analysis guidelines (NCDOT, 2006) and the policy on street and driveway access to North Carolina highways (NCDOT, 2003). These reports discuss standard practices and documentation to be adopted in a TIA study.

2.2 Methods and Tools

Traffic analytical methods and operational tools became an increasingly important part of the traffic engineering family due to their efficiency in modeling and simulating the real world data and traffic performance. A summary of tools that are used to analyze various traffic facilities and scenarios is discussed next.

CORSIM™ 5.0

CORSIM™ 5.0 is a comprehensive microscopic traffic simulation software applicable to surface streets, freeways, and integrated networks with a complete selection of control devices (i.e., stop/yield sign, traffic signals, and ramp metering) (Year Unknown). It simulates traffic and traffic control systems using commonly accepted vehicle and driver behavior models. CORSIM™ 5.0 combines two of the most widely used traffic simulation models, NETSIM for surface streets, and FRESIM for freeways.

TRANSYT-7F™ 11.0

TRANSYT-7F™ 11.0 is a state-of-the-art macroscopic simulation model that considers platoons of vehicles instead of individual vehicles (McTrans, 2003). Unlike other macroscopic models, TRANSYT-7F™ 11.0 assumes uniform distribution within platoon dispersion. TRANSYT-7F™ 11.0 simulates traffic flow with short time increments and hence its representation of traffic flow is more detailed. TRANSYT-7F™ 11.0 also calculates maximum queue length which includes any vehicles joining the queue after the signal indication has turned green.

Synchro® 6.0

Synchro® 6.0 is a software application for optimizing traffic signal timing and performing capacity analysis. The software optimizes splits, offsets, and cycle lengths for individual intersections, an arterial, or a complete network (Trafficware, 2003). Synchro® 6.0 or the most recent version can be used to specify detailed geometry and detector configuration.

VISSIM

VISSIM is a microscopic traffic, public transport, and pedestrian simulation software. It is the most powerful tool available for simulating multi-modal traffic flows, including cars, goods vehicles, buses, heavy rail, trams, LRT, motorcycles, bicycles and pedestrians (PTV Vision, 2009). It is capable of modeling traffic with various traffic control measures in a 3-dimensional environment.

VISSIM is a microscopic simulation software whereas Synchro® 6.0 is a macroscopic simulation software. While VISSIM considers each and every entity (car, pedestrian and bicycle) on the road in analyzing and simulating transportation facilities, Synchro® looks at the macroscopic parameters of the road.

Vargas and Reddy (1996) analyzed TRAF-NETSIM, a micro simulation model to test access management improvements. The basic input values for this model were delay, travel time and queue length. Comparisons were done to evaluate the impact of access management improvements on traffic flow. The study found that access management does improve traffic flow if the improvements were properly designed.

Mystkowski and Khan (1998) estimated the queue lengths using SIGNAL 94, SYNCHRO®, TRANSYT- 7F™, PASSER II- 90 and CORSIM™. The study found that CORSIM™ and TRANSYT- 7F™ gave accurate results under high volume to capacity (v/c) conditions. CORSIM™ also gave close results for medium v/c conditions and for low v/c conditions. The study stated that CORSIM™, TRANSYT- 7F™ and SYNCHRO® were generally preferred.

Bared et al. (2002) used TRANSYT-7F™ and CORSIM™ to determine optimum signal setting and to represent geometric designs with variation in traffic flow at an intersection. Frawley et al. (2004) used VISSIM to quantify the performance measures of travel time, speed and delay along the corridors. As VISSIM cannot optimize the signal timing, Synchro® was used to optimize the signal timings and results were incorporated into VISSIM for evaluation of model.

Muldoon and Bloomberg (2008) of Oregon Department of Transportation (ODOT) suggested vital recommendations for the TIA process. The recommendations included more attention on the selection of apt land use code from ITE trip generation manual, assumption of pass-by trips, seasonal variation of traffic, evaluation of alternate modes of transport, traffic growth rates in the concerned area, future / horizon year analysis and safety analysis. The study did not include any discussion methods or tools for improved forecasts.

2.3 Treatments to Improve Traffic Operations

A discussion of literature review on treatments typically recommended in TIA studies to accommodate access and improve traffic operations is presented next.

2.3.1 Installing Traffic Signal

Traffic signals account for most of the delay that is experienced by motorists on the road network (Levinson, et al., 1996). Part 4 of the Manual on Uniform Traffic Control Devices (MUTCD, 2003) documents the guidelines required for installing a new traffic signal. A traffic control signal should not be installed unless an engineering study indicates that installing a traffic control signal will improve the overall safety and/or operation of the intersection.

The spacing of traffic signals in terms of their frequency and uniformity governs the performance of urban and suburban highways. Closely spaced signals along a corridor results in increased travel delay, frequent stops, and, increased fuel consumption with excessive vehicular emissions. A properly spaced and coordinated signal system has positive impacts on the travel speeds, reduction of crashes and progressive movement of the traffic flow.

2.3.2 Median Treatments

Medians treatments are considered as one of the most effective practices as they play a vital role in controlling operational and safety aspects on roadways. Pedestrian and vehicular safety can be improved with medians. They are generally classified into three types (TRB, 2003).

1. Undivided median: These types of medians do not prevent vehicles physically from crossing over it. An example of an undivided median is painted medians (solid yellow or white markings) such as the one shown in Figure 1.

Figure 1. Undivided Median

2. Two Way Left Turn Lanes (TWLTL): This type of lane is located between the traffic of opposing directions. TWLTL acts as a refuge area for vehicles to make left turns in both the directions. Figure 2 shows an example TWLTL.

Figure 2. Two Way Left Turn Lane (TWLTL)

3. Raised Median: Raised median is a physical barrier on the roadway that separates opposing lanes of traffic. Figure 3 shows a multilane roadway with raised medians.

Figure 3. Raised Median on I-85 in Charlotte, NC

In the case of an undivided median, vehicles have no barrier to prevent them from entering. Hence, an undivided median is not considered as an effective practice.

TWLTL provides a storage area for left turning vehicles. It prevents left turning vehicles from interrupting the through traffic stream (ITE, 2005). It should be noted though that using TWLTL in areas with high frequency of closely spaced drives can create degraded safety and increased conflicts. The efficiency of these types of medians also comes down during high volumes and on multilane roadways. In case of multilane roadways, it creates ambiguous situations for motorists to changing lanes for using TWLTL. Raised medians are safer than undivided medians and TWLTL. They are effective in reducing the number of conflicts, travel delay, controlling the opposing traffic with a physical barrier, eliminating the chance of a head-on collision and even in controlling the left turning movement along the corridor. Raised medians can reduce crash rates to 50 percent (Eisele et al., 2004).

A study in Georgia shows that pedestrian involved crashes and fatalities reduced by 45 percent and 75 percent at locations with raised medians than when compared to TWLTL (Parsonson, et al., 2000).

2.3.2.1 Directional Median Opening and Full Median Opening

A full median opening allows left turns to be made in both directions, whereas a directional opening allows left turns to be made in only one direction. Figure 4 shows a directional median opening.

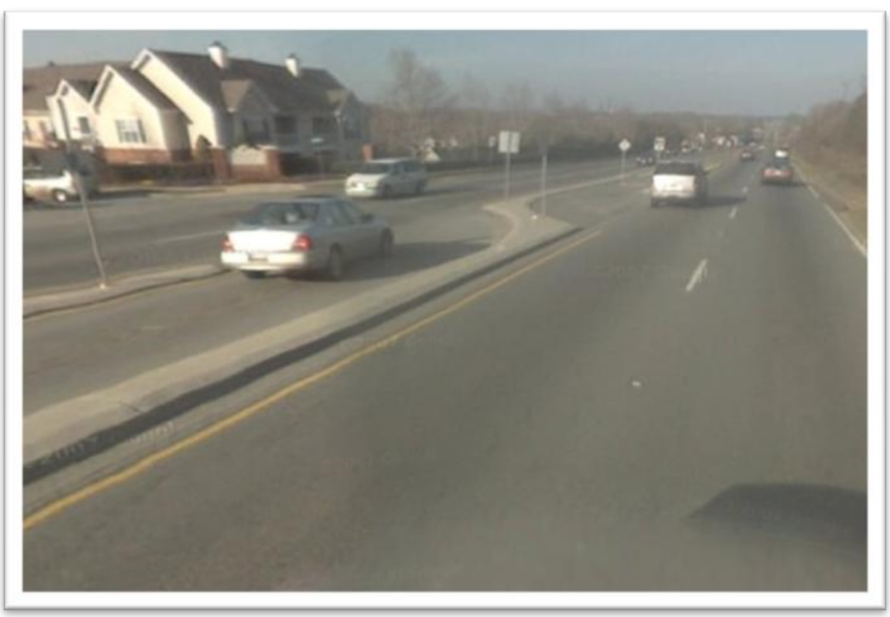

Figure 4. Directional Median Opening on North Tryon in the City of Charlotte, NC

Directional median opening reduces the average travel delay and the number of conflicts per hour more than when compared to a full median opening. The operational and safety characteristics of the corridor were found to be better when a full median opening was converted to a directional median opening (Dissanayake and Lu, 2003).

2.3.3 Auxiliary Lanes (Left, Right and Other)

Widening roads may have adverse effects on residential and business communities. It is generally expected to increase the operational performance, and hence, often a very common recommendation in the TIA studies. Andres et al. (2000) observed counterintuitive results that adding lanes makes traffic worse. The study also documented a research by Moses (1942) who noticed that the highways built around New York City in 1939 were somehow generating greater traffic problems than those existed prior to 1939.

2.3.4 Unsignalized Access Points

Unsignalized access points increases the number of conflict points on driveways. These conflict points slow down the speeds and even increase the crashes rates especially where egress or ingress left turns must cross 2 or more lanes of opposing traffic. As stated in "A policy on Geometric Design of Highways and Streets" (AASHTO, 2001), driveways are effectively the same as intersections and should be designed consistent with their intended use. The numbers of crashes are disproportionately higher at driveways than at intersections; thus their design and location merit special consideration.

2.4 Limitations of Past Research

Overall, literature documents articles and reports on TIA recommended treatments and operational / safety effects due to the same. No research or documented evidence was found on evaluation of both the effectiveness of TIA reports and operational performances of recommended treatments adopted. Addressing questions such as "what was expected to happen?" and "what is happening now?" and comparing the two will serve as valuable inputs when conducting future TIA studies. In addition, developing and using accurate and proven methods to forecast the effects help make better decisions and contribute to improved transportation system performance.

CHAPTER 3: METHODOLOGY AND ANALYTICAL METHODS

As stated in Chapter 1, the objectives of the proposed research are 1) to conduct an operational evaluation of selected TIA sites, and, 2) recommend a framework for assessment and procedures that could be adopted by NCDOT to conduct similar reviews for flagged or random sites in the future so as to improve operational performance on North Carolina streets and highways. A new development within a network can affect the adjacent intersections in terms of increase in traffic and modifications made to the network so as to accommodate the growth in traffic. For example, median treatment recommended at a midblock location can increase the U- Turn traffic volume and conflicts at adjacent intersections along the corridor.

The research methodology proposed in this study involves the following 6 steps.

1. Select TIA case sites
2. Identify MOEs
3. Collect data
4. Methods of operational evaluation and time frame for analysis
5. Descriptive analysis
6. Statistical analysis

Each of the above identified steps is discussed next.

3.1 Select TIA Case Sites

The focus of this step was to identify TIA case sites for evaluation in the State of North Carolina (or, in general, study area). The case sites are selected such that they are geographically distributed throughout the study area. They also represent different levels of urbanization (urban, suburban and rural areas). Valuable input from the Project Panel and local agencies, including availability of necessary documents, were also considered in selecting the TIA case sites.

3.2 Identify Measures of Effectiveness (MOEs)

MOEs pertaining to operational aspects of a roadway were selected and used to conduct analyses of data and evaluate the effectiveness of forecasted methods. Minimizing the number of stops can reduce the travel delay and increase the fuel efficiency, which in turn depends on the signal coordination and spacing. Queuing and spillback results in an increase in the number of stops and delays which are considered to be operational failures as they reduce the efficiency of a roadway. At an intersection, queue lengths are generally observed by counting the number of vehicles in the longest queue. Queue length can be used in determining the length of exclusive auxiliary lanes such as right turn and left turn pockets. Therefore, the following MOEs were selected and used to evaluate the effectiveness of TIA methods and treatments to improve traffic operations.

1. Stops
2. Queue length
3. Travel delay and LOS
4. Total control delay

3.3 Collect Data

Published TIA reports (based on studies conducted prior to the construction of development) along with operational data (traffic volume, stops, queue length, delay, and any other appropriate data) “before” construction of the development and forecasted “after” construction of the development are collected for each case site. The TIA reports have details of existing traffic conditions, forecasted future traffic conditions with and without development, and whether the existing system will be able to accommodate the additional traffic generated by the development at the case site.

Field visits are conducted to observe and collect current/after development traffic data manually on a typical weekday to measure operational performance at selected intersections at each case site. The data collected includes traffic volume, number of stops, queue length and delay along with geometric conditions at selected intersections (or locations) near each TIA case site. The duration for data collection was determined based on the duration of data collection used in collected TIA reports. Data was typically collected during morning peak hours (7 AM – 9 AM) and evening peak hours (4 PM – 6 PM).

3.4 Methods of Operational Evaluation and Time Frame for Analysis

The evaluation of operational performance and forecasting methods was conducted using three different methods in this study. The first method was used to compare the operational performance at selected intersections before and after the construction of the new development proposed in the TIA study using Synchro® traffic simulation software. The second method was used to compare "what was forecasted to happen after the development?" with "what is happening after the development?" using Synchro® traffic simulation software. The third method was used to compare outcomes obtained using Synchro® traffic simulation software with field observations after the development. The methods are discussed next.

3.4.1 Method 1: Study the Operational Performance Before and After the Development at the Site

In this method, the traffic volume and selected MOEs such as number of stops, queue length, delays and LOS in the TIA reports for the "no build" condition are compared with the same MOEs for the "build" condition. These MOEs are computed using Synchro® traffic simulation software. This method helps in studying the effect of the new development with recommended treatments on intersections near the development. The ratio for comparison in this case was computed by dividing each MOE for the "build" condition with the corresponding MOE for the "no build" condition. Ratios less than one, equal to one and greater than one indicate improvement, no change, and degradation in operational performance, respectively.

3.4.2 Method 2: Study the Effectiveness of Methods to Forecast the Operational Effects of the Development

The traffic volume and selected MOEs such as number of stops, queue length, delay and LOS at selected intersections (or locations) for the "build" condition obtained from the

TIA reports are compared with the same MOEs for the “build” condition computed using Synchro® traffic simulation software. While the former are based on forecasts in the TIA report, the later are based on traffic volume and geometric conditions data collected in 2009. The ratio for comparison in this case was computed by dividing each MOE calculated using Synchro® analysis for the “build” condition with the corresponding MOE forecasted in TIA reports for the “build” condition. Ratios less than one, equal to one and greater than one indicate increase, no change, and decrease in “build” condition operational performance than forecasted in TIA reports for the “build” condition, respectively.

3.4.3 Method 3: Study the Effectiveness of the Analytical Procedures to Replicate Field Data

The selected MOEs such as the number of stops and delay collected in the field during 2009 for the “build” condition are compared to the same MOEs computed using Synchro® based on traffic volume and geometric conditions data collected in 2009 for the “build” condition. This method identifies the effectiveness of the adopted analytical procedures in replicating the real world data and operational performance. It also provides insights to obtain better estimates of traffic conditions in the future. The ratio for comparison in this case was computed by dividing each MOE calculated using Synchro® analysis for the “build” condition with the corresponding MOE observed in the field. Ratios less than one, equal to one and greater than one indicate that operational performance is under-estimated, equally estimated, and over-estimated by Synchro®, respectively.

3.5 Descriptive Analysis

Descriptive analysis was conducted by computing “ratio” (example, the number of stops computed from the Synchro® analysis divided by the number of stops forecasted in the TIA reports) for each MOE to evaluate using methods discussed in sub-section 3.4. In Method 1, if the estimated MOE values after the development are lower than or equal to the estimated MOE values before the development, it can be concluded that the recommended improvements after development are effective. Likewise in Method 2, if the forecasted values of MOEs after the development from TIA reports are close to the value of MOEs obtained using Synchro® traffic simulation software after the development, it can be concluded that the forecasted methods are effective. In Method 3, if the estimated values of MOEs after development are close to the value of MOEs observed in the field, it can be concluded that the methods adopted in this research would yield better estimates.

Descriptive analysis was also carried out using intersection delay for all the study intersections. This was done 1) to compare intersection delay before and after the development, and 2) to compare intersection delay under "no build" condition in 2009 and "build" condition in 2009. While the former helps study if there was an increase or decrease in the intersection delay after the development when compared to the before condition, the later helps study of if there was an increase or decrease in intersection delay after the development ("build" condition in 2009) when compared to the projected 2009 "no build" condition.

3.6 Statistical Analysis

T-test for means was used to compare the difference in means between the before and after total control delay. Considering intersection delay as in descriptive analysis would limit the sample size required for performing a T-test. Hence, total control delays by turning movement for each approach are selected for use in statistical analysis. As results may be over-estimated or under-estimated, a two tail test was used.

Statistical analysis was conducted to compare results from Method 2 and Method 3 separately. The decision rules are different for testing these methods. The null and alternative hypotheses for Method 2 T-test are defined as follows.

H_0 (null hypothesis): The difference in the total control delay forecasted in TIA reports and the computed total control delay from Synchro® analysis for the "build" condition is equal to zero.

$$H_0: \mu_{Forecasted}-\mu_{Computed} = 0$$

H_a (alternative hypothesis): The difference in the total control delay forecasted in TIA reports and the computed total control delay from Synchro® analysis for the "build" condition is not equal to zero.

H_a: $\mu_{Forecasted} - \mu_{Computed} \neq 0$

where, $\mu_{Forecasted}$ and $\mu_{Computed}$ are the total control delay forecasted in TIA reports and computed using Synchro®, respectively.

The null and alternative hypotheses for Method 3 T-test are defined as follows.

H_0 (null hypothesis): The difference in the total control delay observed in the field and the computed total control delay from Synchro® analysis for the "build" condition is not equal to zero.

H_0: $\mu_{Observed} - \mu_{Computed} \neq 0$

H_a (alternative hypothesis): The difference in the total control delay observed in

the field and the computed total control delay from Synchro® analysis for the "build" condition is equal to zero.

H_a: $\mu_{Observed} - \mu_{Computed} = 0$

where, $\mu_{Observed}$ and $\mu_{Computed}$ are the total control delay observed in the field and computed using Synchro®, respectively.

The statistical analysis was conducted at a 90 percent confidence level using 0. 1 as the level of significance. If the critical t-value was less than the calculated t-value or if the p-value was less than 0.05, the null hypothesis was rejected at a 90 percent confidence level.

CHAPTER 4: TIA CASE SITES AND STUDY INTERSECTIONS

This chapter provides an overview of the case sites investigated for this study. In all, 8 TIA case sites in North Carolina were reviewed for this study. They are:

1. WT. Harris Boulevard Primax Site, Charlotte
2. Mountain Island Square Site, Charlotte
3. Cato Property Site, Charlotte
4. University Pointe Site, Charlotte
5. Midway Plantation Site, Knightdale
6. Retail Development Site, Youngsville
7. The Bridges at Mint Hill Site, Charlotte
8. Brice - Rea Property Site, Charlotte

A discussion of each TIA case site investigated is provided next.

4.1 WT. Harris Boulevard Primax Site, Charlotte

Primax Properties, LLC proposed a commercial development located on an approximately 549,000 SF of vacant area in the southeast quadrant of E. WT. Harris Boulevard (NC 24) / Rocky River Road (SR 2828) intersection in Charlotte (Kubilins Transportation Group, Inc., 2004). The developer requested a change in zoning to Neighborhood Services (NS) from O-1 (CD). Following are the intersections that fall into the area of influence within the vicinity of the development (as indicated in the WT. Harris Boulevard Primax site TIA report).

1. E. WT. Harris Boulevard (NC 24) / Rocky River Road (SR 2828) (Signalized)
2. E. WT. Harris Boulevard (NC 24) / Grier Road (SR 2976) (Signalized)
3. Rocky River Road (SR 2828) / Grier Road (SR 2976) (Signalized)
4. Rocky River Road (SR 2828) / Proposed Access A (future)
5. E. WT. Harris Boulevard (NC 24) / Proposed Access B (future directional crossover)

E. WT. Harris Boulevard is classified as a Class II thoroughfare according to the 2004 MUMPO Thoroughfare Plan (MUMPO, 2004). It is a four-lane divided roadway with a posted speed limit of 55 mph located on the western edge of the site.

Rocky River Road is classified as a major thoroughfare to the east of Grier Road and as a local street to the west of Grier Road. The two-lane undivided roadway has a posted speed limit of 45 mph and lies along the northern edge of the property.

Grier Road is classified as a major thoroughfare to the east of E. WT. Harris Boulevard and as a minor thoroughfare to the west of E. WT. Harris Boulevard. Grier Road has a posted speed limit of 45 mph.

Currently, about 75 percent of the development is complete and fully operating. Figure 5 shows a view of uncompleted development at the site. Figure 6 shows E. WT. Harris Boulevard / Grier Road intersection under operation during AM peak hour.

Figure 5. Uncompleted Development - WT. Harris Boulevard Primax Site, Charlotte

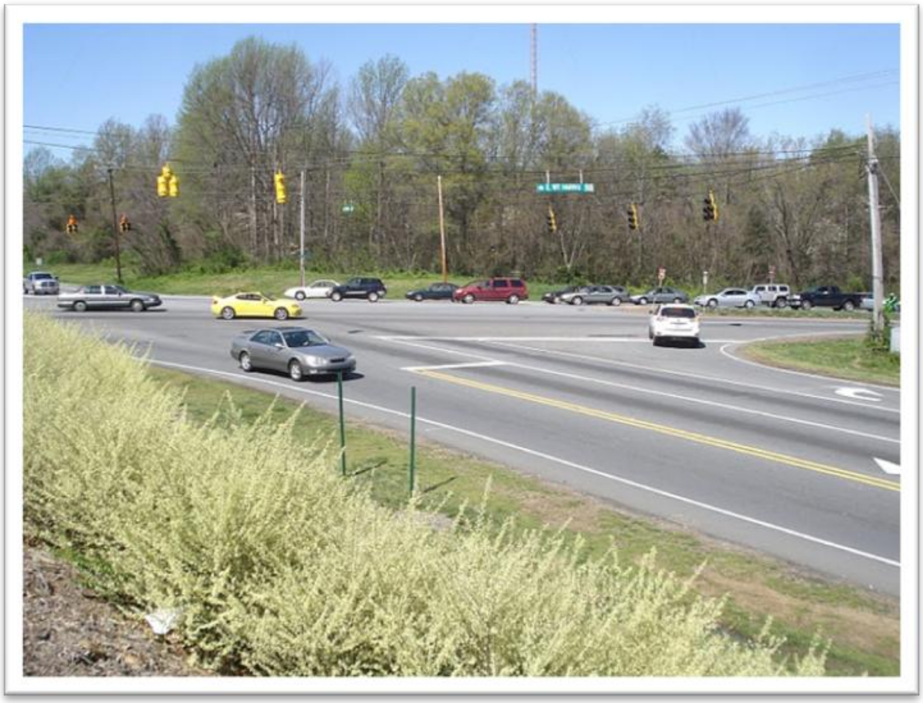

Figure 6. Intersection of E. WT. Harris Boulevard / Grier Road – WT. Harris Primax Site, Charlotte

The TIA report includes the traffic volume counts at the intersections under the influence area along with delay, capacity and LOS obtained using Synchro® 5.0 (Kubilins Transportation Group, Inc., 2004). The background traffic growth rate was assumed as 3 percent, and analysis was done for 2004 and 2009 years under existing and proposed zoning. LOS analysis was done based on HCM criteria for signalized and unsignalized intersections. The proposed development was originally scheduled to be completed in 2009. The TIA study recommended improvements for the site development and are summarized in Table 1. The table also shows the status of implementation or what was built as of fall 2009.

Table 1: Suggested Improvements and Status of Implementation – WT. Harris Boulevard Primax Site, Charlotte

Intersection under influence area	Suggested improvements	Implemented
1. E. WT. Harris Blvd / Grier Rd	1. Additional westbound left lane on Grier Rd	No
	2. Additional northbound and southbound through lane on E. WT. Harris Blvd	No
	3. Extend existing right turn lane on northbound E. WT. Harris Blvd to 500 feet	Yes
2. E. WT. Harris Blvd / Rocky River Rd	1. Additional southbound left turn lane on E. WT. Harris Blvd	Yes
	2. Additional eastbound left turn lane and westbound right turn lane on Rocky River Rd	No
	3. Additional westbound right turn lane on Rocky River Rd	No
	4. Additional eastbound through lane on Rocky River Rd to receive dual left turn lane volumes	No
	5. Additional northbound through lane on E. WT. Harris Blvd	No
3. Rocky River Rd / Grier Rd	1. Extend existing southbound right turn lane to 675 feet	Yes
	2. Extend existing eastbound right turn lane to 450 feet and remark lane as left and right turn combination	No
	3. Additional northbound through lane on Grier Rd	No
	4. Extend the planned widening project on Rocky River Rd to accommodate the dual eastbound lefts and two northbound through lane	No
4. RockyRiver Rd / Proposed Access "A"	1. Construct westbound left turn lane on Rocky River Rd	Yes
	2. Construct eastbound right turn lane on Rocky River Rd	Yes
	3. Construct northbound approach including exiting lane with through and left combination and right turn lane	Yes
5. E. WT. Harris Blvd / Proposed Access "B"	1. Construct southbound left turn lane on E. WT. Harris Blvd	No
	2. Construct northbound right turn lane on E. WT. Harris Blvd	Yes
	3. Construct northbound approach including entering lane and exiting lane that terminate as right turn lane	Yes
*Apart from recommendations at E. WT. Harris Blvd / Rocky River Rd intersection existing westbound through lane was converted to through shared right turn lane		

4.2 Mountain Island Square Site, Charlotte

Mountain Island Plantation, LLC proposed a mixed use development containing retail, office and residential land uses. This property is located in the northern quadrant of the Brookshire Boulevard (NC 16) / Mt. Holly-Huntersville Road intersection (Kubilins Transportation Group, Inc., 2004). As planned, the proposed development consists of medical and dental office, shopping center, fitness club, a restaurant and elderly housing. Following are the intersections that fall into the area of influence within the vicinity of the development (as indicated in the Mountain Island Square site TIA report).

1. Brookshire Boulevard (NC 16) / Mt. Holly Huntersville Road (Signalized)
2. Mt. Holly Huntersville Road / Callabridge Court (Future, Signalized)
3. Mt. Holly Huntersville Road / Couloak Drive (Future, Signalized)

Brookshire Boulevard (NC 16) is classified as a Class II limited access facility according to the 2004 MUMPO Thoroughfare Plan (MUMPO, 2004). Brookshire Boulevard is a 55 mph four-lane divided roadway with grass median in the study area. It is presently operating under signal control at its intersection with Mt. Holly-Huntersville Road.

Mt. Holly-Huntersville Road is a two-lane roadway with a posted speed limit of 45 mph. It is classified as a major thoroughfare according to the 2004 MUMPO Thoroughfare Plan (MUMPO, 2004). Plans for the future include grade separation at Brookshire Boulevard (NC 16) / Mt. Holly Huntersville Road intersection.

Callabridge Court is a three-lane dead end roadway with a TWLTL and no posted speed limit. While Mt. Holly-Huntersville Road / Callabridge Court intersection was an unsignalized intersection before development, it was converted to a signalized intersection after development.

Couloak Drive is a three-lane dead end roadway with no posted limit. It intersects with Mt. Holly-Huntersville Road to form an unsignalized intersection.

Currently, about 60 percent of the development is complete and fully operating. Figure 7 and Figure 8 shows the traffic on southwest bound of Brookshire Boulevard /

Mt. Holly Huntersville Road intersection and development under construction at Mountain Island Square site in fall 2009.

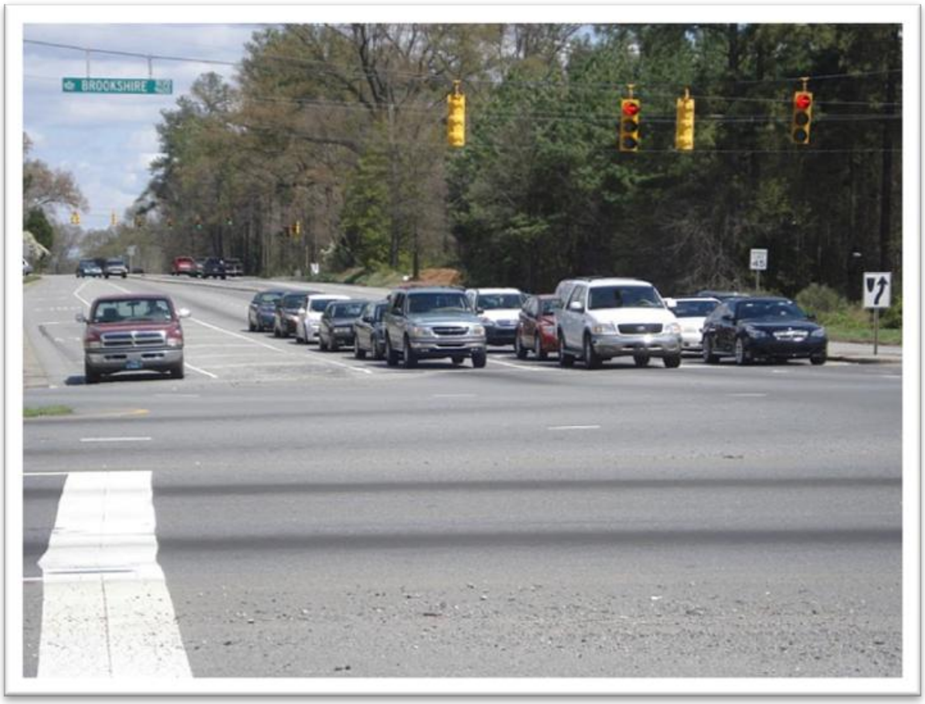

Figure 7. Traffic at Mt. Holly Huntersville Road / Brookshire Boulevard Intersection –Mountain Island Square Site, Charlotte

Figure 8. Development Under Construction at Site- Mountain Island Square Site, Charlotte

The TIA report includes the traffic volume counts at the intersections under the influence area along with delay, capacity and LOS obtained using Synchro® 5.0 (Kubilins Transportation Group, Inc., 2004). The background traffic growth rate was assumed as 3 percent and analysis was done for Scenario 1 (intersections within influence area without grade separation) and Scenario II (analysis with grade separation as well as breaks in the controlled access on Brookshire Boulevard) for the year 2009. LOS analysis was done based on HCM Criteria for signalized and unsignalized intersections. TIA study recommended suitable improvements after the site development are summarized in Table 2. The table also shows the status of implementation or what was built as of fall 2009.

Table 2: Suggested Improvements and Status of Implementation – Mountain Island Square Site, Charlotte

Intersection under influence area	Suggested Improvements	Implemented
1. Mt. Holly Huntersville Rd / Couloak Dr	1. Proposed Signal	No
1. Brookshire Blvd / Mt. Holly Huntersville Rd	1. Recommended additional through lane on all approaches except southbound approach	No
2. Mt. Holly Huntersville Rd / Callabridge Ct & Ron Withrow Access	1. Proposed Ron Withrow access on northbound approach	No
	2. Left turn lane on Mt. Holly Huntersville on eastbound approach	Yes
	3. Southbound through lane on Callbridge Court	No
	4. Second westbound through lane and ex-left lane on Mt. Holly Huntersville Rd	No
	5. Proposed Signal	Yes
*Apart from the recommendations additional exclusive left turn lane was constructed on the southeast approach of Mt. Holly Huntersville Rd / Callabridge Ct intersection		

4.3 Cato Property Site, Charlotte

The Cato Property is a residential development proposed on an approximately 446 acre vacant parcel located along Tom Short Road between Ballantyne Commons Parkway and Ardrey Kell Road in Charlotte, NC (Kubilins Transportation Group, Inc., 2004). The developer requested a change in zoning form R- 3 to MX-1 for 400 acres. The other 46 acre area will be developed in existing zoning. The property was planned to be developed in two phases. Phase I development will be the Centex Property scheduled to be completed by 2010. Phase II will be the Cato Property to be developed from 2010 to 2014. A total of six tracts are scheduled to be completed by 2014, while four of them are anticipated to be constructed by 2010. Following are the intersections that fall under the area of influence of the site (as indicated in the Cato Property site TIA report).

1. Tom Short Road / Ballantyne Commons Parkway (Signalized)
2. Tom Short Road / Ardrey Kell Road (Signalized)
3. Ardrey Kell Road / Providence Road (NC 16) (Signalized)
4. Providence Road (NC 16) / Allison Woods Dr (Unsignalized)

5. Providence Road (NC 16) / I- 485 EB Ramp (Signalized)
6. Ardrey Kell Road / Access A (Future, Unsignalized)
7. Tom Short Road / Access B (Future, Unsignalized)
8. Tom Short Road / Access C (Future, Unsignalized)
9. Tom Short Road / Access D (Future, Unsignalized)
10. Tom Short Road / Access E (Future, Unsignalized)
11. Tom Short Road / Access F (Future, Unsignalized)

Ballantyne Commons Parkway is classified as a major thoroughfare according to the 2004 MUMPO Thoroughfare Plan (MUMPO, 2004). It is a 35 mph two-lane wide roadway.

Tom Short Road is a minor thoroughfare with a speed limit of 45 mph near Ballantyne Commons Parkway and 35 mph on Ardrey Kell Road.

Ardrey Kell Road is a major thoroughfare according to the 2004 MUMPO Thoroughfare Plan (MUMPO, 2004). It is a two-lane shoulder section roadway with a posted speed limit of 45 mph east of Tom Short Road and 35 mph west of Tom Short Road.

Providence Road (NC 16) is classified as a major thoroughfare according to the 2004 MUMPO Thoroughfare Plan (MUMPO, 2004) with a posted speed limit of 45 mph and is currently under widening process. The cross section varies throughout the study area from a six-lane curb gutter section with two four-foot bike lanes on each side to a two-lane shoulder section.

Currently, about 90 percent of Phase I development is complete and fully operating. Construction along the Providence Road and bird's eye view of site location along Tom Short Road at site access "A" are shown in Figure 9 and Figure 10.

Figure 9. Construction at Providence Road - Cato Property Site, Charlotte

Figure 10. Site Location along Tom Short Road at Site Access "A" - Cato Property Site, Charlotte (Source: Bing Maps)

The TIA report includes the traffic volume counts at the intersections under the influence area along with delay, capacity and LOS obtained using Synchro® 5.0 (Kubilins Transportation Group, Inc., 2004). For projecting the traffic volumes, the background growth rate was assumed as 3 percent in the TIA report. The intersections were analyzed to identify the traffic impact that the site development has under existing and proposed zoning conditions. The intersections were analyzed based on HCM LOS criteria assuming full Phase I development in 2010 and Phase I and II full development of the project in 2014. TIA study recommended suitable improvements for the site development are summarized in Table 3. The table also shows the status of implementation or what was built as of fall 2009.

Table 3: Suggested Improvements and Status of Implementation – Cato Property Site, Charlotte

Intersection under influence area	Suggested Improvements	Implemented
1. Tom Short Rd / Ballantyne Commons Parkway	1.Construct a right turn on eastbound of Ballantyne Commons Parkway	No
	2. Construct a left turn on westbound of Ballantyne Commons Parkway	No
2. Tom Short Rd / Ardrey Kell Rd	No improvements suggested	
3. Providence Rd (NC 16) / Ardrey Kell Rd	1. Construct eastbound left turn lane on Ardrey Kell Rd	No
	2. Construct a southbound U-turn lane and U-turn bulb for the same to accommodate U-turning vehicles	No
4. Providence Rd (NC 16) / Allison Woods Dr	1. Construct a northbound directional crossover on Providence Rd	No
	2. Construct a southbound left turn lane on Providence Rd into Mason Property	No
	3. Construct a northbound right turn lane on Providence Rd	No
	4. Construct a westbound right turn lane on Providence Rd	No
5. Providence Rd (NC 16) / I- 485 EB Ramp	1. Construct a northbound U-turn lane on Providence Rd	No
	2. Construct a U-turn bulb on the west side of intersection to accommodate U-turning vehicles	No
6. Ardrey Kell Rd / Access A	1. Construct a eastbound left turn lane on Ardrey Kell Rd	Yes
	2. Construct a southbound approach from Access 'A'	Yes
7. Tom Short Rd / Access B	1. Construct a southbound left turn lane on Tom Short Rd	Yes
	2. Construct a westbound approach from Access 'B'	Yes
8. Tom Short Rd / Access C	1. Construct a southbound left turn lane on Tom Short Rd	Yes
	2. Construct a westbound approach from Access 'C'	Yes
9. Tom Short Rd / Access D	1. Construct a southbound left turn lane on Tom Short Rd	Yes
	2. Construct a westbound approach from Access 'D'	Yes
10. Tom Short Rd / Access E	Phase II (2014)	No
11. Tom Short Rd / Access F	Phase II (2014)	No

4.4 University Pointe Site, Charlotte

KSJ Development, Inc. proposed a retail development on a B-1 SCD zoned parcel located on the west of North Tryon Street (US 29) at The Commons at Chancellor Park Drive. Under the existing zoning, approximately 419,000 SF of retail development has been planned with a full build out year of 2010 (Kubilins Transportation Group, Inc., 2006). The study was conducted to determine if signals and additional lanes are needed on the roads in the study area to accommodate the future traffic. Following are the intersections under the area of influence of the site (as indicated in the University Pointe site TIA report).

1. North Tryon Street (US 29) / The Commons at Chancellor Park Drive (Signalized)
2. North Tryon Street (US 29) / McCullough Drive (Signalized)

North Tryon Street (US 29) is classified as a major thoroughfare according to the MUMPO Thoroughfare Plan (MUMPO, 2004) with a posted speed limit of 45 mph. McCullough Drive is classified as a major collector road that connects back to W. WT. Harris Boulevard.

Currently, about 70 percent of the proposed development is complete and fully operating. Figure 11 shows the eastbound approach of McCullough Drive at North Tryon Street intersection. Figure 12 shows construction of site during its development.

Figure 11. Eastbound Approach of McCullough Drive at North Tryon Street (US 29) – University Pointe Site, Charlotte

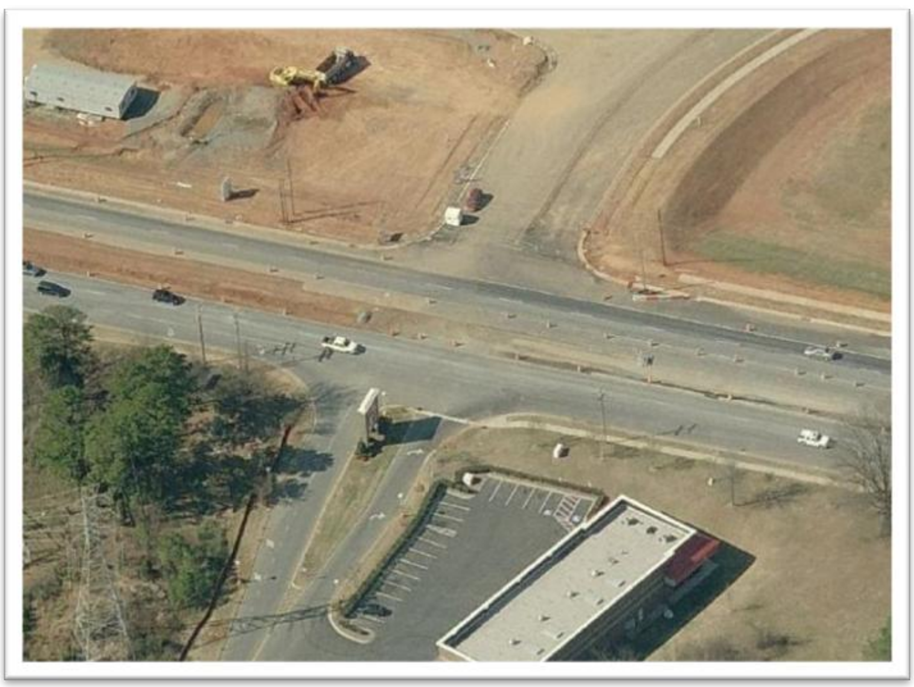

Figure 12. Construction at Site – University Pointe Site, Charlotte (Source: Bing Maps)

The TIA report (Kubilins Transportation Group, Inc., 2006) used Synchro® 6.0 to estimate the delays and LOS for the "no build" and "build" condition. An annual background traffic growth rate of 3 percent was adopted in forecasting the traffic for future years. Suggested improvements for the case site are summarized in Table 4. The table also shows the status of implementation or what was built as of fall 2009.

Table 4: Suggested Improvements and Status of Implementation – University Pointe Site, Charlotte

Intersection under influence area	Suggested Improvements	Implemented
1. North Tryon St (US 29) / The Commons at Chancellor Park Dr	1. Proposed signal	Yes
	2. Construct southbound right turn lane	Yes
	3. Construct eastbound approach	Yes
	4. Construct two Northbound left turn lanes on North Tryon St (US 29)	Yes
2. North Tryon St (US 29) / Site Driveway #1	1. Recommended right in / right out access on North Tryon St (US 29)	Yes
	2. Construct southbound right turn lane	Yes
3. North Tryon St (US 29) / University City Blvd (NC 49)	1. Proposed signal at intersection of University City Blvd (NC 49) and North Tryon St (US 29) after extending University City Blvd (NC 49)	No

4.5 Midway Plantation Development Site, Knightdale

Midway plantation is a commercial retail development in Knightdale, North Carolina and was anticipated to be completed in 2007. The development primarily has 500,000 SF of retail development inclusive of restaurant and bank space (Ramey Kemp and Associates Inc., 2005). It is located on the north side of Knightdale Boulevard (US 64), east of the I-540 at exit 24 B. Following are the intersections under the influence area of the site (as indicated in the Midway Plantation Development site TIA report).

1. Knightdale Boulevard (US 64) / I 540 Northbound (On)ramp (Signalized)
2. Knightdale Boulevard (US 64) / I 540 Southbound (Off)ramp (Signalized)
3. Knightdale Boulevard (US 64) / Site Driveway #1 / Hinton Oaks Boulevard (Future, Signalized)
4. Knightdale Boulevard (US 64) / Site Driveway #3 / Wide Waters Parkway (Signalized)

Knightdale Boulevard (US 64) is a four-lane divided roadway currently operating with six-lanes in the study area. As per NCDOT traffic survey group, in 2007 Knightdale

Boulevard (US 64) carried an annual average daily traffic (AADT) of 21,000 vehicles per day.

Wide Waters Parkway is a two-lane collector roadway operating as a primary access to the residential communities located in close proximity to the study area. It also serves as Site Driveway #3 to the proposed development.

Hinton Oaks Boulevard is a two-lane roadway that carries traffic from the Lynwood Drive and the Site Driveway #1. I-540 is classified as an eight-lane divided freeway by NCDOT and operates with an approximate AADT of 48,000 vehicles per day.

By August 2009, more than 95 percent of the proposed development is complete and fully operating. Figure 13 shows the traffic on eastbound direction of Knightdale Boulevard (US 64). Figure 14 shows the full build out of the development.

Figure 13. Traffic on Eastbound Direction of Knightdale Boulevard (US 64) – Midway Plantation Development Site, Knightdale

Figure 14. Full Built Development Under Operation - Midway Plantation Development Site, Knightdale

The TIA report (Ramey Kemp and Associates Inc., 2005) used Synchro® 5.0 to estimate the delays and LOS for the “no build” and “build” condition. As mentioned in the TIA report, the analysis for the existing conditions in 2005 was not done due to anticipated change in traffic patterns after opening of I-540. Recommendations to better serve the traffic in “build” condition are summarized in Table 5. The table also shows the status of implementation or what was built as of fall 2009. Traffic for the future years were interpolated from the traffic forecasts provided by the NCDOT for the years 2005 and 2025.

Table 5: Suggested Improvements and Status of Implementation – Midway Plantation Development Site, Knightdale

Intersection under influence area	Suggested Improvements	Implemented
1. Knightdale Blvd (US 64) / Lynwood Dr	1. Convert intersections to allow right turns only	Yes
2. Knightdale Blvd (US 64) / Site Driveway #1	1. Construct a site Driveway # 1 and provide traffic signal	Yes
	2. Realign Lynwood Dr to intersect at Driveway #1 and build 4 foot median along the road	Yes
3. Knightdale Blvd (US 64) / Site Driveway #2	1. Recommended Driveway #2 with single egress and ingress lane	Yes
4. Knightdale Blvd (US 64) / Wide Waters Pkwy / Site Driveway #3	1. Construct a Driveway #3 with recommended lane	Yes
	2. Construct additional eastbound left turn lane on Knightdale	Yes
5. Knightdale Blvd (US 64) / Site Driveway #4	1. Recommended Driveway #4 with single ingress lane	Yes
6. Knightdale Blvd (US 64) / Shared Driveway #5	1. Two westbound through lanes with shared right turn lane on US 64 is recommended	Yes

4.6 Retail Development Site, Youngsville

HTA, LLC proposed a retail development to be located at the southeast corner of the intersection US 1 and NC 96 in Youngsville, North Carolina. The development includes 150,000 SF of retail development as per the preliminary site plan (Ramey Kemp and Associates Inc., 2005). Following are the intersections under the influence area of the development (as indicated in the Retail Development site TIA report).

1. US 1 / NC 96 (Signalized)
2. US 1 / Mosswood Boulevard / Green Road (Unsignalized)

US 1 is a major four-lane divided roadway running throughout the study area with a posted speed limit of 55 mph. NC 96 is a two-lane roadway with a posted speed limit of 45 mph in the study area. Green Road and Mosswood Boulevard are two-lane roadways with a posted speed limit of 45 mph. Green Road carries residential traffic while Mosswood Boulevard carries industrial traffic to the east.

As of August 2009, 75 percent of the proposed development is complete and fully operating. Figure 15 shows the traffic on eastbound direction of NC 96 at US 1 intersection while Figure 16 shows the right in / right out site access at US 1.

Figure 15. Eastbound Direction at US 1 / NC 96 Intersection – Retail Development Site, Youngsville

Figure 16. Right In / Right Out Site Access at US 1 - Retail Development Site, Youngsville

The TIA report includes outcomes obtained using Synchro® 5.0 (Ramey Kemp and Associates Inc., 2005) for the years 2005 and 2008. For projecting the traffic volumes, the background growth rate was assumed as 3 percent. The intersections were analyzed based on HCM LOS criteria to identify the traffic impact that the site development has under existing and proposed zoning. TIA study recommended suitable improvements for the site development are summarized in Table 6 along with the status of implementation or what was built as of fall 2009. Table 7 shows the actual driveway permit conditions, recommended improvements and constructed improvements at site.

Table 6: Suggested Improvements and Status of Implementation – Retail Development Site, Youngsville

Intersection under influence area	Suggested Improvements	Implemented
1. US 1 / NC 96	1. Recommended eastbound right turn lane on NC 96	No
6. NC 95 / Mosswood Blvd	1. No geometric imporvements recommended	
3. US 1 / Site Driveways #1, #2	1. One of the access is built with different scenarios which was not in recommendations	Yes
4. US 1 / Site Driveway #3	1. Construct northbound right lane on US 1 and westbound approach to community	Yes
5. NC 96 / Site Driveways #4	1. Construct eastbound right turn lane as recommended on NC 96	Yes
6. NC 96 / Site Driveways #5	1. Constrcut northbound approach of Site Driveway #5 is proposed	Yes

Table 7: Driveway Permit Conditions, Recommended Improvements and Implementation Status – Retail Development Site, Youngsville

Intersection	Recommended Improvements	Recommended in		Implemented in field	Remarks
		TIA	Driveway Permit		
1. US 1 and NC 96	1. Construct an exclusive east bound right turn lane on NC 96	Yes	No	No	
2. US 1 and Green Rd/ Mosswood Blvd	1. No geometric improvements are recommended at this intersection	Yes	NA	NA	
3. US 1 and Site Driveway #1	1. Construct a northbound right turn lane on US 1	Yes	No	No	Currently does not exist at all
	2. Construct westbound approach as site driveway 1 to include one ingress lane and one egress lanes	Yes	No	No	
4. US 1 and Site Driveway #2	1. Construct a northbound right turn lane on US 1	Yes	Yes	Yes	
	2. Construct a southbound left turn on US 1	Yes	Yes	Yes	
	3. Construct westbound approach as site driveway 2 to provide one ingress lane and two egress lanes.	Yes	No	No	
5. US 1 and Site Driveway #3	1. Construct a northbound right turn lane on US 1	Yes	Yes	Yes	
	2. Construct westbound approach as site driveway #3 to include one ingress lane and one egress lanes	Yes	Yes	Yes	
6. NC 96 Frontage Improvements	1. Construct a center left turn along NC 96 from the current terminus of the existing left turn lane at US 1 to just beyond the eastern property boundary.	Yes	Yes	Yes	
7. NC 96 and Site Driveway #4	1. Construct an eastbound right turn lane on NC 96	Yes	Yes	Yes	
	2. Construct northbound approach as site driveway #4 to include one ingress lane and two egress lanes	Yes	Yes	Yes	
8. NC 96 and Site Driveway #5	1. Construct the northbound approach of site driveway #5 to include one ingress lane and one egress lane	Yes	Yes	Yes	
	2. Stripe the center left turn on NC 96 to provide a minimum of 100 feet of storage with 100 feet of taper.	Yes	Yes	Yes	

4.7 The Bridges at Mint Hill Site, Charlotte

General Growth Properties proposed a regional lifestyle center to be located on the northwest corner of Lawyers Road and I-485 in southeast Mint Hill, NC (Kubilins Transportation Group, Inc., 2005). The developer requested a change in zoning from Residential District (R) to BP-CUD (Planned Business, Conditional). Following are the intersections that fall under the influence area of the site (as indicated in the The Bridges at Mint Hill site TIA report).

1. Lawyers Road (SR 1004) / Stevens Mill Road (Signalized)
2. Lawyers Road (SR 1004) / Allen Black Road (Unsignalized)
3. Lawyers Road (SR 1004) / Country Woods Lane (Unsignalized)
4. I–485 NB Ramp / Lawyers Road (SR 1004) (Future, Signalized)
5. I–485 SB Ramp / Lawyers Road (SR 1004) (Unsignalized)
6. Lawyers Road (SR 1004) / Thompson Road (Unsignalized)
7. Lawyers Road (SR 1004) / Bain School Road (Unsignalized)

8. Matthews – Mint Hill Road (NC 51) / Lawyers Road (SR 1004) (Signalized)
9. Matthews – Mint Hill Road / Blair Road (NC 541) / Fairview Road/ Wilgrove-Mint Hill Road (NC 218) (Signalized)
10. Fairview Road (NC 218) / Philadelphia Church Road (Unsignalized)
11. I–485 NB Ramp / NC 218 (Fairview Road) (Future, Signalized)
12. I–485 SB Ramp / NC 218 (Fairview Road) (Unsignalized)

Lawyers Road, a two-lane roadway with 45 mph speed limit, is classified as a major thoroughfare according to the 2004 MUMPO Thoroughfare Plan (MUMPO, 2004). It lies in the southwestern edge of site forming a signalized intersection with Matthews Mint Hill Road to north.

Bain School Road, a two-lane local road, forms an unsignalized 3-legged intersection with Lawyers Road at its southern end. Bain School Road has a posted speed limit of 35 mph and continues as Philadelphia Church Road from Fairview Road.

I-485 is classified as a freeway according to the 2004 MUMPO Thoroughfare Plan (MUMPO, 2004). It is a four-lane divided freeway with a posted speed limit of 65 mph.

Matthews Mint Hill Road (NC 51), a two-lane roadway of 35 mph, is classified as major thoroughfare according to the 2004 MUMPO Thoroughfare Plan (MUMPO, 2004). It widens to a four-lane section between Lawyers Road and Fairview Road forming two signalized intersections.

Fairview Road (NC 218) is a two-lane roadway with a posted speed limit of 45 mph. It is classified as a major thoroughfare according to the 2004 MUMPO Thoroughfare Plan. Fairview Road widens to three-lane section and five-lane section as it approaches Matthews Mint Hill Road and I-485, respectively. Fairview Road becomes Wilgrove Mint Hill Road north of Matthews Mint Hill Road.

Stevens Mill Road is classified as a minor thoroughfare according to the 2004 MUMPO Thoroughfare Plan (MUMPO, 2004). It is a two-lane roadway with a posted speed limit of 45 mph and forms a signalized intersection with Lawyers Road.

Thompson Road, Allen Black road and Country Woods Lane are two-lane local roads and form 3-legged intersections with Lawyers Road.

Figure 17 shows the intersection of Lawyers Road and Stevens Mill Road. Figure 18 shows the incomplete development of The Bridges at Mint Hill site.

The TIA report includes the traffic volume counts at the intersections under the influence area along with delay, capacity and LOS obtained using Synchro® 5.0 (Kubilins Transportation Group, Inc., 2005). For projecting the traffic volumes, a background growth rate of 3 percent was assumed. The intersections were analyzed to identify the traffic impact of the site development under existing and proposed zoning conditions. The traffic analysis was done based on HCM LOS criteria assuming full development of the project in 2009. TIA study recommended suitable improvements after the site development are summarized in Table 8. The table also includes the status of implementation or what was built as of fall 2009**.**

Figure 17. Intersection of Lawyers Road / Stevens Mill Road - The Bridges at Mint Hill Site, Charlotte

Figure 18. Incomplete Development - The Bridges at Mint Hill Site, Charlotte

Table 8: Suggested Improvements and Status of Implementation – The Bridges at Mint Hill Site, Charlotte

Intersection under influence area	Suggested Improvements	Implemented
1. Lawyers Rd (SR 1004) / Stevens Mill Rd	1. Additional exlucisve left turn lane on northbound approach	No
	2. Exlucisve left turn lane on southbound approach	No
	3. Additional through lane with shared right turns on westbound approach	No
	4. Additional through lane and right turn lane on eastbound approach	No
2. Lawyers Rd (SR 1004) / Country Woods Ln	1. Northbound left turn lane on Country Woods Lane	No
3. I – 485 NB Ramp / Lawyers Rd (SR 1004) (Future Signal)	1. Additional exclusive right and left lane on the northbound ramp	No
	2. Additional northbound through lane on ramp	No
	3. Additional eastbound left turn on Lawyers rd	No
4. I – 485 SB Ramp / Lawyers Rd (SR 1004)	1. Construct channelized southbound right turn lane on ramp.	No
	2. Additional through lane on Lawyers Rd on northbound and westbound directions	No
	3. Additional westbound left turn lan on Lawyers Rd	No
	4. Proposed Signal	No
	5. Construct eastbound right turn lane on Lawyers Rd	Yes
5. Lawyers Rd (SR 1004) / Thompson Rd	1. Construct second eastbound through lane on Lawyers Rd	No
	2. Construct northbound left turn lane on Thompson Rd	No
	3. Construct west bound through lane on Lawyers Rd	No
6. Lawyers Rd (SR 1004) / Bain School Rd	1. Realign intersection to form as signalized four legged intersection with access A	No
	2. Construct westbound approach including dual left turn lanes, through-right lane and two receiving lanes	No
	3. Construct eastbound left turn lane on Lawyers Rd	No
	4. Construct dual eastbound right lanes on Lawyers Rd	No
	5. Construct southbound left turn lane on Bain School Rd	No
7. Matthews – Mint Hill Rd (NC 51) / Lawyers Rd (SR 1004)	1. Construct second left turn lane and right turn lane on northbound approach	No
	2. Construct second westbound through lane on Matthews Mint Hill Rd	No
	3. Additional southbound through lane and left turn lane on Lawyers Rd	No
	4. Construct southbound right turn lane on Lawyers Rd	No
	5. Construct eastbound through lane on Matthews Mint Hill Rd	No
8. Matthews – Mint Hill Rd / Blair Rd (NC 541) and Fairview Rd/ Wilgrove-Mint Hill Rd (NC 218)	1. Construct northbound left turn lane Fairview Rd	No
	2. Additional westbound through lane on Matthews Mint Hill Rd	No
9. Fairview Rd (NC 218) / Philadelphia Church Rd	1. Construct southbound right turn lane Fairview rd	No
	2. Construct eastbound left turn lane on Philadelphia Church Rd	No
10. I – 485 SB Ramp and NC 218 (Fairview Rd)	1. Proposed Signal	No

4.8 Brice–Rea Property Site, Charlotte

Real Estate Development Partners, LLC proposed a mixed use development on an approximately 9.48 acre vacant parcel located south of I-485 / Providence Road (NC 16) intersection in Charlotte (Kubilins Transportation Group, Inc., 2005). The developer requested a change in zoning from O-1 (CD) and R- 3 to NS. The following are the seven intersections that fall under the area of influence of the site (as indicated in the Brice – Rea Property site TIA report).

1. Providence Road (NC 16) / Ballantyne Commons Parkway (SR 4979) / McKee Road (Signalized).
2. Providence Road (NC 16) / I-485 WB exit ramp (Signalized)
3. Providence Road (NC 16) / I-485 EB exit ramp (Signalized)
4. Providence Road (NC 16) / Golf Links Drive (Access B, Unsignalized)
5. Providence Road (NC 16) / Providence Commons Shopping Center (Unsignalized- future right in / right out)
6. Providence Road (NC 16) / Ardrey Kelly Road (SR 3632) (Signalized)
7. Providence Road (NC 16) / Providence Country Club Drive (Signalized)

I-485 is classified as a freeway according to the 2004 MUMPO Thoroughfare Plan (MUMPO, 2004). It is a four-lane divided freeway with a posted speed limit of 65 mph.

Ballantyne Commons Parkway (SR 4979) / McKee Road and Ardrey Kell Road (SR 3632) are classified as major thoroughfares according to the MUMPO Thoroughfare Plan (MUMPO, 2004). Both the roadways operate with signal controls at intersection of Providence Road (NC 16) with a speed limit of 35 mph.

Providence Road (NC 16) is classified as a major thoroughfare according to the 2004 MUMPO Thoroughfare Plan (MUMPO, 2004) with a posted speed limit of 45 mph.

Golf Links Drive and Providence Country Club Drive are considered as local streets. Golf Links Drive has no posted speed and is operated under stop control. Providence Country Club Drive operates under signal control with a speed limit 30 mph.

Figure 19 shows the intersection of Providence Road (NC 16) / Ballantyne Commons Parkway. Figure 20 shows the widening of Providence Road (NC 16) at site.

Figure 19. Intersection of Providence Road (NC 16) / Ballantyne Commons Parkway – B rice-Rea Property Site, Charlotte

Figure 20. Widening of Providence Road (NC 16) at Site – Brice-Rea Property Site, Charlotte

The TIA report includes the traffic volume counts at the intersections under the influence area along with delay, capacity and LOS obtained using Synchro® 6.0 (Kubilins Transportation Group, Inc., 2005). For projecting the traffic volumes, the background growth rate was assumed as 3 percent. The intersections were analyzed based on HCM LOS criteria to identify the traffic impact that the site development has under existing and proposed zoning in the years 2004 and 2009. TIA study recommended suitable improvements for the site development are summarized in Table 9. The table also shows the status of implementation or what was built as of fall 2009.

Table 9: Suggested Improvements and Status of Implementation – Brice–Rea Property Site, Charlotte

Intersection under influence area	Suggested Improvements	Implemented
1. Providence Rd (NC 16) / Ballantyne Commons Pkwy (SR 4979)/ McKee Rd	1. Additional southbound through lane, exclusive right lane and exclusive left turn lane on Providence Rd (NC 16)	No
	2.Additional eastbound through lane and exclusive left turn lane on Ballantynes Commons Pkwy	No
	3. Additional northbound through lane and exclusive right turn lane on Providence Rd (NC 16)	No
2. Providence Rd (NC 16) / I-485 WB exit ramp	1. Additional southbound through lane on Providence Rd (NC 16)	No
	2. Additional northbound through lane on Providence Rd (NC 16)	No
3. Providence Rd (NC 16) / I-485 EB exit ramp	1. Additional southbound through lane on Providence Rd (NC 16)	No
	2. Additional northbound through lane on Providence Rd (NC 16)	No
4. Providence Rd (NC 16) / Allison Woods Drive (Access A,)	1. Additional southbound through lane on Providence Rd (NC 16)	No
	2. Additional northbound through lane on Providence Rd (NC 16)	No
5. Providence Rd (NC 16) / Golf Links Dr (Access B,)	1. Construct eastbound left turn lane on Providence Rd (NC 16)	No
	2. Construct southbound right turn lane on Providence Rd (NC 16)	No
	3. Proposed Signal	No
6. Providence Rd (NC 16) / Ardrey Kell Rd	1. Construct southbound right turn lane on Providence Rd (NC 16)	Yes

4.9 Study Intersections

Fifteen signalized and two unsignalized intersections near and adjacent to WT. Harris Boulevard site, Mountain Island Square site, Cato Property site, and University Pointe site in Charlotte region, Midway Plantation Development site in Knightdale, and, Retail Development site in Youngsville were selected for the analysis of operational performances in this study. Intersections in the vicinity of The Bridges at Mint Hill site and Brice Rea Property site were eliminated due to lack of significant improvements since the TIA was conducted.

4.9.1 Intersections at WT. Harris Boulevard Primax Site, Charlotte

The WT. Harris Boulevard Primax site was anticipated to be completed in the year 2009. However, only major developments were completed by 2009. The following intersections near the development were selected for the study.

E. WT Harris Boulevard (NC 24) / Rocky River Road (SR 2828, Signalized): At this intersection, an additional southbound left turn lane on E. WT. Harris Boulevard was constructed. This intersection also serves as an adjacent intersection to two proposed access points.

E. WT Harris Boulevard (NC 24) / Grier Road (SR 2976, Signalized): The northbound right turn lane was extended to 500 feet at this approach. This intersection also serves as an adjacent intersection to one of the proposed access point.

Rocky River Road (SR 2828) / Grier Road (SR 2976, Signalized): This is a 3-legged intersection at which the southbound right turn lane was extended to 675 feet. This intersection also serves as an adjacent intersection to one of the proposed access point.

4.9.2 Intersections at Mountain Island Square Site, Charlotte

The Mountain Island Square site was anticipated to be completed in 2009. However, only major developments were completed by year 2009. It was observed that Scenario 1 with no grade separation at intersections identified in the TIA report was adopted in the construction. The following intersections were selected for the study.

Brookshire Boulevard / Mt. Holly Huntersville Road (Signalized): This intersection is a major intersection located in close proximity to the site. No recommended improvements were implemented at this location.

Mt. Holly Huntersville Road / Callabridge Court / Ron Withrow Access (Signalized): A signal was installed at this location. In addition, an eastbound left turn lane was constructed at this intersection.

4.9.3 Intersections at Cato Property Site, Charlotte

Cato Property developers have implemented all the recommended improvements as identified in the TIA report. The improvements recommended by other developers were not yet completed. The following intersections were selected for the study.

Ardrey Kell Road / Providence Road (NC 16) (Signalized): The intersection is adjacent to one of the access point and Ardrey Kell Road. The recommended improvements were not implemented at this intersection.

Providence Road (NC 16) / Allison Woods Drive (Unsignalized): Allison Woods Drive was extended to Tom Short Road and serves as an access point. No other improvements were suggested at this intersection.

Tom Short Road / Ardrey Kell Road (Signalized): This intersection is adjacent to two access points, first one on Ardrey Kell Road, and the second one on Tom Short Road. No improvements were suggested at this intersection.

Tom Short Road / Ballantyne Commons Parkway (Signalized): This intersection is to adjacent to one of the access point and Tom Short Road intersection. The proposed improvements were not implemented at this intersection.

4.9.4 Intersections at University Pointe Site, Charlotte

A major super centre and out parcels were anticipated to be built by 2010. By fall 2009, only the super centre was completely built. The following intersections were considered for the study.

North Tryon Street (US 29) / The Commons at Chancellor Park Drive (Signalized): This intersection was modified to a four-legged signalized intersection. The newly added eastbound approach has four egress lanes and two ingress lanes. Other improvements included construction of northbound left turn lane and southbound right turn lane at the intersection.

In addition, a right in / right out access from the site was built on the south side of the intersection at a approximate distance of 600 feet. The access point accommodates for ingress and egress lanes. A southbound right turn lane into the site was also constructed at this location.

North Tryon Street (US 29) / McCullough Drive (Signalized): No improvements were suggested at this intersection. It was considered due to impact caused by site traffic and due to its close proximity to the site.

4.9.5 Intersections at Midway Plantation Development Site, Knightdale

Significant improvements were made to the Knightdale Boulevard (US 64) after the proposed development was built. The development was almost fully operational during the time of data collection.

Knightdale Boulevard (US 64) has been widened in the study area (both directions) to sustain the future traffic in association with the R- 2000G Tip project beyond Lynwood Drive.

Knightdale Boulevard (US 64) / Lynwood Drive intersection has been modified to allow right turns only. The Lynwood Drive has been realigned to form a four-legged intersection with Knightdale Boulevard (US 64) and Hinton Oaks Boulevard (driveway that forms an unsignalized intersection). Overall, a traffic signal, median and a driveway from the site were added at this new intersection.

Another driveway has been constructed at Knightdale Boulevard (US 64) / Wide Waters Parkway intersection with two ingress lanes and four egress lanes. The traffic signal, westbound approach and eastbound approach have been modified as needed to accommodate the future traffic.

The intersections of Knightdale Boulevard (US 64) at I 540 Northbound (On)ramp and I 540 Southbound (Off)ramp were also considered for the study. The movements at intersection of Knightdale Boulevard (US 64) / I 540 Southbound (Off)ramp on southbound approach have been restricted for through and left turn vehicles.

4. 9.6 Intersections at Retail Development Site, Youngsville

A major portion of the proposed development was completed at the time of this study. No major changes have been suggested to the adjacent intersections except adding an eastbound right turn lane at US 1 / NC 96 intersection. The unsignalized intersection (US 1 / Mosswood Boulevard) was not altered.

A directional crossover was built at one of the site driveways. One of the proposed driveway access points was not implemented as documented in the driveway permits. Overall, 3 driveways were built as per the recommendations in the TIA report.

CHAPTER 5: DATA COLLECTION

This chapter discusses the data collection efforts. As discussed in the previous chapter, a total of 15 signalized intersections and 2 unsignalized intersections were considered for data collection and analysis. The data was collected during the morning peak hours (7 AM – 9 AM) and evening peak hours (4 PM – 6 PM) on one typical weekday. Data collected included traffic counts by turning movement, heavy vehicle percentages, numbers of stops, queue lengths and vehicle delay by approach at all the intersections. Trained individuals were used to collect data pertaining to the MOEs.

Traffic turning movement volumes are collected manually using Jamar Traffic Data Collector (TDC – 12). Two persons using one counter each collected traffic volumes and heavy vehicle percentages for all approaches (two each) at a four legged intersection. The number of vehicles in the queue and delay were collected for left turn and through traffic movements on each approach of each intersection. Queue and delay for right turning vehicles was not collected. Table 10 shows sample queue and delay data collection sheet used in this study. The data collected was entered into Microsoft Excel spreadsheets for post-processing and analysis.

Table 11 shows data collection schedule for each study intersection of each TIA site.

Table 10: Queue Length and Delay Data Collection Sheet

TRAFFIC OPERATIONAL EVALUATION OF TIA CASE SITES Queue Length & Delay Data Collection Sheet											
Name of the Surveyor:								**Date:**			
Location Name:								**Start Time:**		**End Time:**	
S.No.	**Through Lane**						**Left Lane**				
	# of Vehicles in Queue	**Max. # of Vehicles in Queue**		**Vehicle Arrival at Red**		**Green Signal Time**	**# of Vehicles in Queue**	**Max. # of Vehicles in Queue**	**Vehicle Arrival at Red**		**Green Signal Time**
		Lane 1	**Lane 2**	**First**	**Last**				**First**	**Last**	
1											
2											
4											
5											
6											
9											
10											
11											
12											
13											
14											
15											
16											
18											
19											
20											
21											
22											
23											
24											
25											
26											

Table 11: Data Collection Schedule

WT. Harris Boulevard Primax Site, Charlotte			
Intersection	**Type**	**Date**	**Weekday**
E. WT. Harris Blvd & Rocky River Rd	Signalized	19-May-09	Tuesday
E. WT. Harris Blvd & Grier Rd	Signalized	21-May-09	Thursday
Rocky River Rd & Grier Rd	Signalized	27-May-09	Wednesday
Mountain Island Square Site, Charlotte			
Intersection	**Type**	**Date**	**Weekday**
Mt. Holly Huntersville Rd & Brookshire Blvd	Signalized	7-Jul-09	Tuesday
Mt. Holly Huntersville Rd & Callabridge Ct	Signalized	8-Jul-09	Wednesday
Cato Property Site, Charlotte			
Intersection	**Type**	**Date**	**Weekday**
Tom Short Rd & Ballantyne Commons Pkwy	Signalized	4-Jun-09	Thursday
Tom Short Rd & Ardrey Kell Rd	Signalized	10-Jun-09	Wednesday
Ardrey Kell Rd & Providence Rd	Signalized	11-Jun-09	Thursday
Providence Rd & Allison Woods Dr	Unsignalized	16-Jun-09	Tuesday
University Pointe Site, Charlotte			
Intersection	**Type**	**Date**	**Weekday**
North Tryon St (US 29) & McCullough Dr	Signalized	22-Sep-09	Tuesday
North Tryon St (US 29) & The Commons at Chancellor Park Dr	Signalized	23-Sep-09	Wednesday
Midway Plantation Development Site, Knightdale			
Intersection	**Type**	**Date**	**Weekday**
US 64 & Wide Waters Pkwy	Signalized	11-Aug-09	Tuesday
US 64 & Hinton Oaks Blvd	Signalized	12-Aug-09	Wednesday
US 64 & I 540 NB (On) Ramp	Signalized	13-Aug-09	Thursday
US 64 & I 540 SB (Off) Ramp	Signalized	19-Aug-09	Wednesday
Retail Development Site, Youngsville			
Intersection	**Type**	**Date**	**Weekday**
NC 96 & US 1	Signalized	18-Aug-09	Tuesday
US 1 & Mosswood Blvd	Unsignalized	20-Aug-09	Thursday

CHAPTER 6: EVALUATION OF METHODS TO ESTIMATE OPERATIONAL EFFECTS OF TIA CASE SITES

The operational performance of selected intersections at the TIA case sites are evaluated using three different methods. The analysis and results obtained using the three methods are discussed in this chapter.

TIA reports for all case sites (except University Pointe) were obtained from the NCDOT. TIA report for University Pointe case site was obtained from the consultant who developed the report. Synchro® 5.0 traffic simulation software was used in all selected TIA studies except in TIA study for University Pointe case site. Synchro® 6.0 traffic simulation software was used in TIA study for University Pointe case site.

Traffic data were collected for the “build” condition to compute MOEs such as number of stops, 50th percentile queue length in feet, delay and LOS at selected intersections of each TIA case site using Synchro® 6.0 traffic simulation software. Since the data was collected on an average weekday, 50^{th} percentile queue lengths are considered for analysis. If the data is collected on multiple days (say 5 or more days), queue length data from the day representing the worst condition is chosen and should be compared to 95^{th} percentile queue lengths in analysis. Synchro® 6.0 version was also used to compute MOEs at sites where data has to be projected to the year 2009.

Signal timing data for signalized intersections of WT. Harris Boulevard Primax, Mountain Island Square, Cato Property, and University Pointe TIA case sites in the Charlotte region were obtained from the CDOT. Signal timing data for signalized intersections of Midway Plantation Development, Knightdale and Retail Development, Youngsville TIA case sites were obtained from NCDOT. The signal timing data used for analysis of TIA case site are shown in Appendix A.

6.1 WT. Harris Boulevard Primax Site, Charlotte

The MOEs obtained from the TIA, Synchro® analyses and field observations for WT. Harris Boulevard Primax TIA case site are compared and discussed in this section. Table

12 shows the observed peak hour factor (PHF) and heavy vehicle percentages at the study intersections on the day of data collection.

6.1.1 Method 1: Study the Operational Performance Before and After the Development at the Site

The MOEs for the “no build” condition obtained from the WT. Harris Boulevard Primax site TIA is compared to the MOEs for the “build” condition computed using Synchro® traffic simulation software.

In Table 13, the traffic volumes from the TIA report under “no build” condition are compared with traffic volumes collected in the field for the “build” condition. It was observed that traffic volumes increased considerably (more than the general annual growth of traffic on the roads) at all the 3 study intersections after the development at the TIA site. An increase in PM peak hour turning traffic volumes was noticed on the northbound and westbound approaches of E. WT. Harris Boulevard / Rocky River Road intersection. This could be attributed to the location of the development on the southeast quadrant of the intersection.

Due to the termination of Rocky River Road at Old Concord Road on west side of E. WT. Harris Boulevard / Rocky River Road intersection, a decrease in westbound through traffic volumes was observed. Likewise, an increase in turning traffic volumes on approaches from/to the site was observed at the Rocky River Road / Grier Road and E. WT. Harris Boulevard / Grier Road intersections.

The numbers of stops from the WT. Harris Boulevard Primax site TIA under “no build” conditions are compared with the number of stops for the “build” condition from Synchro® analysis (Table 14). An increase in the number of stops after the development was observed on a majority of approaches at the 3 intersections. The difference in results obtained can be attributed to not only growth in traffic but also to PHF and heavy vehicle percentages (0.9 and 2 percent, respectively) used in the TIA. The PHF and heavy vehicle percentages used for the “build” condition are based on field observation whereas those used in TIA report are Synchro® default values. The change in signal timing patterns and lane configurations from the time of TIA and this study might also have affected the MOE.

The 50th percentile queue length distances from the WT. Harris Boulevard Primax site TIA under "no build" condition is compared to 50th percentile queue length distance for the "build" condition from the Synchro® analysis (Table 15). Trends in results obtained are very similar to those observed in case of the number of stops.

The delay and LOS under "no build" condition are compared to delay and LOS for the "build" condition based on Synchro® analysis (Table 16). All the three intersections under the influence area of the site are separated by a distance of more than 0.5 miles, resulting in no major operational issues due to intersection spacing. The intersection E. WT. Harris Boulevard / Rocky River Road experienced a slight increase in delay after the site development but had the same LOS as during AM and PM peak hours.

An increase in delay was anticipated at the intersection after the site development. However, the additional left turn lane on the southbound direction and converting through lane on westbound direction to a through shared with right turn lane might have controlled the increase in delay at the intersection. The nearest driveway at this intersection was observed at an approximate distance of 300 feet. This could possible result in operational issues in the future.

The E. WT. Harris Boulevard / Grier Road intersection experienced a decrease in delays during AM peak hour but an increase in delays during PM peak hour. None of the recommended treatments except the extension of the right turn lane on northbound direction at this intersection have been implemented. The decrease in delays can be attributed to decrease in traffic volumes during AM peak hours.

None of the suggested improvements except extension of southbound right turn lane were completed at Rocky River Road / Grier Road intersection. The decrease in delays can be attributed to free flow signal operation adopted after the site development. Another possible reason could be incomplete development at the time of this study than was forecasted in the TIA.

6.1.2 Method 2: Study the Effectiveness of Methods to Forecast Operational Effects of the Development

The MOEs for the "build" condition obtained from the WT. Harris Boulevard Primax site TIA is compared with the MOEs for the "build" condition computed using Synchro® traffic simulation software.

In Table 17, the forecasted traffic volumes for the "build" condition from the WT. Harris Boulevard Primax site TIA is compared with the observed traffic volumes from the field. In general, through and left turn traffic volumes forecasted in the WT. Harris Boulevard Primax site TIA for the year 2009 is higher than those observed in the field. On the other hand, the right turn traffic volumes are forecasted to be lower than those observed in the field. However, it was observed that the forecasted and observed right turn traffic volumes differ by a low value (though the ratios are very high).

In Table 18, the number of stops for the "build" condition from the WT. Harris Boulevard Primax site TIA are compared to those computed using Synchro® for the "build" condition. In Table 19, the 50th percentile queue lengths for the "build" condition from the WT. Harris Boulevard Primax site TIA are compared to those computed using Synchro® for the "build" condition. The trends in results obtained are very similar to those observed in case of traffic volumes. The differences in results obtained could be attributed to traffic growth and incomplete development of proposed improvements at the TIA site.

The forecasted delays for the "build" condition during the AM peak hour are slightly lower than the computed delays at all the study intersections while the LOS remained unchanged (Table 20). The forecasted delay at intersection next to the development, E. WT. Harris Boulevard / Rocky River Road intersection, during the PM peak hour was higher than the current delay while the delays at E. WT. Harris Boulevard / Grier Road were lower than computed delays. The forecasted delay at the Rocky River Road / Grier Road intersection was higher during the AM peak hour and lower during the PM peak hour than the observed delay. At present, this intersection operates under free-flow travel conditions at all the times.

The difference in forecasted and computed delays and LOS for the "build" condition could be due to 1) use of PHF and heavy vehicle percentages from field observations, and, 2) existing signal timing patterns that are different than that used in the TIA. In addition, the TIA accounted for completion of development by the year 2009. The incomplete development could have possibly resulted in lower traffic volumes (hence, delays) than forecasted in the TIA report.

6.1.3 Method 3: Study the Effectiveness of Analytical Procedures to Replicate Field Data

The number of stops and delay observed directly from the field are compared to those computed from the Synchro® analysis to examine the effectiveness of the analytical procedures to replicate field data. The observed number of stops and estimated number of stops for the "build" condition are shown in Table 21. The observed average delay and computed average delay are shown in Table 22. The observed and computed number of stops do not follow any specific trends or patterns. The observed average delays at E. WT. Harris Boulevard / Rocky River Road intersection are closer to the computed average delays during the AM and PM peak hour. At E. WT. Harris Boulevard / Grier Road intersection and Rocky River / Grier Road intersection, while the observed average delays are closer to the computed average delays during the AM peak hour, the observed average delays are lower than the computed average delays during the PM peak hour. The difference in the observed and computed number of stops and delay could be attributed to the following.

1. The number of stops on the westbound approach of E. WT. Harris Boulevard / Rocky River Road intersection during high volume AM peak hour was due to shared through and right lane. The right turn stops on through shared right lane were not observed in the field. However, these were accounted and considered by Synchro®.
2. Synchro® manual documents that it does not consider a vehicle in full stop condition unless the vehicle has a delay of a minimum of 10.0 seconds. The field study considered stops when a vehicle was observed to come to a complete stop irrespective of the delay.

Table 12: Observed PHF and Heavy Vehicle Percentages – WT. Harris Boulevard Primax Site, Charlotte

E. WT. Harris Blvd / Rocky River Rd					
Approach	Direction	PHF		Heavy Vehicle Percentage	
		AM	PM	AM	PM
Eastbound	L	0.82	0.66	8	1
	T	0.30	0.81	10	6
	R	0.55	0.78	9	32
Westbound	L	0.84	0.69	3	1
	T	0.64	0.65	2	2
	R	0.89	0.88	1	-
Northbound	L	0.64	0.43	6	19
	T	0.80	0.92	1	1
	R	0.83	0.80	10	1
Southbound	L	0.77	0.88	5	1
	T	0.92	0.90	2	-
	R	0.30	0.81	1	8

E. WT. Harris Blvd / Grier Rd					
Approach	Direction	PHF		Heavy Vehicle Percentage	
		AM	PM	AM	PM
Eastbound	L	0.75	0.82	21	7
	T	0.53	0.87	11	5
	R	0.86	0.93	3	-
Westbound	L	0.89	0.64	1	1
	T	0.75	0.85	5	4
	R	0.61	0.56	22	4
Northbound	L	0.82	0.81	11	15
	T	0.88	0.91	1	1
	R	0.67	0.87	7	1
Southbound	L	0.72	0.83	1	1
	T	0.91	0.96	4	1
	R	0.75	0.54	5	5

Rocky River Rd / Grier Rd					
Approach	Direction	PHF		Heavy Vehicle Percentage	
		AM	PM	AM	PM
Eastbound	L	0.88	0.91	4	1
	R	0.53	0.52	8	5
Northbound	L	0.54	0.58	8	7
	T	0.88	0.89	3	1
Southbound	T	0.87	0.81	2	4
	R	0.93	0.88	1	2

Table 13: Comparison of Traffic Volumes Before and After Development, WT. Harris Boulevard Primax Site, Charlotte

E. WT. Harris Blvd / Rocky River Rd								
Approach	Direction	AM			PM			
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	14	53	3.8	25	77	3.1
	T	53	82	1.5	238	72	0.3
	R	71	11	0.2	57	22	0.4
Westbound	L	102	115	1.1	23	77	3.3
	T	143	31	0.2	44	31	0.7
	R	619	718	1.2	105	318	3.0
Northbound	L	27	36	1.3	36	43	1.2
	T	1,710	1,607	0.9	1,253	1,378	1.1
	R	22	10	0.5	30	84	2.8
Southbound	L	59	102	1.7	435	726	1.7
	T	1,064	1,047	1.0	1,631	1,623	1.0
	R	9	41	4.6	22	52	2.4
E. WT. Harris Blvd / Grier Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	34	42	1.2	43	82	1.9
	T	65	113	1.7	339	317	0.9
	R	196	148	0.8	289	306	1.1
Westbound	L	379	344	0.9	105	286	2.7
	T	382	327	0.9	95	132	1.4
	R	15	69	4.6	28	52	1.9
Northbound	L	236	213	0.9	208	205	1.0
	T	1,769	1,651	0.9	1,262	1,411	1.1
	R	130	220	1.7	441	486	1.1
Southbound	L	25	75	3.0	25	119	4.8
	T	1,130	1,010	0.9	1,130	1,574	1.4
	R	39	39	1.0	39	56	1.4
Rocky River Rd / Grier Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	95	133	1.4	653	771	1.2
	R	1	19	19.0	15	50	3.3
Northbound	L	6	13	2.2	9	7	0.8
	T	175	194	1.1	731	674	0.9
Southbound	T	753	703	0.9	175	352	2.0
	R	821	850	1.0	152	364	2.4

Table 14: Comparison of Stops Before and After Development, WT. Harris Boulevard Primax Site, Charlotte

Approach	Direction	AM			PM		
E. WT. Harris Blvd / Rocky River Rd							
Approach	Direction	Before	After	Ratio	Before	After	Ratio
Eastbound	L	15	34	2.3	20	70	3.5
	T	44	71	1.6	218	61	0.3
	R	13	2	0.2	25	6	0.2
Westbound	L	91	101	1.1	19	70	3.7
	T	220	226	1.0	36	58	1.6
	R	429	322	0.8	43	146	3.4
Northbound	L	28	32	1.1	34	37	1.1
	T	297	414	1.4	749	952	1.3
	R	2	3	1.5	25	24	1.0
Southbound	L	48	94	2.0	385	676	1.8
	T	445	591	1.3	1,033	958	0.9
	R	3	2	0.7	6	3	0.5
E. WT. Harris Blvd / Grier Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	27	39	1.4	32	75	2.3
	T	45	89	2.0	301	267	0.9
	R	96	71	0.7	172	242	1.4
Westbound	L	329	271	0.8	87	175	2.0
	T	332	287	0.9	70	94	1.3
	R	6	39	6.5	5	23	4.6
Northbound	L	215	197	0.9	192	169	0.9
	T	1,501	1,474	1.0	788	1,133	1.4
	R	25	42	1.7	111	191	1.7
Southbound	L	25	63	2.5	25	95	3.8
	T	1,082	452	0.4	537	1,418	2.6
	R	13	3	0.2	13	6	0.5
Rocky River Rd / Grier Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	49	115	2.3	552	676	1.2
	R	1	6	6.0	5	6	1.2
Northbound	T	86	101	1.2	610	549	0.9
Southbound	T	498	332	0.7	92	261	2.8
	R	1	-	-	-	24	NA

Table 15: Comparison of 50th Percentile Queue Length Before and After Development, WT. Harris Boulevard Primax Site, Charlotte

E. WT. Harris Blvd / Rocky River Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	13	85	6.5	23	109	4.7
	T	46	235	5.1	244	76	0.3
	R	-	-	NA	27	-	-
Westbound	L	94	125	1.3	22	100	4.5
	T	267	273	1.0	44	73	1.7
	R	474	372	0.8	47	169	3.6
Northbound	L	29	48	1.7	38	90	2.4
	T	158	245	1.6	438	558	1.3
	R	1	1	1.0	12	26	2.2
Southbound	L	51	63	1.2	429	395	0.9
	T	252	343	1.4	611	553	0.9
	R	1	-	-	4	-	-
E. WT. Harris Blvd / Grier Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	26	54	2.1	35	91	2.6
	T	46	258	5.6	328	406	1.2
	R	96	78	0.8	183	189	1.0
Westbound	L	392	339	0.9	112	575	5.1
	T	339	420	1.2	78	118	1.5
	R	5	35	7.0	-	39	NA
Northbound	L	235	246	1.0	223	286	1.3
	T	925	890	1.0	472	641	1.4
	R	23	29	1.3	110	205	1.9
Southbound	L	25	100	4.0	27	161	6.0
	T	631	256	0.4	316	893	2.8
	R	8	-	-	1	10	10.0
Rocky River Rd / Grier Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	28	63	2.3	650	713	1.1
	R	-	-	NA	3	7	2.3
Northbound	L	-	-	NA	-	-	NA
	T	26	40	1.5	760	722	1.0
Southbound	T	176	148	0.8	111	313	2.8
	R	-	-	NA	-	-	NA

Table 16: Comparison of Delays and LOS Before and After Development, WT. Harris Boulevard Primax Site, Charlotte

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
TIA Delays 2004				
W. T. Harris Blvd / Rocky River Rd	26.6	C	37.7	D
W. T. Harris Blvd / Grier Rd	50.2	D	32.2	C
Rocky River Rd / Grier Rd	12.6	B	35.6	D
Computed Delays 2009				
W. T. Harris Blvd / Rocky River Rd	34.2	C	38.9	D
W. T. Harris Blvd / Grier Rd	49.9	D	72.0	E
Rocky River Rd / Grier Rd	7.0	A	40.4	D

Table 17: Comparison of Traffic Volumes - Forecasted vs. Observed, WT. Harris Boulevard Primax Site, Charlotte

E. WT. Harris Blvd / Rocky River Rd							
Approach	Direction	AM			PM		
		Forecasted	Observed	Ratio	Forecasted	Observed	Ratio
Eastbound	L	51	53	1.0	101	77	0.8
	T	94	82	0.9	348	72	0.2
	R	82	11	0.1	66	22	0.3
Westbound	L	153	115	0.8	122	77	0.6
	T	192	31	0.2	76	31	0.4
	R	938	718	0.8	265	318	1.2
Northbound	L	91	36	0.4	102	43	0.4
	T	2,014	1,607	0.8	1,524	1,378	0.9
	R	28	10	0.4	44	84	1.9
Southbound	L	209	102	0.5	771	726	0.9
	T	1,338	1,047	0.8	1,974	1,623	0.8
	R	24	41	1.7	37	52	1.4
E. WT. Harris Blvd / Grier Rd							
Approach	Direction	AM			PM		
		Forecasted	Observed	Ratio	Forecasted	Observed	Ratio
Eastbound	L	70	42	0.6	71	82	1.2
	T	151	113	0.7	513	317	0.6
	R	227	148	0.7	335	306	0.9
Westbound	L	638	344	0.5	248	286	1.2
	T	554	327	0.6	173	132	0.8
	R	17	69	4.1	32	52	1.6
Northbound	L	277	213	0.8	245	205	0.8
	T	2,120	1,651	0.8	1,525	1,411	0.9
	R	247	220	0.9	688	486	0.7
Southbound	L	91	75	0.8	87	119	1.4
	T	1,339	1,010	0.8	1,807	1,574	0.9
	R	64	39	0.6	79	56	0.7
Rocky River Rd / Grier Rd							
Approach	Direction	AM			PM		
		Forecasted	Observed	Ratio	Forecasted	Observed	Ratio
Eastbound	L	276	133	0.5	1,132	771	0.7
	R	1	19	19.0	17	50	2.9
Northbound	L	7	13	1.9	10	7	0.7
	T	369	194	0.5	1,140	674	0.6
Southbound	T	1,193	703	0.6	378	352	0.9
	R	1,306	850	0.7	415	364	0.9

Table 18: Comparison of Stops - Forecasted vs. Computed, WT. Harris Boulevard Primax Site, Charlotte

E. WT. Harris Blvd / Rocky River Rd							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	L	50	34	0.7	97	70	0.7
	T	86	71	0.8	279	61	0.2
	R	14	2	0.1	41	6	0.1
Westbound	L	140	101	0.7	86	70	0.8
	T	168	224	1.3	65	58	0.9
	R	828	322	0.4	133	156	1.2
Northbound	L	59	32	0.5	63	37	0.6
	T	751	414	0.6	1,402	952	0.7
	R	-	3	NA	13	24	1.8
Southbound	L	183	94	0.5	691	676	1.0
	T	1,025	591	0.6	1,691	958	0.6
	R	6	2	0.3	10	3	0.3
E. WT. Harris Blvd / Grier Rd							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	L	59	39	0.7	47	75	1.6
	T	98	89	0.9	458	267	0.6
	R	110	71	0.6	173	242	1.4
Westbound	L	581	271	0.5	234	175	0.7
	T	505	287	0.6	117	94	0.8
	R	9	39	4.3	13	23	1.8
Northbound	L	201	197	1.0	184	169	0.9
	T	1,801	1,474	0.8	1,156	1,133	1.0
	R	63	42	0.7	430	191	0.4
Southbound	L	72	63	0.9	71	95	1.3
	T	1,165	452	0.4	1,665	1,418	0.9
	R	19	3	0.2	19	6	0.3
Rocky River Rd / Grier Rd							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	L	222	115	0.5	884	676	0.8
	R	-	6	NA	-	6	NA
Northbound	T	112	101	0.9	928	549	0.6
Southbound	T	958	332	0.3	241	261	1.1
	R	4	-	-	-	24	NA

Table 19: Comparison of 50th Percentile Queue length - Forecasted vs. Computed, WT. Harris Boulevard Primax Site, Charlotte

E. WT. Harris Blvd / Rocky River Rd							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	L	26	85	3.3	56	109	1.9
	T	90	235	2.6	470	76	0.2
	R	-	-	NA	44	-	-
Westbound	L	154	125	0.8	180	100	0.6
	T	177	271	1.5	73	73	1.0
	R	503	373	0.7	81	166	2.0
Northbound	L	127	48	0.4	184	90	0.5
	T	30	244	8.1	599	557	0.9
	R	-	1	NA	16	26	1.6
Southbound	L	97	63	0.6	388	395	1.0
	T	543	343	0.6	1,012	553	0.5
	R	4	-	-	8	-	-
E. WT. Harris Blvd / Grier Rd							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	L	61	54	0.9	55	91	1.7
	T	103	258	2.5	518	406	0.8
	R	112	78	0.7	186	189	1.0
Westbound	L	304	325	1.1	134	563	4.2
	T	511	420	0.8	135	110	0.8
	R	8	35	4.4	16	42	2.6
Northbound	L	319	246	0.8	248	286	1.2
	T	838	890	1.1	473	641	1.4
	R	59	29	0.5	526	205	0.4
Southbound	L	78	100	1.3	85	160	1.9
	T	442	256	0.6	816	898	1.1
	R	18	-	-	16	10	0.6
Rocky River Rd / Grier Rd							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	L	136	63	0.5	426	713	1.7
	R	-	-	NA	-	7	NA
Northbound	L	-	-	NA	-	-	NA
	T	66	40	0.6	461	722	1.6
Southbound	T	1,184	148	0.1	230	313	1.4
	R	-	-	NA	-	-	NA

Table 20: Comparison of Delays and LOS - Forecasted vs. Computed, WT. Harris Boulevard Primax Site, Charlotte

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
Forecasted TIA Delays 2009				
WT. Harris Blvd / Rocky River Rd	32.3	C	63.7	E
WT. Harris Blvd / Grier Rd	42.8	D	50.0	D
Rocky River Rd / Grier Rd	24.8	C	26.0	C
Computed Delays 2009				
WT. Harris Blvd / Rocky River Rd	34.2	C	38.9	D
WT. Harris Blvd / Grier Rd	49.9	D	72.0	E
Rocky River Rd / Grier Rd	7.0	A	40.4	D

Table 21: Comparison of Stops – Observed vs. Computed, WT. Harris Boulevard Primax Site, Charlotte

E. WT. Harris Blvd / Rocky River Rd							
Approach	Direction	AM			PM		
		Observed	Computed	Ratio	Observed	Computed	Ratio
Eastbound	L	42	34	0.8	76	70	0.9
	T	17	71	4.2	58	61	1.1
Westbound	L	94	101	1.1	52	70	1.3
	T	5	224	44.8	22	58	2.6
Northbound	L	23	32	1.4	40	37	0.9
	T	156	414	2.7	148	952	6.4
Southbound	L	116	94	0.8	494	676	1.4
	T	353	591	1.7	454	958	2.1
E. WT. Harris Blvd / Grier Rd							
Approach	Direction	AM			PM		
		Observed	Computed	Ratio	Observed	Computed	Ratio
Eastbound	L	274	39	0.1	72	75	1.0
	T	236	89	0.4	264	267	1.0
Westbound	L	51	271	5.3	591	175	0.3
	T	91	287	3.2	85	94	1.1
Northbound	L	174	197	1.1	145	169	1.2
	T	283	1,474	5.2	127	1,133	8.9
Southbound	L	68	63	0.9	153	95	0.6
	T	411	452	1.1	1,137	1,418	1.2
Rocky River Rd / Grier Rd							
Approach	Direction	AM			PM		
		Observed	Computed	Ratio	Observed	Computed	Ratio
Eastbound	L	56	115	2.1	660	676	1.0
Northbound	T	60	101	1.7	1,079	549	0.5
Southbound	T	185	332	1.8	232	261	1.1

Table 22: Comparison of Delays and LOS – Observed vs. Computed, WT. Harris Boulevard Primax Site, Charlotte

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
Observed Delays 2009				
W. T. Harris Blvd / Rocky River Rd	35.0	C	39.0	D
W. T. Harris Blvd / Grier Rd	45.0	D	44.0	D
Rocky River Rd / Grier Rd	7.0	A	33	C
Computed Delays 2009				
W. T. Harris Blvd / Rocky River Rd	34.2	C	38.9	D
W. T. Harris Blvd / Grier Rd	49.9	D	72.0	E
Rocky River Rd / Grier Rd	7.0	A	40.4	D

6.2 Mountain Island Square Site, Charlotte

The MOEs obtained from the TIA, Synchro® analyses and field observations for Mountain Island Square TIA case site are compared and discussed in this section. The observed PHF and heavy vehicle percentages at the study intersections on the day of data collection are shown in Table 23.

6.2.1 Method 1: Study the Operational Performance Before and After the Development at the Site

The MOEs obtained for the "no build" condition from Mountain Island Square site TIA are compared to the MOEs for the "build" condition computed using Synchro® traffic simulation software.

The traffic volumes (Table 24) from the TIA report under "no build" condition are compared with traffic volumes collected in the field for the "build" condition. The traffic volume increased significantly at the 2 considered intersections after the development at the TIA site. A decrease in through traffic volume was noticed on Mt. Holy Huntersville Road in the study area during the AM and PM peak hours.

The numbers of stops from the Mountain Island Square site TIA under the "no build" condition are compared with the numbers of stops for the "build" condition from Synchro® analysis (Table 25). An increase in the number of stops after the development was observed on a majority of approaches at the 2 intersections. The difference in results obtained could be due to growth in traffic, and use of PHF and heavy vehicle percentages from field for the “build” condition. The change in signal timing patterns and lane configurations from the time of TIA study and this study might also have affected the MOE. It should be noted that Mt. Holly-Huntersville Road / Callabridge Court intersection was an unsignalized intersection under the “no build” condition. Hence, the number of stops cannot be produced at this intersection.

The 50th percentile queue length distances from the Mountain Island Square site TIA under the “no build” condition are compared to the 50th percentile queue length distances for the “build” condition from the Synchro® analysis (Table 26). It was observed that the 50th percentile queue length distances have decreased during the AM peak hours and increased during the PM peak hours.

The delay and LOS under “no build” condition are compared to the delay and LOS for the “build” condition based on Synchro® analysis (Table 27). The delay and LOS at Brookshire Boulevard / Mt. Holly Huntersville Road intersection increased at a higher rate. This can be attributed to incomplete implementation of the recommended additional through lane for all approaches except southbound direction.

Traffic signal was installed at the intersection of Mt. Holly-Huntersville Road / Callabridge Court as per recommendations. A heavy traffic spill back during PM peak hours was observed at this location due to the spacing between the intersections of Brookshire Boulevard / Mt. Holly Huntersville Road and Mt. Holly-Huntersville Road / Callabridge Court (separated by approximately 850 feet).

6.2.2 Method 2: Study the Effectiveness of Methods to Forecast the Operational Effects of the Development

The MOEs for the “build” condition obtained from the Mountain Island Square site TIA are compared with the MOEs for the “build” condition computed using Synchro® traffic simulation software.

The forecasted traffic volumes for the “build” condition from the Mountain Island Square site TIA are compared with observed traffic volumes from field in Table 28. In general, the traffic volumes shown in the TIA are higher than those observed in 2009 at the 2 study intersections (exception being north-westbound approach at Brookshire Boulevard / Mt. Holly Huntersville intersection). The decrease in traffic volume for north-westbound approach in TIA at Brookshire Boulevard / Mt. Holly Huntersville intersection could be attributed to construction of I-485 segment after the TIA.

In Table 29 and Table 30, the number of stops and the 50th percentile queue length for the "build" condition from the Mountain Island Square site TIA are compared to those computed using Synchro® for the "build" condition, respectively. Trends in the results obtained are very similar to those observed in case of traffic volumes.

The delay and LOS for the "build" condition from the TIA report are compared to delay and LOS for the "build" condition based on Synchro® analysis (Table 31). The improvements in the TIA are recommended such that the intersections operate at a LOS of "D". The Brookshire Boulevard / Mt. Holly Huntersville Road signalized intersection was expected to operate at LOS "D" but currently experiences a LOS "E" and LOS "F" during the AM and PM peak hours. The Mt. Holly Huntersville Road / Callabridge Court unsignalized intersection was proposed to be a 4-legged signalized intersection. However, it was only converted to a 3 legged signalized intersection. It currently operates at LOS "B" (than expected LOS "D").

6.2.3 Method 3: Study the Effectiveness of Analytical Procedures to Replicate Field Data

The number of stops and delay observed directly from the field are compared to those computed from the Synchro® analysis to examine the effectiveness of the analytical procedures to replicate field data. The numbers of stops observed from the field are compared to those computed using Synchro® in Table 32. The observed and computed number of stops does not follow any specific trends or patterns. The observed average delays at Brookshire Boulevard / Mt. Holly Huntersville Road intersection are lower than the computed average delays during the AM and PM peak hours (Table 33). At Mt. Holly Huntersville Road / Callabridge Court intersection, the observed average delays are higher than the computed average delays during the AM and PM peak hours. As said previously, the field study considered stops when a vehicle was observed to come to a complete stop irrespective of the delay duration.

Table 23: Observed PHF and Heavy Vehicle Percentages – Mountain Island Square Site, Charlotte

Brookshire Blvd / Mt. Holly Huntersville Rd					
Approach	Direction	PHF		Heavy Vehicle Percentage	
		AM	PM	AM	PM
N W Bound	L	0.90	0.80	2	1
	T	0.83	0.82	1	5
	R	0.82	0.45	8	3
S E Bound	L	0.80	0.87	3	-
	T	0.80	0.88	8	1
	R	0.82	0.73	1	-
N E Bound	L	0.88	0.76	-	4
	T	0.95	0.85	4	1
	R	0.92	0.90	1	-
S W Bound	L	0.95	0.59	-	2
	T	0.79	0.78	4	1
	R	0.86	0.70	9	1
Mt. Holly Huntersville Rd / Callabridge Ct					
Approach	Direction	PHF		Heavy Vehicle Percentage	
		AM	PM	AM	PM
S E Bound	L	0.67	0.90	3	-
	R	0.91	0.93	3	-
N E Bound	L	0.80	0.91	4	-
	T	0.81	0.94	5	-
S W Bound	T	0.97	0.80	3	1
	R	0.83	0.78	1	-

Table 24: Comparison of Traffic Volumes Before and After Development, Mountain Island Square Site, Charlotte

Brookshire Blvd / Mt. Holly Huntersville Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
N W Bound	L	93	129	1.4	255	482	1.9
	T	271	346	1.3	1,056	3,059	2.9
	R	75	142	1.9	254	416	1.6
S E Bound	L	235	112	0.5	88	152	1.7
	T	1,291	1,379	1.1	305	469	1.5
	R	66	36	0.5	35	36	1.0
N E Bound	L	15	14	0.9	67	73	1.1
	T	379	201	0.5	483	480	1.0
	R	-	388	NA	121	245	2.0
S W Bound	L	354	432	1.2	100	462	4.6
	T	528	139	0.3	521	716	1.4
	R	82	48	0.6	190	213	1.1
Mt. Holly Huntersville Rd / Callabridge Ct							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
S E Bound	L	39	62	1.6	41	165	4.0
	R	130	190	1.5	104	400	3.8
N E Bound	L	114	249	2.2	108	446	4.1
	T	598	241	0.4	691	547	0.8
S W Bound	T	758	397	0.5	648	405	0.6
	R	65	86	1.3	47	138	2.9

Table 25: Comparison of Stops Before and After Development, Mountain Island Square Site, Charlotte

Brookshire Blvd / Mt. Holly Huntersville Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
N W Bound	L	87	111	1.3	227	400	1.8
	T	166	211	1.3	894	1,950	2.2
	R	8	8	1.0	98	194	2.0
S E Bound	L	217	102	0.5	77	145	1.9
	T	1,126	1,219	1.1	228	429	1.9
	R	30	14	0.5	16	17	1.1
N E Bound	L	15	15	1.0	60	68	1.1
	T	345	414	1.2	406	507	1.2
	R	-	-	NA	27	-	-
S W Bound	L	329	406	1.2	90	318	3.5
	T	452	92	0.2	442	442	1.0
	R	13	14	1.1	91	147	1.6
Mt. Holly Huntersville Rd / Callabridge Ct							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
S E Bound	L	-	52	NA	-	139	NA
	R	-	19	NA	-	107	NA
N E Bound	L	-	194	NA	-	370	NA
	T	-	75	NA	-	103	NA
S W Bound	T	-	270	NA	-	313	NA
	R	-	7	NA	-	44	NA

Table 26: Comparison of 50th Percentile Queue Length Before and After Development, Mountain Island Square Site, Charlotte

Brookshire Blvd / Mt. Holly Huntersville Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
N W Bound	L	116	137	1.2	256	261	1.0
	T	113	118	1.0	511	2,551	5.0
	R	-	-	NA	106	232	2.2
S E Bound	L	150	51	0.3	48	87	1.8
	T	758	799	1.1	138	260	1.9
	R	40	14	0.4	16	24	1.5
N E Bound	L	9	6	0.7	39	43	1.1
	T	438	206	0.5	485	525	1.1
	R	-	-	NA	32	-	-
S W Bound	L	217	206	0.9	61	541	8.9
	T	585	100	0.2	574	1,338	2.3
	R	11	8	0.7	120	195	1.6
Mt. Holly Huntersville Rd / Callabridge Ct							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
S E Bound	L	-	17	NA	-	36	NA
	R	-	-	NA	-	33	NA
N E Bound	L	-	63	NA	-	121	NA
	T	-	34	NA	-	32	NA
S W Bound	T	-	110	NA	-	179	NA
	R	-	-	NA	-	27	NA

Table 27: Comparison of Delays and LOS Before and After Development, Mountain Island Square Site, Charlotte

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
TIA Delays 2004				
Brookshire Blvd / Mt. Holly Huntersville Rd	50.9	D	42.6	D
Mt. Holly Huntersville Rd / Callabridge Ct	4.3	A	3.6	A
Computed Delays 2009				
Brookshire Blvd / Mt. Holly Huntersville Rd	58.1	E	310.7	F
Mt. Holly Huntersville Rd / Callabridge Ct	11.7	B	13.4	B

Table 28: Comparison of Traffic Volumes - Forecasted vs. Observed, Mountain Island Square Site, Charlotte

Brookshire Blvd / Mt. Holly Huntersville Rd							
Approach	Direction	AM			PM		
		Forecasted	Observed	Ratio	Forecasted	Observed	Ratio
N W Bound	L	108	129	1.2	296	482	1.6
	T	314	346	1.1	1,171	3,059	2.6
	R	153	142	0.9	762	416	0.5
S E Bound	L	521	112	0.2	262	152	0.6
	T	1,497	1,379	0.9	303	469	1.5
	R	77	36	0.5	41	36	0.9
N E Bound	L	17	14	0.8	78	73	0.9
	T	528	201	0.4	735	480	0.7
	R	184	388	2.1	140	245	1.8
S W Bound	L	446	432	1.0	713	462	0.6
	T	659	139	0.2	835	716	0.9
	R	229	48	0.2	418	213	0.5
Mt. Holly Huntersville Rd / Callabridge Ct							
Approach	Direction	AM			PM		
		Forecasted	Observed	Ratio	Forecasted	Observed	Ratio
N W Bound	L	48	-	-	309	-	-
	T	-	-	NA	-	-	NA
	R	18	-	-	98	-	-
S E Bound	L	101	62	0.6	280	165	0.6
	T	-	-	NA	-	-	NA
	R	299	190	0.6	875	400	0.5
N E Bound	L	406	249	0.6	730	446	0.6
	T	691	241	0.3	749	547	0.7
	R	112	-	-	233	-	-
S W Bound	L	42	-	-	74	-	-
	T	879	397	0.5	698	405	0.6
	R	173	86	0.5	246	138	0.6

Table 29: Comparison of Stops - Forecasted vs. Computed, Mountain Island Square Site, Charlotte

Brookshire Blvd / Mt. Holly Huntersville Rd							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
N W Bound	L	102	111	1.1	274	399	1.5
	T	205	211	1.0	1,085	1,897	1.7
	R	64	8	0.1	608	176	0.3
S E Bound	L	481	102	0.2	247	144	0.6
	T	1,314	1,219	0.9	262	430	1.6
	R	33	14	0.4	23	17	0.7
N E Bound	L	17	15	0.9	74	68	0.9
	T	492	414	0.8	680	529	0.8
	R	139	-	-	50	-	-
S W Bound	L	418	407	1.0	634	441	0.7
	T	540	92	0.2	552	441	0.8
	R	13	14	1.1	212	136	0.6
Mt. Holly Huntersville Rd / Callabridge Ct							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
N W Bound	L	34	-	-	245	-	-
	T	-	-	NA	-	-	NA
	R	-	-	NA	-	-	NA
S E Bound	L	82	52	0.6	246	139	0.6
	T	-	-	NA	-	-	NA
	R	103	19	0.2	702	107	0.2
N E Bound	L	328	194	0.6	628	372	0.6
	T	290	75	0.3	507	103	0.2
	R	-	-	NA	-	-	NA
S W Bound	L	27	-	-	64	-	-
	T	653	270	0.4	639	313	0.5
	R	16	7	0.4	26	44	1.7

Table 30: Comparison of 50th Percentile Queue Length - Forecasted vs. Computed, Mountain Island Square Site, Charlotte

Brookshire Blvd / Mt. Holly Huntersville Rd

Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
N W Bound	L	135	137	1.0	353	261	0.7
	T	98	118	1.2	516	2,551	4.9
	R	82	-	-	751	232	0.3
S E Bound	L	320	51	0.2	169	87	0.5
	T	878	799	0.9	181	260	1.4
	R	44	14	0.3	28	24	0.9
N E Bound	L	10	6	0.6	50	43	0.9
	T	343	206	0.6	474	525	1.1
	R	179	-	-	64	-	-
S W Bound	L	284	206	0.7	421	541	1.3
	T	381	100	0.3	367	1,338	3.6
	R	-	8	NA	263	195	0.7

Mt. Holly Huntersville Rd / Callabridge Ct

Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
N W Bound	L	22	-	-	222	-	-
	T	-	-	NA		-	NA
	R	-	-	NA	-	-	NA
S E Bound	L	58	17	0.3	244	36	0.1
	T	-	-	NA	-	-	NA
	R	66	-	-	671	33	0.0
N E Bound	L	120	63	0.5	285	121	0.4
	T	116	34	0.3	224	32	0.1
	R	-	-	NA	-	-	NA
S W Bound	L	17	-	-	58	-	-
	T	243	110	0.5	305	179	0.6
	R	-	-	NA	-	27	NA

Table 31: Comparison of Delays and LOS - Forecasted vs. Computed, Mountain Island Square Site, Charlotte

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
TIA Delays 2009				
Brookshire Blvd / Mt. Holly Huntersville Rd	51.9	D	52.3	D
Mt. Holly Huntersville Rd / Callabridge Ct	18.6	B	39.3	D
Computed Delays 2009				
Brookshire Blvd / Mt. Holly Huntersville Rd	58.1	E	310.7	F
Mt. Holly Huntersville Rd / Callabridge Ct	11.7	B	13.4	B

Table 32: Comparison of Stops - Observed vs. Computed, Mountain Island Square Site, Charlotte

Brookshire Blvd / Mt. Holly Huntersville Rd							
Approach	Direction	AM			PM		
		Observed	Computed	Ratio	Observed	Computed	Ratio
N W Bound	L	127	111	0.9	121	400	3.3
	T	242	211	0.9	944	1,950	2.1
S E Bound	L	112	102	0.9	204	145	0.7
	T	60	1,219	20.3	266	429	1.6
N E Bound	L	15	15	1.0	314	68	0.2
	T	158	414	2.6	75	507	6.8
S W Bound	L	386	407	1.1	233	318	1.4
	T	92	92	1.0	274	442	1.6
Mt. Holly Huntersville Rd / Callabridge Ct							
Approach	Direction	AM			PM		
		Observed	Computed	Ratio	Observed	Computed	Ratio
S E Bound	L	55	52	0.9	169	139	0.8
	T	-	-	NA	-	-	NA
N E Bound	L	164	194	1.2	416	370	0.9
	T	72	75	1.0	114	103	0.9
S W Bound	L	-	-	NA	-	-	NA
	T	169	270	1.6	186	313	1.7

Table 33: Comparison of Delays and LOS - Observed vs. Computed, Mountain Island Square Site, Charlotte

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
Observed Delays 2009				
Brookshire Blvd / Mt. Holly Huntersville Rd	39.5	D	51.7	D
Mt. Holly Huntersville Rd / Callabridge Ct	18.4	B	27.0	C
Computed Delays 2009				
Brookshire Blvd / Mt. Holly Huntersville Rd	58.1	E	310.7	F
Mt. Holly Huntersville Rd / Callabridge Ct	11.7	B	13.4	B

6.3 Cato Property Site, Charlotte

The MOEs obtained from the TIA, Synchro® analyses and field observations for Cato Property TIA case site are compared and discussed in this section. Table 34 shows the observed PHF and heavy vehicle percentages at the study intersections on the day of data collection.

6.3.1 Method 1: Study the Operational Performance Before and After the Development at the Site

The MOEs for “no build” condition obtained from the Cato Property site TIA are compared to the MOEs for the “build” condition computed using Synchro® traffic simulation software.

In Table 35, the traffic volumes from the TIA report under “no build” condition are compared to the traffic volumes collected in the field for the “build” condition. It was observed that the traffic volumes increased at a higher rate after the development. This could be due to the traffic growth from the six offsite developments located in close proximity to the site.

The number of stops and 50th percentile queue length distances from the Cato Property site TIA under “no build” condition are compared with the number of stops and 50th percentile queue length distances for the “build” condition from Synchro® analysis (Table 36 and Table 37, respectively). The number of stops and 50th percentile queue length distances are observed to be similar to the trends in traffic volume. The increase in the number of stops and 50th percentile queue length can be attributed to offsite development growth, changes in signal timing patterns, and, use of PHF and heavy vehicle percentages from field observations for the “build” condition.

The delay and LOS under “no build” condition are compared to delay and LOS for the “build” condition based on Synchro® analysis (Table 38). The delay and LOS at Tom Short Road / Ballantyne Commons Parkway and Tom Short Road / Ardrey Kell Road intersection got worse after the site development. The Ardrey Kell Road / Providence Road (NC 16) intersection experienced slight decrease in delay during the AM peak hour with same LOS, but an increase in delay during the PM peak hour. An increase in delay was observed at Providence Road (NC 16) / Allison Woods Drive unsignalized intersection while the LOS remained unchanged. The increase in delay can be attributed to incomplete implementation of the treatments especially at Tom Short Road / Ballantyne Commons Parkway and Tom Short Road / Ardrey Kell Road intersections. It could also be due to construction of 3 new access points between the intersections.

6.3.2 Method 2: Study the Effectiveness of Methods to Forecast the Operational Effects of the Development

The MOEs for the "build" condition obtained from the Cato Property site TIA are compared with the MOEs for the "build" condition computed using Synchro® traffic simulation software. Tom Short Road / Ardrey Kell Road and Providence Road (NC 16) / Allison Woods Drive intersections were not considered in the TIA report.

The traffic volumes in the TIA report were forecasted to the year 2010. These were converted to year 2009 traffic volumes using a 3 percent growth rate. Table 39 shows the estimated traffic volumes for the "build" condition compared to observed traffic volumes from the field. In general, it was observed that the estimated traffic volumes from the TIA report are higher than the observed traffic volumes at all intersections except on minor approaches of Tom Short Road / Ballantyne Commons Parkway intersection.

In Table 40, the number of stops for the "build" condition from the Cato Property site TIA are compared to those computed using Synchro® for the "build" condition. The number of stops from the TIA are higher than those computed using Synchro® for the "build" condition (exception being for northbound approach through traffic at Ardrey Kell Road / Providence Road (NC 16) intersection). The lower number of stops forecasted for the northbound through traffic at Ardrey Kell Road / Providence Road (NC 16) intersection could be attributed to the current congestion caused due to widening of Providence Road (NC 16).

The 50th percentile queue lengths for the "build" condition from the Cato Property site TIA are compared to those computed using Synchro® for the "build" condition (Table 41). The 50th percentile queue lengths from the TIA report are higher than those computed using Synchro® for the "build" condition at Tom Short Road / Ballantyne Commons Parkway intersection (exception being westbound through approach). The

TIA considered an exclusive left lane along the westbound approach. However, a through shared with left lane was observed in field along this approach. This could have resulted in a lower 50th percentile queue length for the “build” condition in TIA analysis. The 50th percentile queue lengths from the TIA are observed to be lower than those computed using Synchro® at Ardrey Kell Road / Providence Road (NC 16) intersection. The difference in results obtained could be attributed to offsite traffic growth near the intersection.

The delay and LOS under “build” condition from the TIA report are compared to delay and LOS for the “build” condition based on Synchro® analysis (Table 42). The TIA study forecasted delays considering all the improvements in place by the year 2010. The TIA indicates that the intersections were designed for a LOS “C”. The Tom Short Road / Ballantyne Commons Parkway intersection currently operates at LOS “D” and LOS “F” during the AM and PM peak hours, respectively (forecasted to operate at LOS “B” during the peak hours in the TIA report). Similarly, Ardrey Kell Road / Providence Road (NC 16) intersection currently operates at LOS “C” and LOS “F” during the AM and PM peak hours, respectively (forecasted to operate at LOS “C” during the PM peak hour in the TIA report). The possible difference in forecasted and computed delay and LOS could be due to growth in traffic, use of PHF and heavy vehicle percentages from the field in the later case, and, difference in cycle lengths used for analysis. It should be noted that the intersection of Tom Short Road / Ballantyne Commons Parkway currently operates with a half cycle length of 75 seconds, whereas a cycle length of 135 seconds was used in the TIA. In the TIA, a cycle length of 150 seconds was used for Ardrey Kell Road / Providence Road (NC 16) intersection. However, at present, this intersection operates under free-flow travel conditions at all the times.

6.3.3 Method 3: Study the Effectiveness of Analytical Procedures to Replicate Field Data

The number of stops and delay observed directly from the field are compared to those computed using Synchro® to examine the effectiveness of the analytical procedures to replicate field data. In Table 43, the numbers of stops observed in the field are compared to the computed numbers of stops for the “build condition. The results obtained do not follow a specific pattern. The observed average delay and computed average delay for all the intersections considered at this site are shown in Table 44. While the observed average delays at the signalized intersections are lower than the computed average delays during the AM and PM peak hours, the observed average delays at the unsignalized intersection are higher than the computed average delays during the AM and PM peak hours. The difference in the observed and computed number of stops and delay could be attributed to limitations in Synchro® traffic simulation software. Synchro® manual documents that it does not consider a vehicle in full stop condition unless the vehicle has a delay of a minimum of 10.0 seconds. The field study considered stops when a vehicle was observed to come to a complete stop irrespective of the delay.

Table 34: Observed PHF and Heavy Vehicle Percentages – Cato Property, Charlotte

Tom Short Rd / Ballantyne Commons Pkwy					
Approach	Direction	PHF		Heavy Vehicle Percentage	
		AM	PM	AM	PM
Eastbound	T	0.88	0.97	2	-
	R	0.72	0.87	6	-
Westbound	L	0.59	0.77	5	-
	T	0.87	0.91	1	-
Northbound	L	0.77	0.73	2	1
	R	0.63	0.80	2	1
Tom Short Rd / Ardrey Kell Rd					
Approach	Direction	PHF		Heavy Vehicle Percentage	
		AM	PM	AM	PM
Eastbound	L	0.63	0.77	12	1
	T	0.84	0.82	1	-
	R	0.78	0.86	8	-
Westbound	L	0.79	0.76	2	-
	T	0.80	0.79	3	-
	R	0.90	0.68	7	3
Northbound	L	0.76	0.83	5	-
	T	0.69	0.86	9	-
	R	0.79	0.88	1	-
Southbound	L	0.46	0.79	-	1
	T	0.54	0.98	-	-
	R	0.55	0.64	2	2
Ardrey Kell Rd / Providence Rd					
Approach	Direction	PHF		Heavy Vehicle Percentage	
		AM	PM	AM	PM
Eastbound	L	0.90	0.81	-	1
	R	0.76	0.87	-	-
Northbound	L	0.82	0.59	1	-
	T	0.90	0.95	1	2
Southbound	T	0.87	0.82	3	1
	R	0.89	0.85	4	1
Providence Rd / Allison Woods Dr					
Approach	Direction	PHF		Heavy Vehicle Percentage	
		AM	PM	AM	PM
Eastbound	L	0.75	0.75	-	-
	R	0.66	0.75	-	-
Northbound	L	0.93	0.58	-	-
	T	0.93	0.83	1	2
Southbound	T	0.90	0.93	4	1
	R	0.58	0.81	-	-

Table 35: Comparison of Traffic Volumes Before and After Development, Cato Property Site, Charlotte

Tom Short Rd / Ballantyne Commons Pkwy							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	T	285	322	1.1	725	738	1.0
	R	14	58	4.1	96	220	2.3
Westbound	L	12	87	7.3	79	187	2.4
	T	647	790	1.2	567	612	1.1
Northbound	L	82	253	3.1	52	111	2.1
	R	26	226	8.7	39	128	3.3
Tom Short Rd / Ardrey Kell Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	8	51	6.4	20	37	1.9
	T	162	174	1.1	204	125	0.6
	R	22	50	2.3	89	76	0.9
Westbound	L	47	67	1.4	104	125	1.2
	T	125	388	3.1	132	63	0.5
	R	2	36	18.0	11	131	11.9
Northbound	L	67	122	1.8	37	76	2.1
	T	22	117	5.3	33	322	9.8
	R	110	133	1.2	84	168	2.0
Southbound	L	9	24	2.7	17	176	10.4
	T	21	46	2.2	56	280	5.0
	R	15	106	7.1	28	28	1.0
Ardrey Kell Rd / Providence Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	286	363	1.3	250	388	1.6
	R	69	73	1.1	173	174	1.0
Northbound	L	76	89	1.2	70	131	1.9
	T	118	1,046	8.9	849	882	1.0
Southbound	T	675	519	0.8	1,023	1,143	1.1
	R	174	286	1.6	232	184	0.8
Providence Rd / Allison Woods Dr							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	4	24	6.0	2	12	6.0
	R	4	8	2.0	2	12	6.0
Northbound	L	1	-	-	1	7	7.0
	T	1,408	1,652	1.2	1,124	1,494	1.3
Southbound	T	839	880	1.0	1,347	1,293	1.0
	R	6	14	2.3	5	68	13.6

Table 36: Comparison of Stops Before and After Development, Cato Property Site, Charlotte

Approach	Direction	AM			PM		
Tom Short Rd / Ballantyne Commons Pkwy							
		Before	After	Ratio	Before	After	Ratio
Eastbound	T	95	178	1.9	286	544	1.9
Westbound	T	290	621	2.1	281	586	2.1
Northbound	L	70	218	3.1	46	99	2.2
	R	11	23	2.1	12	24	2.0
Tom Short Rd / Ardrey Kell Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	7	30	4.3	12	27	2.3
	T	97	109	1.1	125	114	0.9
Westbound	L	29	35	1.2	56	95	1.7
	T	70	278	4.0	63	50	0.8
Northbound	L	44	87	2.0	28	39	1.4
	T	31	141	4.5	37	281	7.6
Southbound	L	9	16	1.8	14	123	8.8
	T	18	50	2.8	42	152	3.6
Ardrey Kell Rd / Providence Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	263	322	1.2	217	331	1.5
	R	11	11	1.0	30	41	1.4
Northbound	L	21	28	1.3	30	73	2.4
	T	35	784	22.4	336	543	1.6
Southbound	T	540	316	0.6	815	890	1.1
	R	-	4	NA	-	15	NA

Table 37: Comparison of 50th Percentile Queue Length Before and After Development, Cato Property Site, Charlotte

Tom Short Rd / Ballantyne Commons Pkwy							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	T	30	88	2.9	130	180	1.4
	R	-	-	NA	-	-	NA
Westbound	L	-	-	NA	-	-	NA
	T	93	592	6.4	119	378	3.2
Northbound	L	24	136	5.7	22	55	2.5
	R	-	-	NA	-	-	NA
Tom Short Rd / Ardrey Kell Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	1	10	10.0	2	12	6.0
	T	17	31	1.8	26	48	1.8
	R	-	-	NA	-	-	NA
Westbound	L	4	10	2.5	10	45	4.5
	T	12	79	6.6	13	19	1.5
	R	-	-	NA	-	-	NA
Northbound	L	7	27	3.9	4	12	3.0
	T	2	45	22.5	4	88	22.0
	R	-	-	NA	-	-	NA
Southbound	L	1	8	8.0	2	101	50.5
	T	2	20	10.0	6	46	7.7
Ardrey Kell Rd / Providence Rd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	291	306	1.1	289	412	1.4
	R	-	-	NA	16	28	NA
Northbound	L	23	25	1.1	25	133	5.3
	T	37	655	17.7	332	412	1.2
Southbound	T	438	276	0.6	1,476	1,388	0.9
	R	-	-	NA	-	11	NA

Table 38: Comparison of Delays and LOS Before and After Development, Cato Property Site, Charlotte

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
TIA Delays 2004				
Tom Short Rd / Ballantyne Commons Pkwy	6.1	A	7.0	A
Tom Short Rd / Ardrey Kell Rd	5.6	A	5.4	A
Ardrey Kell Rd / Providence Rd	25.0	C	42.0	D
Providence Rd / Allison Woods Dr	0.7	A	4.9	A
Computed Delays 2009				
Tom Short Rd / Ballantyne Commons Pkwy	53.0	D	175.3	F
Tom Short Rd / Ardrey Kell Rd	10.9	B	40.7	D
Ardrey Kell Rd / Providence Rd	26.6	C	96.1	F
Providence Rd / Allison Woods Dr	8.5	A	6.7	A

Table 39: Comparison of Traffic Volumes - Forecasted vs. Observed, Cato Property Site, Charlotte

Tom Short Rd / Ballantyne Commons Pkwy							
Approach	Direction	AM			PM		
		Forcasted	Observed	Ratio	Forcasted	Observed	Ratio
Eastbound	T	450	322	0.7	1,017	738	0.7
	R	116	58	0.5	312	220	0.7
Westbound	L	26	87	3.3	116	187	1.6
	T	920	790	0.9	787	612	0.8
Northbound	L	295	253	0.9	161	111	0.7
	R	52	226	4.3	58	128	2.2
Ardrey Kell Rd / Providence Rd							
Approach	Direction	AM			PM		
		Forcasted	Observed	Ratio	Forcasted	Observed	Ratio
Eastbound	L	546	363	0.7	449	388	0.9
	R	225	73	0.3	283	174	0.6
Northbound	L	166	89	0.5	129	131	1.0
	T	192	1,046	5.4	1,100	882	0.8
Southbound	T	891	519	0.6	1,274	1,143	0.9
	R	355	286	0.8	481	184	0.4

Table 40: Comparison of Stops - Forecasted vs. Computed, Cato Property Site, Charlotte

Tom Short Rd / Ballantyne Commons Pkwy								
Approach	Direction	AM			PM			
		Forcasted	Computed	Ratio	Forcasted	Computed	Ratio	
Eastbound	T	188	178	0.9	618	544	0.9	
	R	-	-	NA	8	-	-	
Westbound	L	8	-	NA	56	-	-	
	T	660	621	0.9	343	586	1.7	
Northbound	L	245	218	0.9	130	99	0.8	
	R	10	23	2.3	12	24	2.0	
Ardrey Kell Rd / Providence Rd								
Approach	Direction	AM			PM			
		Forcasted	Computed	Ratio	Forcasted	Computed	Ratio	
Eastbound	L	506	322	0.6	416	331	0.8	
	R	22	11	0.5	82	41	0.5	
Northbound	L	68	28	0.4	74	73	1.0	
	T	54	784	14.5	329	543	1.7	
Southbound	T	883	316	0.4	1,284	890	0.7	
	R	-	4	NA	-	15	NA	

Table 41: Comparison of 50th Percentile Queue Length - Forecasted vs. Computed, Cato Property Site, Charlotte

Tom Short Rd / Ballantyne Commons Pkwy							
Approach	Direction	AM			PM		
		Forcasted	Computed	Ratio	Forcasted	Computed	Ratio
Eastbound	T	112	88	0.8	322	180	0.6
	R	-	-	NA	-	-	NA
Westbound	L	5	-	-	26	-	-
	T	373	592	1.6	184	378	2.1
Northbound	L	156	136	0.9	79	55	0.7
	R	-	-	NA	-	-	NA
Ardrey Kell Rd / Providence Rd							
Approach	Direction	AM			PM		
		Forcasted	Computed	Ratio	Forcasted	Computed	Ratio
Eastbound	L	291	306	1.1	251	412	1.6
	R	-	-	NA	73	28	0.4
Northbound	L	62	25	0.4	80	133	1.7
	T	29	655	22.6	177	412	2.3
Southbound	T	502	276	0.5	715	1,388	1.9
	R	-	-	NA	-	11	NA

Table 42: Comparison of Delays and LOS - Forecasted vs. Computed, Cato Property Site, Charlotte

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
TIA Delays 2009				
Tom Short Rd / Ballantyne Commons Pkwy	16.4	B	11.1	B
Ardrey Kell Rd / Providence Rd	24.2	C	22.9	C
Computed Delays 2009				
Tom Short Rd / Ballantyne Commons Pkwy	53.0	D	175.3	F
Ardrey Kell Rd / Providence Rd	26.6	C	96.1	F

Table 43: Comparison of Stops - Observed vs. Computed, Cato Property Site, Charlotte

Tom Short Rd / Ballantyne Commons Pkwy							
Approach	Direction	AM			PM		
		Observed	Computed	Ratio	Observed	Computed	Ratio
Eastbound	T	78	178	2.3	209	544	2.6
Westbound	T	303	621	2.0	425	586	1.4
Northbound	L	217	218	1.0	95	99	1.0
	R	-	23	NA	-	24	NA
Tom Short Rd / Ardrey Kell Rd							
Approach	Direction	AM			PM		
		Observed	Computed	Ratio	Observed	Computed	Ratio
Eastbound	L	27	30	1.1	24	27	1.1
	T	84	109	1.3	166	114	0.7
Westbound	L	33	35	1.1	52	95	1.8
	T	141	278	2.0	84	50	0.6
Northbound	L	121	87	0.7	83	39	0.5
	T	87	141	1.6	73	281	3.8
Southbound	L	17	16	0.9	25	123	4.9
	T	65	50	0.8	108	152	1.4
Ardrey Kell Rd / Providence Rd							
Approach	Direction	AM			PM		
		Observed	Computed	Ratio	Observed	Computed	Ratio
Eastbound	L	318	322	1.0	462	331	0.7
	R	-	11	NA	-	41	NA
Northbound	L	31	28	0.9	88	73	0.8
	T	369	784	2.1	220	543	2.5
Southbound	T	179	316	1.8	367	890	2.4
	R	-	4	NA	-	15	NA

Table 44: Comparison of Delays and LOS – Observed vs. Computed, Cato Property Site, Charlotte

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
Observed Delays 2009				
Tom Short Rd / Ballantyne Commons Pkwy	11.4	B	5.9	A
Tom Short Rd / Ardrey Kell Rd	6.7	A	13.3	B
Ardrey Kell Rd / Providence Rd	34.0	C	26.0	C
Providence Rd / Allison Woods Dr.	50.0	E	33.0	D
Computed Delays 2009				
Tom Short Rd / Ballantyne Commons Pkwy	53.0	D	175.3	F
Tom Short Rd / Ardrey Kell Rd	10.9	B	40.7	D
Ardrey Kell Rd / Providence Rd	26.6	C	96.1	F
Providence Rd / Allison Woods Dr.	8.5	A	6.7	A

6.4 University Pointe Site, Charlotte

The MOEs obtained from the TIA, Synchro® analyses and field observations for University Pointe TIA case site are compared and discussed in this section. Only PM peak hour was analyzed in the TIA report and (hence) in this study. Table 45 shows the observed PHF and heavy vehicle percentages on the day of data collection.

6.4.1 Method 1: Study the Operational Performance Before and After the Development at the Site

The MOEs for "no build" condition obtained from the University Pointe site TIA are compared to the MOEs for the "build" condition computed using Synchro® traffic simulation software.

In Table 46, the traffic volumes for the "no build" condition from the University Pointe site TIA are compared with traffic volumes collected in the field for the "build" condition. While traffic volumes were generally observed to increase at North Tryon Street (US 29) / McCullough Drive intersection, a slight decrease in turning volumes was noticed at this intersection. At North Tryon Street (US 29) / The Commons at Chancellor Park Drive intersection, traffic volumes were observed to decrease in the northbound direction while an increase in traffic volume was noticed in southbound direction.

The number of stops and 50th percentile queue length distances from the University Pointe site TIA under “no build” condition were compared with the number of stops and 50th percentile queue length distances for the “build” condition from Synchro® analysis (Table 47 and Table 48, respectively). The number of stops and 50th percentile queue length distances were observed to follow similar trends as traffic volume. The growth in traffic and increase in the number of stops and 50th percentile queue length distance could be attributed to the two offsite developments and general annual growth in traffic.

The delay and LOS under “no build” condition are compared to delay and LOS for the “build” condition based on Synchro® analysis (Table 49). The North Tryon Street (US 29) / McCullough Drive intersection currently has the same LOS as in the “no build” condition. This is contrary to the expectation that the operational performance will be lower for the “build” condition due to increase in traffic volume. Better performance than expected could be primarily due to changes in signal phasing and timing patterns. The cycle length in the “no build” condition was 150 seconds while the intersection currently operates with a cycle length of 135 seconds.

The 3-legged unsignalized North Tryon Street (US 29) / The Commons at Chancellor Park Drive intersection in the “no build” condition was converted to a 4-legged signalized intersection in the “build” condition. An improvement in LOS from “F” to “D” was observed at this intersection after the directional crossover at 3-legged unsignalized intersection was converted to a 4-legged signalized intersection. The improvement can also attributed to the newly constructed southbound right turn lane and dual northbound left turn lanes at this intersection.

6.4.2 Method 2: Study the Effectiveness of Methods to Forecast the Operational Effects of the Development

The MOEs for the “build” condition obtained from the University Pointe site TIA are compared with the MOEs for the “build” condition computed using Synchro® traffic simulation software.

The traffic volumes in the TIA report were forecasted to the year 2010. These were converted to year 2009 traffic volumes using a 3 percent growth rate. In Table 50, the traffic volumes for the “build” condition from the University Pointe site TIA are compared with traffic volumes collected in the field for the “build” condition. The forecasted traffic volumes in the TIA are higher than the observed traffic volume (except on the westbound approach of North Tryon Street (US 29) / McCullough Drive intersection). One possible reason for lower observed traffic volumes could be due to the incomplete construction of the proposed adjacent University City Boulevard / US 29 intersection and partial development of the site during the period of study.

In Table 51, the numbers of stops for the “build” condition forecasted in the TIA are compared to those computed using Synchro® for the “build” condition. In Table 52, the 50th percentile queue length distance for the “build” condition from the University Pointe site TIA are compared to those computed using Synchro® for the “build” condition. The trends in results obtained are very similar to those observed in case of traffic volumes.

The delays at the study intersections forecasted in the TIA under “build” condition are compared to the delays computed using the Synchro® for the “build” condition (Table 53). The forecasted delays are higher than the computed delays at both the study intersections. This could be attributed to the incomplete construction of the adjacent intersection as discussed in the case of traffic volumes and different signal timing parameters used in the TIA.

6.4.3 Method 3: Study the Effectiveness of Analytical Procedures to Replicate Field Data

The number of stops and delay observed directly from the field are compared to those computed from the Synchro® analysis to examine the effectiveness of the analytical procedures to replicate field data. While the observed number of stops and the computed number of stops for the “build” condition are shown in Table 54, the observed average delay and computed average delay are shown in Table 55. The observed and computed number of stops does not follow any specific trends or patterns. At the North Tryon Street (US 29) / McCullough Drive intersection, the left turn stops on US 29 are higher than the observed number of stops while the through stops are lower than the observed number of stops. The number of stops at North Tryon Street (US 29) / The Commons at Chancellor Park Drive intersection are close to the Synchro® computed stops for a majority of the approaches. The observed average delays at the University Pointe TIA case site are higher the Synchro® computed delays while the LOS remained the same. This could be attributed to reasons as stated before.

Table 45: Observed PHF and Heavy Vehicle Percentages – University Pointe Site, Charlotte

North Tryon St (US 29) / McCullough Dr			
Approach	Direction	PHF	Heavy Vehicle Percentage
		PM	PM
Eastbound	L	0.91	-
	T	0.66	-
	R	0.92	4
Westbound	L	0.82	-
	T	0.54	-
	R	0.68	-
Northbound	L	0.76	2
	T	0.96	1
	R	0.87	-
Southbound	L	0.78	-
	T	0.91	4
	R	0.75	-
North Tryon St (US 29) / The Commons at Chancellor Park Dr			
Approach	Direction	PHF	Heavy Vehicle Percentage
		PM	PM
Eastbound	L	0.92	-
	T	0.75	-
	R	0.79	1
Westbound	L	0.9	-
	T	0.87	-
	R	0.86	2
Northbound	L	0.79	1
	T	0.93	2
	R	0.86	1
Southbound	L	0.85	-
	T	0.91	2
	R	0.82	1

Table 46: Comparison of Traffic Volumes Before and After Development, University Pointe Site, Charlotte

North Tryon St (US 29) / McCullough Dr				
Approach	Direction	PM		
		Before	After	Ratio
Eastbound	L	76	87	1.1
	T	24	21	0.9
	R	468	443	0.9
Westbound	L	17	30	1.8
	T	10	13	1.3
	R	29	56	1.9
Northbound	L	387	326	0.8
	T	963	1,113	1.2
	R	48	59	1.2
Southbound	L	32	47	1.5
	T	788	928	1.2
	R	60	33	0.6
North Tryon St (US 29) / The Commons at Chancellor Park Dr				
Approach	Direction	PM		
		Before	After	Ratio
Eastbound	L	NA	332	NA
	T	NA	114	NA
	R	NA	95	NA
Westbound	L	-	65	NA
	T	NA	59	NA
	R	157	135	0.9
Northbound	L	NA	302	NA
	T	1,306	1,111	0.9
	R	103	101	1.0
Southbound	L	151	217	1.4
	T	1,199	1,413	1.2
	R	NA	252	NA

Table 47: Comparison of Stops Before and After Development, University Pointe Site, Charlotte

North Tryon St (US 29) / McCullough Dr				
Approach	Direction	PM		
		Before	After	Ratio
Eastbound	L	71	82	1.2
	T	22	19	0.9
	R	389	342	0.9
Westbound	L	15	27	1.8
	T	9	11	1.2
	R	7	12	1.7
Northbound	L	327	317	1.0
	T	287	554	1.9
	R	3	9	3.0
Southbound	L	30	44	1.5
	T	418	599	1.4
	R	13	5	0.4
North Tryon St (US 29) / The Commons at Chancellor Park Dr				
Approach	Direction	PM		
		Before	After	Ratio
Eastbound	L	NA	305	NA
	T	NA	103	NA
	R	NA	10	NA
Westbound	L	NA	59	NA
	T	NA	53	NA
	R	NA	19	NA
Northbound	L	NA	275	NA
	T	NA	896	NA
	R	NA	6	NA
Southbound	L	NA	177	NA
	T	NA	1,159	NA
	R	NA	21	NA

Table 48: Comparison of 50th Percentile Queue Length Before and After Development, University Pointe Site, Charlotte

North Tryon St (US 29) / McCullough Dr				
Approach	Direction	PM		
		Before	After	Ratio
Eastbound	L	80	82	1.0
	T	24	26	1.1
	R	436	306	0.7
Westbound	L	17	30	1.8
	T	10	19	1.9
	R	-	6	NA
Northbound	L	191	201	1.1
	T	161	352	2.2
	R	-	6	NA
Southbound	L	17	25	1.5
	T	229	325	1.4
	R	10	-	-
North Tryon St (US 29) / The Commons at Chancellor Park Dr				
Approach	Direction	PM		
		Before	After	Ratio
Eastbound	L	NA	152	NA
	T	NA	121	NA
	R	NA	-	NA
Westbound	L	NA	60	NA
	T	NA	57	NA
	R	NA	-	NA
Northbound	L	NA	163	NA
	T	NA	449	NA
	R	NA	-	NA
Southbound	L	NA	225	NA
	T	NA	462	NA
	R	NA	-	NA

Table 49: Comparison of Delay and LOS Before and After Development, University Pointe Site, Charlotte

Intersection	PM Peak	
	Delay (sec/veh)	LOS
TIA Delays 2005		
North Tryon St (US 29) / McCullough Dr	24.6	C
North Tryon St (US 29) / The Commons at Chancellor Park Dr	2.3	A
Computed Delays 2009		
North Tryon St (US 29) / McCullough Dr	24.2	C
North Tryon St (US 29) / The Commons at Chancellor Park Dr	38.3	D

Table 50: Comparison of Traffic Volumes - Forecasted vs. Observed, University Pointe Site, Charlotte

North Tryon St (US 29) / McCullough Dr				
Approach	Direction	PM		
		Forecasted	Observed	Ratio
Eastbound	L	168	87	0.5
	T	27	21	0.8
	R	570	443	0.8
Westbound	L	19	30	1.5
	T	12	13	1.1
	R	33	56	1.7
Northbound	L	485	326	0.7
	T	1,803	1,113	0.6
	R	54	59	1.1
Southbound	L	36	47	1.3
	T	1,512	928	0.6
	R	89	33	0.4
North Tryon St (US 29) / The Commons at Chancellor Park Dr				
Approach	Direction	PM		
		Forecasted	Observed	Ratio
Eastbound	L	421	332	0.8
	T	29	114	3.9
	R	364	95	0.3
Westbound	L	92	65	0.7
	T	30	59	2.0
	R	274	135	0.5
Northbound	L	427	302	0.7
	T	1,720	1,111	0.6
	R	165	101	0.6
Southbound	L	224	217	1.0
	T	1,627	1,413	0.9
	R	337	252	0.7

Table 51: Comparison of Stops - Forecasted vs. Computed, University Pointe Site, Charlotte

North Tryon St (US 29) / McCullough Dr				
Approach	Direction	PM		
		Forecasted	Computed	Ratio
Eastbound	L	154	82	0.5
	T	23	19	0.8
	R	499	342	0.7
Westbound	L	17	27	1.6
	T	12	11	0.9
	R	12	12	1.0
Northbound	L	407	317	0.8
	T	1,165	554	0.5
	R	8	9	1.1
Southbound	L	32	44	1.4
	T	1,306	599	0.5
	R	28	5	0.2
North Tryon St (US 29) / The Commons at Chancellor Park Dr				
Approach	Direction	PM		
		Forecasted	Computed	Ratio
Eastbound	L	370	305	0.8
	T	26	103	4.0
	R	289	10	0.0
Westbound	L	86	59	0.7
	T	28	53	1.9
	R	243	19	0.1
Northbound	L	383	275	0.7
	T	1,464	896	0.6
	R	34	6	0.2
Southbound	L	203	177	0.9
	T	1,354	1,159	0.9
	R	19	21	1.1

Table 52: Comparison of 50th Percentile Queue Length - Forecasted vs. Computed, University Pointe Site, Charlotte

North Tryon St (US 29) / McCullough Dr				
Approach	Direction	PM		
		Forecasted	Computed	Ratio
Eastbound	L	180	82	0.5
	T	25	26	1.0
	R	559	306	0.5
Westbound	L	18	30	1.7
	T	11	19	1.7
	R	11	6	0.5
Northbound	L	228	201	0.9
	T	764	352	0.5
	R	7	6	0.9
Southbound	L	19	25	1.3
	T	790	325	0.4
	R	29	-	-
North Tryon St (US 29) / The Commons at Chancellor Park Dr				
Approach	Direction	PM		
		Forecasted	Computed	Ratio
Eastbound	L	258	152	0.6
	T	29	121	4.2
	R	302	-	-
Westbound	L	98	60	0.6
	T	31	57	1.8
	R	262	-	-
Northbound	L	227	163	0.7
	T	1,087	449	0.4
	R	37	-	-
Southbound	L	243	225	0.9
	T	972	462	0.5
	R	19	-	-

Table 53: Comparison of Delays and LOS - Forecasted vs. Computed, University Pointe Site, Charlotte

Intersection	PM Peak	
	Delay (sec/veh)	LOS
Forecasted TIA Delays 2009		
North Tryon St (US 29) / McCullough Dr	36.1	D
North Tryon St (US 29) / The Commons at Chancellor Park Dr	55.7	E
Computed Delays 2009		
North Tryon St (US 29) / McCullough Dr	24.2	C
North Tryon St (US 29) / The Commons at Chancellor Park Dr	38.3	D

Table 54: Comparison of Stops - Observed vs. Computed, University Pointe Site, Charlotte

North Tryon St (US 29) / McCullough Dr				
Approach	Direction	PM		
		Observed	Computed	Ratio
Eastbound	L	84	82	1.0
	T	18	26	1.4
Westbound	L	27	30	1.1
	T	10	19	1.9
Northbound	L	259	201	0.8
	T	183	352	1.9
Southbound	L	45	25	0.6
	T	234	325	1.4
North Tryon St (US 29) / The Commons at Chancellor Park Dr				
Approach	Direction	PM		
		Observed	Computed	Ratio
Eastbound	L	210	152	0.7
	T	72	121	1.7
Westbound	L	66	60	0.9
	T	56	57	1.0
Northbound	L	207	163	0.8
	T	436	449	1.0
Southbound	L	116	225	1.9
	T	456	462	1.0

Table 55: Comparison of Delays and LOS - Observed vs. Computed, University Pointe Site, Charlotte

Intersection	PM Peak	
	Delay (sec/veh)	LOS
Observed Delays 2009		
North Tryon St (US 29) / McCullough Dr	30.5	C
North Tryon St (US 29) / The Commons at Chancellor Park Dr	49.8	D
Computed Delays 2009		
North Tryon St (US 29) / McCullough Dr	24.2	C
North Tryon St (US 29) / The Commons at Chancellor Park Dr	38.3	D

6.5 Midway Plantation Development, Knightdale

The MOEs obtained from the TIA, Synchro® analyses and field observations for Midway Plantation Development TIA case site are compared and discussed in this section. Table 56 shows the observed PHF and heavy vehicle percentages at the study intersections on the day of data collection.

6.5.1 Method 1: Study the Operational Performance Before and After the Development at the Site

The MOEs for the "no build" condition were not provided in the Midway Plantation Development site TIA report. Upon discussions with the TIA consultant, it was found that the TIA study was not done for the base year. The traffic volumes for the base year were provided in the TIA report. These were used to determine the MOEs for the "no build" condition. The 2005 intersection geometric conditions were used in the analysis for the "no build" condition. The results obtained were compared to the MOEs for the "build" condition computed using Synchro® traffic simulation software.

In Table 57, the traffic volumes from the TIA report under the "no build" condition were compared to the traffic volumes collected in the field for the "build" condition. It was observed that traffic volumes do not follow a specific trend but increased on a majority of the approaches. The variations in traffic volumes could be attributed to growth in traffic due to three major offsite developments located in close proximity to the site. Another possible reason could be growth in traffic along Interstate-540.

The number of stops and 50th percentile queue length distances under the “no build” condition are compared with the number of stops and 50th percentile queue length distances for the “build” condition from Synchro® analysis (Table 58 and Table 59, respectively). The number of stops and 50th percentile queue length distances are observed to be similar to the trends in traffic volumes. The differences in results could be attributed to offsite development growth, changes in signal timing patterns, PHF and heavy vehicle percentages used in TIA analysis.

The delay and LOS under the “no build” condition are also compared to delay and LOS for the “build” condition based on Synchro® analysis (Table 60). The delay has increased and LOS decreased after the development than when compared to the “no build” condition (except for Knightdale Boulevard (US 64) / I–540 Southbound (Off)ramp intersection). The improvement in operational performance at this intersection can be attributed to restricting through and left turn movements and allowing free right turns along the southbound approach after the development in the “build” condition than when compared to “no build” condition.

No improvements were suggested at the Knightdale Boulevard (US 64) / I–540 Northbound (On)ramp intersection. The delays were noticed to increase substantially during AM and PM peak hours. The increase in delays at Knightdale Boulevard (US 64) / Site Driveway #1 (Hinton Oaks Boulevard) can be attributed to realignment of Lynwood Drive and signalization of intersection after constructing driveway from the site. The widening of Knightdale Boulevard (US 64) from four-lane to six-lane divided roadway throughout the study area might have controlled the increase in delay during the AM peak hours but unacceptable delays were observed during the PM peak hours.

6.5.2 Method 2: Study the Effectiveness of Methods to Forecast the Operational Effects of the Development

The MOEs for the “build” condition obtained from the Midway Plantation Development site TIA are compared with MOEs for the “build” condition computed using Synchro® traffic simulation software.

The TIA report provided the MOEs for the full build out year 2007. The traffic volumes for the year 2007 were interpolated using NCDOT forecasts for the years 2005 and 2025. The interpolation accounted for adjacent industrial developments and proposed I–540 in the study area. Since the majority of the offsite developments were in place, the traffic was projected to year 2009 using a background growth rate of 3 percent. The forecasted traffic volumes for the “build” condition for year 2009 are compared with observed traffic volumes from field (Table 61). In general, the forecasted 2009 traffic volumes from the TIA are higher than observed traffic volumes at the study intersections. The difference in forecasted and observed traffic volumes could be attributed to growth in traffic from the offsite developments and forecasted traffic from the proposed I–540 in the study area.

The forecasted number of stops and 50th percentile queue length distances for the “build” condition are compared with the computed number of stops and 50th percentile queue length distances for the “build” condition from Synchro® analysis (Table 62 and Table 63, respectively). The number of stops and 50th percentile queue length distances were observed to follow similar trends as traffic volumes at the study intersections.

The forecasted delay and LOS under the “build” conditions for the year 2009 are compared to the computed delay and LOS for the “build condition” based on Synchro® analysis (Table 64). The delays were forecasted for the year 2009 considering all the improvements in place. The TIA report indicates that the intersections were designed for a LOS “C”. The forecasted average intersection delay at Knightdale Boulevard (US 64) / I–540 Southbound (Off)ramp intersection are higher than computed average intersection delay using Synchro® traffic simulation software. This could be attributed to restricting through and left turn movements and allowing free right turns. The forecasted average intersection delay at all other intersections are lower than computed average intersection delay obtained from Synchro® analysis under the current conditions.

6.5.3 Method 3: Study the Effectiveness of Analytical Procedures to Replicate Field Data

The number of stops and delay observed directly from the field are compared to those computed from the Synchro® analysis to examine the effectiveness of the analytical procedures to replicate field data. The observed numbers of stops are generally lower than the computed number of stops for the “build” condition (Table 65). The observed average delay and computed delay for all the selected intersections are shown in Table

66. The observed field average delays at the Knightdale Boulevard (US 64) / Southbound (Off) ramp intersection are very close to the computed delays during the AM and PM peak hours. The observed field average delays at Knightdale Boulevard (US 64) / Northbound (On)ramp and Knightdale Boulevard (US 64) / Site Driveway #3 (Wide Waters Parkway) intersections are lower than the computed delays during the AM and PM peak hours. The computed delay at the Knightdale Boulevard (US 64) / Site Driveway #1 (Hinton Oaks Boulevard) intersection is close to field delay during AM peak hours and lower during PM peak hours.

Table 56: Observed PHF and Heavy Vehicle Percentages – Midway Plantation Development Site, Knightdale

Approach	Direction	PHF		Heavy Vehicle Percent	
Knightdale Blvd (US 64) / Southbound Off Ramp					
		AM	PM	AM	PM
Eastbound	T	0.93	0.89	7	2
	R	0.77	0.89	11	6
Westbound	L	0.76	0.84	2	1
	T	0.89	0.92	4	1
Southbound	R	0.90	0.90	1	1
Knightdale Blvd (US 64) / Northbound On Ramp					
Approach	Direction	PHF		Heavy Vehicle Percent	
		AM	PM	AM	PM
Eastbound	L	0.70	0.79	3	1
	T	0.79	0.86	13	1
Westbound	T	0.84	0.92	6	1
	R	0.82	0.93	6	1
Northbound	L	0.48	0.75	6	1
	T	0.25	0.25	-	-
	R	0.73	0.75	1	1
Knightdale Blvd (US 64) / Site Drive #1 (Hinton Oaks Blvd)					
Approach	Direction	PHF		Heavy Vehicle Percent	
		AM	PM	AM	PM
Eastbound	L	0.83	0.80	6	1
	T	0.82	0.92	6	3
	R	0.50	0.58	4	-
Westbound	L	0.85	0.79	2	-
	T	0.89	0.92	5	3
	R	0.68	0.79	14	-
Northbound	L	0.75	0.86	2	1
	T	0.25	0.75	-	-
	R	0.59	0.85	-	1
Southbound	L	0.38	0.97	25	-
	T	0.25	0.67	100	-
	R	0.25	0.53	-	6
Knightdale Blvd (US 64) / Site Drive #3 (Wide Waters Pkwy)					
Approach	Direction	PHF		Heavy Vehicle Percent	
		AM	PM	AM	PM
Eastbound	L	0.76	0.60	5	4
	T	0.84	0.87	8	3
	R	0.81	0.91	8	2
Westbound	L	0.70	0.75	-	2
	T	0.90	0.82	3	3
	R	0.50	0.83	7	2
Northbound	L	0.84	0.80	4	2
	T	0.28	0.43	-	-
	R	0.54	0.46	1	5
Southbound	L	0.71	0.77	10	1
	T	0.38	0.70	-	1
	R	0.88	0.45	-	1

Table 57 Comparison of Traffic Volumes Before and After Development, Midway Plantation Development, Knightdale

Knightdale Blvd (US 64) / Southbound Off Ramp							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	T	907	845	0.9	1,132	1,625	1.4
	R	275	71	0.3	337	85	0.3
Westbound	L	109	170	1.6	89	252	2.8
	T	1,294	1,007	0.8	1,034	924	0.9
Southbound	L	594	-	-	726	-	-
	R	248	285	1.1	303	379	1.3
Knightdale Blvd (US 64) / Northbound On Ramp							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	223	448	2.0	272	444	1.6
	T	1,278	824	0.6	1,586	3,029	1.9
Westbound	T	1,029	1,174	1.1	817	965	1.2
	R	653	558	0.9	535	367	0.7
Northbound	L	374	50	0.1	306	60	0.2
	T	-	4	NA	-	-	NA
	R	121	196	1.6	99	795	8.0
Knightdale Blvd (US 64) / Site Drive #1 (Hinton Oaks Blvd)							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	59	70	1.2	14	488	34.9
	T	1,113	1,278	1.1	1,394	2,327	1.7
	R	-	6	NA	-	30	NA
Westbound	L	40	51	1.3	32	73	2.3
	T	1,334	1,347	1.0	1,078	1,213	1.1
	R	43	19	0.4	10	44	4.4
Northbound	L	336	215	0.6	224	114	0.5
	T	5	-	-	1	21	21.0
	R	48	71	1.5	32	82	2.6
Southbound	L	9	3	0.3	36	85	2.4
	T	1	3	3.0	5	8	1.6
	R	12	3	0.3	50	38	0.8
Knightdale Blvd (US 64) / Site Drive #3 (Wide Waters Pkwy)							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	145	79	0.5	33	247	7.5
	T	978	877	0.9	1,416	3,017	2.1
	R	47	58	1.2	13	645	49.6
Westbound	L	32	70	2.2	9	264	29.3
	T	1,377	1,215	0.9	958	899	0.9
	R	96	26	0.3	22	152	6.9
Northbound	L	10	221	22.1	46	596	13.0
	T	-	27	NA	-	60	NA
	R	6	41	6.8	31	272	8.8
Southbound	L	20	37	1.9	77	260	3.4
	T	-	6	NA	-	73	NA
	R	30	56	1.9	116	138	1.2

Table 58: Comparison of Stops Before and After Development, Midway Plantation Development, Knightdale

Knightdale Blvd (US 64) / Southbound Off Ramp

Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	T	618	234	0.4	802	461	0.6
	R	189	-	-	238	-	-
Westbound	L	93	156	1.7	79	210	2.7
	T	748	-	-	307	-	-
Southbound	L	524	-	-	451	-	-
	R	84	-	-	137	1	0.0

Knightdale Blvd (US 64) / Northbound On Ramp

Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	211	371	1.8	267	256	1.0
	T	446	124	0.3	1,332	1,686	1.3
Westbound	T	160	754	4.7	177	911	5.1
	R	234	138	0.6	184	27	0.1
Northbound	L	353	26	0.1	292	26	0.1
	T	-	25	NA	-	26	NA
	R	110	54	0.5	91	482	5.3

Knightdale Blvd (US 64) / Site Drive #1 (Hinton Oaks Blvd)

Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	55	63	1.1	15	372	24.8
	T	248	559	2.3	100	1,218	12.2
	R	-	1	NA	-	6	NA
Westbound	L	39	47	1.2	20	71	3.6
	T	29	588	20.3	290	884	3.0
	R	-	3	NA	4	20	5.0
Northbound	L	310	205	0.7	209	109	0.5
	T	6	3	0.5	2	20	10.0
	R	41	66	1.6	28	73	2.6
Southbound	L	9	3	0.3	32	78	2.4
	T	2	3	1.5	6	19	3.2
	R	11	3	0.3	37	16	0.4

Knightdale Blvd (US 64) / Site Drive #3 (Wide Waters Pkwy)

Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	107	76	0.7	29	152	5.2
	T	225	439	2.0	98	2,610	26.6
	R	-	-	NA	-	-	NA
Westbound	L	31	63	2.0	10	246	24.6
	T	1,217	524	0.4	507	856	1.7
	R	53	8	0.2	8	107	13.4
Northbound	L	10	200	20.0	41	434	10.6
	T	6	65	10.8	28	178	6.4
	R	-	-	NA	-	-	NA
Southbound	L	19	36	1.9	72	245	3.4
	T	11	14	1.3	-	71	NA
	R	12	43	3.6	94	70	0.7

Table 59: Comparison of 50th Percentile Queue Length Before and After Development, Midway Plantation Development, Knightdale

Knightdale Blvd (US 64) / Southbound Off Ramp							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	T	233	85	0.4	301	176	0.6
	R	192	-	-	242	-	-
Westbound	L	104	210	2.0	85	347	4.1
	T	424	-	-	142	-	-
Southbound	L	592	-	-	1,190	-	-
	R	89	-	-	147	-	-
Knightdale Blvd (US 64) / Northbound On Ramp							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	114	358	3.1	151	184	1.2
	T	137	55	0.4	526	825	1.6
Westbound	T	38	374	9.8	62	465	7.5
	R	140	158	1.1	115	477	4.1
Northbound	L	189	72	0.4	155	46	0.3
	T	-	81	NA	-	46	NA
	R	114	80	0.7	95	2,437	25.7
Knightdale Blvd (US 64) / Site Drive #1 (Hinton Oaks Blvd)							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	30	57	1.9	7	348	49.7
	T	102	308	3.0	31	684	22.1
	R	-	2	NA	-	13	NA
Westbound	L	43	81	1.9	34	130	3.8
	T	10	300	30.0	132	517	3.9
	R	1	5	5.0	3	38	12.7
Northbound	L	167	208	1.2	111	96	0.9
	T	5	-	-	1	40	40.0
	R	42	170	4.0	22	127	5.8
Southbound	L	4	5	1.3	17	62	3.6
	T	1	17	17.0	5	50	10.0
	R	9	16	1.8	29	44	1.5
Knightdale Blvd (US 64) / Site Drive #3 (Wide Waters Pkwy)							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	45	73	1.6	15	181	12.1
	T	58	258	4.4	32	2,858	89.3
	R	-	-	NA	-	-	NA
Westbound	L	16	67	4.2	4	253	63.3
	T	463	283	0.6	185	545	2.9
	R	33	17	0.5	4	181	45.3
Northbound	L	5	159	31.8	22	734	33.4
	T	5	233	46.6	30	1,815	60.5
	R	-	-	NA	-	-	NA
Southbound	L	9	36	4.0	39	242	6.2
	T	8	35	4.4	-	149	NA
	R	8	73	9.1	99	132	1.3

Table 60: Comparison of Delays and LOS Before and After Development, Midway Plantation Development, Knightdale

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
TIA Delays 2005				
Knightdale Blvd (US 64) / SB Off Ramp	35.3	D	141.0	F
Knightdale Blvd (US 64) / NB On Ramp	18.3	B	21.5	C
Knightdale Blvd (US 64) / Site Dr #1 (Hinton Oaks Blvd)	12.6	B	13.6	B
Knightdale Blvd (US 64) / Site Dr #3 (Wide Waters Pkwy)	29.8	C	13.3	B
Computed Delays 2009				
Knightdale Blvd (US 64) / SB Off Ramp	7.8	A	16.1	B
Knightdale Blvd (US 64) / NB On Ramp	25.6	C	283.7	F
Knightdale Blvd (US 64) / Site Dr #1 (Hinton Oaks Blvd)	29.9	C	37.0	D
Knightdale Blvd (US 64) / Site Dr #3 (Wide Waters Pkwy)	34.5	C	282.0	F

Table 61: Comparison of Traffic Volumes - Forecasted vs. Observed, Midway Plantation Development, Knightdale

Knightdale Blvd (US 64) / Southbound Off Ramp							
Approach	Direction	AM			PM		
		Forecasted	Observed	Ratio	Forecasted	Observed	Ratio
Eastbound	T	1,222	845	0.7	1,762	1,628	0.9
	R	325	71	0.2	395	85	0.2
Westbound	L	208	170	0.8	274	252	0.9
	T	1,726	1,007	0.6	1,605	924	0.6
Southbound	L	-	-	NA	-	-	NA
	R	290	285	1.0	354	379	1.1
Knightdale Blvd (US 64) / Northbound On Ramp							
Approach	Direction	AM			PM		
		Forecasted	Observed	Ratio	Forecasted	Observed	Ratio
Eastbound	L	261	448	1.7	318	444	1.4
	T	1,742	824	0.5	2,555	3,029	1.2
Westbound	T	1,493	1,174	0.8	1,516	965	0.6
	R	878	558	0.6	861	367	0.4
Northbound	L	441	50	0.1	362	60	0.2
	T	-	4	NA	-	-	NA
	R	205	196	1.0	302	795	2.6
Knightdale Blvd (US 64) / Site Drive #1 (Hinton Oaks Blvd)							
Approach	Direction	AM			PM		
		Forecasted	Observed	Ratio	Forecasted	Observed	Ratio
Eastbound	L	273	70	0.3	489	488	1.0
	T	1401	1,278	0.9	2038	2,327	1.1
	R	-	6	NA	-	30	NA
Westbound	L	63	51	0.8	50	73	1.5
	T	1893	1,347	0.7	1813	1,213	0.7
	R	94	19	0.2	140	44	0.3
Northbound	L	401	215	0.5	267	114	0.4
	T	41	-	-	54	21	0.4
	R	50	71	1.4	66	82	1.2
Southbound	L	86	3	0.0	332	85	0.3
	T	20	3	0.1	69	8	0.1
	R	73	3	0.0	263	38	0.1
Knightdale Blvd (US 64) / Site Drive #3 (Wide Waters Pkwy)							
Approach	Direction	AM			PM		
		Forecasted	Observed	Ratio	Forecasted	Observed	Ratio
Eastbound	L	160	79	0.5	269	247	0.9
	T	1,239	877	0.7	1,689	3,017	1.8
	R	141	58	0.4	478	645	1.3
Westbound	L	95	70	0.7	332	264	0.8
	T	1,756	1,215	0.7	1,259	899	0.7
	R	70	26	0.4	118	152	1.3
Northbound	L	230	221	1.0	408	596	1.5
	T	33	27	0.8	72	60	0.8
	R	153	41	0.3	159	272	1.7
Southbound	L	69	37	0.5	359	260	0.7
	T	21	6	0.3	80	73	0.9
	R	56	56	1.0	248	138	0.6

Table 62: Comparison of Stops - Forecasted vs. Computed, Midway Plantation Development, Knightdale

Knightdale Blvd (US 64) / Southbound Off Ramp							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	T	533	234	0.4	1,461	461	0.3
	R	139	-	-	285	-	-
Westbound	L	141	156	1.1	246	210	0.9
	T	535	-	-	212	-	-
Southbound	L	-	-	NA	-	-	NA
	R	135	-	-	167	1	0.0
Knightdale Blvd (US 64) / Northbound On Ramp							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	L	242	371	1.5	301	256	0.9
	T	1,051	124	0.1	1,445	1,686	1.2
Westbound	T	222	754	3.4	318	911	2.9
	R	346	138	0.4	329	27	0.1
Northbound	L	406	26	0.1	337	26	0.1
	T	-	25	NA	-	26	NA
	R	183	54	0.3	216	482	2.2
Knightdale Blvd (US 64) / Site Drive #1 (Hinton Oaks Blvd)							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	L	265	63	0.2	466	372	0.8
	T	382	559	1.5	1,175	1,218	1.0
	R	-	588	NA	-	6	NA
Westbound	L	63	47	0.7	46	71	1.5
	T	548	596	1.1	1,091	884	0.8
	R	5	3	0.6	35	20	0.6
Northbound	L	373	66	0.2	252	109	0.4
	T	38	-	-	50	20	0.4
	R	40	68	1.7	55	73	1.3
Southbound	L	72	3	0.0	309	78	0.3
	T	20	3	0.2	64	19	0.3
	R	59	3	0.1	222	16	0.1
Knightdale Blvd (US 64) / Site Drive #3 (Wide Waters Pkwy)							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	L	138	76	0.6	247	152	0.6
	T	324	439	1.4	1,838	2,610	1.4
	R	-	-	NA	-	-	NA
Westbound	L	90	63	0.7	296	246	0.8
	T	1,544	524	0.3	927	856	0.9
	R	31	8	0.3	51	107	2.1
Northbound	L	213	200	0.9	368	434	1.2
	T	163	65	0.4	201	178	0.9
	R	-	-	NA	-	-	NA
Southbound	L	64	36	0.6	319	245	0.8
	T	25	14	0.6	74	71	1.0
	R	33	43	1.3	217	70	0.3

Table 63: Comparison of 50th Percentile Queue Length - Forecasted vs. Computed, Midway Plantation Development, Knightdale

Knightdale Blvd (US 64) / Southbound Off Ramp							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	T	190	85	0.4	551	176	0.3
	R	132	-	-	287	-	-
Westbound	L	305	210	0.7	249	347	1.4
	T	204	-	-	15	-	-
Southbound	L	-	-	NA	-	-	NA
	R	149	-	-	181	-	-
Knightdale Blvd (US 64) / Northbound On Ramp							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	L	142	358	2.5	173	184	1.1
	T	387	55	0.1	769	825	1.1
Westbound	T	66	374	5.7	116	465	4.0
	R	499	158	0.3	209	477	2.3
Northbound	L	229	72	0.3	187	46	0.2
	T	-	81	NA	-	46	NA
	R	207	80	0.4	432	2,437	5.6
Knightdale Blvd (US 64) / Site Drive #1 (Hinton Oaks Blvd)							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	L	143	57	0.4	260	348	1.3
	T	142	308	2.2	415	684	1.6
	R	-	2	NA	-	13	NA
Westbound	L	67	81	1.2	47	130	2.8
	T	135	300	2.2	355	517	1.5
	R	6	5	0.8	36	38	1.1
Northbound	L	198	208	1.1	135	96	0.7
	T	40	-	-	53	40	0.8
	R	43	170	4.0	44	127	2.9
Southbound	L	38	5	0.1	167	62	0.4
	T	19	17	0.9	66	50	0.8
	R	61	16	0.3	162	44	0.3
Knightdale Blvd (US 64) / Site Drive #3 (Wide Waters Pkwy)							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	L	73	73	1.0	129	181	1.4
	T	110	258	2.3	846	2,858	3.4
	R	-	-	NA	-	-	NA
Westbound	L	47	67	1.4	176	253	1.4
	T	564	283	0.5	348	545	1.6
	R	20	17	0.9	26	181	7.0
Northbound	L	114	159	1.4	205	734	3.6
	T	170	233	1.4	236	1,815	7.7
	R	-	-	NA	-	-	NA
Southbound	L	35	36	1.0	197	242	1.2
	T	27	35	1.3	78	149	1.9
	R	35	73	2.1	223	132	0.6

Table 64: Comparison of Delays and LOS - Forecasted vs. Computed, Midway Plantation Development, Knightdale

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
TIA Delays 2009				
Knightdale Blvd (US 64) / SB Off Ramp	32.6	C	25.4	C
Knightdale Blvd (US 64) / NB On Ramp	25.6	C	33.6	C
Knightdale Blvd (US 64) / Site Dr #1 (Hinton Oaks Blvd)	20.0	C	28.6	C
Knightdale Blvd (US 64) / Site Dr #3 (Wide Waters Pkwy)	32.8	C	52.5	D
Computed Delays 2009				
Knightdale Blvd (US 64) / SB Off Ramp	7.8	A	16.1	B
Knightdale Blvd (US 64) / NB On Ramp	25.6	C	283.7	F
Knightdale Blvd (US 64) / Site Dr #1 (Hinton Oaks Blvd)	29.6	C	37.0	D
Knightdale Blvd (US 64) / Site Dr #3 (Wide Waters Pkwy)	34.5	C	282.0	F

Table 65: Comparison of Stops - Observed vs. Computed, Midway Plantation Development, Knightdale

Knightdale Blvd (US 64) / Southbound Off Ramp							
Approach	Direction	AM			PM		
		Observed	Computed	Ratio	Observed	Computed	Ratio
Eastbound	T	82	234	2.9	67	461	6.9
Westbound	L	149	156	1.0	184	210	1.1
Knightdale Blvd (US 64) / Northbound On Ramp							
Approach	Direction	AM			PM		
		Observed	Computed	Ratio	Observed	Computed	Ratio
Eastbound	L	275	371	1.3	191	256	1.3
	T	53	124	2.3	175	1,686	9.6
Westbound	T	152	754	5.0	216	911	4.2
Northbound	L	41	26	0.6	39	26	0.7
	T	-	-	NA	-	-	NA
Knightdale Blvd (US 64) / Site Drive #1 (Hinton Oaks Blvd)							
Approach	Direction	AM			PM		
		Observed	Computed	Ratio	Observed	Computed	Ratio
Eastbound	L	46	63	1.4	285	372	1.3
	T	107	559	5.2	338	1,218	3.6
Westbound	L	43	47	1.1	45	71	1.6
	T	203	588	2.9	638	884	1.4
Northbound	L	159	205	1.3	80	109	1.4
	T	5	3	0.6	24	20	0.8
Southbound	L	3	3	1.0	80	78	1.0
	T	3	3	1.0	6	19	3.2
Knightdale Blvd (US 64) / Site Drive #3 (Wide Waters Pkwy)							
Approach	Direction	AM			PM		
		Observed	Computed	Ratio	Observed	Computed	Ratio
Eastbound	L	70	76	1.1	169	152	0.9
	T	367	439	1.2	459	2,610	5.7
Westbound	L	71	63	0.9	194	246	1.3
	T	418	524	1.3	385	856	2.2
Northbound	L	151	200	1.3	209	434	2.1
	T	14	65	4.6	39	178	4.6
Southbound	L	36	36	1.0	221	245	1.1
	T	8	14	1.8	54	71	1.3

Table 66: Comparison of Delays and LOS - Observed vs. Computed, Midway Plantation Development, Knightdale

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
Observed Delays 2009				
Knightdale Blvd (US 64) / SB Off Ramp	9.2	A	15.9	B
Knightdale Blvd (US 64) / NB On Ramp	27.9	C	25.7	C
Knightdale Blvd (US 64) / Site Dr #1 (Hinton Oaks Blvd)	27.0	C	73.2	F
Knightdale Blvd (US 64) / Site Dr #3 (Wide Waters Pkwy)	28.4	C	52.9	E
Computed Delays 2009				
Knightdale Blvd (US 64) / SB Off Ramp	7.8	A	16.1	B
Knightdale Blvd (US 64) / NB On Ramp	25.6	C	283.7	F
Knightdale Blvd (US 64) / Site Dr #1 (Hinton Oaks Blvd)	29.6	C	37.0	D
Knightdale Blvd (US 64) / Site Dr #3 (Wide Waters Pkwy)	34.5	C	282.0	F

6.6 Proposed Retail Development, Youngsville

The MOEs obtained from the TIA, Synchro® analyses and field observations for Proposed Retail Development TIA case site are compared and discussed in this section. Table 67 shows the observed peak hour factor (PHF) and heavy vehicle percentages at the study intersections on the day of data collection.

6.6.1 Method 1: Study the Operational Performance Before and After the Development at the Site

The "no build" condition MOEs obtained from Proposed Retail Development site TIA are compared to the MOEs for the "build" condition computed using Synchro® traffic simulation software.

The traffic volumes (Table 68) from the TIA report under "no build" condition are compared with traffic volumes collected in the field for the "build" condition. It was observed that traffic volumes slightly decreased on a majority of the approaches at US 1 / NC 96 signalized intersection during the AM peak hours and increased during the PM peak hours. However, the variations observed in the traffic volume are very low at this intersection. At US 1 / Mosswood Boulevard unsignalized intersection, traffic volumes were observed to decrease or remain the same during the AM and PM peak hours after the site development.

The number of stops and 50th percentile queue length distances under "no build" condition were compared with the number of stops and 50th percentile queue length distances for the “build” condition from Synchro® analysis (Table 69 and Table 70, respectively). The number of stops at NC 96 and US 1 was observed to be similar to the trends in traffic volumes. Note that the numbers are very low though the ratio was observed to be high. The 50th percentile queue length was observed to increase at the US 1 / NC 96 intersection.

The delay and LOS under “no build” condition are compared to delay and LOS for the “build” condition based on Synchro® analysis (Table 71). The delay and LOS conditions slightly increased during the AM peak hours and increased considerably during the PM peak hours at the US 1 / NC 96 intersection. This can be attributed to an increase in traffic volume during the PM peak hours and due to presence of 2 access points each at an approximate distance of 450 feet on the northbound and westbound approaches of the intersection. At US 1 / Mosswood Boulevard intersection, the delays decreased during the AM peak hours (possibly due to decrease in traffic volumes) and increased during the PM peak hours. The installation directional crossover had no effect on this intersection. The variations could be due to significant difference in PHF used in the TIA report and increase in traffic volumes.

6.6.2 Method 2: Study the Effectiveness of Methods to Forecast the Operational Effects of the Development

The MOEs for the “build” condition obtained from Proposed Retail Development site TIA are compared with MOEs for the “build” condition computed using Synchro® traffic simulation software.

The TIA provided the MOEs for the full build out year 2008 using traffic projections with a background growth rate of 3 percent. The forecasted traffic volumes for the year 2008 in the TIA were projected to year 2009 using the same growth rate used in the TIA report. The projected traffic volumes for the “build” condition in the year 2009 are compared with observed traffic volumes from the field (Table 72). The forecasted traffic volumes are higher than observed traffic volumes at the study intersections.

The forecasted number of stops and 50th percentile queue length distances for the “build” condition obtained from projected traffic volumes were compared with the computed number of stops and 50th percentile queue length distances for the “build” condition from Synchro® analysis (Table 73 and Table 74, respectively). The number of stops and 50th percentile queue length distance at US 1 / NC 96 signalized intersection were observed to be similar to the trends in traffic volumes. As US 1 / Mosswood Boulevard intersection is unsignalized, the number of stops and 50th percentile queue length were not produced in Synchro®.

The forecasted delay and LOS for the year 2009 under the "build" condition are compared to the computed delay and LOS for the "build" condition based on Synchro® analysis (Table 75). The delays were forecasted for the year 2009 considering that all the improvements are in place. The forecasted delays at US 1 / NC 96 intersection are higher than the computed delays. This can be attributed to the decrease in traffic volumes observed at the intersection. The delays at US 1 / Mosswood Boulevard increased slightly during the AM peak hours while the LOS remained the same. The LOS during the PM peak hours was computed to be "F" while the TIA report showed an error for delay and LOS.

6. 6.3 Method 3: Study the Effectiveness of Analytical Procedures to Replicate Field Data

The number of stops and delay observed directly from the field are compared to those computed from the Synchro® analysis to examine the effectiveness of the analytical procedures to replicate field data. The numbers of stops observed are compared to the computed number of stops for the "build" condition in Table 76. The numbers of stops observed in the field are generally close to the computed number of stops (except for three turning movements).

The observed average delay and computed average delay for intersections are shown in Table 77. The observed field average delays at US 1 / NC 96 are very close to the computed delays during the AM and PM peak hours. The LOS was also observed to be the same. The observed field average delays at US 1 / Mosswood Boulevard unsignalized intersection are lower than the computed average delays while the LOS remained the same.

Table 67: Observed PHF and Heavy Vehicle Percentages – Retail Development Site, Youngsville

US 1 / NC 96					
Approach	Direction	PHF		Heavy Vehicle Percent	
		AM	PM	AM	PM
Eastbound	L	0.71	0.75	3	7
	T	0.89	0.90	4	11
	R	0.94	0.80	7	5
Westbound	L	0.79	0.74	8	3
	T	0.83	0.88	6	3
	R	0.71	0.78	9	2
Northbound	L	0.78	0.81	3	1
	T	0.81	0.88	2	3
	R	0.61	0.78	2	4
Southbound	L	0.50	71.00	13	2
	T	0.75	0.94	4	5
	R	0.72	0.69	7	7
US 1 / Mosswood Blvd					
Approach	Direction	AM		PM	
		Before	After	Before	After
Eastbound	L	1.00	0.67	-	-
	T	0.50	0.50	-	-
	R	0.77	0.89	2	-
Westbound	L	0.75	0.26	17	4
	T	0.25	0.25	-	-
	R	0.38	0.25	33	6
Northbound	L	0.72	0.25	4	3
	T	0.86	0.91	3	3
	R	0.68	0.50	-	25
Southbound	L	0.63	0.39	6	-
	T	0.91	0.92	4	4
	R	0.25	0.63	-	-

Table 68: Comparison of Traffic Volumes Before and After Development, Proposed Retail Development, Youngsville

US 1 / NC 96							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	67	48	0.7	41	33	0.8
	T	143	124	0.9	150	155	1.0
	R	150	120	0.8	94	106	1.1
Westbound	L	48	63	1.3	90	101	1.1
	T	123	139	1.1	123	126	1.0
	R	18	17	0.9	21	37	1.8
Northbound	L	86	103	1.2	192	226	1.2
	T	538	618	1.1	945	758	0.8
	R	97	90	0.9	71	59	0.8
Southbound	L	21	20	1.0	14	37	2.6
	T	792	606	0.8	577	666	1.2
	R	78	52	0.7	64	47	0.7
US 1 / Mosswood Blvd							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	3	4	1.3	5	8	1.6
	T	10	4	0.4	1	2	2.0
	R	51	49	1.0	35	39	1.1
Westbound	L	49	27	0.6	113	58	0.5
	T	5	1	0.2	7	-	-
	R	30	3	0.1	25	13	0.5
Northbound	L	29	23	0.8	53	51	1.0
	T	740	810	1.1	1,085	1,042	1.0
	R	130	60	0.5	320	28	0.1
Southbound	L	38	10	0.3	9	11	1.2
	T	1,003	864	0.9	740	930	1.3
	R	1	-	-	2	5	2.5

Table 69: Comparison of Stops Before and After Development, Proposed Retail Development, Youngsville

US 1 / NC 96							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	44	35	0.8	29	20	0.7
	T	205	188	0.9	175	210	1.2
	R	-	-	NA	-	-	NA
Westbound	L	35	54	1.5	69	89	1.3
	T	92	97	1.1	98	97	1.0
	R	-	-	NA	-	-	NA
Northbound	L	69	89	1.3	148	189	1.3
	T	283	416	1.5	461	545	1.2
	R	24	9	0.4	22	8	0.4
Southbound	L	20	18	0.9	15	33	2.2
	T	580	446	0.8	398	554	1.4
	R	32	9	0.3	26	11	0.4

Table 70: Comparison of 50th Percentile Queue Length Before and After Development, Proposed Retail Development, Youngsville

US 1 / NC 96							
Approach	Direction	AM			PM		
		Before	After	Ratio	Before	After	Ratio
Eastbound	L	23	37	1.6	14	21	1.5
	T	107	151	1.4	87	195	2.2
	R	-	-	NA	-	-	NA
Westbound	L	17	26	1.5	34	50	1.5
	T	50	89	1.8	50	91	1.8
	R	-	-	NA	-	-	NA
Northbound	L	36	84	2.3	75	201	2.7
	T	58	201	3.5	108	254	2.4
	R	7	2	0.3	8	4	0.5
Southbound	L	9	26	2.9	5	38	7.6
	T	162	175	1.1	113	242	2.1
	R	15	3	0.2	10	7	0.7

Table 71: Comparison of Delays and LOS Before and After Development, Proposed Retail Development, Youngsville

Intersection	AM Peak		PM Peak	
	Delay(sec/veh)	LOS	Delay(sec/veh)	LOS
TIA Delays 2005				
US 1 / NC 96	19.3	B	17.4	B
US 1 / Mosswood Blvd	16.0	B	606.1	F
Computed Delays 2009				
US 1 / NC 96	28.9	C	36.0	D
US 1 / Mosswood Blvd	6.4	A	992.5	F

Table 72: Comparison of Traffic Volumes - Forecasted vs. Observed, Proposed Retail Development, Youngsville

US 1 / NC 96							
Approach	Direction	AM			PM		
		Forecasted	Observed	Ratio	Forecasted	Observed	Ratio
Eastbound	L	75	48	0.6	46	33	0.7
	T	195	124	0.6	239	155	0.6
	R	183	120	0.7	148	106	0.7
Westbound	L	140	63	0.4	415	101	0.2
	T	152	139	0.9	169	126	0.7
	R	56	17	0.3	99	37	0.4
Northbound	L	168	103	0.6	470	226	0.5
	T	660	618	0.9	1,246	758	0.6
	R	109	90	0.8	80	59	0.7
Southbound	L	104	20	0.2	210	37	0.2
	T	928	606	0.7	723	666	0.9
	R	88	52	0.6	72	47	0.7
US 1 / Mosswood Blvd							
Approach	Direction	AM			PM		
		Forecasted	Observed	Ratio	Forecasted	Observed	Ratio
Eastbound	L	3	4	1.3	5	8	1.6
	T	11	4	0.4	1	2	1.9
	R	58	49	0.8	39	39	1.0
Westbound	L	56	27	0.5	127	58	0.5
	T	5	1	0.2	8	-	-
	R	42	3	0.1	44	13	0.3
Northbound	L	33	23	0.7	60	51	0.9
	T	1,002	810	0.8	1,610	1,042	0.6
	R	146	60	0.4	361	28	0.1
Southbound	L	48	108	2.2	27	11	0.4
	T	1,258	864	0.7	1,205	930	0.8
	R	1	-	-	2	5	2.4

Table 73: Comparison of Stops - Forecasted vs. Computed, Proposed Retail Development, Youngsville

US 1 / NC 96							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	L	63	35	0.6	44	20	0.5
	T	161	188	1.2	219	210	1.0
	R	39	-	NA	50	NA	NA
Westbound	L	120	54	0.5	383	89	0.2
	T	165	97	0.6	214	97	0.5
	R	-	-	NA	-	NA	NA
Northbound	L	141	89	0.6	425	189	0.4
	T	441	416	0.9	1,120	545	0.5
	R	16	9	0.6	18	8	0.4
Southbound	L	88	18	0.2	190	33	0.2
	T	772	446	0.6	662	554	0.8
	R	24	9	0.4	29	11	0.4

Table 74: Comparison of 50th Percentile Queue Length - Forecasted vs. Computed, Proposed Retail Development, Youngsville

US 1 / NC 96							
Approach	Direction	AM			PM		
		Forecasted	Computed	Ratio	Forecasted	Computed	Ratio
Eastbound	L	57	37	0.6	59	21	0.4
	T	143	151	1.1	300	195	0.7
	R	25	-	-	58	-	-
Westbound	L	54	26	0.5	273	50	0.2
	T	148	89	0.6	289	91	0.3
	R	-	-	NA	-	-	NA
Northbound	L	125	84	0.7	574	201	0.4
	T	205	201	1.0	770	254	0.3
	R	10	2	0.2	22	4	0.2
Southbound	L	78	26	0.3	265	38	0.1
	T	344	175	0.5	468	242	0.5
	R	19	3	0.2	36	7	0.2

Table 75: Comparison of Delays and LOS - Forecasted vs. Computed, Proposed Retail Development, Youngsville

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
TIA Delays 2009				
US 1 / NC 96	36.6	D	62.0	E
US 1 / Mosswood Blvd	5.0	A	ERR	NA
Computed Delays 2009				
US 1 / NC 96	28.9	C	36.0	D
US 1 / Mosswood Blvd	6.4	A	992.5	F

Table 76: Comparison of Stops - Observed vs. Computed, Proposed Retail Development, Youngsville

US 1 / NC 96							
Approach	Direction	AM			PM		
		Observed	Computed	Ratio	Observed	Computed	Ratio
Eastbound	L	34	35	1.0	27	20	0.7
	T	93	188	2.0	113	210	1.9
Westbound	L	69	54	0.8	106	89	0.8
	T	94	97	1.0	111	97	0.9
Northbound	L	87	89	1.0	169	189	1.1
	T	160	416	2.6	464	545	1.2
Southbound	L	24	18	0.8	39	33	0.8
	T	354	446	1.3	427	554	1.3

Table 77: Comparison of Delays and LOS - Observed vs. Computed, Proposed Retail Development, Youngsville

Intersection	AM Peak		PM Peak	
	Delay(sec/veh)	LOS	Delay(sec/veh)	LOS
Observed Delays 2009				
US 1 / NC 96	34.5	C	41.3	D
US 1 / Mosswood Blvd	15.8	B	150	F
Computed Delays 2009				
US 1 / NC 96	28.9	C	36.0	D
US 1 / Mosswood Blvd	6.4	A	992.5	F

6.7 Effectiveness of Treatments

In this case, descriptive analysis was conducted to compare intersection delay before and after the development to study if there was an increase or decrease in the intersection delay due to deployed treatments. The treatments installed at the TIA sites included median, additional right turn or left turn lane, additional approach, traffic signals, increase or decrease in cycle length, access points and uninstallation of directional crossovers.

Table 78 shows a summary of results obtained for the intersection nearest to the site based on the treatment adopted. It was observed that intersection delay has increased (degradation in operational performance) even with incomplete development at all the intersections near the sites after construction of the development and deployment of various treatments.

Table 79 shows a summary of results for all the intersections considered for analysis at each site. An increase in intersection delay was observed at most of the selected intersections. The only (adjacent) intersections where a decrease in intersection delay was observed are 1) E. WT. Harris Boulevard / Grier Road intersection and Rocky River Road / Grier Road intersection (WT. Harris Primax TIA case site), 2) North Tryon Street / The Commons at Chancellor Park Drive intersection (University Pointe TIA case site), 3) Knightdale Boulevard / I 540 SB Ramp intersection (Midway Plantation TIA case site), and 4) (US 1 / Mosswood Boulevard intersection (Retail Development TIA case site, Youngsville). In general, the reasons for decrease in intersection delay cannot be attributed to a specific treatment. At Knightdale Boulevard / I 540 SB Ramp intersection, the decrease in intersection delay can probably be attributed to conversion of full movement southbound approach to free right turning approach.

Table 78: Intersection Delay Before and After Development by Treatment and TIA Case Site

Treatment at Intersection near Site	WT. Harris Primax Site		Mt. Island Square Site		Cato Property Site		University Pointe Site	Midway Plantation Site		Retail Development Site	
Counter measure	**AM**	**PM**	**AM**	**PM**	**AM**	**PM**	**PM**	**AM**	**PM**	**AM**	**PM**
Median installation											
Additional right turn lane							I				
Additional left turn lane	I	I	I	I			I	I	I		
Traffic signal installation			I	I			I				
Reducing cycle length					I	I					
Increasing cycle length	I	I								I	I
Additional approach							I	I	I		
Access points within functional boundary											
Uninstallation of directional crossover							I				
No measures											

Note: I indicates increase and D indicates decrease in intersection delay.

Table 79: Intersection Delay Before and After Development by TIA Case Site

<table>
<tr><th rowspan="3">Site</th><th rowspan="3">Intersection</th><th colspan="4">Intersection Delays</th></tr>
<tr><th colspan="2">AM</th><th colspan="2">PM</th></tr>
<tr><th>Before</th><th>After</th><th>Before</th><th>After</th></tr>
<tr><td rowspan="3">WT. Harris Primax Site, Charlotte</td><td>E. WT. Harris Blvd & Rocky River Rd</td><td colspan="2">I</td><td colspan="2">I</td></tr>
<tr><td>E. WT. Harris Blvd & Grier Rd</td><td colspan="2">D</td><td colspan="2">I</td></tr>
<tr><td>Rocky River Rd & Grier Rd</td><td colspan="2">D</td><td colspan="2">I</td></tr>
<tr><td rowspan="2">Mt. Island Square Site, Charlotte</td><td>Mt. Holly Huntersville Rd & Brookshire Blvd</td><td colspan="2">I</td><td colspan="2">I</td></tr>
<tr><td>Mt. Holly Huntersville Rd & Callabridge Ct</td><td colspan="2">I</td><td colspan="2">I</td></tr>
<tr><td rowspan="3">Cato Property, Charlotte</td><td>Tom Short Rd & Ballantyne Commons Pkwy</td><td colspan="2">I</td><td colspan="2">I</td></tr>
<tr><td>Tom Short Rd & Ardrey Kell Rd</td><td colspan="2">I</td><td colspan="2">I</td></tr>
<tr><td>Ardrey Kell Rd & Providence Rd</td><td colspan="2">I</td><td colspan="2">I</td></tr>
<tr><td rowspan="2">University Pointe, Charlotte</td><td>North Tryon St & Commons at Chancellor Dr</td><td colspan="2"></td><td colspan="2">I</td></tr>
<tr><td>North Tryon St & McCullough Dr</td><td colspan="2"></td><td colspan="2">D</td></tr>
<tr><td rowspan="4">Midway Plantation Site, Knightdale</td><td>Knightdale Blvd & I 540 SB Ramp</td><td colspan="2">D</td><td colspan="2">D</td></tr>
<tr><td>Knightdale Blvd & I 540 NB Ramp</td><td colspan="2">I</td><td colspan="2">I</td></tr>
<tr><td>Knightdale Blvd & Hinton Oaks Dr</td><td colspan="2">I</td><td colspan="2">I</td></tr>
<tr><td>Knightdale Blvd & Widewaters Pkwy</td><td colspan="2">I</td><td colspan="2">I</td></tr>
<tr><td rowspan="2">Retail Development Site, Youngsville</td><td>US 1 & NC 96</td><td colspan="2">I</td><td colspan="2">I</td></tr>
<tr><td>US 1 & Mosswood Blvd</td><td colspan="2">D</td><td colspan="2">I</td></tr>
</table>

Note: I indicates increase and D indicates decrease in intersection delay. Intersections shown in bold font are the intersections nearest to the site while others are adjacent intersections.

6.8 Statistical Analysis

As discussed in Section 3.6, T-test was conducted to study if the total control delay from Method 2 and Method 3 are significantly different. The total control delay based on through and left turn movements for each approach of all study intersections excluding two intersections was used for statistical analysis for Method 2. The two intersections were excluded as geometric conditions and site conditions as forecasted in the TIA reports for the respective sites are different from what exists in the field right now. The excluded intersections are Mt. Holly Huntersville Road / Callabridge Court intersection and Knightdale Boulevard (US 64) / I- 540 Southbound Ramp. The Mt. Holly Huntersville Road / Callabridge Court intersection was forecasted to be a 4-legged signalized intersection in the TIA report. However, it was observed to be a 3-legged signalized intersection in 2009. Similarly, southbound approach of Knightdale Boulevard (US 64) / I- 540 Southbound Ramp was forecasted to be a full movement approach but was observed to be a free right turn approach in 2009.

The results obtained from statistical analysis based on Method 2 outcomes are shown in Table 80. It can be observed that total control delays forecasted in the TIA are not significantly different than the computed total control delay (null hypothesis was accepted) during the AM peak hour. However, the results are significantly different during the PM peak hours (null hypothesis was rejected). The positive T-stat indicates that total control delays forecasted in the TIA are generally greater than total control delay estimated using Synchro® in this study.

The results obtained from statistical analysis based on Method 3 outcomes are shown in Table 81. The null hypothesis was rejected during both the AM and PM peak hours. This indicates that the difference in total control delay from field observations and those computed using Synchro® in this study are statistically insignificant. It should be noted that PHF and heavy vehicle percentages from field data were used in computing MOEs in this study.

Table 80: Statistical Analysis Results for Method 2

Significance Level	Peak Hour	T- stat	T- critical	P- value	Decision
0.10	AM	1.10	1.65	0.27	Accept Null Hypothesis
	PM	1.70	1.65	0.08	Reject Null Hypothesis

Table 81: Statistical Analysis Results for Method 3

Significance Level	Peak Hour	T-stat	T- critical	P- value	Decision
0.10	AM	1.93	1.65	0.050	Reject Null Hypothesis
	PM	3.36	1.36	0.001	Reject Null Hypothesis

CHAPTER 7: CONCLUSIONS

The focus of this research study was to conduct an evaluation of tools and methods to estimate traffic operational performance of intersections at select identified TIA case sites. The evaluation was conducted using three different methods. The first method was used to compare the operational performance at selected intersections before and after the construction of the new development proposed in the TIA study using Synchro® traffic simulation software. The second method was used to compare "what was forecasted to happen after the development?" with "what is happening after the development?" using Synchro® traffic simulation software. The third method was used to compare outcomes obtained using Synchro® traffic simulation software with field observations after the development.

The study found that measures of effectiveness (MOEs) such as the number of stops, 50th percentile queue lengths, and delays at intersections near the development generally increased after the development was built. This can be attributed to general growth of traffic and traffic generated by the new development. It was also observed that other offsite developments aggravated/contributed to traffic problems at some intersections. It was felt that traffic generated by these offsite developments was either under-estimated or not fully considered/factored in the traffic impact analysis (TIA). Considering growth and possible causes of traffic problems due to these peripheral developments could help identify improved solutions to better serve corridor traffic.

It was found from evaluations that MOEs are generally conservative for the conducting of the TIA. The computed ratios tend to be very high for lower values (say, low right turn traffic volume along an approach) than when compared to those with higher values.

The difference in "what was forecasted to happen?" and "what is happening right now?" could be attributed to aspects such as incomplete or delayed development, economic conditions, using default PHF and heavy vehicle percentages, and growth rate that may not be representative to that area. Field observations at the study intersections yielded very different PHF and heavy vehicle percentages than default values. While using default PHF and heavy vehicle percentage values (0.9 and 2 percent, respectively) would yield conservative forecasts if PHF is greater than 0.9 and heavy vehicle percentage is less than 2 percent, it may not be appropriate or suitable when PHF is lower than 0.9 or heavy vehicle percentage is greater than 2 percent. Where appropriate lower PHF or higher heavy vehicle percentages than default values need to be used based on field observations.

The cycle lengths and signal phasing/timing parameters used in TIA often differ from what was being used in the field under current conditions. These real world field adjusted timings do have an effect on “what was forecasted to happen?” and “what is happening right now?” Recognizing these inherent distinctions, it is recommended that NCDOT Traffic Impact Study guidelines be utilized for proposed signal timing and phasing, and actual timing and phasing be used for studying and modeling of existing signals. This would also assist in easy comparison and effective evaluation of treatments after the deployment.

A generic pre-approved default growth rate of 3 percent was used in projecting future traffic in most of the TIA studies reviewed as a part of this research. The growth rate may naturally vary based on changes to land use characteristics, offsite developments economic factors, the percentage of acreage already developed, and the type of facility. Considering improved regional growth rates would yield better estimates.

Intersection delays and LOS are the only MOEs considered in most TIA reports. Considering other MOEs such as the number of stops and 50th percentile queue length would not only provide more insights on operational performance of intersections but also help in identifying suitable and appropriate solutions to improve traffic performance (example, use reduced cycle length or increase number of left turn lanes if queue length for left turn traffic of a approach is very high). These fundamental MOEs typically are provided as outputs by Synchro® traffic simulation software which is normally used by private engineering firms / consultants in TIA analysis for forecasts. In addition, the TIA should also include a safety assessment / evaluation of the site. This would help better understand the effect of the development and treatments on crashes at intersections and access points near the site.

Data collected for one typical week day are normally used in TIA studies. Turning movement traffic volume data was collected for one day for the traffic operational evaluation of TIA case sites in this research. Though data collected on a typical weekday and under normal weather conditions was used in this study, it may not accurately reflect conditions of an “average” day. Collecting and using data for multiple days would reduce the variability that can lead to any traffic count biased results. Using average day data observed from multiple days or average results from analysis done for multiple days could yield improved and more reliable results.

In most of the TIA reports, traffic conditions were forecast using 3 years as the expected time frame for completion of construction. It was observed that several proposed developments and improvements were not complete (vacant parcels and incomplete implementation of transportation projects, possibly due to current state of the economy) at the time of this study. The complete build out year target was 2009 for most of the case sites reviewed. The percent of development completed for the case sites varied between 60 percent to 95 percent. Given the variability associated with construction schedules the research team is of the opinion that studies that considered a five (5) year build out could yield important traffic operational considerations and needs for these sites. For instance, a development was scheduled for full build out in 3 years. If the construction was delayed due to unforeseen conditions (such as fall in economy), the current practice of only a three year build out analysis would not even address traffic conditions of the ‘revised” opening date. A five year analysis (build out) would better allow the decision makers to implement treatments based on the post opening years of developments.

Economic conditions have changed significantly over the last 3 years. The change in gas price and growing unemployment could contribute to reduced vehicles miles of travel and differences in computed MOEs. Conducting analysis assuming 5 years as complete build out year would help in better allocation of resources based on the needs.

As stated before, incomplete development was observed during the study year at several case sites. However, the observed MOEs are higher in value than the forecasted MOEs even with partial development. Collecting and analyzing data under “ground-zero” conditions prior to start of construction of the development in addition to collection and analysis of data at regular intervals (say, every year) throughout the construction of the development would help better understand the operational effects of "new" phased developments. This would also help identify, plan and deploy treatments at suitable times over the project duration in the future.

The outcomes from operational evaluation of TIA case sites are expected to contribute to significant business improvements and yield improved knowledge and practices with regard to what works, what does not work, and what NCDOT can do to improve operational performance of developing roadways in North Carolina. Some results obtained (example, decrease in traffic volumes) may be counter-intuitive in nature. However, lessons learned from this research study can serve as valuable inputs to NCDOT in making decisions or adopting policies that would lead to use of better methods for forecasting and formally evaluating the proportional impacts of new developments. Though the number of sites (6) limited the scope of the project, the sites considered in the study reflect different types of land use such as residential, commercial and mixed. Since the procedure for performing a TIA is similar statewide, it was felt that the number of selected sites or intersections was sufficient for this effort.

7.1 Recommended Framework for Assessment

The recommended framework for future assessment based on outcomes from this research is discussed in this section.

- Collect traffic data for multiple days
  - Traffic volume, PHF and heavy vehicle percentages
  - Signal timing and phasing data based on NCDOT TIA guidelines for proposed signals
  - Signal timing and phasing data based on in-service signal operations for existing signals
- Observe and document MOEs in the field before and after development
  - Delay
  - Stops
  - Queue length
  - Crashes (type, location, severity) and crash rates

- For consistency in modeling/analysis, use a PHF of 0.9 or lower and heavy vehicle percentages of 2 percent or higher to yield conservative forecasts
- Consider a generic background traffic growth rate equal to 3 percent if local development patterns or trends in traffic at intersections and locations near the new development have not changed significantly (less than or equal to 3 percent) during the past 5 years. If local development patterns or trends in traffic at intersections and locations near the new development are greater than 3 percent, use the value as the representative background traffic growth rate.
- Develop and analyze Synchro® / SimTraffic models to generate outputs using multiple seed numbers
  - Average of all must be used
- Evaluate the following scenarios
  - Baseline conditions and 5 years as full build out year
    - 1) No build existing in future
    - 2) No build with offsite developments
    - 3) Build with the proposed development in future, and
    - 4) Build with proposed and other developments that were approved
- Collect and analyze data under "ground-zero" conditions prior to start of construction of the development in addition to collection and analysis of data at regular intervals (say, every year) throughout the construction of the development.

7.2 Implementation Plan

The outcomes from this research project and the details in the report could be used to proactively apply the adopted method(s) and perform similar reviews for flagged or random TIA sites in the future. The conclusions can be used to better understand and forecast operational performance on roads so as to efficiently allocate available resources. It is recommended that NCDOT work with three (3) consulting firms who conduct TIA studies of three (3) new (but different types of) developments and have them consider and include PHF, heavy vehicle percentages, and signal phasing / timing patterns based on NCDOT TIA guidelines to better estimate traffic conditions based on five (5) year build out analysis horizon. The development and change in traffic conditions at these sites would need to be periodically monitored over the five year pilot time frame to identify how the traffic increased up to and into the build out year.

It is also recommended that a follow up study be conducted by reviewing approximately 50 TIA studies approved between 2000 and 2005 (say, 10 constructed sites per year) to examine the time for complete build out (of both land use development and roadway improvement projects) by type of development. Such a study would help establish the most appropriate number of years for use as forecast or build out year in TIA.

REFERENCES

1. Andres, D., P. Z. Elizabeth, and J. Speck (2000). Why Building Roads Doesn't Ease Congestion, An excerpt from Suburban Nation: The Rise of Sprawl and the Decline of the American Dream. North Point Press, 2000, pp (88-94).
2. A Policy on Geometric Design of Highways and Streets (2001). Published by American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C.
3. Bared, J. G., and E. I. Kaisar (2002). Median U-Turn Design As an Alternative Treatment for Left Turns at Signalized Intersections: ITE Journal, Institute of Transportation Engineers.
4. Dissanayake, S., and J. Lu (2003). Access Management Techniques to Improve Traffic Operations and Safety: A Case Study of Full vs. Directional Median Opening. Proceedings of the 2003 Mid-Continent Transportation Research Symposium, Ames, Iowa.
5. Edwards, M. (Year Unknown). Community Guide to Development Impact Analysis. Land Information and Computer Graphics Facility webpage: http://www.lic.wisc.edu/shapingdane/facilitation/all_resources/impacts/analysis_traffic.htm, Last Accessed December 30, 2009.
6. Eisele, W. L., W. E. Frawley, and C. M. Toycen. (2004). Estimating the Impacts of Access Management Techniques. Report 0-4221-2, Texas Transportation Institute, The Texas A&M University System, College Station, Texas.
7. Federal Highway Administration, FHWA (2003). Manual on Uniform Traffic Control Devices For Streets and Highways. Highway Traffic Signals, Part #4. Federal Highway Administration, Washington, DC.
8. Federal Highway Administration, FHWA (Year Unknown). Corridor Simulation (CORSIM™ / TSIS) – Traffic Analysis Tools Program, Federal Highway Administration, Washington, DC.

9. Frawley E. W., and L. W. Eisele (2004). Estimating The Impacts of Access Management with Micro Simulation: Lessons Learned. Sixth National Access Management Conference, Transportation Research Board, Kansas City, Missouri.
10. Institute of Transportation Engineers, ITE (2005). Median Treatments. Traffic Information Progress Series, Traffic Engineering Council, Washington, D.C.
11. Kubilins Transportation Group, Inc. (2004) Level of Service Analysis for Mountain Island Square. Prepared by Kubilins Transportation Group, Inc., Charlotte, North Carolina.
12. Kubilins Transportation Group, Inc. (2004). Traffic Impact Analysis for WT. Harris Boulevard Primax Site. Prepared by Kubilins Transportation Group, Inc., Charlotte, North Carolina.
13. Kubilins Transportation Group, Inc. (2004). Traffic Impact Analysis for Cato Property – Revised. Prepared by Kubilins Transportation Group, Inc., Charlotte, North Carolina.
14. Kubilins Transportation Group, Inc. (2006). Signal Warrant Analysis and Traffic Simulation for University Pointe. Prepared by Kubilins Transportation Group, Inc., Charlotte, North Carolina.
15. Kubilins Transportation Group, Inc. (2004). Traffic Impact Analysis for The Bridges at Mint Hill. Prepared by Kubilins Transportation Group, Inc., Charlotte, North Carolina.
16. Kubilins Transportation Group, Inc. (2004). Traffic Impact Analysis for Brice-Rea Property. Prepared by Kubilins Transportation Group, Inc., Charlotte, North Carolina.
17. Levinson, H. S., T. Lomax, S. Turner (1996). Signal Spacing - A Key to Access Management. Second National Access Management Conference, Transportation Research Board, Vail, Colorado.
18. McTrans (2003). Traffic Network Study Tool (TRANSYT-7F), McTrans webpage: http://mctrans.ce.ufl.edu/featured/TRANSYT-7F/, Last Accessed March 21, 2010.
19. Muldoon, D., and L. Bloomberg (2008). Development of Best Practices for Traffic Impact Studies. Transportation Research Board Conference 2008, Washington, DC.

20. MUMPO (2004). Thoroughfare Plan. Prepared by Mecklenburg – Union Metropolitan Planning Organization (MUMPO), Charlotte, North Carolina.
21. Mystkowski, C., and S. Khan (1998). Estimating Queue Lengths Using SIGNAL 94, SYNCHRO®3, TRANSYT 7F, PASSER II-90 AND CORSIM™. Transportation Research Board Conference 1998, Washington, D.C.
22. North Carolina Department of Transportation, NCDOT (2003). Policy on Street and Driveway Access to North Carolina Highways, NCDOT Congestion Management webpage: http://www.ncdot.org/doh/preconstruct/altern/value/manuals/pos.pdf, Last Accessed February 23, 2010.
23. North Carolina Department of Transportation, NCDOT (2006). Capacity Analysis Guidelines (Revised), NCDOT Congestion Management webpage: http://www.ncdot.org/doh/pre construct/traffic/Congestion/CM/docs/TIA.pdf, Last Accessed February 23, 2010.
24. Parsonson, P. S., M. G. Waters III and J. S. Fincher (2000). Georgia Study Confirms the Continuing Safety Advantage of Raised Medians Over Two-Way Left-Turn Lanes. Fourth National Conference on Access Management, Portland, Oregon.
25. PTV Vision (2009). VISSIM. PTV America webpage: http://www.ptvag.com/fileadmin/files_ptvag.com/download/traffic/Broschures_Flyer/VISSIM/VISSIM_Brochure_e_2009_LowRes.pdf, Last Accessed December 31, 2009.
26. Ramey Kemp & Associates (2005). Traffic Impact Analysis for the Proposed Midway Plantation Development – Revised. Prepared by Ramey Kemp & Associates, Raleigh, North Carolina.
27. Ramey Kemp & Associates (2005). Traffic Impact Analysis for the Proposed Retail Development – Revised. Prepared by Ramey Kemp & Associates, Raleigh, North Carolina.
28. TRB (2003). Access Management Manual. Published by Transportation Research Board, Washington, D.C.
29. Trafficware (2003). Synchro® plus SimTraffic 6, Trafficware, Inc. webpage: http://www.trafficware.com/assets/pdfs/Synchro%20plus%20SimTraffic%206.pdf, Last Accessed December 31, 2009.

30. Vargas, F., and G. V. Reddy (1996). Does Access Management Improve Traffic Flow? Can NETSIM be used to Evaluate? Second National Access Management Conference, Transportation Research Board, Vail, Colorado.

APPENDIX A

Table 82: Signal Timing/Phasing Parameters for WT. Harris Blvd / Rocky River Rd Intersection

Observed Signal Timings								
WT. Harris Blvd & Rocky River Rd								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	NBL	SBT		EB&WB	SBL	NBT		
Protection	PO				PO			
Split	16.0	91.0		43.0	18.0	89.0		
Yellow	3.3	5.1		3.8	3.5	4.7		
All Red	2.0	1.1		3.0	2.3	1.1		
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	NBL	SBT		EB&WB	SBL	NBT		
Protection	PO				PO			
Split	15.0	105.0		30.0	45.0	75.0		
Yellow	3.3	5.1		3.8	3.5	4.7		
All Red	2.0	1.1		3.0	2.3	1.1		
Forecasted Signal Timings								
WT. Harris Blvd & Rocky River Rd								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	SBL	NBT	WBL	EBT	NBL	SBT	EBL	WBT
Protection	PO		PO		PO		PO	
Split	23.0	73.0	19.0	25.0	17.0	79.0	8.0	36.0
Yellow	5.0	5.0	3.5	5.0	4.0	5.5	3.5	5.0
All Red	2.0	0.5	0.5	2.0	2.0	1.0	0.5	2.0
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	SBL	NBT	WBL	EBT	NBL	SBT	EBL	WBT
Protection	PO		PO		PO		PO	
Split	53.0	58.0	11.0	28.0	12.0	99.0	12.0	27.0
Yellow	5.0	5.0	3.5	5.0	4.0	5.5	3.5	5.0
All Red	2.0	0.5	0.5	2.0	2.0	1.0	0.5	2.0

Table 83: Signal Timing/Phasing Parameters for WT. Harris Blvd / Grier Rd Intersection

Observed Signal Timings								
WT. Harris Blvd & Grier Rd								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	SBL	NBT		WBT	NBL	SBT	WBL	EBT
Protection	PO				PO		PPQ	
Split	13.0	84.0		53.0	32.0	65.0	35.0	18.0
Yellow	3.3	5.6		3.5	3.7	4.8	3.0	3.8
All Red	1.7	1.1		2.7	1.9	1.2	3.4	3.0
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	SBL	NBT		WBT	NBL	SBT	WBL	EBT
Protection	PO				PO		PPQ	
Split	14.0	82.0		54.0	24.0	72.0	24.0	30.0
Yellow	3.3	5.6		3.5	3.7	4.8	3.0	3.8
All Red	1.7	1.1		2.7	1.9	1.2	3.4	3.0
Forecasted Signal Timings								
WT. Harris Blvd & Grier Rd								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	SBL	NBT		EBTL	NBL	SBT		WBTL
Protection	PO				PO			
Split	12.0	66.0		62.0	20.0	58.0		62.0
Yellow	3.5	3.5		3.5	3.5	3.5		3.5
All Red	0.5	0.5		0.5	0.5	0.5		0.5
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	SBL	NBT		EBTL	NBL	SBT		WBTL
Protection	PO				PO			
Split	12.0	65.0		73.0	19.0	58.0		73.0
Yellow	3.5	3.5		3.5	3.5	3.5		3.5
All Red	0.5	0.5		0.5	0.5	0.5		0.5

Table 84: Signal Timing/Phasing Parameters for Rocky River Rd / Grier Rd Intersection

Observed Signal Timings								
Rocky River Rd & Grier Rd								
AM PEAK (Free Operation)								
Phase Entry	1	2	3	4	5	6	7	8
Movement		SBT		EBL		NBTL		
Protection								
Split								
Yellow		3.7		3.9		3.9		
All Red		1.7		1.6		1.4		
PM PEAK (Free Operation)								
Phase Entry	1	2	3	4	5	6	7	8
Movement		SBT		EBL		NBTL		
Protection								
Split								
Yellow		3.7		3.9		3.9		
All Red		1.7		1.6		1.4		
Forecasted Signal Timings								
Rocky River Rd & Grier Rd								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		NETL		EBL		SWT		
Protection						PO		
Split		120.0		40.0		120.0		
Yellow		4.0		4.0		4.0		
All Red		2.6		3.0		2.6		
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		NETL		EBL		SWT		
Protection						PO		
Split		79.0		81.0		79.0		
Yellow		4.0		4.0		4.0		
All Red		2.6		3.0		2.6		

Table 85: Signal Timing/Phasing Parameters for Mt. Holly Huntersville Rd / Brookshire Blvd Intersection

Observed Signal Timings									
Mt. Holly Huntersville Rd & Brookshire Blvd									
AM PEAK									
Phase Entry	1	2	3	4	5	6	7	8	
Movement	NBL	SBT	WBL	EBT	SBL	NBT	EBL	WBT	
Protection	PO		PO		PO		PO		
Split	25.0	75.0	30.0	35.0	25.0	70.0	20.0	45.0	
Yellow	3.5	5.0	3.5	4.6	3.4	5.2	3.6	4.5	
All Red	2.9	1.5	3.3	2.7	3.0	1.5	3.3	2.7	
PM PEAK									
Phase Entry	1	2	3	4	5	6	7	8	9
Movement	NBL	SBT	WBL	EBT	SBL	NBT	EBL	WBT	NBL
Protection	PO		PO		PO		PO		PO
Split	32.0	50.0	29.0	35.0	20.0	90.0	20.0	44.0	20
Yellow	3.5	5.0	3.5	4.6	3.4	5.2	3.6	4.5	3.5
All Red	2.9	1.5	3.3	2.7	3.0	1.5	3.3	2.7	2.9
Forecasted Signal Timings									
Mt. Holly Huntersville Rd & Brookshire Blvd									
AM PEAK									
Phase Entry	1	2	3	4	5	6	7	8	
Movement	NBL	SBT	WBL	EBT	SBL	NBT	EBL	WBT	
Protection	PO		PO		PO		PO		
Split	16.0	90.0	32.0	35.0	40.1	65.9	11.3	55.7	
Yellow	5.3	5.3	4.7	4.7	5.3	5.3	4.7	4.7	
All Red	1.4	1.4	2.6	2.3	1.4	1.4	2.6	2.3	
PM PEAK									
Phase Entry	1	2	3	4	5	6	7	8	
Movement	NBL	SBT	WBL	EBT	SBL	NBT	EBL	WBT	
Protection	PO		PO		PO		PO		
Split	38.3	34.7	54.0	46.0	21.0	52.0	11.4	88.6	
Yellow	5.3	5.3	4.7	4.7	5.3	5.3	4.7	4.7	
All Red	1.4	1.4	2.6	2.3	1.4	1.4	2.6	2.3	

Table 86: Signal Timing/Phasing Parameters for Mt. Holly Huntersville Rd / Callabridge Ct Intersection

Observed Signal Timings								
Mt. Holly Huntersville Rd & Callabridge Ct								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		SBL		EBT			EBL	WBT
Protection							PO	
Split		25.0		75.0			25.0	50.0
Yellow		3.1		4.3			3.4	4.6
All Red		3.1		1.6			2.4	1.7
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		SBL		EBT			EBL	WBT
Protection							PO	
Split		36.0		94.0			37.0	57.0
Yellow		3.1		4.3			3.4	4.6
All Red		3.1		1.6			2.4	1.7
Forecasted Signal Timings								
Mt. Holly Huntersville Rd & Callabridge Ct								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		EBT	NBL	SBTL	EBL	WBTL		NBTL
Protection			PPT		PO			
Split		82.0	12.0	26.0	30.0	52.0		38.0
Yellow		4.7	3.5	4.7	3.5	4.7		4.7
All Red		1.2	0.5	1.2	0.5	1.2		1.2
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		EBT	NBL	SBTL	EBL	WBTL		NBTL
Protection			PPT		PO			
Split		77.0	8.0	35.0	43.0	34.0		43.0
Yellow		4.7	3.5	4.7	3.5	4.7		4.7
All Red		1.2	0.5	1.2	0.5	1.2		1.2

Table 87: Signal Timing/Phasing Parameters for Tom Short Rd / Ballantyne Commons Pkwy Intersection

Observed Signal Timings								
Tom Short Rd & Ballantyne Commons Pkwy								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		NB		WB				EB
Protection								
Split		30.0		45.0				45.0
Yellow		3.6		4.0				4.0
All Red		1.6		1.6				1.6
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		NB		WB				EB
Protection								
Split		15.0		50.0				50.0
Yellow		3.6		4.0				4.0
All Red		1.6		1.6				1.6
Forecasted Signal Timings								
Tom Short Rd & Ballantyne Commons Pkwy								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		NB		WB				EB
Protection								
Split		32.0		78.0				78.0
Yellow		4.0		4.7				4.7
All Red		1.0		2.0				2.0
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		NB		WB				EB
Protection								
Split		25.0		110.0				110.0
Yellow		4.0		4.7				4.7
All Red		1.0		2.0				2.0

Table 88: Signal Timing/Phasing Parameters for Providence Rd / Ardrey Kell Rd Intersection

Observed Signal Timings								
Providence Rd & Ardrey Kell Rd								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		NB			NBL	SB		EB
Protection					PP			
Split		87.0			18.0	69.0		33.0
Yellow		4.5			3.0	4.5		3.0
All Red		1.1			3.0	1.3		2.7
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		NB			NBL	SB		EB
Protection					PP			
Split		110.0			14.0	96.0		30.0
Yellow		4.5			3.0	4.5		3.0
All Red		1.1			3.0	1.3		2.7
Forecasted Signal Timings								
Providence Rd & Ardrey Kell Rd								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		NBTL			NBL	SBTU		EBL
Protection					PP			
Split		109.0			25.9	83.1		41.0
Yellow		4.7			4.7	4.7		4.7
All Red		1.6			1.2	1.6		1.3
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		NBTL			NBL	SBTU		EBL
Protection					PP			
Split		122.0			25.0	97.0		28.0
Yellow		4.7			4.7	4.7		4.7
All Red		1.6			1.2	1.6		1.6

Table 89: Signal Timing/Phasing Parameters for North Tryon St / McCullough Dr Intersection

Observed Signal Timings								
North Tryon St & McCullough Dr								
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	NBL	SBT		EBT	SBL	NBT		WBT
Protection	PO				PO			
Split	38.0	56.0		41.0	14.0	80.0		41.0
Yellow	3.6	4.3		3.6	3.4	4.6		3.8
All Red	2.7	1.3		2.1	2.7	1.3		2.2
Forecasted Signal Timings								
North Tryon St & McCullough Dr								
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	SBL	NBT		EBTL	NBL	SBT		WBTL
Protection	PO				PO			
Split	14.0	109.0		27.0	43.0	80.0		27.0
Yellow	4.7	4.7		4.0	4.7	4.7		4.0
All Red	1.5	1.4		2.1	1.7	1.4		2.2

Table 90: Signal Timing/Phasing Parameters for North Tryon St / The Commons at Chancellor Park Dr Intersection

Observed Signal Timings								
North Tryon St & The Commons at Chancellor Park Dr								
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	NBL	SBT	WBL	EBT	SBL	NBT	EBL	WBT
Protection	PO		PO		PO		PO	
Split	31.0	57.0	21.0	26.0	21.0	67.0	27.0	20.0
Yellow	3.1	4.5	3.1	3.6	3.2	4.4	3.0	3.7
All Red	3.7	1.9	3.3	3.1	3.3	1.9	3.5	3.1
Forecasted Signal Timings								
North Tryon St & The Commons at Chancellor Park Dr								
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	SBL	NBT	WBL	EBT	NBL	SBT	EBL	WBT
Protection	PO		PO		PO		PO	
Split	24.3	79.6	20.0	26.1	24.9	79.0	24.0	22.1
Yellow	4.7	4.7	3.5	4.0	4.7	4.7	4.0	4.0
All Red	1.7	1.4	0.5	2.1	1.7	1.4	2.1	2.1

Table 91: Signal Timing/Phasing Parameters for Knightdale Blvd (US 64) / I 540 SB Ramp Intersection

Observed Signal Timings								
Knightdale Blvd (US 64) & I 540 SB Ramp								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	WBL	EBT				WBT		
Protection	PO							
Split	26.3	126.0				126.1		
Yellow	3.3	4.4				4.6		
All Red	3.0	1.6				1.5		
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	WBL	EBT				WBT		
Protection	PO							
Split	26.3	126.0				126.1		
Yellow	3.3	4.4				4.6		
All Red	3.0	1.6				1.5		
Forecasted Signal Timings								
Knightdale Blvd (US 64) & I 540 SB Ramp								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	WBL	EBT		SBT		WBT		
Protection	PO							
Split	16.0	66.0		58.0		82.0		
Yellow	5.0	5.0		5.0		5.0		
All Red	2.0	2.0		2.0		2.0		
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	WBL	EBT		SBT		WBT		
Protection	PO							
Split	39.0	68.0		33.0		107.0		
Yellow	5.0	5.0		5.0		5.0		
All Red	2.0	2.0		2.0		2.0		

Table 92: Signal Timing/Phasing Parameters for Knightdale Blvd (US 64) / I 540 NB Ramp Intersection

Observed Signal Timings								
Knightdale Blvd (US 64) & I 540 NB Ramp								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	EBT			NBTL	EBL	WBT		
Protection					PO			
Split	125.9			31.2	31.3	125.8		
Yellow	4.6			3.7	3.3	4.4		
All Red	1.3			2.5	3.0	1.4		
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	EBT			NBTL	EBL	WBT		
Protection					PO			
Split	125.9			31.2	31.3	125.8		
Yellow	4.6			3.7	3.3	4.4		
All Red	1.3			2.5	3.0	1.4		
Forecasted Signal Timings								
Knightdale Blvd (US 64) & I 540 NB Ramp								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		EBT	NBL		EBL	WBT	NBR	
Protection					PO			
Split		113.0	27.0		18.0	95.0	27.0	
Yellow		5.0	5.0		5.0	5.0	5.0	
All Red		2.0	2.0		2.0	2.0	2.0	
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement		EBT			EBL	WBT		NBL
Protection					PO			
Split		116.0			21.0	95.0		24.0
Yellow		5.0			5.0	5.0		5.0
All Red		2.0			2.0	2.0		2.0

Table 93: Signal Timing/Phasing Parameters for Knightdale Blvd (US 64) / Hinton Oaks Blvd Intersection

Observed Signal Timings								
Knightdale Blvd (US 64) & Hinton Oaks Blvd								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	WBL	EBT	NBL	SBT	EBL	WBT	SBL	NBT
Protection	PO		PO		PO		PO	
Split	26.4	126.3	26.8	36.9	26.6	126.0	27.1	36.6
Yellow	3.4	4.6	3.8	3.8	3.6	4.4	4.1	3.6
All Red	3.0	1.7	3.0	3.1	3.0	1.6	3.0	3.0
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	WBL	EBT	NBL	SBT	EBL	WBT	SBL	NBT
Protection	PO		PO		PO		PO	
Split	26.4	126.3	26.8	36.9	26.6	126.0	27.1	36.6
Yellow	3.4	4.6	3.8	3.8	3.6	4.4	4.1	3.6
All Red	3.0	1.7	3.0	3.1	3.0	1.6	3.0	3.0
Forecasted Signal Timings								
Knightdale Blvd (US 64) & Hinton Oaks Blvd								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	WBL	EBT	NBL	SBT	EBL	WBT	SBL	NBT
Protection	PO		PO		PO		PO	
Split	16.0	77.0	28.0	19.0	22.0	71.0	14.0	33.0
Yellow	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
All Red	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	WBL	EBT	NBL	SBT	EBL	WBT	SBL	NBT
Protection	PO		PO		PO		PO	
Split	14.0	83.0	23.0	20.0	31.0	66.0	24.0	19.0
Yellow	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
All Red	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Table 94: Signal Timing/Phasing Parameters for Knightdale Blvd (US 64) / Wide Waters Pkwy Intersection

Observed Signal Timings								
Knightdale Blvd (US 64) & Wide Waters Pkwy								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	WBL	EBT	NBL	SBT	EBL	WBT	SBL	NBT
Protection	PO		PO		PO		PO	
Split	26.8	127.0	26.6	21.7	26.8	126.7	26.8	28.9
Yellow	3.2	4.5	3.3	3.8	3.2	4.5	3.2	4.0
All Red	3.6	2.5	3.3	2.9	3.6	2.2	3.6	2.9
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	WBL	EBT	NBL	SBT	EBL	WBT	SBL	NBT
Protection	PO		PO		PO		PO	
Split	26.8	127.0	26.6	21.7	26.8	126.7	26.8	28.9
Yellow	3.2	4.5	3.3	3.8	3.2	4.5	3.2	4.0
All Red	3.6	2.5	3.3	2.9	3.6	2.2	3.6	2.9
Forecasted Signal Timings								
Knightdale Blvd (US 64) & Wide Waters Pkwy								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	SBL	NBT	WBL	EBT	NBL	SBT	EBL	WBT
Protection	PO		PO		PO		PO	
Split	17.0	34.0	17.0	72.0	23.0	28.0	20.0	69.0
Yellow	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
All Red	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	WBL	EBT	NBL	SBT	EBL	WBT	SBL	NBT
Protection	PO		PO		PO		PO	
Split	20.0	72.0	26.0	22.0	24.0	68.0	21.0	27.0
Yellow	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
All Red	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Table 95: Signal Timing/Phasing Parameters for US 1 / NC 96 Intersection

Observed Signal Timings								
US1 & NC 96								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	SBL	NBT	WBL	EBTL	NBL	SBT		WBT
Protection	PO		PO		PO			
Split	26.5	126.7	26.4	56.4	26.4	126.4		57.0
Yellow	3.0	5.5	3.1	4.2	3.0	5.2		5.0
All Red	3.5	1.2	3.3	2.2	3.4	1.2		2.0
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	SBL	NBT	WBL	EBTL	NBL	SBT		WBT
Protection	PO		PO		PO			
Split	26.5	126.7	26.4	56.4	26.4	126.4		57.0
Yellow	3.0	5.5	3.1	4.2	3.0	5.2		5.0
All Red	3.5	1.2	3.3	2.2	3.4	1.2		2.0
Forecasted Signal Timings								
US1 & NC 96								
AM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	NBL	SBT	WBL	EBT	SBL	NBT	EBL	WBT
Protection	PO		PO		PO		PO	
Split	42.0	79.0	25.0	49.0	31.0	90.0	27.0	47.0
Yellow	4.5	5.1	5.0	5.1	4.5	5.1	5.0	5.1
All Red	2.5	2.0	2.0	2.6	2.5	2.0	2.0	2.6
PM PEAK								
Phase Entry	1	2	3	4	5	6	7	8
Movement	NBL	SBT	WBL	EBT	SBL	NBT	EBL	WBT
Protection	PO		PO		PO		PO	
Split	63.0	51.0	31.0	35.0	32.0	82.0	14.0	52.0
Yellow	4.5	5.1	5.0	5.1	4.5	5.1	5.0	5.1
All Red	2.5	2.0	2.0	2.6	2.5	2.0	2.0	2.6