MODELING THE INFLUENCE OF LAND USE DEVELOPMENTS WITHIN THE VICINITY OF THE LINK AND NETWORK CHARACTERISTICS ON TRAVEL TIME

by

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ABSTRACT

AJINKYA S. MANE. Modeling the influence of land use developments within the vicinity of the link and network characteristics on travel time. (Under the guidance of DR.SRINIVAS S. PULUGURTHA)

From the year 2000 to the year 2010, the total population in the United States increased by 12.1%. About ~80% of the total population resides in the urban areas. The growth in the urban population influenced the urban sprawl, congestion, and, subsequently delays on the existing road infrastructure. Urban sprawl is directly linked to the land use developments and has a significant influence on the operational performance of the neighboring links, leading to congestion and delay. Further, traffic condition, day-of-the-week, time-of-the-day, and network characteristics of the upstream, downstream, cross streets, and intersecting links also influence the operational performance of the link. Therefore, one needs to consider spatial dependency and the influence on links within the proximity (based on the distance decay effect), over time, to compute travel time variability or reliability. The goal of this dissertation is to model the influence of developments on travel time variations to improve mobility of people and goods. The objectives of the dissertation research are:

1. To identify the predictor variables which could influence the operational performance of link in terms of travel time and travel time variations,
2. To identify to what extent the influence of proximal land use developments persist on travel times,
3. To compare before and after travel times and travel time variations on neighboring links of new developments, and,

4. To develop the relationship between land use developments on travel times and travel time variations on neighboring links by land use type, area type [Central Business District (CBD), CBD fringe, and urban area], and by speed limit categories (speed limit < 45 mph, 45 – 50 mph, > 50 mph).

Data for 259 road links were selected within the city of Charlotte, North Carolina (NC). The land use developments and network characteristics were collected from the local agencies, while real-world travel time data were collected from the private agency. Three years of data, from the year 2013 to the year 2015, were considered in this research.

Thirty-five different types of land use developments were considered in this research. The spatial dependency was incorporated by considering the land use developments within 0.5 miles, 1-mile, 2 miles, and 3 miles of the selected link. Network characteristics of the upstream, downstream, upstream and downstream cross street, and intersecting links were also considered to address the spatial dependency.

Pearson correlation coefficients were computed by considering before-and-after data to investigate the relationship between land use developments and travel time measures. Forty-eight models were developed in this research. Of these, twelve models were developed by considering different buffer widths, eighteen models were developed by classifying the links by area type [Central Business District (CBD), CBD Fringe / Other Business District (OBD), and urban area], and eighteen models were developed by classifying the links based on the speed limit (< 45mph, 45 to 50 mph, and > 50mph). Each of the developed models were validated using the Root Mean Square Error (RMSE), the Mean Absolute Percentage Error (MAPE), and the Mean Percentage Error (MPE) considering data for links, which were not used for model development.

Log-link with Gamma distribution model was observed to be the best-fitted model for the data used in this research. Models were developed by incorporating all the predictor variables at a time (backward elimination) and also by selecting the independent variables based on Pearson correlation coefficients. The results obtained indicate that land use developments have a significant influence on the travel times. Different land use categories contribute to the average travel time based on the buffer width, area type, and the link speed limit.

Developing the models by classifying the links based on the speed limit (< 45 mph, 45 to 50 mph, and > 50 mph) was observed to be the best approach to examine the relationship between land use developments and the average travel time. However, capturing the land use developments within 1-mile from a link was observed to be the best approach to examine the relationship between the land use developments and the average travel time by buffer width and area type.

Typically, travel times on a selected link is higher during the evening peak period compared to the morning peak and the afternoon off-peak period. The results obtained indicate that, typically, the number of lanes and the posted speed limit are negatively associated with the travel time of the selected link. Some of the important findings are listed next.

1. Car wash, convenience store, department store, multi-family, office, fast food, funeral home, hospital, and supermarket type land uses within 0.5 miles from a link increase the average travel time.
2. In the CBD area, department store, government and multi-family type land uses within 1-mile from a link increase the average travel time.

3. In the CBD fringe / OBD area, daycare, multi-family, shopping mall, and supermarket type land uses within 1-mile from a link increase the average travel time.
4. In the urban area, convenience store, department store, fast food, funeral home, multi-family, recreational, retail, and supermarket type land uses within 1-mile from a link increase the average travel time.

Such findings help professionals and planners in land use planning decisions and can reduce the congestion through proactive implementation of mitigation measures. In addition to the procedure followed in the traffic impact studies, the developed relationships could be helpful to quantify the influence of land use developments on the travel time based on the type of land use development, area type, and the speed limit of the link.

DEDICATION

to My Family

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LIST OF ABBREVIATIONS

BT	buffer time
BTI	buffer time index
CBD	central business district
DOW	day-of-the-week
ITE	institute of transportation engineers
GEE	generalized estimating equation
OBD	Other Business District
PT	planning time
PTI	planning time index
RITIS	regional integrated transportation information system
RTDM	regional travel demand model
TAZ	traffic analysis zones
TIS	traffic impact studies
TOD	time-of-the-day
TTV	travel time variability
VMT	vehicle miles traveled

CHAPTER 1: INTRODUCTION

Transportation planning decisions influence land use development activities, while land use development decisions influence travel demand patterns and operational performance of the transportation system. This research study focuses on understanding the relationship between the land use developments and the operational performance of transportation system.

1.1 Motivation and Background

The United States of America has experienced growth in economic development, population, and health standards in the last few decades. As a result of this economic development, people migrated to the major cities from other countries as well as from rural areas. This has contributed to urban sprawl in many major cities. From the year 2000 to 2010, the urban population in the United States increased by 12.1% (Census data, 2012). About ~80% of the population resides in the urban areas.

The growth in the urban population has influenced the urban sprawl, congestion, and, subsequently delays on the existing road infrastructure. Further, with the construction of high-quality highways, which connect the central business district (CBD) with the suburban area, people tend to live farther from the city center. This leads to an increase in trip lengths and traffic volume on existing roads, resulting in higher travel times and delays. Safe, reliable, and ecological transportation system is, therefore, a need of the hour. On the contrary, one can also argue that economic development and land use development are the result of improved transportation facilities and accessibility.

A land use development refers to a parcel of land used for residential, commercial, recreational, institutional or other activities. It can be further classified as civic, offices, medical, hospital, hotel / motel, institutional, residential (single family attached / detached and multi-family), recreational, parking lots, mixed-use, etc. type land uses. Generally, new land use developments influence the operational performance on neighboring road links in terms of traffic volume and travel time. For example, if a multi-family residential complex is developed in any part of the city, the vehicle owners in the developed multi-family residential complex will contribute to additional traffic volume on the existing neighboring roads.

New land use developments occur in every part of the city due to rapid economic development and to meet the demand for better living standards. The induced traffic volume generated from such land use developments often result in increased congestion and vehicular delay on the existing roads. The increase in traffic congestion and vehicular delay leads to additional travel time, increase in fuel consumption, and increase in vehicle's wear and tear. Also, increased congestion on major corridors influence the economy and reduce air quality due to increased emissions from vehicles. This justifies the need to study the impact of the new land use development on existing transportation facilities. This will help the planning authorities make improved land use planning decisions and identify proactive solutions to mitigate mobility and congestion problems (examples, increase the capacity of existing roadways or construct new roads within the vicinity of the new land use development).

New land use developments influence the demographic and socioeconomic characteristics of an area, hence, traffic volume, and travel time performance measures within the vicinity. Also, the influence of new land use developments on travel time can vary based on the area / part of the city (Central Business District (CBD), urban and suburban) and land use type. For example, a multi-story building in CBD / downtown area will generate different amount of traffic volume when compared with a mid-sized commercial complex in an urban area. In addition, the influence of a small size commercial development within the vicinity of low speed limit roads, in terms of traffic generation / attraction, would be different compared to a small size commercial development within the vicinity of freeways. Therefore, evaluating the influence of new land use developments based on the land use type, area type, and speed limit of the road on the travel time performance measures and variation in travel times on neighboring road links / along the corridor would help in understanding the impact of new land use development on the transportation infrastructure.

1.2 Problem Statement

Researchers have been examining the relationship between land use characteristics and travel behavior since the last three decades. These efforts include examining the relationship between the land use development and associated change in travel behavior in terms of vehicle miles traveled (VMT), trip length, mode choice, and vehicle hours traveled (Ewing and Cervero, 2010). The relationship between land use development and travel behavior is influenced by countless predictor variables, such as demographic, socioeconomic, dependency on personal cars, car ownership, distance between residential and job location for every individual, selection of mode of transportation, etc. Data collection for some of the parameters, for every individual, is a meticulous task. In addition, there may be some privacy concerns. Therefore, due to the complexity and the influence of several external factors on the travel behavior parameters, researchers are still arguing about whether land use characteristics affect the travel behavior or the other way.

In addition to the relationship between land use developments and travel behavior, researchers have been examining the relationship between the land use decisions and the travel time performance measures, indirectly, using traffic impact studies or transportation modeling or traffic simulation software. However, with recent advancements in the technology, it is possible to capture continuous, dynamic and comprehensive travel time for every major corridor in a city. This data helps to understand the relationship between land use developments and travel time performance measures directly. This will help to understand how and to what extent land use developments influence transportation system performance.

1.3 Research Objectives

The objectives of this research are as follows:

1. To identify the predictor variables which could influence the operational performance on a link in terms of travel time and travel time variations,
2. To identify to what extent the influence of proximal land use developments persist on travel times,
3. To compare before and after travel times and travel time variations on neighboring links of new developments, and,
4. To develop the relationship between land use developments on the travel times and travel time variations on neighboring links by land use type, area type [Central

Business District (CBD), CBD fringe, and urban area], and speed limit categories (speed limit < 45 mph, 45 – 50 mph, > 50 mph).

1.4 Organization of the Report

The rest of the report is comprised of eight chapters. Chapter 2 summarizes previous studies on different approaches to conduct traffic impact studies and to quantify the influence of new land use developments on travel behavior. Data collection and data processing adopted for this study are discussed in Chapter 3. Chapter 4 provides the comprehensive framework to investigate the influence of new land use developments on transportation system performance, in terms of travel time. Chapter 5 discusses the results related to the correlation analysis. Chapter 6, Chapter 7 and Chapter 8 discuss the model development and validation by buffer width, area type, and speed limit, respectively. Lastly, conclusions from this research study are presented in Chapter 9.

CHAPTER 2: LITERATURE REVIEW

This chapter comprises of information related to traditional traffic impact studies, which investigate the influence of different land use developments on neighboring links in terms of traffic volume. This chapter also presents different ideologies and approaches from the last three decades, to address the relationship between land use developments and travel behavior.

2.1 Traffic Impact Study (TIS) and Limitations in TIS Assessment

Traditionally, a traffic impact study (TIS) is conducted to investigate the impact of land use developments on nearby road links by forecasting the increase in traffic volume. Typically, the TIS is conducted before the implementation of a new development. The Institute of Transportation Engineers (ITE) Trip Generation Manual is commonly used to predict the number of trips due to the new development (Muldoon and Bloomberg, 2008). The most recent version, 9th edition (ITE, 2012) of the Trip Generation Manual, has a total of 172 land use types.

The ITE Trip Generation Manual helps to forecast the number of trips generated by a land use type by considering its area. Each land use type is typically measured in terms of area (1,000 square feet), except for residential, lodging, and recreational type land uses. Recreational type land use (park/ golf course/ marina/ campground) are typically measured in acres. However, residential type land use is measured in dwelling units, while lodging (motel/ hotel / resort hotel) type land use is measured in terms of number of rooms.

In addition, trip generation rates and distributions are typically forecasted for morning and evening peak hours (AM and PM Peak Hour).

Schneider and Hong (1990) researched the use of small sized traffic analysis zones (TAZ) in suburban area of large metropolitan areas to conduct TISs. Here, regression analysis was used by considering rentable building space, development, and housing densities as the predictor variables and trip attraction from TAZ as the dependent variable. The research suggested that the proposed method will help in the review and approval process of building permits. Wang (2005) integrated simulation models, GIS, and visualization for traffic impact analysis in terms of Level of Service (LOS). In their study, the LOS for each link was defined based on volume/capacity ratio.

It is important to compare the forecasted traffic and actual post-development traffic condition. This will help assess the effectiveness and limitations in TIS. Muldoon and Bloomberg (2008) studied thirty TISs on private large developments, such as retail, church, industrial, prison, and office land use area located in Oregon. They have compared the forecasted traffic and post-development actual traffic condition for selected developments. It was observed that predicted parameters such as intersection operations, daily trips, and trip distribution were partially consistent with the actual condition. However, predicted turning movements for peak-hour trips were hardly (least) consistent with the actual condition. In addition, for retail type land use area, the difference between the predicted and actual peak hour traffic generation was observed in the range of -55% to 153%. For industrial and office type land use areas, the predicted peak hour trip generation is higher than the actual traffic scenario. Further, similar results were observed for developments in the urban area.

Another approach is to use travel demand model to forecast traffic generated by a proposed new development on neighboring links. As stated by Mamun et al. (2011a), there are two approaches in TISs using travel demand models: the link distribution percentage approach, and, special generator approach. They conducted an empirical study on the Alachua / Gainesville Metropolitan Planning Organization model to compare the effectiveness of both the methods. It was observed that both the methods provide similar results. However, the study recommended link distribution percent approach due to its simplistic approach for implementation. Another study by Mamun et al. (2011) proposed origin-destination based approach to conduct TISs and demonstrated their proposed methodology on a network located in the Sioux Falls, South Dakota.

Pulugurtha and Mora (2015) compared what was forecasted with the observed field conditions at six TIS sites. They concluded that the construction of new development will lead to an increase in traffic volume, the number of stops, and delay at the intersections near the new development. Also, traffic generated due to the off-site developments are either underestimated or not typically considered in the TIAs. Therefore, incorporating peak hour factor, off-site developments, regional traffic growth rates, and percentage of heavy vehicles in TIAs would provide better forecasts. Phase-wise planning and implementation may also assist with better utilization of the resources.

Each Department of Transportation (DOT) follows independently designed guidelines to conduct TIS assessments (Dey and Fricker, 1992; California DOT, 2002; NCDOT, 2003). Muldoon and Bloomberg (2008) stated that, sometimes, land use codes from ITE’s manual are matched with the proposed land use development though the actual characteristics of the land use development may not match. In addition, for a particular land use development, different land use codes can be applied due to overlapping of definitions in the ITE Trip Generation Manual. It is sometimes tricky and confusing to get the accurate forecasted trips even though the manual provides strong guidelines to forecast trips. Further, DeRobertis et al. (2014) pointed out the assumptions followed in TISs needs to be readdressed. Firstly, trip generation rates due to the future land use development is similar to the past land use developments. It does not account for transit and pedestrian infrastructure developed within the vicinity of the development. Secondly, the mitigation measures typically include increasing the roadway capacity, which could result in induced demand or other profound effects. Thirdly, TISs does not accommodate the effect of an increase in vehicle traffic on safety of other modes of transportation such as bike, pedestrians, and transit.

2.2 Relationship between Land Use and Travel Behavior

Ewing (1995) argued that there are typically two approaches to address the relation between land use and travel time. The first one assumes that land use patterns affect the travel behavior, while the second one has a cynical view on this relation. Several researchers studied the relationship between the land use characteristics and travel behavior (Crane, 1996; Banister, 1997; Wegener and Fürst, 1999; Crane, 2000; Meurs and Haaijer, 2001; Stead, 2001; Stead and Marshall, 2001; Handy 2002; Zhang, 2013).

Ewing and Cervero (2010) stated that the most commonly used parameters of travel behavior are VMT, trip length, mode choice, and vehicle hours traveled. To quantify built environment, Cervero and Kockelman (1997) established three ‘D’s as variables: density, design, and diversity. Two more D’s were added afterward and defined as destination accessibility and distance to transit (Ewing et al., 2009).

Density is measured in per unit area. The variables such as population, dwelling units, and building floor area are generally expressed in density. The net or gross area can be used to represent density. Design indicates the characteristics of road network. Road network in CBD / downtown area is different when compared to road network in urban / suburban area. The variables such as the width of road, the presence of sidewalk, and pedestrian crossings are used to represent design parameters. Diversity indicates the different number of land use areas within a study area. Typically, entropy index and dissimilarity index are used to represent diversity (Kockelman, 1997). However, entropy index is majorly used over dissimilarity index. Mathematical formulation of entropy and dissimilarity index are presented in Equation 1 and Equation 2, respectively.

$$Entropy \ = \sum_{i=1}^{I} \frac{P_i \ln(P_i)}{\ln(I)} \tag{1}$$

where, P_i is the proportion of land use in i^{th} land use type, and,

I is the number of land uses in the particular study area.

Entropy index lies between 0 and 1, since it is normalized using natural logarithm. Zero indicates homogeneous land use pattern in a study area and one indicates all land use types are equally distributed in the study area.

$$Dissimilarity = \sum_{j}^{k} \sum_{i=1}^{8} \frac{X_i/8}{K} \tag{2}$$

where, K is the number of developed grid cells in a census block, j is grid cells indexes, and,

X_i =1 if neighboring adjacent grid-cell have different land uses; 0 otherwise.

Crane (1996) stated that auto travel may or may not increase with change in land use and with the improved transit-and-pedestrian accessibility. However, it may increase with the present demand (if demand is price-elastic or income elastic). At macro-level, Wegener and Fürst (1999) summarized the results of past empirical studies and concluded that residential density along with mixed land uses are negatively correlated with trip length. In terms of mode choice, residential density is negatively correlated with the use of private vehicle / car and positively correlated with public transportation. Further, Handy (2005) conducted a literature review and concluded that an increase in highway capacity would influence sprawl (in urban and suburban area). However, the degree of sprawl is uncertain and depends upon the local condition.

Holtzclaw (1994) studied the influence of neighborhood characteristics such as residential density, household size, household income, shopping, pedestrian and transit accessibility with car ownership, and VMT per household. The regression coefficient indicated that total VMT and the number of households decrease by ~25% with a 200% increase in density. Similarly, Burchell et at. (1998) and Ewing (1997) concluded that highly dense land use areas reduce VMT. Ewing and Cervero (2001) concluded that VMT and vehicles travel (VT) per capita decreases by ~5% with a 200% increase in neighborhood density.

Overall, most of the studies have concluded that a highly dense development will result in a reduction in VMT. On the other hand, Crane (2000) argued that VMT per household might be lower in highly dense places due to low-income community and lack of other useful information in the dataset. Further, Stead (2001) conducted a research study in Britain and concluded that land use characteristics explain only one-third of the variation in total distance traveled by per capita. The socioeconomic characteristics can explain up to two-third of the variation in distance traveled by per capita in different wards / areas. However, their study also concluded that land use characteristics such as settlement size, mixed land use, and local amenities contribute to the sustainable travel patterns.

Litman (2005) studied the effect of land use factors such as regional accessibility, density, land use mix, and connectivity of roads on travel behavior characteristics. The study quantified the effectiveness of modeling the effect of land use on travel behavior at block level or census tracks. Several other researchers (Gordon and Peers, 1994; Walters et al, 2000; McCormack et al, 2001, Kuzmyak and Pratt, 2003; Ewing and Cervero, 2010; Sperry et al., 2012) observed similar findings.

Sperry et al. (2012) conducted a study to analyze the induced trips generated by a mixed land use site located in the suburban area of Dallas, Texas. Their results indicated that VMT reduced in that region, even after the generation of induced trips by mixed land use area. In terms of population density, Jenks and Jones (2009) stated that densely populated neighborhood would generate growth in the surrounding area. This would influence travel times and shopping trips, which are located close to these neighborhoods.

To quantify the influence of new land use development, it is necessary to identify the boundary condition of the study area to better comprehend the relations. Harvey and Clark (1965) stated that, due to urban sprawl, time is wasted by traveling to vacant land between the city center and suburban area. Moreover, Jun (2004) studied the effect of urban growth boundary on development pattern and commuting in the Portland city, OR. Their study results indicate that, within the urban growth boundary, travel time increased drastically compared to the outside of urban growth boundary. In addition, their study concluded that, due to the development of more housing units in suburban area, the commuting travel time is higher in the suburban area compared to the commuting travel time in the central city. Further, Carvero and Day (2008) advocated that Transit Oriented Development (TOD) along the transit line may result in reducing the travel time.

Land use density has been explored extensively to quantify the relationship between the built environment and travel behavior in terms of VMT. As per Ewing and Cervero (2001), VMT itself is a complex travel behavior parameter as it contributes to trip length, trip frequency, and mode choice of the individual. However, National Research Council (2010) and Brownstone (2008) pointed out that most researchers quantify the effect of land use density on VMT in terms of elasticities. For example, 40% increase in land use density (independent variable) will reduce the VMT by 5%. The results obtained by Brownstone and Golob (2008) indicate that VMT will reduce by 1,200 miles per year per household with an additional 1,000 dwelling units per sq. mile. Here, Brownstone (2008) pointed out that 1,000 dwelling units represent 40% of density value in the dataset and 1,200 miles per year per household represent 5% of the sample mean. Such scenarios do not imply the amplitude of land use density on VMT. Therefore, Brownstone (2008) stated that the direct simple linear relation, an increase in density will reduce the VMT, is inconceivable. Further, the characteristics of built environment such as demographic, socioeconomic characteristics (household size, income, age), vehicle ownership, distance between residential area and employment center, and available modes of transportation should be considered in the analysis (Badoe and Miller, 2000).

Zhao and Chung (2001) have researched on the estimation of annual average daily traffic (AADT) by considering land use characteristics. Pulugurtha and Kusam (2012) researched, by considering land use, demographic, and socioeconomic characteristics as the predictor variables, to estimate AADT on the selected links. In their study, multiple buffer widths around the selected links were considered to capture geospatially distributed predictor variables. This was followed by another study to examine the role of spatial dependency on AADT of links (Kusum and Pulugurtha, 2015). Duddu and Pulugurtha (2013) researched on the estimation of link level AADT by considering land use characteristics. In their study, negative binomial model and multi-layered neural network model were developed to estimate AADT on the selected links. The principle behind their study was that the effect of land use characteristics on AADT of a selected link decreases with an increase in the distance from the subject link.

2.3 Influence of Land Use Developments by Area Type

The land use characteristics vary with respect to the area type (CBD, urban, and suburban area). Zhang (2013) investigated the relationship between the land use developments and travel behavior in the suburban area of Phoenix Metropolitan Region. Their study concluded that the residents in the suburban area are more intensive in their travel behavior when compared to the residents in the central city. Further, it was observed that variation in travel behavior between commuters in the suburban and urban area was small. The study was conducted using TAZ level data. Socioeconomic parameters were obtained from the census data and were assigned to each respective TAZ. This methodology is beneficial to investigate travel behavior between the TAZs but not within the individual TAZ (at the micro-level / at road links / at corridor level near to the land use development).

After the World War II, neo-traditional neighborhood design became popular to design and build suburban areas. In this design, residential and non-residential land uses are located in close proximity. The neighborhood is well connected by street network, pedestrian, and bike facilities (Friedman et al., 1994). Friedman et al. (1994) investigated the traditional and standard suburban areas in San Francisco Bay area. The regional travel survey data in the year 1980 were analyzed in their study. They also researched on the effect of neo-traditional neighborhood design in the suburban area and concluded that this design has a significant effect on travel behavior. However, more factors such as household income, socioeconomic characteristics, and vehicle ownership should be considered to check the relative influence on travel behavior.

Ewing and Cervero (2001) stated that CBD areas with high accessibility will produce less VMT than dense mixed-land use developments in suburbs. On contrary, several researchers discussed the blemishes in the traditional methodology and concluded that there is no relationship between land use and travel pattern (Kitamura et al., 1997; Boarnet and Sarmiento, 1998; Crane and Crepeau, 1998; Snellen et al., 2002; Bagley and Mokhtarian, 2002; Schwanen, 2003).

Maat et al. (2005) concluded that relationship between land use and travel behavior is a complex phenomenon which cannot be addressed through simplified distance-oriented and trip-oriented approaches. Kitamura et al. (1997) studied the effect of attitudinal and land use characteristics on travel behavior in five diverse neighborhoods in San Francisco. A total of 39 attitudinal characteristics related to urban life were considered in their study.

These 39 attitudinal characteristics were classified into eight factors, such as pro-environment, pro-transit, urban villager, suburbanite, time pressure automotive mobility, willing to pay a toll on uncongested road, and workaholic. Their results obtained indicate that attitudes are more strongly correlated to travel behavior than land use characteristics.

Mane and Pulugurtha (2018) have studied the influence of land use developments by area type (CBD, urban and suburban) on neighboring links, by comparing the before and after travel times. Their study concluded that land use developments have an influence on travel time measures. However, multiple land use developments may occur along the particular link / route and could influence travel time measures of the selected link / route. Therefore, instead of identifying the land use development and quantifying its influence on neighboring links, capturing the land use developments along the corridor and then evaluating the influence of land use developments on travel time measures would be an effective way to investigate the aforementioned relationship.

2.4 Approaches to Examine the Relationship

There are different approaches to examine the relationship between land use and travel behavior. Handy (1996) categorized the research approaches into three parts: simulation, disaggregate, and aggregate analysis. In addition to these approaches, mode choice and activity-based models are used to investigate the relationship between urban form and travel behavior. Here, the term “urban form” does not resemble only land use patterns but also incorporates characteristics of urban design and transportation system.

In simulation studies, travel demand models are used to identify the impact of built environment on travel behavior. Typically, researchers consider hypothetical situations in simulation studies (Kulash et al., 1990, Stone et al., 1992, McNally and Ryan, 1993). In the disaggregate analysis, each household or individual person's data is used to examine the relationship between the built environment and travel behavior. In aggregate studies, aggregate data at TAZ or census tract level are used to model the relationship between characteristics of built environment and travel behavior (Friedman et al. 1994; Cervero and Gorham, 1995). In majority of the studies, travel behavior (VMT, trip length, trip frequency, and mode choice) is used as the dependent variable and characteristics of built environment (access to work, density, network characteristics, era of development, socio-economic characteristics, etc.) are used as the independent variables (Handy, 2005).

In addition, as suggested by Handy (2002), there exists a difference between the travel patterns and travel behavior. Travel patterns deal with travel characteristics at aggregate level, such as the number of trips or mode split in the selected zones. Travel behavior refers to households and individual choices. The analysis of both travel pattern and travel behavior provides different results. Travel pattern studies provide the information related to the effect of urban form on travel. On the other hand, travel behavior studies quantify what and how urban form relates to travel.

The descriptive analysis is an important tool to know what is going on (Crane, 2000). However, multivariate statistical analysis helps to explain the reasons behind the relationship between outcome and input variables. Traditionally, the relationship between land use and travel behavior is developed using Ordinary Least Square (OLS) regression, where travel behavior is considered as the dependent variable and land use characteristics are considered as the independent variables.

Boarnet (2011) concluded that, researchers have underestimated the standard error of coefficient in multiple regression models; which resulted in an extravagant significant level of estimated coefficients. However, this can be corrected using multilevel linear modeling (Ewing et. al, 2004). Zhang (2013) stated that, due to the drawbacks in OLS regression, structural equation modeling may provide insights on the role of land use characteristics on travel behavior. Geographically Weighted Regression (GWR) is another method to evaluate the relationship between land use characteristics and travel behavior (Nowrouzian and Srinivasan, 2013).

2.5 Travel Time as a System Performance

Travel time provides intriguing details of travel behavior / patterns along a link / corridor. Motorists usually plan their travel for the recurring congestion. The recurring congestion fluctuates based on the day-of-the-week (DOW) and time-of-the-day (TOD). However, unexpected congestion on daily trips is the worst for the motorists. Therefore, the reliability of the routes plays an important role for motorists to plan their travel and selection of the route.

According to Ebeling (1997), reliability is defined as the probability that a component or system will perform a required function (without failure) during a time period, when used under stated operating condition. In addition, according to Elefteriadou (2005), the travel time reliability is the level of variability between the expected travel time (scheduled, average or median travel time) and the actual travel time. It can be used to represent the level of service (LOS) of a link / corridor. Minimizing the travel time variation helps provide reliable routes for commuters who travel by private vehicle / car.

Travel time can be quantified in different ways to represent a system performance. Table 1 summarizes various travel time reliability measures that can be used to quantify the relationship between a new land use development and travel behavior in terms of travel time. Reliability measures such as Buffer Time Index (BTI) and Planning Time Index (PTI) can be used to compare different road links / corridors (Pulugurtha et al., 2015). However, measures such as Buffer Time (BT) and Planning Time (PT) can be used to compare the before-and-after condition of a road (National Center for Transit Research - NCTR, 2010; Pulugurtha et al., 2015).

Table 1 Travel Time System Performance Measures (Source: Pulugurtha et al., 2013)

Index	Measure / Equation	Index	Measure / Equation
NCHRP (1998) Definition	Standard deviation of travel time	λ_{skew} (Van Lint et al., 2004)	$\frac{TT_{90} - TT_{50}}{TT_{50} - TT_{10}}$
AASHTO (2008) Definition	On-time performance	λ_{Var} (Van Lint, & Van Zuylen, 2005)	$\frac{TT_{90} - TT_{10}}{TT_{50}}$
TranSystems Definition (2005)	Probability on-time performance	Variability (Wakabayashi, 2010)	TT_{85}-TT_{15}
Buffer Time (BT) (Lomax et al., 2004)	$TT_{95} - TT_{Avg}$	Variability (Wakabayashi, 2010)	TT_{80}-TT_{20}
Buffer Time Index (BTI) (Lomax et al., 2004)	$\frac{TT_{95} - TT_{Avg}}{TT_{Avg}} \times 100$	Variability (Wakabayashi, 2010)	TT_{70}-TT_{30}
First worst travel time over a month (Wakabayashi & Matsumoto, 2012)	TT_{95}	Acceptable Travel Time Variation Index (Wakabayashi, 2010)	$P(TT_{avg}+A\mathrm{TTV})$
Second worst travel time over a month (Wakabayashi & Matsumoto, 2012)	TT_{90}	Desired Travel Time Reduction Index (Wakabayashi, 2010)	$P(TT_{avg}-D\mathrm{TTR})$
Planning Time (PT) (Wakabayashi & Matsumoto, 2012)	TT_{95}	Travel Time Index (TTI) (Lyman & Bertini, 2008)	$\frac{TT_{avg}}{TT_{free\ flow}}$
Planning Time Index (PTI) (Sisiopiku & Islam, 2012)	$\frac{TT_{95}}{TT_{free\ flow}}$	Frequency of Congestion (Lyman & Bertini, 2008)	Percent of days/periods that are congested
Travel Time Variability (TTV) (Tu et al., 2007)	$TT_{90} - TT_{10}$		

2.6 Limitations of Previous Research

The review of past literature indicates that the relationship between land use characteristics and travel behavior needs further investigation. Moreover, different travel behavior parameters (VMT, trip length, mode choice, vehicle hours traveled, etc.) were extensively researched to investigate the relationships in the past. These parameters are difficult to capture, are time consuming to collect, and need extensive surveys. Also, travel behavior parameters are influenced by many external factors such as demographic, socioeconomic characteristics, automobile ownership, distance from residential to employment center, and availability of different modes of transportation such as transit, bike, and pedestrian infrastructure, etc. Capturing this data at TAZ level is a meticulous and time-consuming process. Collecting some of the parameters related to individual persons involves privacy issues. Also, with constant development and consistent growth, it is difficult to quantify the magnitude of land use development in terms of travel behavior.

Moreover, traditional TISs are meant to estimate the future trip generation rates by the future planned development. However, DOTs have different guidelines to perform TISs. Also, the guidelines provided by the ITE Trip Generation Manual has its own assumptions, as discussed in Section 2.2. Further, researchers observed a huge variation between the estimated number of trips and the actual number of trips using traditional TIS approach.

Ultimately, practitioners and researchers are curious about quantifying the influence of new developments, in terms of simple and easy to understand parameter such as travel time. With the advancement in technology, one can capture travel time information for most major links in a road network. As travel time influences travel behavior and can be easily understood by system managers and motorists, it is important to quantify the influence of new developments on travel time and travel time variations. Such an approach could change the way TISs due to new developments are currently conducted. Also, analyzing the influence of a new development at TAZ level may not be useful, since TAZs are developed based on the census block information. In addition, analyzing the influence of multiple land use developments along the link / corridor would be a possible solution to quantify the relationship between land use developments and travel times. Further, analyzing by area type and by classifying the links based on the speed limit as a filtering factor will help generate the results based on the typical structure of urban areas in the United States.

CHAPTER 3: STUDY AREA, DATA COLLECTION, AND DATA PROCESSING

This chapter presents the study area, data collection, and data processing adopted in this research.

3.1 Selection of Road Links

In this research, the city of Charlotte, NC was considered as the study area. I-485 (freeway) is the outer beltway for the city of Charlotte and was considered as the study boundary limit. The regional travel demand model (RTDM) was obtained from the city of Charlotte Department of Transportation (CDoT). In the RTDM, each road link is geospatially coded in geospatial environment. Majority of the links (excluding local streets and drive-throughs) are linked with the Regional Integrated Transportation Information System (RITIS) database by a unique Traffic Message Channel (TMC) code (generally referred to as “link” in this research). The RITIS is the travel time data source.

The main challenge lies with integrating the RTDM and RITIS databases in a geospatial environment. In the RITIS database, TMC code is assigned based on the particular direction of traffic movement. In the RTDM database, for a particular link, TMC codes are assigned as two separate columns based on the direction of traffic movement (TMC_AB and TMC_BA). In addition, same stretch of the link is divided into multiple links in the RTDM database. Therefore, merging the multiple links with respect to TMC codes in the RTDM database was the foremost step. This was carried out using “merge” tool in ArcGIS, using one TMC code column at a time.

Further, the length of some links are less than 0.05 miles (264 ft.), which were not considered in the selection of links in this research. The links less than 0.05 miles are typically connectors between the major corridors. Due to their small length, the travel time on these links is a few seconds (< 3 seconds). Hence, it does not provide the intrigued details related to travel time variation.

The objective of this research is to identify the land use characteristics within the vicinity of road links and quantify their influence on travel time performance. Therefore, defining the boundary condition is an important decision to quantify up to what extent the results would be informative. Land use developments just outside the study boundary could have an influence on the links closer to the study boundary. Hence, the road links were selected in such a way that they are located at least 3 miles from the study boundary (I-485). In addition, link lengths between the RTDM and RITIS databases varied in some cases. Therefore, the road links were selected with an error of = ± 0.1 mile (difference between the lengths from the RTDM and RITIS databases). In addition, every year agency is adding more and more links to collect travel time data. Therefore, for analyzing over the years data, the selected links should be consistent, geospatially, over the years in both the databases. Finally, a total of 259 links were selected. Figure 1 illustrates the study boundary and selected road links in this research.

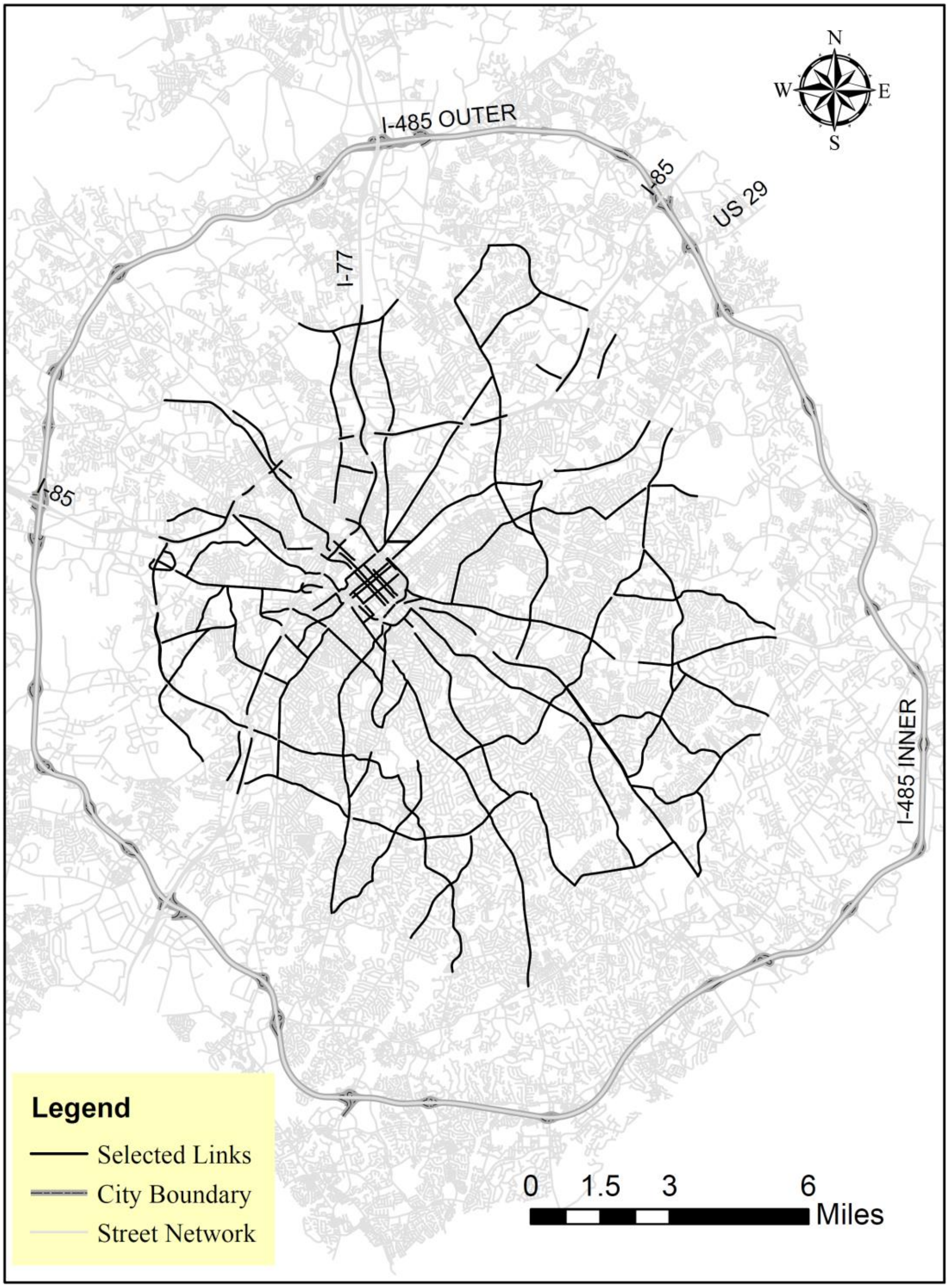

Figure 1 Selected links in this research.

3.2 Data Collection

After selecting the road links, data collection was performed in different stages: travel time, parcel level land use development, traffic, and network characteristics.

For the selected links (259 links), travel time data were downloaded from the RITIS website (www.ritis.org) in a raw unprocessed format from 2013 to 2015. The raw unprocessed data includes travel time for every one-minute interval. For every link, the RITIS provides speed, average speed, reference speed (estimated free flow speed or 85th percentile of observed speed data), travel time, and score. The score represents the type of data: 30 represents real-world travel time data, 20 represents real-world travel time data on multiple links, and 10 represent historical travel time data. Only the real-world travel time (score=30) data were considered in this research.

Parcel level land use development data were collected from the city of Charlotte Planning Division in geospatial format. The data includes year of built, heated area, and the number of units by land use type. Land use developments till year 2015 were considered in this research.

The upstream link, downstream link, upstream and downstream cross streets, and intersecting road links could have an influence on travel time measures of the selected link. Therefore, the network characteristics of upstream link, downstream link, upstream and downstream cross streets, and intersecting road links were considered to address the spatial correlation aspect. On a selected link, if there are multiple intersecting road links, the average number of lanes and speed limit were considered as the network characteristics of intersecting links. Figure 2 illustrates spatial dependency and criteria used to identify upstream link, downstream link, cross streets and intersecting links for a selected link.

Network characteristics such as the speed limit and the number of lanes for the aforementioned links were captured using RTDM database.

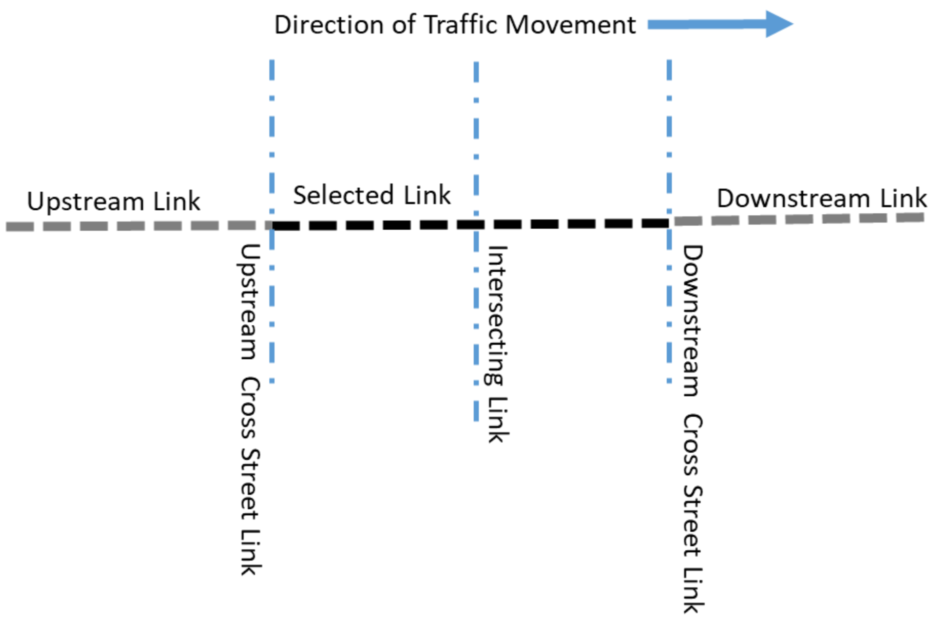

Figure 2 Spatial dependency criteria for a selected link.

The AADT was collected for 213 links from the RTDM database. The RTDM considers traffic volume collected by CDOT and NCDOT, to compute Average Annual Weekday Traffic (AAWT). Also, the conversion factor between AAWT and AADT is considered as 1.08 by CDOT (AAWT = 1.08 * AADT). However, not all the links have computed AAWT in the RTDM database. Further, traffic counts are typically collected once or twice in the year and sometimes at alternate years. Therefore, AADT computed from traffic counts do not represent the actual traffic scenario on a link over the year.

3.3 Data Processing

Data processing is an important step before the analysis. Data processing was carried out in two parts: parcel level land use development and travel time data.

3.3.1 Travel Time

The raw real-world travel time data were imported in Microsoft SQL server. Missing data points were checked and removed from the database. For the selected 259 links, the travel time measures were computed for the years 2013, 2014, and 2015, seperately. Several queries were written in the Microsoft SQL server to compute travel time measures, such as 10th percentile travel time, 15th percentile travel time, 50th percentile travel time, 85th percentile travel time , 95th percentile travel time (PT), average travel time (ATT), Buffer Time Index (BTI), and Planning Time Index (PTI). These travel time measures were computed for each link by aggregating at the day-of-the-week (DOW) and the time-of-the-day (TOD). Day-of-the-week (DOW) was classified as weekday (Monday to Friday) and weekend (Saturday and Sunday). TOD is classified as morning peak period (MPP) (7AM to 9AM), afternoon off-peak period (OPP) (9 AM to 4 PM), evening peak period (EPP) (4 PM to 7 PM), and nighttime period (NTP) (7 PM to 7AM). These TOD resembles the general traffic trends in the city of Charlotte area, North Carolina. In addition, travel time measures were converted into per mile (by dividing with link length) to reduce discrepancies that might arise due to varied link lengths. Finally, for all the selected 259 links, ATT, PT, BT, BTI and PTI were computed for each year with respect to DOW and TOD.

The mathematical expressions to compute PTI, BT, and BTI are represented as Equation 3, Equation 4, and Equation 5, respectively. Also, free flow travel time was considered as the 15th percentile travel time in Equation 3. The description about all the travel time measures is explained in Lomax et al. (2001).

$$Planning\ Time\ Index = \frac{95th\ percentile\ Travel\ Time}{Free\ Flow\ Travel\ Time} \tag{3}$$

$$Buffer\ Time\ = 95th\ percentile\ Travel\ Time - Average\ Travel\ Time \tag{4}$$

$$Buffer\ Time\ Index = \frac{95th\ percentile\ Travel\ Time - Average\ Travel\ time}{Average\ Travel\ Time} \tag{5}$$

3.3.2 Land Use Development

Parcel level land use development data were obtained in geospatial format (shapefile). ArcGIS software was used to examine and extract the land use development data. Missing, abrupt values, and duplicate data points were removed from the dataset. The raw dataset consists of 95 distinct land use categories. Each of the parcels provides information, such as the number of units, built year, and heated area (in square foot). Typically, heated area is the living area of any land use. In this research, land use developments were reclassified into thirty-five categories (Table 2).

Buffers were generated around each selected link using “buffer” feature in ArcGIS. A buffer is used in the proximity analysis and buffer width is the distance from the point of interest to the boundary of a buffer. In this study, a point of interest is a line feature (link). Four buffer widths (0.5 miles, 1-mile, 2 miles, and 3 miles) were generated around each of the selected links. The shapefile of land use developments was overlaid on the generated buffers (Figure 3). Land use developments within each of the generated buffers were extracted using “intersect” feature in ArcGIS. The “intersected” files were imported in the Microsoft Excel. Finally, based on the “year built” column, land use developments until the year 2013, 2014 and 2015 were aggregated separately using pivot table feature in Microsoft Excel. For example, within the proximity of 0.5 miles from a particular link, there are only five new developments in the year 2013. However, travel time on the selected link would be influenced by all the land use developments, which were developed before the year 2013. Therefore, to examine the relationship between travel time measures and land use development for the year 2013, land use developments until the year 2013 were captured in this study.

For each of the selected links, the sum of the heated area by land use categories within four different buffer widths and until the year 2013, 2014, and 2015 were aggregated separately in the land use database.

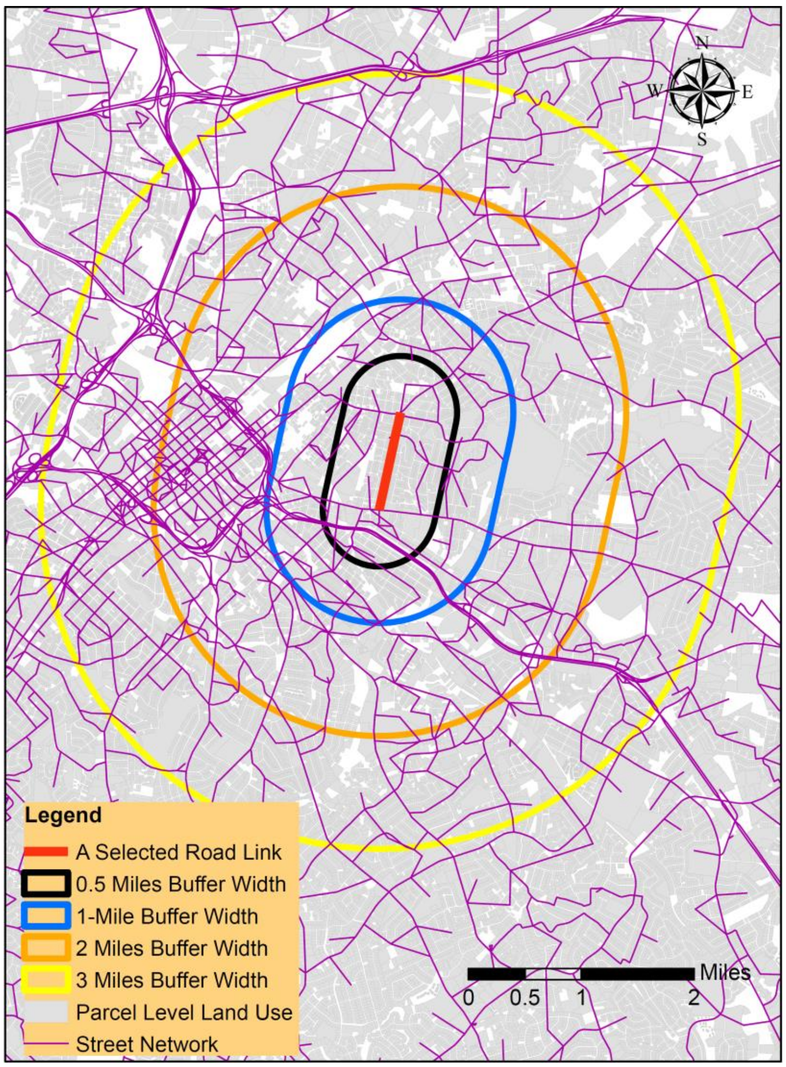

Figure 3 Spatial overlay of land use on different buffer widths around a road link.

Table 2 Description of Land Use Development Categories

Land Use Categories	Description
Attached Residential	Condo, condo hi-rise, townhouse
Auto Dealer	Auto dealer; auto dealer > 75,000 SF
Bank	Bank
Car Wash	Car wash self-service, car wash drive through
Church	Church
Commercial Service	Commercial / service, service station, commercial condominium, furniture showroom
Convenience Store	Convenience store
Daycare	Daycare
Department Store	Department and drug store
Fast Food	Fast food
Funeral Home	Funeral home
Government	County, state, federal, municipal government buildings
Hospital	Hospital
Hotel/Motel	Hotel Lodging Hi-Rise > 6 stories, Motel/hotel Lodging <7 stories
Industrial	Areas with manufacturing, processing and assembling of parts, distribution centers and transportation terminals; specialized industrial operations
Industrial Lg.	Industrial > 75,000 SF
Institutional	College-public, institutional, lab-research
Manufactured Home Construction	Manufactured home-double wise, manufactured home-singlewide
Manufacturing	light manufacturing, heavy manufacturing; light & heavy manufacturing > 75,000 SF
Medical	Medical and medical condominium
Multi-Family	Areas with a variety of housing types; 12–43 dwelling units per acre; apartment - townhouse, apartment - garden, apartment - hi-rise>6stories, nursing home, assisted living
Office	Office condominium, hi-rise> 6 stories
Parking Garage	Parking garage; parking garage > 75,000 SF
Recreational	Theatre, night club, bowling alley/ skating rink, club – lodge
Restaurant	Restaurant
Retail	Area utilized for retail shops
School	Area utilized for schools public private
Service Garage	Service garage; service garage>75,000 SF
Shopping Mall	Shopping mall
Single-Family Residential	Area with primarily single-family housing where houses have one common wall with the adjacent house / no walls are connected; patio, duplex, triplex, group home
Stadium/Arena	Stadium /arena
Supermarket	Supermarket
Truck Terminal	Truck terminal
Utility	Mechanical equipment building, utility
Warehouse	Area utilized for manufacturing and wholesale trade/distribution process; mini warehouse, lumber yard, food packing, bottler/brewery, cold storage

CHAPTER 4: METHODOLOGY

This chapter presents the methodology adopted in this research. Figure 4 represents the systematic procedure followed in this research.

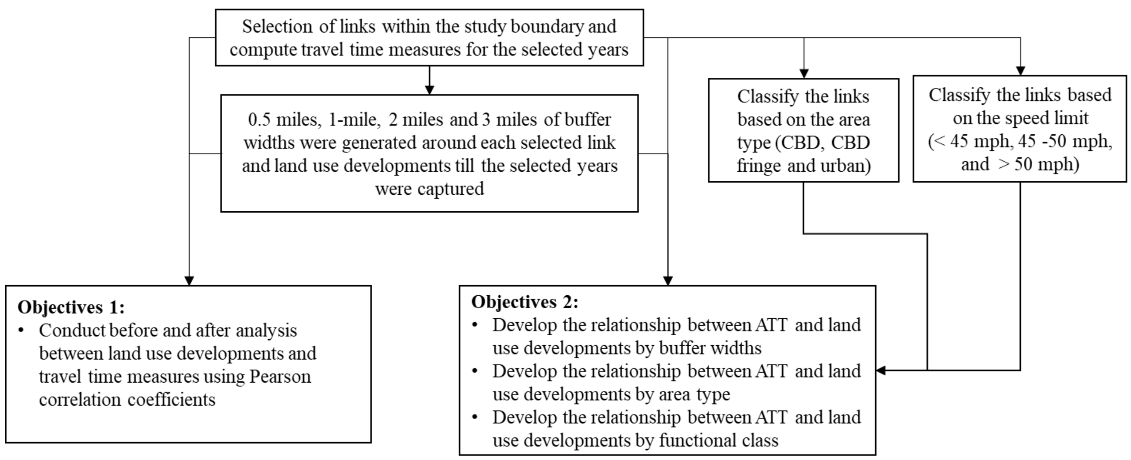

Figure 4 Methodology - flowchart

4.1 Correlation Analysis

In this research, correlation analysis was performed by computing Pearson correlation coefficients. The coefficient suggests a linear relationship between the two variables and provides the confidence interval at which the coefficient is significant. The range of Pearson correlation coefficients is from -1 to +1. Pearson correlation coefficients that were significant at a 95% confidence interval were classified into six categories. They are:

- High negative correlation (less than -0.5) represented as HN
- Moderate negative correlation (-0.5 to -0.3) represented as MN
- Low negative correlation (-0.3 to 0) represented as LN

- Low positive correlation (0 to +0.3) represented as LP
- Moderate positive correlation (+0.3 to +0.5) represented as MP
- High positive correlation (greater than 0.5) represented as HP

4.1.1 Correlation between Traffic, Land Use, and Network Characteristics

Twelve network characteristics were considered to examine the relationships. They are listed as follow.

- Speed limit (Link_SL) and the number of lanes (Link_# of Lanes) for the selected link
- Speed limit (US_SL) and the number of lanes (US_# of Lanes) for the upstream link
- Speed limit (DS_SL) and the number of lanes (DS_# of Lanes) for the downstream link
- Speed limit (US_Cross street_SL) and the number of lanes (US_Cross street_# of Lanes) for the upstream cross street
- Speed limit (DS_Cross street_SL) and the number of lanes (DS_Cross street_# of Lanes) for the downstream cross street
- Speed limit (Intersection_SL) and the number of lanes (Intersection_# of Lanes) for the intersecting links

Pearson correlation coefficients were computed between all the aforementioned network characteristics and AADT of the selected links (213 links). This is because, of the 259 selected links, the AADT data was available for 213 links in the RTDM database, as stated previously in Section 3.2. Three years (2013 to 2015) of AADT were collected from the RTDM database. Individual year AADT data were considered for this analysis. The changes in the network characteristics by each year were not available in the RTDM or in any other database. Therefore, network characteristics were assumed as unchanged within these three years. Overall, the sample size for the correlation analysis was 639 samples (213 links × 3 years).

A positive correlation coefficient indicates that AADT increases with an increase in the related network characteristic (the speed limit or the number of lanes, and vice versa for negative correlation coefficient.

4.1.2 Correlation between Travel Time Measures and Land Use Characteristics

Firstly, the ratios between the travel time measures (ATT, PT, BT, BTI, and PTI) in 2014 and 2013 were computed by DOW (weekday and weekend) and TOD (MPP, OPP, EPP, and NTP), for each selected link. Likewise, the ratios between the travel time measures in 2015 and 2014 were computed by DOW and TOD for each selected link. This provides the before-and-after scenario for travel time measures.

Secondly, the ratios between the land use developments till 2014 and till 2013 were computed for the four different buffer widths (0.5 miles, 1-mile, 2 miles and 3 miles). Likewise, the ratios between land use characteristics till 2015 and till 2014 were computed for the four buffer widths.

Finally, both the ratios of travel time measures and land use characteristics for 2014 by 2013 and for 2015 by 2014 were integrated, for each link, and used for the Pearson correlation coefficient analysis. Overall, the sample size for the correlation analysis was 518 samples [259 links × 2 (Ratio between 2015 and 2014, Ratio between 2014 and 2013)]. A positive correlation coefficient indicates that, the ratio of travel time measures increases on the link as the ratio of a land use development increases. In other words, travel time measure increases on the selected link with an increase in the land use development within the buffer width, and vice versa for the negative correlation.

Additionally, Pearson correlation coefficients were computed between land use developments and travel time measures based on the DOW and TOD for the four different buffer widths datasets, separately.

4.2. Model Development and Validation

The methodology adopted for developing the relationship between the land use developments and the ATT with respect to buffer widths, area type and the speed limit is discussed in this section. Statistical models were developed using Generalized Estimating Equation (GEE). The GEE is developed by Liang and Zeger (1986). It is an extension of generalized linear model and applicable even if the dependent variable is not normally distributed. The dependent variable (ATT) has over three years of data with respect to multiple links, TOD and DOW. The influence of land use and network characteristics on the travel time and travel time variation can be better captured through the ATT than other travel time measures, such as PT, BT, BTI and PTI. Also, considering the PT or PTI as the dependent variable would illustrate the influence of land use developments and network characteristics on travel times during the first or second worst traffic scenario (say, during a month). However, these worst traffic scenarios might be the resultant of a crash. Therefore, in this research, the ATT was considered as the dependent variable. The predictor variables are land use developments within different buffer widths, TOD, and DOW, for multiple years. This complete dataset is known as longitudinal or panel dataset. Ballinger (2004) provide a detailed discussion regarding the applicability of GEE models for longitudinal dataset.

Three main points in developing the GEE model are: link function, distribution, and the correlation structure of the dependent variable. Distributions such as Gamma, Poisson, binomial, Negative binominal, normal, and multinomial distributions can be selected based on the type of dependent variable. Typically, Poisson and negative binominal distribution are better for count models. Natural log, square, square root, and reciprocal of the dependent variable can be used as a link function. For the correlated structure, auto regressive, independent, exchangeable and unstructured can be used in the model development (Ballinger, 2004).

Pan (2001) proposed Quasi Likelihood under Independence Model Criterion (QIC) and Corrected Quasi Likelihood under Independence Model Criterion (QICC) parameters to select the best-fitted model.

In this research, several linear and non-linear functions, along with the several distributions of dependent variables, were explored. During model development in SPSS®, TMC codes, year, DOW, and TOD were kept as the subject variables The best model was selected based on QIC and QICC values. The lower the QIC and QICC, the better is the goodness of fit. Moreover, the difference between QIC and QICC should be generally low for a good model. For further analysis, preferred buffer widths were selected based on the statistical performance of the developed models.

4.2.1 Selection of Variables for Model Development

The ATT by DOW and TOD for all the three years (2013 to 2015) were considered as the dependent variable. Land use developments till that year, network characteristics of selected, upstream, downstream, upstream and downstream cross streets and intersecting links were considered as the predictor variable. In addition, DOW and TOD were considered as the predictor variables. DOW was considered as the dichotomous variable with the weekday represented as '1' and the weekend represented as '0'. In terms of TOD, four binary variables were generated, which are MPP, OPP, EPP, and NTP.

4.2.2 Check Multicollinearity between Predictor Variables

The selected predictor variables may be correlated to each other. To avoid multicollinearity between predictor variables, the cut-off value of Pearson correlation coefficient was set up as -0.3 and +0.3 (i.e., Pearson correlation coefficient value less than or equal to -0.3 or greater than or equal to 0.3 are assumed to be correlated to each other) (at least at a 95% confidence level). The correlation between the predictor variables were checked at least at a 95% confidence interval. For model development, only one predictor variable was selected between the two correlated predictor variables at a time. This leads to multiple models with combinations of predictor variables.

4.2.3 Relationship between ATT and Land Use Developments by Buffer Width

Firstly, the relationship between the ATT and land use developments, for different buffer widths (0.5 miles, 1 mile, 2 miles and 3 miles), were developed. Out of the 259 links, 206 links (80%) were selected for model development and the remaining 53 links (20%) were selected for validation of models. Overall, the sample size for model development was samples 4,944 (206 links × 3 years × 2 DOW × 4 TOD) and the sample size for validation was 1,272 samples (53 links × 3 years × 2 DOW × 4 TOD).

For each buffer width, three models were developed. First model was developed by incorporating all the predictor variables in the model and then removing the predictor variable with p-value greater than 0.05, one at a time. This process is also known as backward elimination method. Second and third models were developed based on the combination of predictor variables, which were independent of each other, as stated previously in Section 4.2.2. In addition, the predictor variables such as DOW and TOD were enforced in the models to be able to predict the ATT on a particular DOW and TOD periods.

4.2.4 Relationship between ATT and Land Use Developments by Area Type

Similar to the models by buffer widths, the relationship between ATT and land use developments were developed by classifying the links by area type. In the RTDM database, area type is classified into five categories: CBD, CBD Fringe / Other Business District (OBD), urban, suburban and rural area. Each TAZ is assigned either one of the area types based on the population and employment density. Likewise, each link is assigned to an area type based on the surrounding TAZs (Table 3). Figure 5 illustrates the selection of links by area type.

Out of the 259 links, 48 links, 68 links, and 143 links were located in the CBD, CBD fringe / OBD, and urban area, respectively. A total of 38 links in the CBD, 55 links in the CBD fringe / OBD, and 113 links in the urban area (80%) were selected for model development. The remaining 10 links in the CBD, 13 links in the CBD fringe / OBD, and 30 links in the urban area (20%) were selected for model validation. The selected land use developments within the preferred buffer widths, network characteristics, DOW, and TOD were considered as the predictor variables. Overall, the sample size for model development of the CBD, the CBD fringe/ OBD, and the urban area were 912 samples (38 links × 3 years × 2 DOW × 4 TOD), 1,320 samples (55 links × 3 years × 2 DOW × 4 TOD), and 2,712 (113 links × 3 years × 2 DOW × 4 TOD), respectively. Likewise, the sample size for validation of the CBD, the CBD fringe/ OBD, and the urban area models were 240, 312, and 720 samples, respectively.

Similar to the models by buffer widths, three models were developed for each of the area type and buffer width. For each area type and each selected buffer width, the first model was developed using the backward elimination method. The other two models were developed by selecting the predictor variables, which were independent of each other (at a 95% confidence level).

Table 3 Classification of Area Type based on Population and Employment Density

Area Type	**Population Density (per square mile)**	**Employment Density (per square mile)**
CBD	<375 / or >=375	>10,500
CBD Fringe / OBD	<375 / or >=375	>2,600
Urban	Population Density + (Employment Density /1.6) > 2,100	
Suburban	Population Density + (Employment Density /1.6) <= 2,100	
Rural	< 375	0 to 2,600

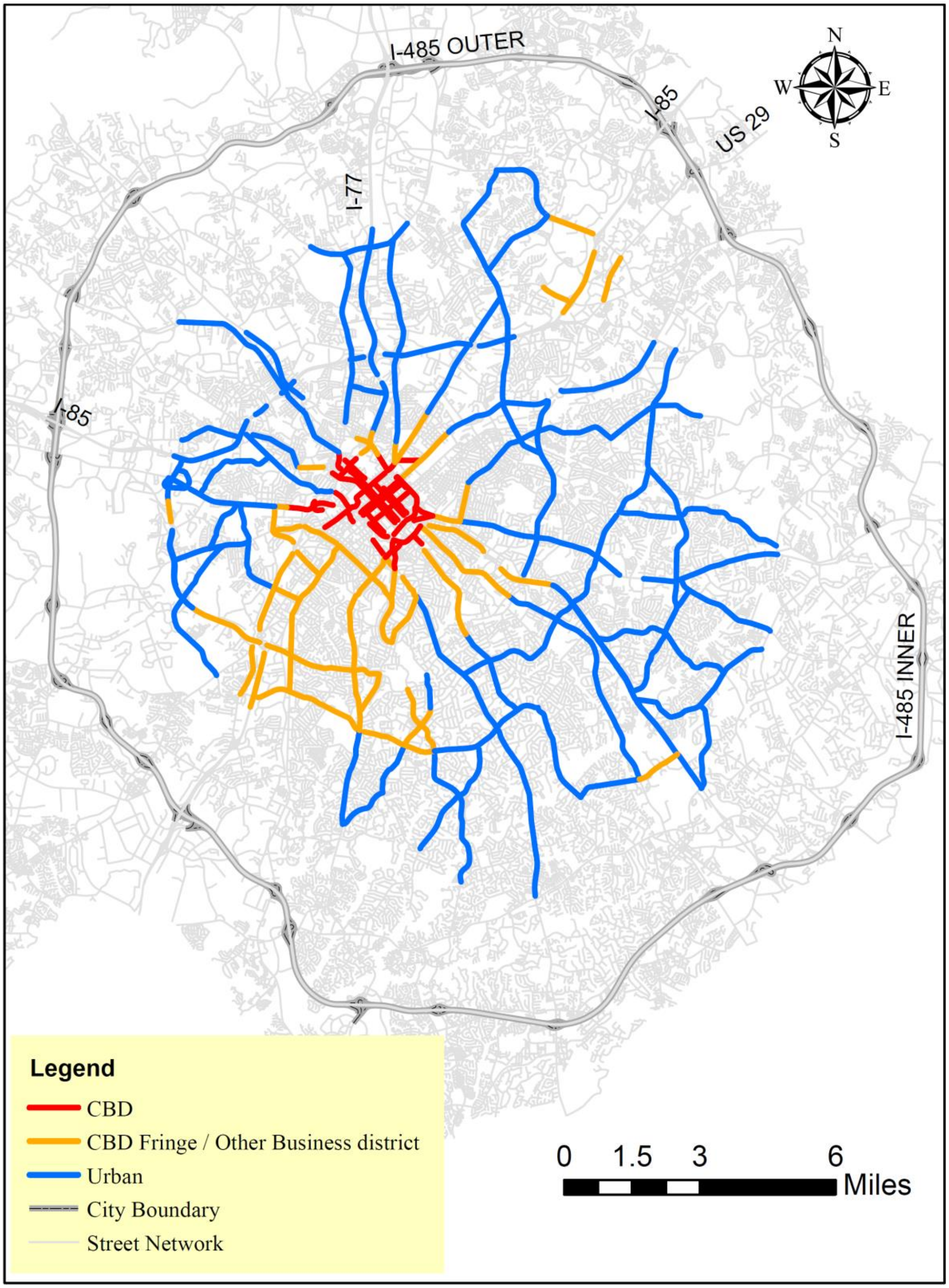

Figure 5 Classification of links by area type.

4.2.5 Relationship between ATT and Land Use Developments by Speed Limit

Similar to the models by area type, the relationship between ATT and land use developments were developed by classifying the links by the speed limit. The speed limit is divided into three categories: less than 45 mph, 45 to 50 mph, and greater than 50 mph. Each of the classifications resembles a unique traffic and driving experience. Out of the 259 links, 112 links, 114 links, and 33 links have a speed limit less than 45 mph, between 45 – 50 mph, and greater than 50 mph, respectively. Figure 6 illustrates the selection of links by speed limit. A total of 89 links with speed limit less than 45 mph, 91 links with speed limit between 45 to 50 mph, and 26 links with speed limit greater than 50 mph were selected for model development. This total accounts for about 80% of the total sample. The remaining 23 links with speed limit less than 45 mph, 23 links with speed limit between 45 to 50 mph, and 7 links with speed limit greater than 50 mph were selected for model validation. The validation sample accounts for about 20% of the total sample. The selected land use developments within the preferred buffer widths, network characteristics, DOW, and TOD were considered as the predictor variables. Overall, the sample size for model development of links with speed limit less than 45 mph, 45 to 50 mph, and greater than 50 mph were 2,136 samples (89 links × 3 years × 2 DOW × 4 TOD), 2,184 samples (91 links × 3 years × 2 DOW × 4 TOD), and 624 (26 links × 3 years × 2 DOW × 4 TOD), respectively. Likewise, the sample size for validation of links with speed limit less than 45 mph, 45 to 50 mph, and greater than 50 mph were 552, 552, and 168 samples, respectively.

Similar to the models by buffer widths, three models were developed for each of the speed limit category and buffer width. For each speed limit category and each selected buffer width, the first model was developed using the backward elimination method. The other two models were developed by selecting the predictor variables, which were independent of each other (at a 95% confidence level).

4.2.6 Validate the Models

Each of the developed model was validated using the Root Mean Square Error (RMSE), the Mean Absolute Percentage Error (MAPE), and the Mean Percentage Error (MPE). The RMSE, MAPE, and MPE are computed using Equation 6, Equation 7, and Equation 8. RMSE, MAPE and MPE closer to zero indicate the best-fitted model. Also, positive percentage sign in MPE indicates that the model under-predicts compared to the actual ATT. In this research, MPE was considered to check whether the model under-predicts or over-predicts compared to the actual ATT.

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{t=1}^{n}(\mathrm{Actual}_{\mathrm{ATT}} - \mathrm{Predicted}_{\mathrm{ATT}})^2}{n}} \tag{6}$$

$$\mathrm{MAPE} = \frac{1}{n}\sum_{t=1}^{n} \left| \frac{\mathrm{Actual\_ATT} - \mathrm{Predicted\_ATT}}{\mathrm{Actual\_ATT}} \right| \tag{7}$$

$$\mathrm{MPE} = \frac{1}{n}\sum_{t=1}^{n}\left(\frac{\mathrm{Actual\_ATT} - \mathrm{Predicted\_ATT}}{\mathrm{Actual\_ATT}}\right) \tag{8}$$

where,

n = number of observations,

Actual_ATT= Observed average travel time, and,

Predicted_ATT= predicted average travel time.

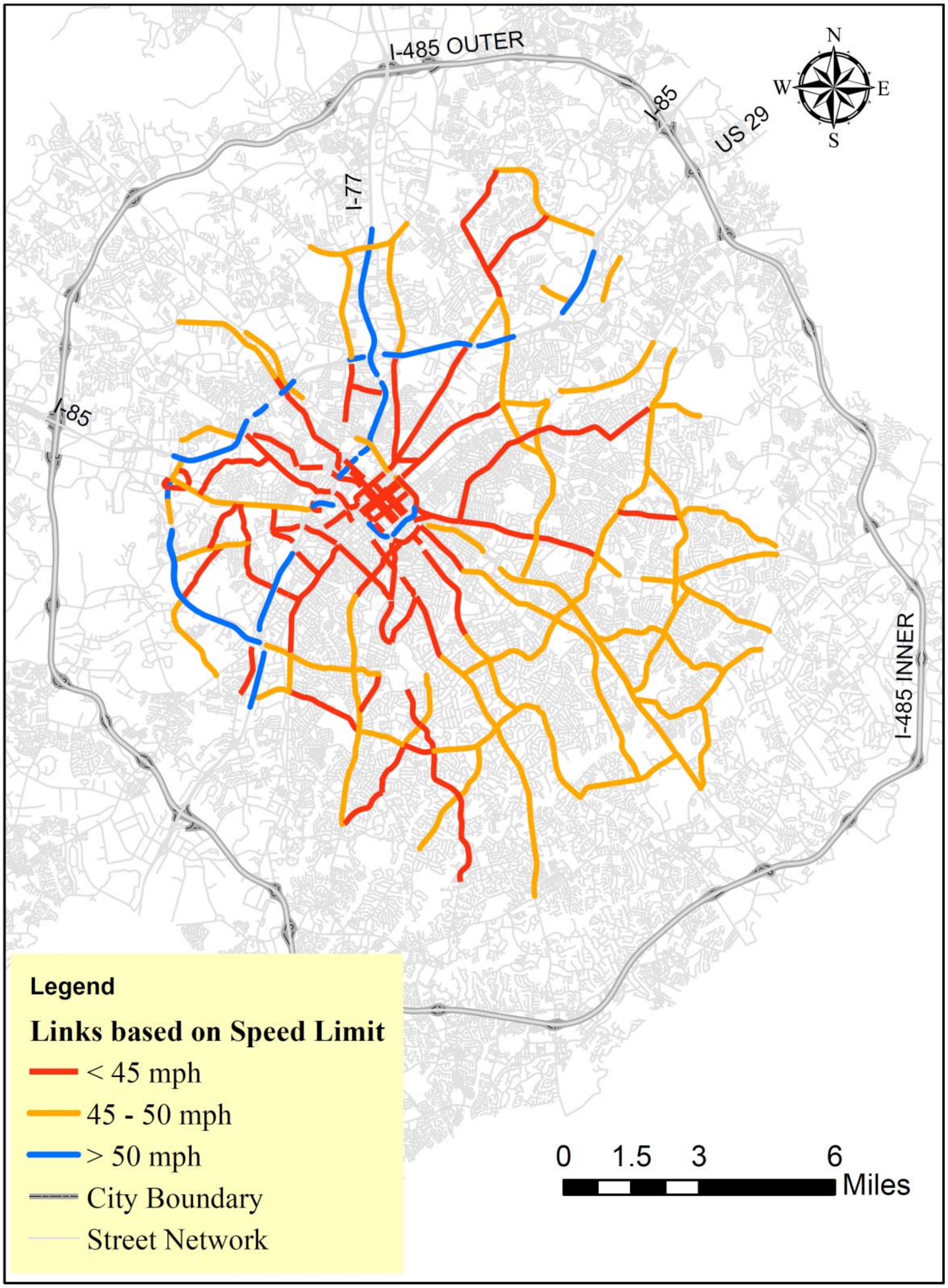

Figure 6 Classification of links by speed limit.

CHAPTER 5: CORRELATION ANALYSIS

This chapter presents the results obtained from the correlation analysis. The correlation between traffic and network characteristics was examined to find a surrogate parameter to represent traffic volume in the model development process. For this analysis, the correlation between AADT of each individual year (2013 to 2015) and network characteristics from the RTDM database was examined as described in Section 4.1.1 and the corresponding results are presented in Section 5.1. In addition, the correlation between travel time measures and land use developments for different time periods were examined based on the computed ratios as described in Section 4.1.2 and the results obtained are presented from Section 5.2 to Section 5.5. A positive correlation coefficient for results presented from Section 5.2 to Section 5.5 indicates that, the ratio of travel time measures increases on the link as the ratio of a land use development increases. In other words, travel time measure increases on the selected link with an increase in the land use development within the buffer width, and vice versa for the negative correlation.

5.1. Correlation between Traffic and Network Characteristics

Table 4 summarizes the correlation between traffic and network characteristics. The number of lanes and the speed limit of the selected links, the number of lanes of upstream links, and the number of lanes and the speed limit of downstream links are highly correlated with the AADT. In this study, for a link, the computed AADT was collected from the RTDM database in terms of AAWT. Also, for a link, the AAWT are typically computed based on the traffic counts once or twice in a year. Also, for a particular link, typically, travel times are collected at every 1-minute interval. Therefore, to make the data consistent with real-world scenario, instead of considering AADT as the predictor variable, the network characteristics of the selected link were considered as the surrogate predictor variables for AADT.

Table 4 Correlation between Traffic and Network Characteristics

Parameters	AADT	Link_# of Lanes	Link_SL	US_# of Lanes	US_SL	DS_# of Lanes	DS_SL	US_Cross street_# of Lanes	US_Cross street_SL	DS_Cross street_# of Lanes	DS_Cross street_SL	Intersection _# of Lanes
Link_# of Lanes	HP		MP	HP	MP	HP	MP	LN	LN	LN	LP	LN
Link_SL	HP	MP		MP	MP	MP	HP	MN		LN	MP	MN
US_# of Lanes	HP	HP	MP		HP	MP	MP	LN		LN		LN
US_SL	MP	MP	MP	HP		LP	LP	LN		LN	LP	LN
DS_# of Lanes	HP	HP	MP	MP	LP		HP	LN	LN	LN		LN
DS_SL	HP	MP	HP	MP	LP	HP		LN		LN	LP	LN
US_Cross street_# of Lanes	LN	LN	MN	LN	LN	LN	LN		LP	MP	LN	MP
US_Cross street_SL		LN				LN		LP		LP	LP	LP
DS_Cross street_# of Lanes	LN	LN	LN	LN	LN	LN	LN	MP	LP		LP	LP
DS_Cross street_SL	LP	LP	MP		LP		LP	LN	LP	LP		LN
Intersection_# of Lanes	MN	LN	MN	LN	LN	LN	LN	MP	LP	LP	LN	
Intersection_SL	MN	LN	MN	LN	LN	LN	LN	MP	LP	LP	LN	HP

5.2 Correlation between Travel Time Measures and Land Use Developments - Morning Peak Period

Table 5 summarizes the Pearson correlation coefficient results obtained for the morning peak period. The results obtained indicate that, during a weekday morning peak period, areas with car wash and retail stores within 0.5 miles and 1-mile from a link have a positive correlation with BT and BTI. Likewise, areas with hotel/ motel and multi-family type land use within 0.5 miles and 1-mile from a link have a positive correlation with ATT. Further, areas with multi-family and supermarket within 2 miles and 3 miles from a link have a positive correlation with most of the travel time measures.

With respect to weekend morning peak period, areas with hotels/ motels within 0.5 miles and 1-mile from a link have a positive correlation with ATT, PT and PTI. Likewise, areas with bank, retail and supermarket within 0.5 miles from a link have a positive correlation with BT and BTI. Similarly, areas with convenience store, parking garage, and retail within 1-mile from a link have a positive correlation with BT and BTI. Further, areas with multi-family, recreational, retail, and service garage within 2 miles from a link have a positive correlation with majority of the travel time measures. The areas with convenience store, multi-family, recreational, and supermarket within 3 miles from a link also have a positive correlation with most of the travel time measures.

5.3 Correlation between Travel Time Measures and Land Use Developments - Afternoon Off-peak Period

Table 6 summarizes the Pearson correlation coefficient results obtained for the afternoon off-peak period. During a weekday, the areas with hotel/motel, service garage, and single-family residential within 0.5 miles from a link have a positive correlation with

ATT. Likewise, areas with bank, car wash and retail within 0.5 miles from a link have a positive correlation with BT and BTI. Similarly, areas with multi-family type land use within 1-mile, 2 miles, and 3 miles from a link have a positive correlation with all the travel time measures. In addition, areas with retail, service garage, and supermarkets within 2 miles and 3 miles from a link have a positive correlation with most of the travel time measures. Further, areas with single-family residential within 2 miles and 3 miles from a link have a positive correlation with the ATT, however, a negative correlation with the BTI.

During weekend, the areas with hotel/motel and service garage, within 0.5 miles from a link have a positive correlation with the ATT. Likewise, areas with car wash, convenience store, multi-family, parking garage, and recreational within 1-mile from a link have a positive correlation with BT and BTI. However, areas with attached residential, fast food, hotel/ motel, office, and utility type land uses within 2 miles from a link have a negative correlation with BT and BTI. Further, areas with multi-family, recreational, and service garage within 2 miles and 3 miles from a link have a positive correlation with most of the travel time measures.

5.4 Correlation between Travel Time Measures and Land Use Developments - Evening Peak Period

Table 7 summarizes the Pearson correlation coefficient results obtained for the evening peak period. During a weekday, the areas with car wash within 0.5 miles, 1-mile, and 2 miles from a link have a positive correlation with BT and BTI. Likewise, areas with convenience store, multi-family, and parking garage within 1-mile from a link have a positive correlation with most of the travel time measures. Further, areas with multi-family, retail, service garage and supermarkets within 2 miles and 3 miles from a link have a positive correlation with most of the travel time measures.

During weekend, the areas with fast food, hotel/motel and service garage type land use within 0.5 miles from a link have a positive correlation with travel time measures. Likewise, areas with fast food, multi-family, recreational, retail, and supermarkets within 1-mile from a link have a positive correlation with BT and BTI. The areas with convenience store, multi-family, recreational, retail, school, service garage and supermarkets within 2 miles from a link have a positive correlation with BT and BTI. However, the attached residential, hotel/ motel, and office type land uses within 2 miles from a link have a negative correlation with BT and BTI. Likewise, bank, hotel/motel, medical, office, and warehouse type land uses within 3 miles from a link have a negative correlation with BT and BTI.

5.5 Correlation between Travel Time Measures and Land Use Developments - Nighttime Period

Table 8 summarizes the Pearson correlation coefficient results obtained for the nighttime period. During weekday, the areas with bank, car wash, and institutional type land uses within 0.5 miles from a link have a positive correlation with BTI. Likewise, areas with convenience store, institutional, multi-family, recreational, retail, and school type land uses within 1-mile from a link have a positive correlation with BT and BTI. Similarly, areas with convenience store, multi-family, recreational, retail, school, service garage, and supermarkets within 2 miles and 3 miles from a link have a positive correlation with most of the travel time measures.

During weekend, the areas with attached residential, bank, convenience store, institutional, and retail stores within 0.5 miles from a link have a positive correlation with BT and BTI. Likewise, areas with multi-family, parking garage, recreational, and retail type land uses within 1-mile from a link have a positive correlation with majority of the travel time measures. Further, areas with multi-family, recreational, school, service garage and supermarkets within 2 miles and 3 miles from a link have a positive correlation with most of the travel time measures.

Table 5 Correlation between Travel Time Measures and Land Use Characteristics - Morning Peak Period

Morning Peak Period Weekday

Parameters	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential											LN	LN	LN	LN				LN	LN	
Auto Dealer	LN								LP											
Bank			LP	LP																
Car Wash			LP	LP				LP	LP											
Church													LP	LP						
Commercial Service																				
Convenience Store									LP				LP	LP		LP	LP	LP	LP	LP
Daycare																				
Department Store																				
Fast Food												LN			LN	LN	LN	LN	LN	LN
Funeral Home																				
Government																				
Hospital																				
Hotel / Motel	LP	LP			LP	LP							LN	LN				LN	LN	
Industrial																				
Industrial Lg																				
Institutional																		LP	LP	
Manufactured Home Construction						LN	LN	LN	LN	LN					LP	LP		LN	LN	
Manufacturing																				
Medical																				
Multi-Family	LP	LP			LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office											LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage						LP	LP													
Recreational																LP	LP	LP	LP	LP
Restaurant																				
Retail			LP	LP				LP	LP		LP	LP	LP	LP	LP					
School													LP	LP				LP	LP	
Service Garage											LP	LP			LP	LP	LP			
Shopping Mall																				
Single-Family Residential								LN	LN		LP							LN	LN	
Stadium /Arena																				
Supermarket											LP	LP	LP	LP		LP	LP	LP	LP	LP
Truck Terminal																				
Utility						LN	LN				LN	LN	LN	LN	LN					
Warehouse																		LN	LN	

Morning Peak Period Weekend

Parameters	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential						LN		LN	LN		LN	LN	LN	LN	LN	LN		LN	LN	
Auto Dealer																				
Bank			LP	LP														LN	LN	LN
Car Wash													LP	LP				LP	LP	
Church																				
Commercial Service																				
Convenience Store								LP	LP				LP	LP		LP	LP	LP	LP	LP
Daycare																				
Department Store																				
Fast Food												LN	LN	LN	LN	LN	LN	LN	LN	LN
Funeral Home																				
Government											LN		LN					LN	LN	
Hospital													LN	LN		LN	LN	LN	LN	LN
Hotel / Motel	LP	LP	LP		LP	LP	LP			LP			LN	LN				LN	LN	
Industrial																				
Industrial Lg																				
Institutional																				
Manufactured Home Construction						LN	LN	LN	LN			LP			LP	LP	LP		LN	LP
Manufacturing																				
Medical																		LN	LN	
Multi-Family						LP	LP	LP		LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office											LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage								LP	LP											
Recreational												LP	LP	LP	LP	LP	LP	LP	LP	LP
Restaurant																				
Retail			LP	LP				LP	LP		LP	LP	LP	LP			LP	LP	LP	
School													LP	LP				LP	LP	
Service Garage											LP	LP	LP	LP	LP					
Shopping Mall																				
Single-Family Residential								LN	LN		LP							LN	LN	
Stadium /Arena																				
Supermarket			LP	LP												LP	LP	LP	LP	LP
Truck Terminal																				
Utility																				
Warehouse																		LN	LN	

Table 6 Correlation between Travel Time Measures and Land Use Characteristics - Afternoon Off-Peak Period

Parameters	Afternoon Off-Peak Period Weekday																			
	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential											LN	LN	LN	LN	LN			LN	LN	
Auto Dealer	LN																			
Bank			LP	LP																
Car Wash			LP	LP				LP	LP				LP	LP				LP	LP	
Church														LP						
Commercial Service																				
Convenience Store							LP	LP	LP	LP			LP	LP		LP	LP	LP	LP	LP
Daycare																				
Department Store																				
Fast Food									LN		LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Funeral Home																				
Government																				
Hospital																LN				
Hotel / Motel	LP	LP			LP	LP	LP			LP			LN	LN				LN	LN	
Industrial																				
Industrial Lg																				
Institutional																		LP	LP	
Manufactured Home Construction						LN	LN	LN	LN	LN					LP	LP		LN	LN	LP
Manufacturing																				
Medical																				
Multi-Family						LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office												LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage	LN																			
Recreational																LP	LP	LP	LP	LP
Restaurant																				
Retail			LP	LP				LP	LP		LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
School									LP				LP	LP	LP			LP	LP	
Service Garage	LP										LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Shopping Mall																				
Single-Family Residential	LP							LN	LN		LP	LP		LN		LP		LN	LN	
Stadium /Arena																				
Supermarket											LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Truck Terminal																				
Utility						LN	LN				LN	LN			LN					
Warehouse																		LN	LN	

Parameters	Afternoon Off-Peak Period Weekend																			
	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential											LN	LN	LN	LN	LN			LN	LN	
Auto Dealer																				
Bank																		LN	LN	LN
Car Wash								LP	LP				LP	LP						
Church																				
Commercial Service																				
Convenience Store			LP	LP				LP	LP				LP	LP		LP	LP	LP	LP	LP
Daycare																				
Department Store																				
Fast Food												LN	LN	LN	LN	LN	LN	LN	LN	LN
Funeral Home																				
Government																			LN	
Hospital																LN	LN			
Hotel / Motel	LP	LP			MP	LP	LP			LP			LN	LN	LP			LN	LN	LP
Industrial																				
Industrial Lg																				
Institutional														LP				LP	LP	
Manufactured Home Construction						LN	LN	LN	LN	LN	LP	LP			MP	LP	LP		LN	LP
Manufacturing																				
Medical																		LN	LN	LN
Multi-Family						LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office											LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage								LP	LP											
Recreational								LP	LP		LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Restaurant																				
Retail											LP	LP	LP	LP				LP	LP	
School													LP	LP				LP	LP	
Service Garage	LP										LP	LP	LP	LP	LP	LP		LP	LP	
Shopping Mall																				
Single-Family Residential								LN			LP	LP			LP			LN	LN	LP
Stadium /Arena																				
Supermarket																LP	LP	LP	LP	LP
Truck Terminal																				
Utility						LN					LN	LN	LN	LN						
Warehouse																		LN	LN	

Table 7 Correlation between Travel Time Measures and Land Use Characteristics - Evening Peak Period

Parameters	Evening Peak Period Weekday																			
	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential											LN	LN			LN	LN	LN	LN	LN	
Auto Dealer																				
Bank			LP	LP									LN	LN				LN	LN	LN
Car Wash			LP	LP				LP	LP				LP	LP					LP	
Church													LP	LP				LP	LP	
Commercial Service																				
Convenience Store							LP	LP	LP	LP			LP	LP		LP	LP	LP	LP	LP
Daycare																				
Department Store																				
Fast Food	LN					LN	LN	LN		LN	LN	LN			LN	LN	LN	LN		LN
Funeral Home																				
Government																	LN			LN
Hospital													LN	LN		LN	LN			LN
Hotel / Motel	LP				LP	LP			LN				LN	LN				LN	LN	
Industrial																				
Industrial Lg																				
Institutional																			LP	
Manufactured Home Construction						LN	LN	LN	LN	LN					LP	LP		LN	LN	
Manufacturing																				
Medical									LN									LN	LN	
Multi-Family						LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office												LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage	LN					LP	LP	LP		LP										
Recreational																		LP	LP	
Restaurant																				
Retail								LP	LP		LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
School													LP	LP				LP	LP	
Service Garage											LP	LP	LP	LP	LP	LP	LP	LP		LP
Shopping Mall																				
Single-Family Residential	LP								LN		LP					LP		LN	LN	
Stadium /Arena																				
Supermarket											LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Truck Terminal																				
Utility						LN	LN	LN	LN	LN	LN	LN	LN	LN	LN					
Warehouse																	LN	LN	LN	LN

Parameters	Evening Peak Period Weekend																			
	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential											LN	LN	LN	LN	LN				LN	
Auto Dealer																				
Bank																		LN	LN	LN
Car Wash									LP											
Church																				
Commercial Service																				
Convenience Store													LP	LP		LP	LP	LP	LP	LP
Daycare																				
Department Store																				
Fast Food			LP	LP				LP	LP			LN			LN	LN	LN	LN		LN
Funeral Home																				
Government																				
Hospital																				
Hotel / Motel	LP	LP			LP	LP	LP			LP	LP		LN	LN				LN	LN	
Industrial																				
Industrial Lg																				
Institutional																				
Manufactured Home Construction						LN	LN	LN	LN	LN	LP	LP			LP	LP	LP		LN	LP
Manufacturing																				
Medical																		LN	LN	LN
Multi-Family						LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office											LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage																				
Recreational								LP	MP			LP	LP	LP	LP	LP	LP	LP	LP	LP
Restaurant																				
Retail								LP	LP		LP	LP	LP	LP	LP					
School									LP				LP	LP				LP	LP	
Service Garage	LP										LP	LP	LP	LP	LP			LP	LP	
Shopping Mall																				
Single-Family Residential											LP	LP		LN	LP	LP	LP		LN	LP
Stadium /Arena																				
Supermarket							LP	LP	LP	LP		LP	LP	LP	LP		LP	LP	LP	LP
Truck Terminal																				
Utility						LN	LN				LN									
Warehouse																		LN	LN	

Table 8 Correlation between Travel Time Measures and Land Use Characteristics - Nighttime Period

Parameters	Nighttime Period Weekday																			
	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential											LN	LN	LN	LN	LN		LN	LN	LN	LN
Auto Dealer																				
Bank				LP								LN	LN	LN	LN		LN	LN	LN	LN
Car Wash				LP																
Church													LP	LP						
Commercial Service																				
Convenience Store								LP	LP			LP	LP	LP	LP	LP	LP	MP	MP	LP
Daycare																				
Department Store																				
Fast Food											LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Funeral Home																				
Government													LN				LN	LN	LN	LN
Hospital					LN		LN	LN	LN	LN		LN	LN	LN	LN	LN	LN	LN	LN	LN
Hotel / Motel	LP	LP			LP	LP	LP		LN	LP			LN	LN				LN	LN	
Industrial																				
Industrial Lg																				
Institutional			LP	LP				LP	LP				LP	LP				LP	LP	
Manufactured Home Construction						LN	LN	LN	LN	LN		LP			LP	LP		LN	LN	
Manufacturing																				
Medical								LN	LN			LN	LN	LN	LN		LN	LN	LN	LN
Multi-Family						LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office							LN	LN	LN	LN	LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage																				
Recreational								LP	LP			LP	LP	LP	LP	LP	LP	MP	MP	LP
Restaurant																				
Retail								LP	LP		LP	LP	LP	LP	LP		LP	LP	LP	
School								LP	LP		LP	LP	LP	LP	LP		LP	LP	LP	LP
Service Garage	LP										LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Shopping Mall																				
Single-Family Residential						LN	LN	LN	LN		LP			LN				LN	LN	
Stadium /Arena																	LN			LN
Supermarket	LP										LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Truck Terminal																				
Utility						LN	LN	LN			LN	LN	LN	LN	LN			LN	LN	
Warehouse																	LN	LN	LN	LN

Parameters	Nighttime Period Weekend																			
	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential			LP	LP				LN	LN	LN	LN	LN	LN	LN	LN			LN	LN	LN
Auto Dealer																				
Bank			LP	LP									LN	LN		LN	LN	LN	LN	LN
Car Wash																			LP	
Church														LP						
Commercial Service																				
Convenience Store			LP	LP			LP	LP	LP				LP	LP		LP	LP	LP	LP	LP
Daycare																				
Department Store																				
Fast Food											LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Funeral Home																				
Government		LN			LN								LN	LN	LN			LN	LN	LN
Hospital						LN	LN	LN	LN	LN		LN	LN	LN	LN				LN	LN
Hotel / Motel	LP	LP			LP	LP	LP		LN	LP			LN	LN				LN	LN	
Industrial																				
Industrial Lg																				
Institutional			LP	LP				LP	LP				LP	LP				LP	LP	
Manufactured Home Construction						LN	LN	LN	LN	LN	LP	LP			LP	LP		LN	LN	
Manufacturing																				
Medical													LN	LN			LN	LN	LN	LN
Multi-Family						LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office								LN	LN		LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage						LP	LP	LP	LP	LP										
Recreational							LP	LP	LP	LP		LP	LP	LP	LP	LP	LP	MP	MP	LP
Restaurant																				
Retail			LP	LP		LP	LP	LP	LP		LP	LP	LP	LP	LP					
School								LP	LP		LP	LP	LP	LP	LP		LP	LP	LP	LP
Service Garage											LP	LP	LP	LP	LP			LP	LP	LP
Shopping Mall																				
Single-Family Residential	LP										LP	LP		LN		LP		LN	LN	
Stadium /Arena																LN				
Supermarket												LP		LP	LP	LP	LP	LP	LP	LP
Truck Terminal																				
Utility											LN	LN	LN	LN	LN		LN	LN	LN	LN
Warehouse																		LN	LN	LN

CHAPTER 6: STATISTICAL MODELS BY BUFFER WIDTH

This chapter presents the results obtained from the developed statistical models to examine the relationship between ATT and land use characteristics by buffer width.

Descriptive statistics for each of the buffer width dataset are presented in Table 9 and Table 10. The descriptive statistics consists of all the 4,944 samples considered for the model development. For selecting the best-fitted function for model development, linear model, log-link with Gamma distribution, log link with Poisson distribution, and log-link with Negative binomial distribution models were first developed using backward elimination method for 0.5 miles buffer width dataset (Table 11 and Table 12). Log-link with Poisson distribution and log-link with Negative binomial distribution models are typically used to estimate counts. Therefore, the depended variable (ATT) was considered in seconds (integer) to develop the count model.

The computed QIC and QICC indicate that log-link with Gamma distribution model was observed to be a better fit compared to the other models. The general expression for the best-fitted models is presented as Equation 9.

$$\mathrm{Ln}\ (\mathrm{ATT}) = \mathrm{f}\ (\mathrm{Land\ use\ developments, on-network\ characteristics, DOW, TOD}\ ) \quad (9)$$

Twelve statistical models were developed using buffer width dataset to examine the relationship between proximal land use developments and ATT. For each of the buffer width dataset, the model was developed using backward elimination method by considering all the predictor variables irrespective of the correlation between the predictor variables. These models are best suitable for predicting the dependent variable rather than quantifying the influence of predictor variables on the ATT. The influence of predictor variables on the ATT is interpreted using Model 1 and Model 2 in each of the buffer widths. The Model 1 and Model 2 were developed by first checking the multicollinearity between the predictor variables and then by selecting the predictor variables which were independent of each other (at a 95% confidence level). The Pearson correlation matrices for different buffer width datasets are presented in Appendix A (Table A2 to Table A5). The selection of predictor variables by buffer width is summarized in Table 13.

Per Gujarti (2012), if the objective of the regression analysis is to forecast / predict the dependent variable, then mulicollinearity is not a serious problem. The developed backward elimination model helps to forecast / predict the dependent variable (ATT). However, due to the multicollinearity between the predictor variables, the influence of predictor variables on the dependent variable can be questionable. In case of Model 1 and Model 2, the developed models not only help to accurately forecast the dependent variable but also to quantify the influence of critical predictor variables on the dependent variable while minimizing the effect of multicollinearity.

In all the developed models (Table 14 to Table 17), the coefficients of TOD and DOW are consistent. In all the developed models, the results obtained indicate that, compared to the weekend, the ATT is higher on weekdays when all the other variables are held constant. In addition, the ATT is higher during the evening peak period when compared to the morning peak period and the afternoon off-peak period, when all the other variables are held constant. Also, the coefficients of the network characteristics were observed to be consistent in almost all the developed models. The results obtained indicate that, the number of lanes and the speed limit of the selected link have a negative influence on the ATT.

6.1 Developed Models – 0.5 miles

The Model 1 and Model 2 developed with 0.5 miles buffer width dataset indicates that areas with convenience store, department store, multi-family, car wash, fast food, funeral home, hospital, office, and supermarket type land uses have a positive influence on the ATT (Table 14). However, areas with auto dealer, daycare, industrial, manufactured home construction, manufacturing, and single-family residential type land uses have a negative influence on the ATT. In addition, the speed limit of downstream cross street has a positive influence on the ATT. However, the speed limit of upstream cross street has a negative influence on the ATT.

6.2 Developed Models – 1 mile

The Model 1 and Model 2 developed with 1-mile buffer width dataset indicates that areas with auto dealer, fast food, office, department store, multi-family and utility type land uses have a positive influence on the ATT (Table 15). However, areas with hospital, industrial, service garage, large industrial, manufactured home construction, and single-family residential type land uses have a negative influence on the ATT. In addition, the speed limit of downstream cross street has a positive influence on the ATT. However, the speed limit of upstream cross street has a negative influence on the ATT.

6.3 Developed Models – 2 miles

The Model 1 and Model 2 developed with 2 miles buffer width dataset indicates that areas with retail, single-family residential, office, and supermarket type land uses have a positive influence on the ATT (Table 16). However, areas with daycare and large industrial type land uses have a negative influence on the ATT.

6.4 Developed Models – 3 miles

Lastly, Model 1 and Model 2 developed with 3 miles buffer width dataset indicates that areas with retail, single-family residential, stadium/arena, and supermarket type land uses have a positive influence on the ATT (Table 17). However, areas with daycare type land uses and the speed limit of upstream cross street link have a negative influence on the ATT.

Each of the developed models was validated using data for 53 selected links, which were not considered for model development. Summary of all the developed models by buffer width is presented in Table 18. The computed MAPE and RMSE closer to zero indicates the best-fitted model for the data used in this research. All the developed models are acceptable. However, the models for 0.5 miles and 1-mile buffer widths outperformed all the other models based on QIC, QICC, MAPE, and RMSE. Also, in all the developed models, the predicted ATT was higher compared to the actual ATT (negative MPE).

Table 9 Descriptive Statistics for 0.5 mile and 1-mile Data

Parameters	0.5 miles				1-mile			
	Min.	Max.	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.
ATT (minutes)	0.85	6.45	1.97	0.72	0.85	6.45	1.97	0.72
Attached Residential	0.00	1,853.72	426.49	420.52	0.00	3,621.39	1,073.37	835.38
Auto Dealer	0.00	702.80	27.97	97.62	0.00	961.00	46.22	132.80
Bank	0.00	292.47	29.81	64.18	0.00	382.34	78.08	115.26
Car Wash	0.00	23.54	3.20	4.19	0.00	28.89	7.33	6.41
Church	0.00	780.41	192.55	166.80	25.25	1,425.72	474.16	326.85
Commercial Service	0.00	966.39	88.40	164.11	0.00	1,072.46	208.95	262.73
Convenience Store	0.00	29.73	7.02	5.81	0.00	38.89	15.88	8.60
Daycare	0.00	123.06	13.11	17.12	0.00	143.57	31.31	20.92
Department Store	0.00	1,058.43	35.13	144.43	0.00	1,120.80	83.74	238.41
Fast Food	0.00	31.37	7.85	7.68	0.00	43.04	16.26	10.21
Funeral Home	0.00	63.13	4.39	11.91	0.00	71.44	9.06	15.71
Government	0.00	4,657.18	480.23	1,060.53	0.00	4,753.02	1,047.50	1,624.82
Hospital	0.00	3,670.49	172.82	614.32	0.00	4,400.51	489.08	1,197.39
Hotel / Motel	0.00	3,314.05	324.49	662.77	0.00	3,325.79	762.57	1,012.48
Industrial	0.00	50.92	2.47	7.68	0.00	81.14	7.25	14.92
Industrial Lg	0.00	103.37	1.51	12.38	0.00	103.37	6.02	24.21
Institutional	0.00	1,683.84	185.09	379.85	0.00	2,674.65	449.37	706.02
Manufactured Home Construction	0.00	30.50	1.16	3.50	0.00	93.80	3.42	10.12
Manufacturing	0.00	911.92	103.51	158.70	0.00	1,461.16	283.65	294.37
Medical	0.00	1,598.78	71.21	188.07	0.00	2,310.76	216.52	432.60
Multi-Family	0.00	5,444.90	1,351.24	1,226.09	74.44	10,329.40	3,329.75	2,334.62
Office	0.00	20,128.58	1,964.29	4,366.76	5.06	23,462.55	4,834.41	7,334.00
Parking Garage	0.00	9,458.15	1,054.09	2,058.28	0.00	16,873.53	2,752.49	4,127.55
Recreational	0.00	269.43	56.29	60.62	4.09	339.68	140.63	95.55
Restaurant	0.00	172.90	34.14	37.43	0.00	316.09	86.28	76.73
Retail	0.00	819.85	151.63	139.54	1.62	1,855.88	372.91	287.45
School	0.00	830.08	263.77	211.89	0.00	1,837.61	648.44	336.52
Service Garage	0.00	669.60	57.77	82.55	0.00	993.62	140.81	136.13
Shopping Mall	0.00	978.93	148.45	190.26	0.00	1,538.93	319.28	301.87
Single-Family Residential	21.03	8,861.19	1,825.75	1,562.72	553.84	17,085.75	5,726.78	3,596.05
Stadium /Arena	0.00	2,999.96	220.36	627.34	0.00	3,022.60	537.95	1,016.00
Supermarket	0.00	164.03	24.31	34.50	0.00	266.06	47.33	49.59
Truck Terminal	0.00	627.72	15.91	60.68	0.00	757.17	60.08	126.63
Utility	0.00	96.10	8.78	21.29	0.00	130.24	18.78	29.23
Warehouse	0.00	5,107.52	857.31	963.53	4.49	9,097.35	2,409.42	2,103.91
Link_# of Lanes	1.00	4.00	2.12	0.77	1.00	4.00	2.12	0.77
Link_SL (mph)	35.00	65.00	42.73	7.40	35.00	65.00	42.73	7.40
DS_# of Lanes	0.00	5.00	1.88	1.04	0.00	5.00	1.88	1.04
DS_SL (mph)	0.00	65.00	38.20	15.77	0.00	65.00	38.20	15.77
US_# of Lanes	0.00	5.00	2.09	1.02	0.00	5.00	2.09	1.02
US_SL (mph)	0.00	65.00	39.05	14.18	0.00	65.00	39.05	14.18
DS_Cross street_# of Lanes	0.00	6.00	2.83	1.55	0.00	6.00	2.83	1.55
DS_Cross street_SL (mph)	0.00	55.00	39.22	10.93	0.00	55.00	39.22	10.93
US_Cross street_# of Lanes	0.00	6.00	2.81	1.43	0.00	6.00	2.81	1.43
US_Cross street_SL (mph)	0.00	55.00	40.23	10.22	0.00	55.00	40.23	10.22
Intersection_# of Lanes	0.00	4.00	1.65	1.01	0.00	4.00	1.65	1.01
Intersection_SL (mph)	0.00	45.00	22.61	13.46	0.00	45.00	22.61	13.46

Note: Land use categories were considered in square feet.

Table 10 Descriptive Statistics for 2 miles and 3 miles Data

Parameters	2 miles				3 miles			
	Min.	Max.	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.
ATT (minutes)	0.85	6.45	1.97	0.72	0.85	6.45	1.97	0.72
Attached Residential	86.68	7,304.24	3,009.71	1,876.94	424.08	12,261.02	5,687.30	2,634.71
Auto Dealer	0.00	1,048.54	110.16	201.75	0.00	1,059.45	222.25	278.72
Bank	5.20	621.68	168.52	158.58	25.03	699.42	269.97	187.73
Car Wash	0.78	59.02	21.57	11.98	5.15	86.34	40.07	14.55
Church	377.60	3,340.75	1,430.52	684.32	749.89	4,786.49	2,656.29	981.48
Commercial Service	4.18	1,337.35	527.08	397.52	88.06	2,294.77	913.54	503.56
Convenience Store	2.96	115.00	50.03	18.20	17.54	163.14	103.47	29.32
Daycare	17.32	197.41	92.06	37.03	77.60	285.08	179.51	45.97
Department Store	0.00	1,187.91	186.35	321.40	42.44	1,764.40	314.73	391.39
Fast Food	9.75	94.63	49.55	17.98	30.67	149.32	99.49	25.60
Funeral Home	0.00	80.39	25.66	24.71	0.00	126.89	44.73	29.46
Government	15.41	6,357.07	2,097.26	2,277.42	67.28	8,701.26	3,209.20	2,836.02
Hospital	0.00	4,449.36	1,237.69	1,812.11	0.00	4,753.27	2,084.27	2,037.00
Hotel / Motel	0.00	4,254.03	1,537.91	1,301.50	0.00	6,586.00	2,508.22	1,698.82
Industrial	0.00	155.06	22.21	29.16	0.00	167.60	50.02	46.19
Industrial Lg	0.00	103.37	12.04	33.17	0.00	192.10	24.09	49.00
Institutional	0.00	2,907.05	986.35	1,117.85	10.49	3,158.92	1,531.06	1,208.12
Manufactured Home Construction	0.00	145.94	12.55	25.38	0.00	162.07	27.06	40.15
Manufacturing	0.00	2,474.60	914.36	643.01	0.00	4,102.97	1,700.20	1,041.36
Medical	21.89	2,540.03	636.13	749.68	81.25	2,778.70	1,204.72	944.40
Multi-Family	630.95	19,499.66	9,457.88	4,681.57	2,971.33	35,593.55	17,187.54	6,127.92
Office	137.17	26,598.16	10,191.78	10,234.17	963.32	36,427.48	15,756.53	11,460.63
Parking Garage	0.00	18,357.74	5,822.62	6,713.78	0.00	24,024.77	8,864.04	7,444.86
Recreational	39.80	849.86	394.06	173.73	210.14	1,303.78	749.80	267.21
Restaurant	6.96	527.83	230.93	146.06	29.01	789.39	407.59	184.90
Retail	88.29	2,696.49	1,064.52	548.74	500.62	3,400.25	1,966.88	689.23
School	412.83	3,449.01	1,841.53	702.57	911.96	6,333.30	3,558.12	1,206.73
Service Garage	5.74	1,387.35	421.61	285.13	36.25	2,193.43	838.78	469.70
Shopping Mall	45.51	2,528.31	927.91	481.47	486.94	4,404.26	1,911.36	622.53
Single-Family Residential	3,830.96	42,184.47	19,574.86	8,290.43	12,876.72	80,529.15	40,618.63	14,233.54
Stadium /Arena	0.00	3,283.42	1,022.62	1,370.60	0.00	3,283.42	1,479.39	1,480.66
Supermarket	0.00	434.79	156.96	92.47	71.31	628.76	305.28	127.37
Truck Terminal	0.00	1,105.95	181.59	252.98	0.00	1,615.07	398.14	394.35
Utility	0.12	176.94	48.70	51.35	0.99	248.76	90.27	72.87
Warehouse	74.82	20,097.45	7,323.59	4,876.16	145.20	31,850.10	14,774.29	8,320.04
Link_# of Lanes	1.00	4.00	2.12	0.77	1.00	4.00	2.12	0.77
Link_SL (mph)	35.00	65.00	42.73	7.40	35.00	65.00	42.73	7.40
DS_# of Lanes	0.00	5.00	1.88	1.04	0.00	5.00	1.88	1.04
DS_SL (mph)	0.00	65.00	38.20	15.77	0.00	65.00	38.20	15.77
US_# of Lanes	0.00	5.00	2.09	1.02	0.00	5.00	2.09	1.02
US_SL (mph)	0.00	65.00	39.05	14.18	0.00	65.00	39.05	14.18
DS_Cross street_# of Lanes	0.00	6.00	2.83	1.55	0.00	6.00	2.83	1.55
DS_Cross street_SL (mph)	0.00	55.00	39.22	10.93	0.00	55.00	39.22	10.93
US_Cross street_# of Lanes	0.00	6.00	2.81	1.43	0.00	6.00	2.81	1.43
US_Cross street_SL (mph)	0.00	55.00	40.23	10.22	0.00	55.00	40.23	10.22
Intersection_# of Lanes	0.00	4.00	1.65	1.01	0.00	4.00	1.65	1.01
Intersection_SL (mph)	0.00	45.00	22.61	13.46	0.00	45.00	22.61	13.46

Note: Land use categories were considered in square feet.

Table 11 Developed Linear and Log-link Models for 0.5 miles Buffer Width

Parameters	Linear			Log-Link Gamma Distribution		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	2.721	0.061	<0.05	1.324	0.028	<0.05
[Weekday=1]	0.131	0.011	<0.05	0.071	0.005	<0.05
[MPP=1]	0.053	0.014	<0.05	0.028	0.006	<0.05
[OPP=1]	0.077	0.014	<0.05	0.039	0.006	<0.05
[EPP=1]	0.204	0.016	<0.05	0.104	0.007	<0.05
Attached Residential	-1.31E-04	<0.001	<0.05	-4.94E-05	<0.001	<0.05
Auto Dealer	-5.05E-04	<0.001	<0.05	-2.67E-04	<0.001	<0.05
Bank	-1.40E-03	<0.001	<0.05	-4.76E-04	<0.001	<0.05
Car Wash	8.76E-03	0.002	<0.05	5.16E-03	<0.001	<0.05
Church	-	-	-	-	-	-
Commercial Service	-4.79E-04	<0.001	<0.05	-2.14E-04	<0.001	<0.05
Convenience Store	6.02E-03	0.001	<0.05	3.50E-03	<0.001	<0.05
Daycare	-3.61E-03	<0.001	<0.05	-1.75E-03	<0.001	<0.05
Department Store	-9.21E-04	<0.001	<0.05	-3.65E-04	<0.001	<0.05
Fast Food	-	-	-	-	-	-
Funeral Home	2.41E-03	<0.001	<0.05	1.06E-03	<0.001	<0.05
Government	1.02E-04	<0.001	<0.05	4.65E-05	<0.001	<0.05
Hospital	-2.54E-04	<0.001	<0.05	-9.45E-05	<0.001	<0.05
Hotel / Motel	5.92E-05	<0.001	0.033	-	-	-
Industrial	-4.69E-03	<0.001	<0.05	-2.61E-03	<0.001	<0.05
Industrial Lg	-	-	-	-	-	-
Institutional	-3.29E-04	<0.001	<0.05	-1.30E-04	<0.001	<0.05
Manufactured Home Construction	-8.44E-03	<0.001	<0.05	-3.90E-03	<0.001	<0.05
Manufacturing	-	-	-	-	-	-
Medical	1.32E-04	<0.001	0.024	5.89E-05	<0.001	0.009
Multi-Family	-	-	-	-	-	-
Office	-1.06E-04	<0.001	<0.05	-3.21E-05	<0.001	<0.05
Parking Garage	3.88E-04	<0.001	<0.05	1.26E-04	<0.001	<0.05
Recreational	-	-	-	-1.36E-04	<0.001	0.043
Restaurant	3.73E-03	<0.001	<0.05	1.39E-03	<0.001	<0.05
Retail	2.46E-04	<0.001	<0.05	1.63E-04	<0.001	<0.05
School	8.13E-05	<0.001	0.006	-	-	-
Service Garage	-	-	-	-	-	-
Shopping Mall	-	-	-	6.16E-05	<0.001	0.006
Single-Family Residential	-9.07E-05	<0.001	<0.05	-4.44E-05	<0.001	<0.05
Stadium /Arena	-	-	-	-	-	-
Supermarket	1.46E-03	<0.001	<0.05	8.12E-04	<0.001	<0.05
Truck Terminal	4.26E-04	<0.001	<0.05	3.61E-04	<0.001	<0.05
Utility	-3.86E-03	<0.001	<0.05	-1.26E-03	<0.001	<0.05
Warehouse	-7.04E-05	<0.001	<0.05	-4.92E-05	<0.001	<0.05
Link_# of Lanes	-0.055	0.017	0.001	-0.041	0.007	<0.05
Link_SL (mph)	-0.025	0.001	<0.05	-0.017	<0.001	<0.05
DS_# of Lanes	-0.058	0.008	<0.05	-0.040	0.005	<0.05
DS_SL (mph)	-	-	-	0.001	<0.001	<0.05
US_# of Lanes	-0.062	0.016	<0.05	-0.031	0.006	<0.05
US_SL (mph)	0.005	<0.001	<0.05	0.002	<0.001	<0.05
DS_Cross street_# of Lanes	0.066	0.005	<0.05	0.032	0.002	<0.05
DS_Cross street_SL (mph)	0.003	<0.001	<0.05	0.001	<0.001	0.002
US_Cross street_# of Lanes	0.019	0.006	0.002	0.014	0.003	<0.05
US_Cross street_SL (mph)	-0.004	<0.001	<0.05	-0.003	<0.001	<0.05
Intersection_# of Lanes	-0.061	0.018	<0.05	-0.037	0.008	<0.05
Intersection_SL (mph)	0.010	0.001	<0.05	0.006	<0.001	<0.05
QIC	793.326			217.019		
QICC	788.683			207.885		

Note: Land use categories were considered in square feet.

Table 12 Developed Log-Link Models for 0.5 miles Buffer Width

Parameters	Log-link Poisson Distribution			Log-Link Negative Binomial Distribution		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	5.314	0.034	<0.05	5.397	0.030	<0.05
[Weekday=1]	0.067	0.005	<0.05	0.071	0.005	<0.05
[MPP=1]	0.028	0.007	<0.05	0.028	0.006	<0.05
[OPP=1]	0.040	0.007	<0.05	0.039	0.006	<0.05
[EPP=1]	0.103	0.008	<0.05	0.104	0.007	<0.05
Attached Residential	-5.74E-05	<0.001	<0.05	-5.34E-05	<0.001	<0.05
Auto Dealer	-2.64E-04	<0.001	<0.05	-2.57E-04	<0.001	<0.05
Bank	-4.03E-04	<0.001	<0.05	-4.66E-04	<0.001	<0.05
Car Wash	5.29E-03	<0.001	<0.05	4.95E-03	<0.001	<0.05
Church	-	-	-	-	-	-
Commercial Service	-2.13E-04	<0.001	<0.05	-1.97E-04	<0.001	<0.05
Convenience Store	3.78E-03	<0.001	<0.05	3.66E-03	<0.001	<0.05
Daycare	-2.05E-03	<0.001	<0.05	-1.91E-03	<0.001	<0.05
Department Store	-4.25E-04	<0.001	<0.05	-3.64E-04	<0.001	<0.05
Fast Food	-	-	-	-	-	-
Funeral Home	1.15E-03	<0.001	<0.05	1.12E-03	<0.001	<0.05
Government	4.24E-05	<0.001	<0.05	4.39E-05	<0.001	<0.05
Hospital	-9.82E-05	<0.001	<0.05	-9.40E-05	<0.001	<0.05
Hotel / Motel	-	-	-	-	-	-
Industrial	-3.27E-03	<0.001	<0.05	-2.70E-03	<0.001	<0.05
Industrial Lg	-	-	-	-	-	-
Institutional	-1.39E-04	<0.001	<0.05	-1.27E-04	<0.001	<0.05
Manufactured Home Construction	-3.92E-03	<0.001	<0.05	-3.81E-03	<0.001	<0.05
Manufacturing	7.22E-05	<0.001	<0.05	3.63E-05	<0.001	0.049
Medical	5.79E-05	<0.001	0.021	5.95E-05	<0.001	0.009
Multi-Family	-	-	-	-	-	-
Office	-4.10E-05	<0.001	<0.05	-3.34E-05	<0.001	<0.05
Parking Garage	1.50E-04	<0.001	<0.05	1.29E-04	<0.001	<0.05
Recreational	-	-	-	-	-	-
Restaurant	1.35E-03	<0.001	<0.05	1.30E-03	<0.001	<0.05
Retail	1.64E-04	<0.001	<0.05	1.60E-04	<0.001	<0.05
School	-	-	-	-	-	-
Service Garage	-	-	-	-	-	-
Shopping Mall	5.34E-05	<0.001	0.025	6.34E-05	<0.001	0.005
Single-Family Residential	-4.69E-05	<0.001	<0.05	-4.45E-05	<0.001	<0.05
Stadium /Arena	-	-	-	-	-	-
Supermarket	8.86E-04	<0.001	<0.05	8.32E-04	<0.001	<0.05
Truck Terminal	3.61E-04	<0.001	<0.05	3.75E-04	<0.001	<0.05
Utility	-1.58E-03	<0.001	<0.05	-1.29E-03	<0.001	<0.05
Warehouse	-5.32E-05	<0.001	<0.05	-5.34E-05	<0.001	<0.05
Link_# of Lanes	-0.035	0.008	<0.05	-0.039	0.007	<0.05
Link_SL (mph)	-0.016	<0.001	<0.05	-0.017	<0.001	<0.05
DS_# of Lanes	-0.046	0.006	<0.05	-0.043	0.005	<0.05
DS_SL (mph)	0.001	<0.001	<0.05	0.001	<0.001	<0.05
US_# of Lanes	-0.032	0.006	<0.05	-0.030	0.006	<0.05
US_SL (mph)	0.002	<0.001	<0.05	0.002	<0.001	<0.05
DS_Cross street_# of Lanes	0.035	0.002	<0.05	0.032	0.002	<0.05
DS_Cross street_SL (mph)	0.001	<0.001	0.003	0.001	<0.001	0.002
US_Cross street_# of Lanes	0.013	0.003	<0.05	0.014	0.003	<0.05
US_Cross street_SL (mph)	-0.003	<0.001	<0.05	-0.003	<0.001	<0.05
Intersection_# of Lanes	-0.043	0.008	<0.05	-0.036	0.008	<0.05
Intersection_SL (mph)	0.006	<0.001	<0.05	0.006	<0.001	<0.05
QIC	16,601.197			123.207		
QICC	16,352.311			206.903		

Note: ATT (dependent variable) was considered in seconds to develop count models, and land use categories were considered in square feet.

Table 13 Selected Predictor Variables to Develop Models by Buffer Width

Parameters	0.5 Miles		1 Mile		2 Miles		3 Miles	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
[Weekday=1]	✓	✓	✓	✓	✓	✓	✓	✓
[MPP=1]	✓	✓	✓	✓	✓	✓	✓	✓
[OPP=1]	✓	✓	✓	✓	✓	✓	✓	✓
[EPP=1]	✓	✓	✓	✓	✓	✓	✓	✓
Attached Residential								
Auto Dealer	✓		✓	✓	✓			
Bank								
Car Wash		✓						
Church								
Commercial Service	✓							
Convenience Store	✓							
Daycare	✓	✓				✓		✓
Department Store	✓		✓	✓				
Fast Food		✓	✓	✓				
Funeral Home		✓						
Government								
Hospital		✓	✓					
Hotel / Motel								
Industrial	✓	✓	✓					
Industrial Lg				✓		✓		
Institutional								
Manufactured Home Construction	✓	✓	✓	✓				
Manufacturing	✓							
Medical								
Multi-Family	✓			✓				
Office		✓	✓			✓		
Parking Garage								
Recreational								
Restaurant								
Retail					✓		✓	
School	✓	✓						
Service Garage			✓					
Shopping Mall								
Single-Family Residential	✓			✓	✓		✓	
Stadium /Arena								✓
Supermarket		✓				✓		✓
Truck Terminal								
Utility	✓			✓				
Warehouse		✓						
Link_# of Lanes		✓		✓		✓	✓	✓
Link_SL (mph)	✓		✓					
DS_# of Lanes								
DS_SL (mph)								
US_# of Lanes								
US_SL (mph)								
DS_Cross street_# of Lanes								
DS_Cross street_SL (mph)	✓	✓		✓			✓	✓
US_Cross street_# of Lanes								
US_Cross street_SL (mph)		✓		✓			✓	
Intersection_# of Lanes								
Intersection_SL (mph)								

Note: Land use categories were considered in square feet.

Table 14 Developed Models for 0.5 miles Buffer Width

Parameters_0.5 miles	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.324	0.028	<0.05	1.875	0.024	<0.05	1.130	0.021	<0.05
[Weekday=1]	0.071	0.005	<0.05	0.072	0.006	<0.05	0.071	0.007	<0.05
[MPP=1]	0.028	0.006	<0.05	0.029	0.008	<0.05	0.028	0.009	0.001
[OPP=1]	0.039	0.006	<0.05	0.040	0.008	<0.05	0.040	0.009	<0.05
[EPP=1]	0.104	0.007	<0.05	0.106	0.009	<0.05	0.106	0.010	<0.05
Attached Residential	-4.94E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-2.67E-04	<0.001	<0.05	-8.43E-05	<0.001	<0.05	-	-	-
Bank	-4.76E-04	<0.001	<0.05	-	-	-	-	-	-
Car Wash	5.16E-03	0.001	<0.05	-	-	-	6.14E-03	0.001	<0.05
Church	-	-	-	-	-	-	-	-	-
Commercial Service	-2.14E-04	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	3.50E-03	0.001	<0.05	3.18E-03	0.001	<0.05	-	-	-
Daycare	-1.75E-03	<0.001	<0.05	-1.05E-03	<0.001	<0.05	-2.43E-03	<0.001	<0.05
Department Store	-3.65E-04	<0.001	<0.05	1.07E-04	<0.001	<0.05	-	-	-
Fast Food	-	-	-	-	-	-	3.88E-03	<0.001	<0.05
Funeral Home	1.06E-03	<0.001	<0.05	-	-	-	1.81E-03	<0.001	<0.05
Government	4.65E-05	<0.001	<0.05	-	-	-	-	-	-
Hospital	-9.45E-05	<0.001	<0.05	-	-	-	2.49E-05	<0.001	<0.05
Hotel / Motel	-	-	-	-	-	-	-	-	-
Industrial	-2.61E-03	<0.001	<0.05	-3.84E-03	<0.001	<0.05	-3.26E-03	<0.001	<0.05
Industrial Lg	-	-	-	-	-	-	-	-	-
Institutional	-1.30E-04	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-3.90E-03	<0.001	<0.05	-1.75E-03	<0.001	<0.05	-1.07E-02	0.001	<0.05
Manufacturing	-	-	-	-2.27E-04	<0.001	<0.05	-	-	-
Medical	5.89E-05	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	-	-	-	7.32E-05	<0.001	<0.05	-	-	-
Office	-3.21E-05	<0.001	<0.05	-	-	-	3.88E-05	<0.001	<0.05
Parking Garage	1.26E-04	<0.001	<0.05	-	-	-	-	-	-
Recreational	-1.36E-04	<0.001	0.043	-	-	-	-	-	-
Restaurant	1.39E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	1.63E-04	<0.001	<0.05	-	-	-	-	-	-
School	-	-	-	-	-	-	-	-	-
Service Garage	-	-	-	-	-	-	-	-	-
Shopping Mall	6.16E-05	<0.001	<0.05	-	-	-	-	-	-
Single-Family Residential	-4.44E-05	<0.001	<0.05	-3.31E-05	<0.001	<0.05	-	-	-
Stadium /Arena	-	-	-	-	-	-	-	-	-
Supermarket	8.12E-04	<0.001	<0.05	-	-	-	1.12E-03	<0.001	<0.05
Truck Terminal	3.61E-04	<0.001	<0.05	-	-	-	-	-	-
Utility	-1.26E-03	<0.001	<0.05	-	-	-	-	-	-
Warehouse	-4.92E-05	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-0.041	0.007	<0.05	-	-	-	-0.217	0.004	<0.05
Link_SL (mph)	-0.017	0.001	<0.05	-0.034	<0.001	<0.05	-	-	-
DS_# of Lanes	-0.040	0.005	<0.05	-	-	-	-	-	-
DS_SL (mph)	0.001	<0.001	<0.05	-	-	-	-	-	-
US_# of Lanes	-0.031	0.006	<0.05	-	-	-	-	-	-
US_SL (mph)	0.002	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.032	0.002	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	0.001	<0.001	<0.05	0.003	<0.001	<0.05	0.001	<0.001	<0.05
US_Cross street_# of Lanes	0.014	0.003	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.003	<0.001	<0.05	-	-	-	-0.007	<0.001	<0.05
Intersection_# of Lanes	-0.037	0.008	<0.05	-	-	-	-	-	-
Intersection_SL (mph)	0.006	0.001	<0.05	-	-	-	-	-	-
QIC	217.019			238.032			280.148		
QICC	207.885			237.882			276.906		
RMSE	0.467			0.469			0.552		
MAPE	17%			16%			20%		
MPE	-6%			-6%			-7%		

Note: Land use categories were considered in square feet.

Table 15 Developed Models for 1-mile Buffer Width

Parameters_1-mile	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.345	0.035	<0.05	1.950	0.019	<0.05	1.155	0.025	<0.05
[Weekday=1]	0.071	0.005	<0.05	0.071	0.007	<0.05	0.071	0.007	<0.05
[MPP=1]	0.028	0.007	<0.05	0.029	0.009	<0.05	0.028	0.010	<0.05
[OPP=1]	0.038	0.006	<0.05	0.040	0.009	<0.05	0.040	0.010	<0.05
[EPP=1]	0.104	0.008	<0.05	0.106	0.010	<0.05	0.105	0.010	<0.05
Attached Residential	4.61E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-	-	-	1.47E-04	<0.001	<0.05	-	-	-
Bank	-	-	-	-	-	-	-	-	-
Car Wash	-6.29E-03	<0.001	<0.05	-	-	-	-	-	-
Church	-3.79E-05	<0.001	<0.05	-	-	-	-	-	-
Commercial Service	6.11E-05	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	5.73E-03	<0.001	<0.05	-	-	-	-	-	-
Daycare	-1.34E-03	<0.001	<0.05	-	-	-	-	-	-
Department Store	-2.16E-04	<0.001	<0.05	-	-	-	1.56E-04	<0.001	<0.05
Fast Food	2.13E-03	<0.001	<0.05	3.53E-03	<0.001	<0.05	1.12E-03	<0.001	<0.05
Funeral Home	-8.12E-04	<0.001	<0.05	-	-	-	-	-	-
Government	3.63E-05	<0.001	<0.05	-	-	-	-	-	-
Hospital	-1.21E-04	<0.001	<0.05	-2.87E-05	<0.001	<0.05	-	-	-
Hotel / Motel	4.05E-05	<0.001	<0.05	-	-	-	-	-	-
Industrial	-1.95E-03	<0.001	<0.05	-1.84E-03	<0.001	<0.05	-	-	-
Industrial Lg	-	-	-	-	-	-	-1.12E-03	<0.001	<0.05
Institutional	-4.39E-05	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-9.91E-04	<0.001	<0.05	-	-	-	-9.76E-04	<0.001	<0.05
Manufacturing	-	-	-	-	-	-	-	-	-
Medical	-3.33E-05	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	1.08E-05	<0.001	<0.05	-	-	-	5.19E-05	<0.001	<0.05
Office	-2.81E-05	<0.001	<0.05	1.03E-05	<0.001	<0.05	-	-	-
Parking Garage	6.45E-05	<0.001	<0.05	-	-	-	-	-	-
Recreational	-1.96E-04	<0.001	<0.05	-	-	-	-	-	-
Restaurant	3.90E-04	<0.001	<0.05	-	-	-	-	-	-
Retail	-	-	-	-	-	-	-	-	-
School	5.82E-05	<0.001	<0.05	-	-	-	-	-	-
Service Garage	-	-	-	-1.90E-04	<0.001	<0.05	-	-	-
Shopping Mall	-	-	-	-	-	-	-	-	-
Single-Family Residential	-2.41E-05	<0.001	<0.05	-	-	-	-1.40E-05	<0.001	<0.05
Stadium /Arena	-7.20E-05	<0.001	<0.05	-	-	-	-	-	-
Supermarket	-	-	-	-	-	-	-	-	-
Truck Terminal	7.55E-05	<0.001	<0.05	-	-	-	-	-	-
Utility	7.54E-04	<0.001	<0.05	-	-	-	6.46E-04	<0.001	<0.05
Warehouse	-3.59E-05	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-	-	-	-	-	-	-0.227	0.005	<0.05
Link_SL (mph)	-0.019	<0.001	<0.05	-0.034	<0.001	<0.05	-	-	-
DS_# of Lanes	-0.025	0.003	<0.05	-	-	-	-	-	-
DS_SL (mph)	-	-	-	-	-	-	-	-	-
US_# of Lanes	-0.052	0.005	<0.05	-	-	-	-	-	-
US_SL (mph)	0.004	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.039	0.002	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	0.001	<0.001	<0.05	-	-	-	0.002	<0.001	<0.05
US_Cross street_# of Lanes	0.017	0.003	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.005	<0.001	<0.05	-	-	-	-0.007	<0.001	<0.05
Intersection_# of Lanes	-	-	-	-	-	-	-	-	-
Intersection_SL (mph)	0.005	<0.001	<0.05	-	-	-	-	-	-
QIC	225.219			256.858			322.564		
QICC	220.152			254.810			321.199		
RMSE	0.459			0.521			0.591		
MAPE	16%			18%			21%		
MPE	-5%			-7%			-6%		

Note: Land use categories were considered in square feet.

Table 16 Developed Models for 2 miles Buffer Width

Parameters_2 miles	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.449	0.0378	<0.05	1.910	0.0238	<0.05	0.849	0.0182	<0.05
[Weekday=1]	0.070	0.0048	<0.05	0.071	0.0072	<0.05	0.069	0.0081	<0.05
[MPP=1]	0.028	0.0063	<0.05	0.028	0.0096	<0.05	0.028	0.0111	<0.05
[OPP=1]	0.038	0.0061	<0.05	0.039	0.0096	<0.05	0.040	0.0111	<0.05
[EPP=1]	0.103	0.0072	<0.05	0.106	0.0105	<0.05	0.105	0.0119	<0.05
Attached Residential	-4.93E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-2.67E-04	<0.001	<0.05	-	-	-	-	-	-
Bank	6.11E-04	<0.001	<0.05	-	-	-	-	-	-
Car Wash	-3.25E-03	<0.001	<0.05	-	-	-	-	-	-
Church	-1.25E-04	<0.001	<0.05	-	-	-	-	-	-
Commercial Service	-4.82E-05	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	9.63E-04	<0.001	<0.05	-	-	-	-	-	-
Daycare	-1.49E-03	<0.001	<0.05	-	-	-	-2.90E-04	<0.001	<0.05
Department Store	-1.32E-04	<0.001	<0.05	-	-	-	-	-	-
Fast Food	-	-	-	-	-	-	-	-	-
Funeral Home	2.15E-03	<0.001	<0.05	-	-	-	-	-	-
Government	-5.37E-05	<0.001	<0.05	-	-	-	-	-	-
Hospital	-4.60E-05	<0.001	<0.05	-	-	-	-	-	-
Hotel / Motel	-3.52E-05	<0.001	<0.05	-	-	-	-	-	-
Industrial	3.25E-04	<0.001	<0.05	-	-	-	-	-	-
Industrial Lg	-	-	-	-	-	-	-4.98E-04	<0.001	<0.05
Institutional	-1.10E-04	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	9.47E-04	<0.001	<0.05	-	-	-	-	-	-
Manufacturing	-3.00E-05	<0.001	<0.05	-	-	-	-	-	-
Medical	-	-	-	-	-	-	-	-	-
Multi-Family	1.93E-05	<0.001	<0.05	-	-	-	-	-	-
Office	-2.68E-05	<0.001	<0.05	-	-	-	1.21E-05	<0.001	<0.05
Parking Garage	8.00E-05	<0.001	<0.05	-	-	-	-	-	-
Recreational	-	-	-	-	-	-	-	-	-
Restaurant	5.86E-04	<0.001	<0.05	-	-	-	-	-	-
Retail	1.24E-04	<0.001	<0.05	7.87E-05	<0.001	<0.05	-	-	-
School	-	-	-	-	-	-	-	-	-
Service Garage	1.33E-04	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	-	-	-	-	-	-	-	-	-
Single-Family Residential	-1.52E-05	<0.001	<0.05	1.44E-06	<0.001	<0.05	-	-	-
Stadium /Arena	-4.38E-05	<0.001	<0.05	-	-	-	-	-	-
Supermarket	-	-	-	-	-	-	5.18E-04	<0.001	<0.05
Truck Terminal	-2.57E-04	<0.001	<0.05	-	-	-	-	-	-
Utility	1.09E-03	<0.001	<0.05	-	-	-	-	-	-
Warehouse	-	-	-	-	-	-	-	-	-
Link_# of Lanes	0.016	0.0077	<0.05	-	-	-	-0.211	0.0049	<0.05
Link_SL (mph)	-0.017	<0.001	<0.05	-0.034	<0.001	<0.05	-	-	-
DS_# of Lanes	-0.054	0.0056	<0.05	-	-	-	-	-	-
DS_SL (mph)	0.001	<0.001	<0.05	-	-	-	-	-	-
US_# of Lanes	-0.060	0.0065	<0.05	-	-	-	-	-	-
US_SL (mph)	0.003	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.043	0.0024	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	0.002	<0.001	<0.05	-	-	-	-	-	-
US_Cross street_# of Lanes	0.025	0.0028	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.003	<0.001	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	-	-	-	-	-	-	-	-	-
Intersection_SL (mph)	0.005	<0.001	<0.05	-	-	-	-	-	-
QIC	221.091			279.365			379.973		
QICC	214.686			277.281			378.232		
RMSE	0.477			0.569			0.700		
MAPE	18%			19%			24%		
MPE	-7%			-5%			-7%		

Note: Land use categories were considered in square feet.

Table 17 Developed Models for 3 miles Buffer Width

Parameters_3 miles	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.685	0.042	<0.05	1.071	0.028	<0.05	0.822	0.022	<0.05
[Weekday=1]	0.070	0.005	<0.05	0.069	0.009	<0.05	0.069	0.009	<0.05
[MPP=1]	0.028	0.006	<0.05	0.027	0.012	<0.05	0.027	0.012	<0.05
[OPP=1]	0.038	0.006	<0.05	0.039	0.012	<0.05	0.040	0.012	<0.05
[EPP=1]	0.103	0.007	<0.05	0.103	0.013	<0.05	0.104	0.013	<0.05
Attached Residential	2.48E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-1.73E-04	<0.001	<0.05	-	-	-	-	-	-
Bank	-1.05E-03	<0.001	<0.05	-	-	-	-	-	-
Car Wash	-	-	-	-	-	-	-	-	-
Church	-1.17E-04	<0.001	<0.05	-	-	-	-	-	-
Commercial Service	-3.51E-04	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	1.18E-03	<0.001	<0.05	-	-	-	-	-	-
Daycare	-6.49E-04	<0.001	<0.05	-	-	-	-3.19E-04	<0.001	<0.05
Department Store	1.66E-04	<0.001	<0.05	-	-	-	-	-	-
Fast Food	-	-	-	-	-	-	-	-	-
Funeral Home	6.51E-04	<0.001	<0.05	-	-	-	-	-	-
Government	9.78E-05	<0.001	<0.05	-	-	-	-	-	-
Hospital	-	-	-	-	-	-	-	-	-
Hotel / Motel	6.72E-05	<0.001	<0.05	-	-	-	-	-	-
Industrial	-1.85E-03	<0.001	<0.05	-	-	-	-	-	-
Industrial Lg	5.72E-04	<0.001	<0.05	-	-	-	-	-	-
Institutional	-5.77E-05	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-2.37E-04	<0.001	<0.05	-	-	-	-	-	-
Manufacturing	-	-	-	-	-	-	-	-	-
Medical	1.41E-04	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	5.58E-06	<0.001	<0.05	-	-	-	-	-	-
Office	-2.47E-05	<0.001	<0.05	-	-	-	-	-	-
Parking Garage	3.60E-05	<0.001	<0.05	-	-	-	-	-	-
Recreational	5.57E-04	<0.001	<0.05	-	-	-	-	-	-
Restaurant	-1.42E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	1.85E-04	<0.001	<0.05	1.11E-04	<0.001	<0.05	-	-	-
School	1.14E-04	<0.001	<0.05	-	-	-	-	-	-
Service Garage	-1.67E-04	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	-	-	-	-	-	-	-	-	-
Single-Family Residential	-1.81E-05	<0.001	<0.05	1.74E-06	<0.001	<0.05	-	-	-
Stadium /Arena	-4.07E-05	<0.001	<0.05	-	-	-	7.54E-05	<0.001	<0.05
Supermarket	5.31E-04	<0.001	<0.05	-	-	-	5.02E-04	<0.001	<0.05
Truck Terminal	1.80E-04	<0.001	<0.05	-	-	-	-	-	-
Utility	-6.78E-04	<0.001	<0.05	-	-	-	-	-	-
Warehouse	-	-	-	-	-	-	-	-	-
Link_# of Lanes	0.016	0.008	<0.05	-0.186	0.005	<0.05	-0.214	0.005	<0.05
Link_SL (mph)	-0.021	<0.001	<0.05	-	-	-	-	-	-
DS_# of Lanes	-0.047	0.006	<0.05	-	-	-	-	-	-
DS_SL (mph)	0.002	<0.001	<0.05	-	-	-	-	-	-
US_# of Lanes	-0.043	0.007	<0.05	-	-	-	-	-	-
US_SL (mph)	0.002	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.042	0.002	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	0.001	<0.001	<0.05	-	-	-	-	-	-
US_Cross street_# of Lanes	-	-	-	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.003	<0.001	<0.05	-0.010	<0.001	<0.05	-	-	-
Intersection_# of Lanes	-0.039	0.008	<0.05	-	-	-	-	-	-
Intersection_SL (mph)	0.007	<0.001	<0.05	-	-	-	-	-	-
QIC	231.277			391.852			407.383		
QICC	225.114			388.527			405.383		
RMSE	0.429			0.716			0.733		
MAPE	16%			23%			24%		
MPE	-5%			-6%			-7%		

Note: Land use categories were considered in square feet.

Table 18 Performance of Developed Models by Buffer Width – Summary

Buffer Width	Performance Parameters	Backward Elimination	Model 1	Model 2
0.5 Miles	QIC	217.019	238.032	280.148
	QICC	207.885	237.882	276.906
	RMSE	0.467	0.469	0.552
	MAPE	17%	16%	20%
	MPE	-6%	-6%	-7%
1-Mile	QIC	225.219	256.858	322.564
	QICC	220.152	254.810	321.199
	RMSE	0.459	0.521	0.591
	MAPE	16%	18%	21%
	MPE	-5%	-7%	-6%
2 Miles	QIC	221.091	279.365	379.973
	QICC	214.686	277.281	378.232
	RMSE	0.477	0.569	0.700
	MAPE	18%	19%	24%
	MPE	-7%	-5%	-7%
3 Miles	QIC	231.277	391.852	407.383
	QICC	225.114	388.527	405.383
	RMSE	0.429	0.716	0.733
	MAPE	16%	23%	24%
	MPE	-5%	-6%	-7%

6.5 Discussion related to the Developed Models by Buffer Width

The models for 0.5 miles and 1-mile buffer widths were found to be better-fit models to examine the relationship between land use developments and ATT. The positive sign of coefficient indicates that the predictor variable contributes more to ATT when compared to a predictor variable with the negative sign. An increase in areas with department store, fast food, multi-family, and office type land uses within 0.5 miles and 1-mile from a link increases the ATT. However, an increase in area with industrial, manufactured home construction, and single-family residential type land use within 0.5 miles and 1-mile from a link decreases the ATT. (Table 19). However, an increase in hospitals within 0.5 miles from a link increases the ATT and within 1-mile from a link decreases the ATT. Also, an increase in area with single-family residential within 0.5 miles and 1-mile from a link decreases the ATT and within 2 miles and 3 miles from a link increases the ATT (Table 19 and Table 20). Likewise, an increase in area with supermarket within 1-mile, 2 miles and 3 miles from a link and area with office within 0.5 miles, 1-mile and 2 miles from a link increases the ATT. However, an increase in daycare land use within 0.5 miles, 2 miles and 3-miles from a link decreases the ATT.

Table 19 Comparison of Developed Models by Buffer Width – 0.5 miles and 1-mile

Parameters	0.5 miles			1-mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	P	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	P	P	P	P	P	P
[EPP=1]	P	P	P	P	P	P
Attached Residential	N			P		
Auto Dealer	N	N			P	
Bank	N					
Car Wash	P		P	N		
Church				N		
Commercial Service	N			P		
Convenience Store	P	P		P		
Daycare	N	N	N	N		
Department Store	N	P		N		P
Fast Food			P	P	P	P
Funeral Home	P		P	N		
Government	P			P		
Hospital	N		P	N	N	
Hotel / Motel				P		
Industrial	N	N	N	N	N	
Industrial Lg						N
Institutional	N			N		
Manufactured Home Construction	N	N	N	N		N
Manufacturing		N				
Medical	P			N		
Multi-Family		P		P		P
Office	N		P	N	P	
Parking Garage	P			P		
Recreational	N			N		
Restaurant	P			P		
Retail	P					
School				P		
Service Garage					N	
Shopping Mall	P					
Single-Family Residential	N	N		N		N
Stadium /Arena				N		
Supermarket	P		P			
Truck Terminal	P			P		
Utility	N			P		P
Warehouse	N			N		
Link_# of Lanes	N		N			N
Link_SL (mph)	N	N		N	N	
DS_# of Lanes	N			N		
DS_SL (mph)	P					
US_# of Lanes	N			N		
US_SL (mph)	P			P		
DS_Cross street_# of Lanes	P			P		
DS_Cross street_SL (mph)	P	P	P	P		P
US_Cross street_# of Lanes	P			P		
US_Cross street_SL (mph)	N		N	N		N
Intersection_# of Lanes	N					
Intersection_SL (mph)	P			P		

Table 20 Comparison of Developed Models by Buffer Width – 2 miles and 3 miles

Parameters	2 miles			3 miles		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	P	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	P	P	P	P	P	P
[EPP=1]	P	P	P	P	P	P
Attached Residential	N			P		
Auto Dealer	N			N		
Bank	P			N		
Car Wash	N					
Church	N			N		
Commercial Service	N			N		
Convenience Store	P			P		
Daycare	N		N	N		N
Department Store	N			P		
Fast Food						
Funeral Home	P			P		
Government	N			P		
Hospital	N					
Hotel / Motel	N			P		
Industrial	P			N		
Industrial Lg			N	P		
Institutional	N			N		
Manufactured Home Construction	P			N		
Manufacturing	N					
Medical				P		
Multi-Family	P			P		
Office	N		P	N		
Parking Garage	P			P		
Recreational				P		
Restaurant	P			N		
Retail	P	P		P	P	
School				P		
Service Garage	P			N		
Shopping Mall						
Single-Family Residential	N	P		N	P	
Stadium /Arena	N			N		P
Supermarket			P	P		P
Truck Terminal	N			P		
Utility	P			N		
Warehouse						
Link_# of Lanes	P		N	P	N	N
Link_SL (mph)	N	N		N		
DS_# of Lanes	N			N		
DS_SL (mph)	P			P		
US_# of Lanes	N			N		
US_SL (mph)	P			P		
DS_Cross street_# of Lanes	P			P		
DS_Cross street_SL (mph)	P			P		
US_Cross street_# of Lanes	P					
US_Cross street_SL (mph)	N			N	N	
Intersection_# of Lanes				N		
Intersection_SL (mph)	P			P		

CHAPTER 7: STATISTICAL MODELS BY AREA TYPE

This chapter presents the results obtained from the statistical models developed to examine the relationship between ATT and land use characteristics by area type.

Eighteen models were developed using the area type datasets. As 0.5 miles and 1-mile buffer widths were observed to be suitable to analyze the influence of proximal land use developments on the ATT, the models were developed only using 0.5 miles and 1-mile buffer width datasets. Similar to the earlier procedure, for each of the buffer width and area type data, a model is developed using backward elimination method. The Model 1 and Model 2 were developed by avoiding the multicollinearity between the predictor variables. Pearson correlation matrices by area type dataset are presented in Appendix A (Table A6 to Table A11). The selection of predictor variables by buffer widths and area types are summarized in Table 21 and Table 22. The backward elimination models can be used for estimating the ATT. However, the influence of predictor variables on the ATT is interpreted using Model 1 and Model 2. Each of the developed models by area types are discussed next.

7.1 CBD Area

In all the developed models (0.5 miles and 1-mile buffer widths), the coefficients of TOD and DOW are consistent (Table 23 and Table 24). In all the developed models, the results obtained indicate that, compared to the weekend, the ATT is higher on weekdays when all the other variables are held constant. In addition, the ATT is higher during the evening peak period when compared to the morning peak period and the afternoon off-peak period, when all other variables are held constant. The results obtained indicate that the number of lanes and the speed limit of the selected link have a negative influence on the ATT. However, the number of lanes of the upstream cross street and the intersecting link have a positive influence on the ATT.

The Model 1 and Model 2 developed with 0.5 miles buffer width dataset for the CBD area indicates that areas with office and multi-family type land uses have a positive influence on the ATT (Table 23). However, areas with industrial, supermarket, and warehouse type land uses have a negative influence on the ATT.

The Model 1 and Model 2 developed with 1-mile buffer width dataset for CBD area indicates that areas with department store, government, and multi-family type land uses have a positive influence on the ATT (Table 24). However, areas with convenience store, funeral home, and supermarket type land uses have a negative influence on the ATT.

7.2 CBD Fringe / OBD Area

Similar to the models developed for the CBD area, the coefficients of TOD and DOW are consistent in all the CBD Fringe / OBD area models (Table 25 and Table 26). Also, DOW and TOD interpretations are similar to the models developed for the CBD area. The results obtained indicate that the number of lanes and the speed limit of the selected link have a negative influence on the ATT. However, the speed limit of the downstream cross street has a positive influence on the ATT.

The Model 1 and Model 2 developed with 0.5 miles buffer width dataset for CBD fringe / OBD area indicates that areas with multi-family, office, fast food, and supermarket type land uses have a positive influence on the ATT (Table 25). However, areas with commercial service, industrial, recreational, school, church, government, hotel/motel, and stadium/ arena type land uses have a negative influence on the ATT.

The Model 1 and Model 2 developed with 1-mile buffer width data for CBD fringe / OBD area indicates that areas with daycare, multi-family, shopping mall, and supermarket land uses have a positive influence on the ATT (Table 26). However, areas with industrial, truck terminal, convenience store, large industrial, recreational, and utility type land uses have a negative influence on the ATT.

7.3 Urban Area

Similar to the models developed for the CBD area, the coefficients of TOD and DOW are consistent in all the urban area models (Table 27 and Table 28). Also, DOW and TOD interpretations are similar to the models developed for the CBD area. The results obtained indicate that the speed limit of the selected link has a negative influence on the ATT.

The Model 1 and Model 2 developed with 0.5 miles buffer width dataset, for the urban area, indicates that areas with bank, convenience store, hospital, large industrial, retail, stadium/arena, fast food, funeral home, government, medical, multi-family, and truck terminal type land uses have a positive influence on the ATT (Table 27). However, areas with hotel/motel, industrial, institutional, manufactured home construction, manufacturing, recreational, school, and single-family residential type land uses have a negative influence on the ATT.

The Model 1 and Model 2 developed with 1-mile buffer width dataset, for the urban area, indicates that areas with fast food, multi-family, convenience store, department store, funeral home, recreational, retail, and supermarket type land uses have a positive influence on the ATT (Table 28). However, areas with large industrial, manufacturing, parking garage, school, manufactured home construction, and office type land uses have a negative influence on the ATT.

Each of the developed models was validated by selecting 10 links in the CBD area, 13 links in the CBD fringe / OBD area, and 29 links in the urban area. These links were not considered for model development. Summary of all the developed models by the buffer width is presented in Table 29. The computed MAPE and RMSE closer to zero indicates the best-fitted model for the data used in this research. The backward elimination models for CBD area underperformed when compared to models developed by checking the multicollinearity based on the QIC, QICC, RMSE and MAPE. Also, in almost all the developed models (except backward elimination and model 2 for CBD fringe area with 0.5 miles buffer width dataset and backward elimination model for CBD fringe area with 1-mile buffer width dataset), the predicted ATT was higher compared to the actual ATT (negative MPE).

Table 21 Selected Predictor Variables to Develop Models by Area Type - 0.5 miles

Parameters_0.5 miles	CBD		CBD Fringe / OBD		Urban	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
[Weekday=1]	✓	✓	✓	✓	✓	✓
[MPP=1]	✓	✓	✓	✓	✓	✓
[OPP=1]	✓	✓	✓	✓	✓	✓
[EPP=1]	✓	✓	✓	✓	✓	✓
Attached Residential					✓	
Auto Dealer						
Bank					✓	
Car Wash						
Church				✓		
Commercial Service		✓	✓			
Convenience Store			✓		✓	
Daycare				✓		
Department Store					✓	✓
Fast Food				✓		✓
Funeral Home						✓
Government				✓		✓
Hospital			✓		✓	✓
Hotel / Motel				✓	✓	
Industrial		✓	✓	✓	✓	✓
Industrial Lg					✓	
Institutional			✓	✓	✓	✓
Manufactured Home Construction			✓		✓	✓
Manufacturing						✓
Medical						✓
Multi-Family		✓	✓			✓
Office	✓		✓			
Parking Garage						✓
Recreational			✓		✓	
Restaurant						
Retail					✓	
School		✓	✓		✓	
Service Garage						
Shopping Mall						
Single-Family Residential						✓
Stadium /Arena				✓	✓	✓
Supermarket	✓			✓		
Truck Terminal					✓	✓
Utility		✓			✓	✓
Warehouse	✓					
Link_# of Lanes		✓		✓		
Link_SL (mph)	✓		✓		✓	✓
DS_# of Lanes						
DS_SL (mph)						
US_# of Lanes						
US_SL (mph)						
DS_Cross street_# of Lanes						
DS_Cross street_SL (mph)	✓		✓		✓	✓
US_Cross street_# of Lanes		✓				
US_Cross street_SL (mph)						
Intersection_# of Lanes		✓				
Intersection_SL (mph)						

Table 22 Selected Predictor Variables to Develop Models by Area Type - 1-mile

Parameters_1-mile	CBD		CBD Fringe / OBD		Urban	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
[Weekday=1]	✓	✓	✓	✓	✓	✓
[MPP=1]	✓	✓	✓	✓	✓	✓
[OPP=1]	✓	✓	✓	✓	✓	✓
[EPP=1]	✓	✓	✓	✓	✓	✓
Attached Residential						
Auto Dealer						
Bank						
Car Wash						
Church						
Commercial Service		✓				✓
Convenience Store	✓	✓		✓		✓
Daycare			✓			
Department Store	✓					✓
Fast Food			✓		✓	
Funeral Home	✓					✓
Government	✓					
Hospital						✓
Hotel / Motel						
Industrial			✓			
Industrial Lg				✓	✓	
Institutional						
Manufactured Home Construction					✓	✓
Manufacturing					✓	
Medical			✓			
Multi-Family		✓	✓		✓	
Office				✓		✓
Parking Garage					✓	
Recreational				✓		✓
Restaurant						
Retail				✓		✓
School					✓	
Service Garage						
Shopping Mall			✓	✓		
Single-Family Residential						
Stadium /Arena						
Supermarket	✓			✓		✓
Truck Terminal			✓			
Utility				✓		
Warehouse						
Link_# of Lanes		✓		✓		✓
Link_SL (mph)	✓		✓		✓	
DS_# of Lanes						
DS_SL (mph)						
US_# of Lanes						
US_SL (mph)						
DS_Cross street_# of Lanes						
DS_Cross street_SL (mph)			✓	✓	✓	✓
US_Cross street_# of Lanes		✓				
US_Cross street_SL (mph)						
Intersection_# of Lanes		✓				
Intersection_SL (mph)						

Table 23 Developed Models for 0.5 miles Buffer Width – CBD Area

Parameters_0.5 miles_CBD	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	-6.149	0.490	<0.05	2.151	0.054	<0.05	0.591	0.041	<0.05
[Weekday=1]	0.044	0.007	<0.05	0.043	0.017	<0.05	0.042	0.016	<0.05
[MPP=1]	0.007	0.010	0.465	0.003	0.024	0.894	0.003	0.023	0.880
[OPP=1]	0.016	0.009	0.084	0.015	0.024	0.533	0.016	0.023	0.483
[EPP=1]	0.067	0.011	<0.05	0.070	0.026	<0.05	0.066	0.024	<0.05
Attached Residential	3.21E-03	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-	-	-	-	-	-	-	-	-
Bank	1.04E-02	0.002	<0.05	-	-	-	-	-	-
Car Wash	2.72E-01	0.016	<0.05	-	-	-	-	-	-
Church	5.11E-03	<0.001	<0.05	-	-	-	-	-	-
Commercial Service	-8.89E-03	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	7.45E-02	0.007	<0.05	-	-	-	-	-	-
Daycare	1.19E-01	0.015	<0.05	-	-	-	-	-	-
Department Store	-4.99E-02	0.006	<0.05	-	-	-	-	-	-
Fast Food	6.05E-02	0.010	<0.05	-	-	-	-	-	-
Funeral Home	-6.88E-02	0.007	<0.05	-	-	-	-	-	-
Government	-5.50E-04	<0.001	<0.05	-	-	-	-	-	-
Hospital	3.21E-03	<0.001	<0.05	-	-	-	-	-	-
Hotel / Motel	7.91E-04	<0.001	<0.05	-	-	-	-	-	-
Industrial	2.74E-01	0.044	<0.05	-	-	-	-2.38E-02	0.003	<0.05
Industrial Lg	-	-	-	-	-	-	-	-	-
Institutional	-4.80E-04	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-	-	-	-	-	-	-	-	-
Manufacturing	5.66E-03	<0.001	<0.05	-	-	-	-	-	-
Medical	-6.67E-03	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	5.95E-05	<0.001	<0.05	-	-	-	8.67E-05	<0.001	-
Office	1.69E-04	<0.001	<0.05	1.73E-05	<0.001	<0.05	-	-	-
Parking Garage	-	-	-	-	-	-	-	-	-
Recreational	-1.47E-02	0.001	<0.05	-	-	-	-	-	-
Restaurant	-2.85E-02	0.003	<0.05	-	-	-	-	-	-
Retail	3.71E-03	<0.001	<0.05	-	-	-	-	-	-
School	-4.90E-03	<0.001	<0.05	-	-	-	-	-	-
Service Garage	2.08E-02	0.002	<0.05	-	-	-	-	-	-
Shopping Mall	1.21E-02	0.002	<0.05	-	-	-	-	-	-
Single-Family Residential	2.57E-03	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-	-	-	-	-	-	-	-	-
Supermarket	-1.46E-01	0.009	<0.05	-2.39E-03	0.001	<0.05	-	-	-
Truck Terminal	-4.17E-02	0.002	<0.05	-	-	-	-	-	-
Utility	6.93E-03	0.002	<0.05	-	-	-	-	-	-
Warehouse	-5.01E-04	<0.001	<0.05	-4.37E-05	<0.001	<0.05	-	-	-
Link_# of Lanes	0.918	0.043	<0.05	-	-	-	-0.199	0.014	<0.05
Link_SL (mph)	-0.158	0.014	<0.05	-0.040	0.001	<0.05	-	-	-
DS_# of Lanes	0.326	0.043	<0.05	-	-	-	-	-	-
DS_SL (mph)	-0.064	0.004	<0.05	-	-	-	-	-	-
US_# of Lanes	-0.805	0.039	<0.05	-	-	-	-	-	-
US_SL (mph)	0.245	0.018	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.635	0.034	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	-0.068	0.004	<0.05	0.005	<0.001	<0.05	-	-	-
US_Cross street_# of Lanes	-	-	-	-	-	-	0.080	0.006	<0.05
US_Cross street_SL (mph)	-0.022	0.002	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	0.583	0.035	<0.05	-	-	-	0.157	0.008	<0.05
Intersection_SL (mph)	-	-	-	-	-	-	-	-	-
QIC	105.259			72.510			71.574		
QICC	100.079			72.348			70.484		
RMSE	178.202			0.754			1.113		
MAPE	4324%			22%			27%		
MPE	-4228%			-14%			-6%		

Note: Land use categories were considered in square feet.

Table 24 Developed Models for 1-mile Buffer Width – CBD Area

Parameters_1-mile_CBD	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.130	0.104	<0.05	2.241	0.057	<0.05	0.543	0.073	<0.05
[Weekday=1]	0.044	0.007	<0.05	0.041	0.017	<0.05	0.043	0.016	<0.05
[MPP=1]	0.007	0.010	0.497	0.002	0.024	0.928	0.003	0.022	0.878
[OPP=1]	0.016	0.010	0.105	0.014	0.024	0.573	0.017	0.023	0.459
[EPP=1]	0.067	0.012	<0.05	0.067	0.025	<0.05	0.068	0.024	<0.05
Attached Residential	-4.888E-04	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-	-	-	-	-	-	-	-	-
Bank	4.889E-03	<0.001	<0.05	-	-	-	-	-	-
Car Wash	-5.485E-02	0.007	<0.05	-	-	-	-	-	-
Church	-	-	-	-	-	-	-	-	-
Commercial Service	1.458E-03	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	1.918E-02	0.004	<0.05	-	-	-	-8.955E-03	0.003	<0.05
Daycare	1.143E-02	0.002	<0.05	-	-	-	-	-	-
Department Store	-	-	-	2.113E-03	<0.001	<0.05	-	-	-
Fast Food	-	-	-	-	-	-	-	-	-
Funeral Home	2.212E-02	0.003	<0.05	-3.515E-03	0.001	<0.05	-	-	-
Government	3.131E-04	<0.001	<0.05	1.103E-04	<0.001	<0.05	-	-	-
Hospital	-2.173E-04	<0.001	<0.05	-	-	-	-	-	-
Hotel / Motel	7.082E-04	<0.001	<0.05	-	-	-	-	-	-
Industrial	1.074E-01	0.008	<0.05	-	-	-	-	-	-
Industrial Lg	-	-	-	-	-	-	-	-	-
Institutional	-	-	-	-	-	-	-	-	-
Manufactured Home Construction	-	-	-	-	-	-	-	-	-
Manufacturing	-	-	-	-	-	-	-	-	-
Medical	-	-	-	-	-	-	-	-	-
Multi-Family	1.207E-04	<0.001	<0.05	-	-	-	7.344E-05	<0.001	<0.05
Office	-	-	-	-	-	-	-	-	-
Parking Garage	-1.732E-04	<0.001	<0.05	-	-	-	-	-	-
Recreational	-7.025E-03	<0.001	<0.05	-	-	-	-	-	-
Restaurant	-5.216E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	3.210E-03	<0.001	<0.05	-	-	-	-	-	-
School	-3.445E-04	<0.001	<0.05	-	-	-	-	-	-
Service Garage	1.933E-03	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	2.207E-03	<0.001	<0.05	-	-	-	-	-	-
Single-Family Residential	-2.245E-04	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-3.414E-04	<0.001	<0.05	-	-	-	-	-	-
Supermarket	-2.276E-03	<0.001	<0.05	-1.952E-03	<0.001	<0.05	-	-	-
Truck Terminal	-1.020E-02	0.001	<0.05	-	-	-	-	-	-
Utility	1.443E-03	<0.001	<0.05	-	-	-	-	-	-
Warehouse	-1.798E-04	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	0.236	0.038	<0.05	-	-	-	-0.248	0.017	<0.05
Link_SL (mph)	-	-	-	-0.047	0.001	<0.05	-	-	-
DS_# of Lanes	0.147	0.014	<0.05	-	-	-	-	-	-
DS_SL (mph)	-0.016	0.001	<0.05	-	-	-	-	-	-
US_# of Lanes	0.055	0.010	<0.05	-	-	-	-	-	-
US_SL (mph)	-0.019	0.002	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.112	0.011	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	-0.004	0.001	<0.05	-	-	-	-	-	-
US_Cross street_# of Lanes	-0.092	0.007	<0.05	-	-	-	0.075	0.006	<0.05
US_Cross street_SL (mph)	-0.012	0.002	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	-0.568	0.035	<0.05	-	-	-	0.162	0.008	<0.05
Intersection_SL (mph)	0.051	0.002	<0.05	-	-	-	-	-	-
QIC	97.341			75.244			72.109		
QICC	92.921			73.983			69.645		
RMSE	12.153			0.822			1.119		
MAPE	343%			21%			29%		
MPE	-305%			-9%			-2%		

Note: Land use categories were considered in square feet.

Table 25 Developed Models for 0.5 miles Buffer Width – CBD Fringe Area

Parameters_0.5 miles_OBD	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.412	0.073	<0.05	1.782	0.037	<0.05	0.966	0.027	<0.05
[Weekday=1]	0.083	0.007	<0.05	0.083	0.011	<0.05	0.084	0.012	<0.05
[MPP=1]	0.033	0.008	<0.05	0.034	0.014	<0.05	0.035	0.015	<0.05
[OPP=1]	0.059	0.008	<0.05	0.064	0.015	<0.05	0.064	0.016	<0.05
[EPP=1]	0.139	0.011	<0.05	0.142	0.017	<0.05	0.142	0.018	<0.05
Attached Residential	-3.027E-04	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-	-	-	-	-	-	-	-	-
Bank	2.752E-03	<0.001	<0.05	-	-	-	-	-	-
Car Wash	-2.841E-02	0.003	<0.05	-	-	-	-	-	-
Church	5.105E-04	<0.001	<0.05	-	-	-	-2.012E-04	<0.001	<0.05
Commercial Service	-2.973E-04	<0.001	<0.05	-1.333E-04	<0.001	<0.05	-	-	-
Convenience Store	-9.374E-03	0.002	<0.05	-	-	-	-	-	-
Daycare	-5.286E-03	<0.001	<0.05	-	-	-	-	-	-
Department Store	-1.244E-03	<0.001	<0.05	-	-	-	-	-	-
Fast Food	1.084E-02	0.002	<0.05	-	-	-	9.483E-03	<0.001	<0.05
Funeral Home	-2.060E-02	0.001	<0.05	-	-	-	-	-	-
Government	-3.908E-04	<0.001	<0.05	-	-	-	-1.056E-04	<0.001	<0.05
Hospital	-1.657E-04	<0.001	<0.05	-	-	-	-	-	-
Hotel / Motel	-2.739E-04	<0.001	<0.05	-	-	-	-1.530E-04	<0.001	<0.05
Industrial	-	-	-	-3.171E-02	0.002	<0.05	-6.130E-03	0.002	<0.05
Industrial Lg	8.769E-03	<0.001	<0.05	-	-	-	-	-	-
Institutional	-	-	-	-	-	-	-	-	-
Manufactured Home Construction	-	-	-	-	-	-	-	-	-
Manufacturing	-2.671E-04	<0.001	<0.05	-	-	-	-	-	-
Medical	3.372E-04	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	6.185E-05	<0.001	<0.05	4.328E-05	<0.001	<0.05	-	-	-
Office	-	-	-	3.782E-05	<0.001	<0.05	-	-	-
Parking Garage	1.196E-04	<0.001	<0.05	-	-	-	-	-	-
Recreational	-1.171E-03	<0.001	<0.05	-2.635E-04	<0.001	<0.05	-	-	-
Restaurant	-1.228E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	-2.275E-04	<0.001	<0.05	-	-	-	-	-	-
School	-1.215E-04	<0.001	<0.05	-1.385E-04	<0.001	<0.05	-	-	-
Service Garage	-	-	-	-	-	-	-	-	-
Shopping Mall	7.255E-04	<0.001	<0.05	-	-	-	-	-	-
Single-Family Residential	-6.995E-05	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-1.080E-03	<0.001	<0.05	-	-	-	-9.672E-04	<0.001	<0.05
Supermarket	2.606E-03	<0.001	<0.05	-	-	-	3.260E-03	<0.001	<0.05
Truck Terminal	-7.758E-03	<0.001	<0.05	-	-	-	-	-	-
Utility	-	-	-	-	-	-	-	-	-
Warehouse	2.303E-04	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-0.042	0.014	<0.05	-	-	-	-0.240	0.008	<0.05
Link_SL (mph)	-0.008	0.002	<0.05	-0.033	<0.001	<0.05	-	-	-
DS_# of Lanes	-	-	-	-	-	-	-	-	-
DS_SL (mph)	-	-	-	-	-	-	-	-	-
US_# of Lanes	-	-	-	-	-	-	-	-	-
US_SL (mph)	-0.004	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.098	0.006	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	-0.010	<0.001	<0.05	0.003	<0.001	<0.05	-	-	-
US_Cross street_# of Lanes	-0.054	0.005	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	0.002	<0.001	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	-0.074	0.016	<0.05	-	-	-	-	-	-
Intersection_SL (mph)	0.010	0.001	<0.05	-	-	-	-	-	-
QIC	106.254			74.978			84.415		
QICC	101.985			77.523			83.744		
RMSE	0.642			0.454			0.518		
MAPE	27%			18%			18%		
MPE	2%			-4%			1%		

Note: Land use categories were considered in square feet.

Table 26 Developed Models for 1-mile Buffer Width – CBD Fringe Area

Parameters_1-mile_OBD	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	0.578	0.033	<0.05	1.699	0.038	<0.05	1.129	0.040	<0.05
[Weekday=1]	0.083	0.007	<0.05	0.084	0.011	<0.05	0.085	0.013	<0.05
[MPP=1]	0.034	0.008	<0.05	0.035	0.014	<0.05	0.036	0.017	<0.05
[OPP=1]	0.060	0.008	<0.05	0.065	0.015	<0.05	0.067	0.018	<0.05
[EPP=1]	0.138	0.011	<0.05	0.143	0.016	<0.05	0.144	0.019	<0.05
Attached Residential	-	-	-	-	-	-	-	-	-
Auto Dealer	1.018E-03	<0.001	<0.05	-	-	-	-	-	-
Bank	1.650E-03	<0.001	<0.05	-	-	-	-	-	-
Car Wash	-1.682E-02	0.002	<0.05	-	-	-	-	-	-
Church	5.847E-04	<0.001	<0.05	-	-	-	-	-	-
Commercial Service	-1.061E-03	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	-	-	-	-	-	-	-5.351E-03	<0.001	<0.05
Daycare	-1.796E-03	<0.001	<0.05	7.079E-04	<0.001	<0.05	-	-	-
Department Store	-3.408E-04	<0.001	<0.05	-	-	-	-	-	-
Fast Food	1.239E-02	0.001	<0.05	-	-	-	-	-	-
Funeral Home	-1.947E-02	0.001	<0.05	-	-	-	-	-	-
Government	-2.005E-04	<0.001	<0.05	-	-	-	-	-	-
Hospital	2.359E-04	<0.001	<0.05	-	-	-	-	-	-
Hotel / Motel	-1.415E-04	<0.001	<0.05	-	-	-	-	-	-
Industrial	-9.380E-03	0.001	<0.05	-3.380E-03	<0.001	<0.05	-	-	-
Industrial Lg	1.404E-02	<0.001	<0.05	-	-	-	-4.904E-03	<0.001	<0.05
Institutional	1.152E-04	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-	-	-	-	-	-	-	-	-
Manufacturing	-	-	-	-	-	-	-	-	-
Medical	-5.084E-04	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	5.112E-05	<0.001	<0.05	8.724E-06	<0.001	<0.05	-	-	-
Office	-	-	-	-	-	-	-	-	-
Parking Garage	1.024E-04	<0.001	<0.05	-	-	-	-	-	-
Recreational	-8.340E-04	<0.001	<0.05	-	-	-	-2.167E-04	<0.001	<0.05
Restaurant	-2.656E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	2.966E-04	<0.001	<0.05	-	-	-	-	-	-
School	-1.560E-04	<0.001	<0.05	-	-	-	-	-	-
Service Garage	1.258E-03	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	-	-	-	1.574E-04	<0.001	<0.05	5.868E-05	<0.001	<0.05
Single-Family Residential	-5.411E-05	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	1.653E-04	<0.001	<0.05	-	-	-	-	-	-
Supermarket	-	-	-	-	-	-	1.397E-03	<0.001	<0.05
Truck Terminal	-1.136E-03	<0.001	<0.05	-6.758E-04	<0.001	<0.05	-	-	-
Utility	-	-	-	-	-	-	-5.860E-04	<0.001	<0.05
Warehouse	-	-	-	-	-	-	-	-	-
Link_# of Lanes	-0.138	0.016	<0.05	-	-	-	-0.272	0.010	<0.05
Link_SL (mph)	-	-	-	-0.033	<0.001	<0.05	-	-	-
DS_# of Lanes	0.067	0.017	<0.05	-	-	-	-	-	-
DS_SL (mph)	-0.007	<0.001	<0.05	-	-	-	-	-	-
US_# of Lanes	-0.163	0.014	<0.05	-	-	-	-	-	-
US_SL (mph)	0.018	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.089	0.006	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	-0.005	<0.001	<0.05	0.003	<0.001	<0.05	-	-	-
US_Cross street_# of Lanes	-0.062	0.005	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-	-	-	-	-	-	-	-	-
Intersection_# of Lanes	-0.142	0.022	<0.05	-	-	-	-	-	-
Intersection_SL (mph)	0.030	0.002	<0.05	-	-	-	-	-	-
QIC	98.804			74.339			94.452		
QICC	100.599			75.255			94.629		
RMSE	0.736			0.507			0.466		
MAPE	26%			22%			18%		
MPE	8%			-8%			-2%		

Note: Land use categories were considered in square feet.

Table 27 Developed Models for 0.5 miles Buffer Width – Urban Area

Parameters_0.5 miles_Urban	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.245	0.043	<0.05	1.859	0.028	<0.05	1.941	0.028	<0.05
[Weekday=1]	0.073	0.005	<0.05	0.074	0.007	<0.05	0.075	0.007	<0.05
[MPP=1]	0.032	0.007	<0.05	0.034	0.009	<0.05	0.034	0.009	<0.05
[OPP=1]	0.035	0.006	<0.05	0.037	0.008	<0.05	0.036	0.008	<0.05
[EPP=1]	0.098	0.008	<0.05	0.100	0.010	<0.05	0.101	0.010	<0.05
Attached Residential	2.569E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-	-	-	-	-	-	-	-	-
Bank	3.634E-03	<0.001	<0.05	2.464E-03	<0.001	<0.05	-	-	-
Car Wash	8.058E-03	0.001	<0.05	-	-	-	-	-	-
Church	-	-	-	-	-	-	-	-	-
Commercial Service	-3.580E-04	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	5.623E-03	<0.001	<0.05	7.484E-03	<0.001	<0.05	-	-	-
Daycare	-1.576E-03	<0.001	<0.05	-	-	-	-	-	-
Department Store	-6.908E-04	<0.001	<0.05	-	-	-	-	-	-
Fast Food	2.636E-03	<0.001	<0.05	-	-	-	2.635E-03	<0.001	<0.05
Funeral Home	1.304E-03	<0.001	<0.05	-	-	-	1.178E-03	<0.001	<0.05
Government	2.019E-04	<0.001	<0.05	-	-	-	1.055E-04	<0.001	<0.05
Hospital	2.879E-04	<0.001	<0.05	2.848E-04	<0.001	<0.05	2.265E-04	<0.001	<0.05
Hotel / Motel	-	-	-	-5.114E-05	<0.001	<0.05	-	-	-
Industrial	-1.086E-03	<0.001	<0.05	-2.524E-03	<0.001	<0.05	-3.738E-03	<0.001	<0.05
Industrial Lg	-9.646E-04	<0.001	<0.05	2.010E-03	<0.001	<0.05	-	-	-
Institutional	-1.010E-04	<0.001	<0.05	-5.418E-04	<0.001	<0.05	-5.090E-04	<0.001	<0.05
Manufactured Home Construction	-3.696E-03	<0.001	<0.05	-5.155E-03	<0.001	<0.05	-3.607E-03	<0.001	<0.05
Manufacturing	-	-	-	-2.884E-04	<0.001	<0.05	-3.023E-04	<0.001	<0.05
Medical	-	-	-	-	-	-	5.603E-04	<0.001	<0.05
Multi-Family	-5.117E-05	<0.001	<0.05	-	-	-	1.098E-05	<0.001	<0.05
Office	-4.696E-05	<0.001	<0.05	-	-	-	-	-	-
Parking Garage	1.190E-04	<0.001	<0.05	-	-	-	-	-	-
Recreational	-	-	-	-2.156E-04	<0.001	<0.05	-	-	-
Restaurant	2.623E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	-	-	-	1.860E-04	<0.001	<0.05	-	-	-
School	-	-	-	-1.083E-04	<0.001	<0.05	-	-	-
Service Garage	-	-	-	-	-	-	-	-	-
Shopping Mall	-1.771E-04	<0.001	<0.05	-	-	-	-	-	-
Single-Family Residential	-4.473E-05	<0.001	<0.05	-	-	-	-2.909E-05	<0.001	<0.05
Stadium /Arena	1.670E-04	<0.001	<0.05	4.065E-05	<0.001	<0.05	5.243E-05	<0.001	<0.05
Supermarket	3.705E-04	<0.001	<0.05	-	-	-	-	-	-
Truck Terminal	4.777E-04	<0.001	<0.05	-	-	-	8.314E-05	<0.001	<0.05
Utility	-1.917E-03	<0.001	<0.05	-	-	-	-	-	-
Warehouse	-8.469E-05	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-0.056	0.008	<0.05	-	-	-	-	-	-
Link_SL (mph)	-0.014	<0.001	<0.05	-0.032	<0.001	<0.05	-0.032	<0.001	<0.05
DS_# of Lanes	-	-	-	-	-	-	-	-	-
DS_SL (mph)	-	-	-	-	-	-	-	-	-
US_# of Lanes	-0.063	0.009	<0.05	-	-	-	-	-	-
US_SL (mph)	0.004	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.025	0.003	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	-	-	-	-	-	-	-	-	-
US_Cross street_# of Lanes	0.027	0.003	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.005	<0.001	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	-	-	-	-	-	-	-	-	-
Intersection_SL (mph)	0.003	<0.001	<0.05	-	-	-	-	-	-
QIC	127.621			112.092			114.028		
QICC	122.710			117.490			115.414		
RMSE	0.336			0.459			0.352		
MAPE	15%			16%			15%		
MPE	-5%			-6%			-4%		

Note: Land use categories were considered in square feet

Table 28 Developed Models for 1-mile Buffer Width – Urban Area

Parameters_1-mile_Urban	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.267	0.044	<0.05	1.848	0.030	<0.05	0.741	0.021	<0.05
[Weekday=1]	0.073	0.005	<0.05	0.076	0.008	<0.05	0.076	0.008	<0.05
[MPP=1]	0.033	0.007	<0.05	0.035	0.010	<0.05	0.035	0.010	<0.05
[OPP=1]	0.035	0.006	<0.05	0.037	0.009	<0.05	0.038	0.010	<0.05
[EPP=1]	0.097	0.008	<0.05	0.103	0.011	<0.05	0.103	0.012	<0.05
Attached Residential	1.977E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-1.077E-04	<0.001	<0.05	-	-	-	-	-	-
Bank	2.113E-03	<0.001	<0.05	-	-	-	-	-	-
Car Wash	-	-	-	-	-	-	-	-	-
Church	-	-	-	-	-	-	-	-	-
Commercial Service	-3.590E-04	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	6.054E-03	<0.001	<0.05	-	-	-	4.988E-03	<0.001	<0.05
Daycare	-2.526E-03	<0.001	<0.05	-	-	-	-	-	-
Department Store	-3.346E-04	<0.001	<0.05	-	-	-	6.520E-05	<0.001	<0.05
Fast Food	-	-	-	2.821E-03	<0.001	<0.05	-	-	-
Funeral Home	-	-	-	-	-	-	1.255E-03	<0.001	<0.05
Government	2.516E-04	<0.001	<0.05	-	-	-	-	-	-
Hospital	3.393E-05	<0.001	<0.05	-	-	-	-	-	-
Hotel / Motel	-7.994E-05	<0.001	<0.05	-	-	-	-	-	-
Industrial	-1.741E-03	<0.001	<0.05	-	-	-	-	-	-
Industrial Lg	4.788E-04	<0.001	<0.05	-3.708E-04	<0.001	<0.05	-	-	-
Institutional	-3.557E-04	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-1.636E-03	<0.001	<0.05	-	-	-	-2.067E-03	<0.001	<0.05
Manufacturing	1.348E-04	<0.001	<0.05	-4.670E-05	<0.001	<0.05	-	-	-
Medical	-	-	-	-	-	-	-	-	-
Multi-Family	-1.934E-05	<0.001	<0.05	7.699E-06	<0.001	<0.05	-	-	-
Office	5.017E-05	<0.001	<0.05	-	-	-	-1.724E-05	<0.001	<0.05
Parking Garage	-	-	-	-7.257E-06	<0.001	<0.05	-	-	-
Recreational	-	-	-	-	-	-	4.215E-04	<0.001	<0.05
Restaurant	-8.503E-04	<0.001	<0.05	-	-	-	-	-	-
Retail	1.958E-04	<0.001	<0.05	-	-	-	3.705E-05	<0.001	<0.05
School	1.380E-04	<0.001	<0.05	-1.126E-04	<0.001	<0.05	-	-	-
Service Garage	2.125E-04	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	-	-	-	-	-	-	-	-	-
Single-Family Residential	-2.886E-05	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-6.633E-05	<0.001	<0.05	-	-	-	-	-	-
Supermarket	4.608E-04	<0.001	<0.05	-	-	-	5.028E-04	<0.001	<0.05
Truck Terminal	2.451E-04	<0.001	<0.05	-	-	-	-	-	-
Utility	-3.566E-03	<0.001	<0.05	-	-	-	-	-	-
Warehouse	-6.173E-05	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-0.037	0.008	<0.05	-	-	-	-0.223	0.005	<0.05
Link_SL (mph)	-0.015	<0.001	<0.05	-0.031	<0.001	<0.05	-	-	-
DS_# of Lanes	-	-	-	-	-	-	-	-	-
DS_SL (mph)	-	-	-	-	-	-	-	-	-
US_# of Lanes	-0.089	0.009	<0.05	-	-	-	-	-	-
US_SL (mph)	0.004	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.033	0.003	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	-	-	-	-	-	-	0.001	<0.001	<0.05
US_Cross street_# of Lanes	0.026	0.003	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.004	<0.001	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	-	-	-	-	-	-	-	-	-
Intersection_SL (mph)	0.005	<0.001	<0.05	-	-	-	-	-	-
QIC	119.963			118.939			133.508		
QICC	125.287			118.226			132.035		
RMSE	0.318			0.317			0.366		
MAPE	14%			14%			18%		
MPE	-5%			-5%			-7%		

Note: Land use categories were considered in square feet.

Table 29 Performance of Developed Models by Area Type - Summary

Buffer Width	Models	Parameters	Backward Elimination	Model 1	Model 2
0.5 Miles	CBD	QIC	105.259	72.510	71.574
		QICC	100.079	72.348	70.484
		RMSE	178.202	0.754	1.113
		MAPE	4324%	22%	27%
		MPE	-4228%	-14%	-6%
	CBD Fringe / OBD	QIC	106.254	74.978	84.415
		QICC	101.985	77.523	83.744
		RMSE	0.642	0.454	0.518
		MAPE	27%	18%	18%
		MPE	2%	-4%	1%
	Urban	QIC	127.621	112.092	114.028
		QICC	122.710	117.490	115.414
		RMSE	0.336	0.459	0.352
		MAPE	15%	16%	15%
		MPE	-5%	-6%	-4%
1-Mile	CBD	QIC	97.341	75.244	72.109
		QICC	92.921	73.983	69.645
		RMSE	12.153	0.822	1.119
		MAPE	343%	21%	29%
		MPE	-305%	-9%	-2%
	CBD Fringe / OBD	QIC	98.804	74.339	94.452
		QICC	100.599	75.255	94.629
		RMSE	0.736	0.507	0.466
		MAPE	26%	22%	18%
		MPE	8%	-8%	-2%
	Urban	QIC	119.963	118.939	133.508
		QICC	125.287	118.226	132.035
		RMSE	0.318	0.317	0.366
		MAPE	14%	14%	18%
		MPE	-5%	-5%	-7%

7.4 Discussion related to the Developed Models by Area Type

In all the developed models by area type, an increase in the speed limit of the selected link decreases the ATT. In CBD area, an increase in area with multi-family within 0.5 miles and 1-mile from a link increases the ATT (Table 30). However, in the CBD area, an increase in area with supermarkets within 0.5 miles and 1-mile from a link decreases the ATT.

Likewise, in CBD Fringe / OBD area, an increase in area with multi-family and supermarket type land use within 0.5 miles and 1-mile from a link increases the ATT (Table 31). However, in the CBD Fringe / OBD area, an increase in areas with industrial and recreational type land uses within 0.5 miles and 1-mile from a link decreases the ATT.

Similarly, in the urban area, an increase in area with convenience store, fast food, funeral home, multi-family, and retail within 0.5 miles and 1-mile from a link increases the ATT (Table 32). However, in urban area, an increase in areas with manufactured home construction, manufacturing, and school type land uses within 0.5 miles and 1-mile from a link decreases the ATT. Further, in the urban area, an increase in area with recreational type land use within 0.5 miles from a link decreases the ATT, however, within 1-mile from a link increases the ATT. Likewise, an increase in area with large industrial within 0.5 miles from a link increases the ATT, however, within 1-mile from a link decreases the ATT.

Further, the developed backward elimination model for CBD area should not be used for estimating the ATT due to high errors in the validation results. Based on QIC, QICC, RMSE and MAPE, for models by area type, 0.5 miles buffer was observed to be the better fit (lower QIC and QICC, lower difference between QIC to QICC, lower RMSE and MAPE) to explain the relationship between the land use developments and the ATT when compared to 0.5 miles buffer width. Further, for each of the area type, Model 1 was observed to be the better fit to estimate the ATT compared to other models (Table 29).

Table 30 Comparison of Developed Models for the CBD Area

Parameters_CBD	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	N	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	P	P	P	P	P	P
[EPP=1]	P	P	P	P	P	P
Attached Residential	P			N		
Auto Dealer						
Bank	P			P		
Car Wash	P			N		
Church	P					
Commercial Service	N			P		
Convenience Store	P			P		N
Daycare	P			P		
Department Store	N				P	
Fast Food	P					
Funeral Home	N			P	N	
Government	N			P	P	
Hospital	P			N		
Hotel / Motel	P			P		
Industrial	P		N	P		
Industrial Lg						
Institutional	N					
Manufactured Home Construction						
Manufacturing	P					
Medical	N					
Multi-Family	P		P	P		P
Office	P	P				
Parking Garage				N		
Recreational	N			N		
Restaurant	N			N		
Retail	P			P		
School	N			N		
Service Garage	P			P		
Shopping Mall	P			P		
Single-Family Residential	P			N		
Stadium /Arena				N		
Supermarket	N	N		N	N	
Truck Terminal	N			N		
Utility	P			P		
Warehouse	N	N		N		
Link_# of Lanes	P		N	P		N
Link_SL (mph)	N	N			N	
DS_# of Lanes	P			P		
DS_SL (mph)	N			N		
US_# of Lanes	N			P		
US_SL (mph)	P			N		
DS_Cross street_# of Lanes	P			P		
DS_Cross street_SL (mph)	N	P		N		
US_Cross street_# of Lanes			P	N		P
US_Cross street_SL (mph)	N			N		
Intersection_# of Lanes	P		P	N		P
Intersection_SL (mph)				P		

Table 31 Comparison of Developed Models for the CBD Fringe / OBD Area

Parameters_OBD	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	P	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	P	P	P	P	P	P
[EPP=1]	P	P	P	P	P	P
Attached Residential	N					
Auto Dealer				P		
Bank	P			P		
Car Wash	N			N		
Church	P		N	P		
Commercial Service	N	N		N		
Convenience Store	N					N
Daycare	N			N	P	
Department Store	N			N		
Fast Food	P		P	P		
Funeral Home	N			N		
Government	N		N	N		
Hospital	N			P		
Hotel / Motel	N		N	N		
Industrial		N	N	N	N	
Industrial Lg	P			P		N
Institutional				P		
Manufactured Home Construction						
Manufacturing	N					
Medical	P			N		
Multi-Family	P	P		P	P	
Office		P				
Parking Garage	P			P		
Recreational	N	N		N		N
Restaurant	N			N		
Retail	N			P		
School	N	N		N		
Service Garage				P		
Shopping Mall	P				P	P
Single-Family Residential	N			N		
Stadium /Arena	N		N	P		
Supermarket	P		P			P
Truck Terminal	N			N	N	
Utility						N
Warehouse	P					
Link_# of Lanes	N		N	N		N
Link_SL (mph)	N	N			N	
DS_# of Lanes				P		
DS_SL (mph)				N		
US_# of Lanes				N		
US_SL (mph)	N			P		
DS_Cross street_# of Lanes	P			P		
DS_Cross street_SL (mph)	N	P		N	P	
US_Cross street_# of Lanes	N			N		
US_Cross street_SL (mph)	P					
Intersection_# of Lanes	N			N		
Intersection_SL (mph)	P			P		

Table 32 Comparison of Developed Models for the Urban Area

Parameters_Urban	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	P	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	P	P	P	P	P	P
[EPP=1]	P	P	P	P	P	P
Attached Residential	P			P		
Auto Dealer				N		
Bank	P	P		P		
Car Wash	P					
Church						
Commercial Service	N			N		
Convenience Store	P	P		P		P
Daycare	N			N		
Department Store	N			N		P
Fast Food	P		P		P	
Funeral Home	P		P			P
Government	P		P	P		
Hospital	P	P	P	P		
Hotel / Motel		N		N		
Industrial	N	N	N	N		
Industrial Lg	N	P		P	N	
Institutional	N	N	N	N		
Manufactured Home Construction	N	N	N	N		N
Manufacturing		N	N	P	N	
Medical			P			
Multi-Family	N		P	N	P	
Office	N			P		N
Parking Garage	P				N	
Recreational		N				P
Restaurant	P			N		
Retail		P		P		P
School		N		P	N	
Service Garage				P		
Shopping Mall	N					
Single-Family Residential	N		N	N		
Stadium /Arena	P	P	P	N		
Supermarket	P			P		P
Truck Terminal	P		P	P		
Utility	N			N		
Warehouse	N			N		
Link_# of Lanes	N			N		N
Link_SL (mph)	N	N	N	N	N	
DS_# of Lanes						
DS_SL (mph)						
US_# of Lanes	N			N		
US_SL (mph)	P			P		
DS_Cross street_# of Lanes	P			P		
DS_Cross street_SL (mph)						P
US_Cross street_# of Lanes	P			P		
US_Cross street_SL (mph)	N			N		
Intersection_# of Lanes						
Intersection_SL (mph)	P			P		

CHAPTER 8: STATISTICAL MODELS BY SPEED LIMIT

This chapter presents the results obtained from the statistical models developed to examine the relationship between ATT and land use characteristics by the speed limit.

In this step, the selected links were classified into three categories (less than 45 mph, between 45 to 50mph and greater than 50mph) based on the speed limit. Eighteen models were developed based on the speed limit datasets. As 0.5 miles and 1-mile buffer widths were observed to be suitable to analyze the influence of proximal land use developments on the ATT, the models were developed using only 0.5 miles and 1-mile buffer width datasets. Similar to the earlier procedure, for each buffer width and the speed limit classification, a model is developed using the backward elimination method. The Model 1 and Model 2 were then developed by avoiding the multicollinearity between the predictor variables. Pearson correlation matrices by the speed limit dataset are presented in Appendix A (Table A12 to Table A17). The selection of predictor variables by buffer width and speed limit categories are summarized in Table 33 and Table 34. The backward elimination models can be used for estimating the ATT. However, the influence of predictor variables on the ATT is interpreted using Model 1 and Model 2. Each of the developed models by the speed limit are discussed next.

8.1 Speed Limit < 45 mph

In all the developed models (0.5 miles and 1-mile buffer widths), the coefficients of TOD and DOW are consistent (Table 35 and Table 36).

The results obtained indicate that, compared to the weekend, the ATT is higher on weekdays when all the other variables are held constant. In addition, the ATT is higher during the evening peak period when compared to the morning peak period and the afternoon off-peak period, when all the other variables are held constant. The results obtained indicate that the speed limit of the selected link has a negative influence on the ATT. However, the number of lanes of the downstream cross street and the intersecting links, and the speed limit of intersecting links have a positive influence on the ATT.

The Model 1 and Model 2 developed with 0.5 miles buffer width data for speed limit less than 45 mph category indicates that areas with commercial service, multi-family, school, hospital, and stadium/arena type land use have a positive influence on the ATT (Table 35). However, areas with auto dealer, daycare, funeral home, industrial, manufactured home construction, supermarket, and shopping mall type land uses have a negative influence on the ATT.

The Model 1 and Model 2 developed with 1-mile buffer width data for speed limit less than 45 mph category indicates that areas with multi-family, school, fast food, office, and warehouse type land use have a positive influence on the ATT (Table 36). However, areas with convenience store, department store, funeral home, auto dealer, and daycare type land uses have a negative influence on the ATT.

8.2 Speed Limit between 45 to 50 mph

Similar to the models developed by selecting the links with speed limit less than 45 mph, the coefficients of TOD and DOW are consistent in all the models developed by selecting the links with speed limit between 45 to 50 mph (Table 37 and Table 38). Also, DOW and TOD interpretations are similar to the models developed by selecting the links with speed limit less than 45 mph. The results obtained indicate that the speed limit of the selected link and the upstream link have a negative influence on the ATT. However, the speed limit of the downstream link has a positive influence on the ATT.

The Model 1 and Model 2 developed with 0.5 miles buffer width for the speed limit between 45 to 50 mph category dataset indicates that areas with fast food, hotel/motel, medical, utility, convenience store, and department store land uses have a positive influence on the ATT (Table 37). However, areas with church, government, industrial, manufacturing, recreational, commercial store, hospital, manufactured home construction, multi-family, and school type land uses have a negative influence on the ATT.

The Model 1 and Model 2 developed with 1-mile buffer width for the speed limit between 45 to 50 mph category dataset indicates that areas with medical, shopping mall, convenience store, department store, and supermarket type land uses have a positive influence on the ATT (Table 38). However, areas with daycare, industrial, manufactured home construction, recreational, government, hospital, and multi-family type land uses have a negative influence on the ATT.

8.3 Speed Limit greater than 50 mph

Similar to the models developed by selecting the links with the speed limit less than 45 mph, the coefficients of TOD and DOW are consistent in all the models developed by selecting the links with the speed limit greater than 50 mph category (Table 39 and Table 40). Also, DOW and TOD interpretations are similar to the models developed by selecting the links with the speed limit less than 45 mph category. The results obtained indicate that the number of lanes and the speed limit of the selected link have a negative influence on the ATT.

The Model 1 and Model 2 developed with 0.5 miles buffer width for the speed limit greater than 50 mph category dataset indicates that areas with institutional, commercial service, hospital, and manufacturing type land uses have a positive influence on the ATT (Table 39). However, areas with auto dealer, manufactured home construction, shopping mall, and supermarket type land uses have a negative influence on the ATT.

The Model 1 and Model 2 developed with 1-mile buffer width for the speed limit greater than 50 mph category dataset indicates that areas with commercial service and industrial type land uses have a positive influence on the ATT (Table 40). However, areas with manufactured home construction, shopping mall, and supermarket type land uses have a negative influence on the ATT.

Each of the developed models was validated by selecting 23 links with speed limit less than 45 mph, 23 links with speed limit between 45 to 50 mph, and 7 links with speed limit greater than 50 mph. These links were not considered for model development. Summary of all the developed models by buffer width and speed limit is presented in Table 41. The backward elimination models for speed limit greater than 50 mph underperformed than the models developed by checking the multicollinearity based on the QIC, QICC, RMSE and MAPE. Also, in all the developed models, the predicted ATT was higher compared to the actual ATT (negative MPE).

Table 33 Selected Predictor Variables to Develop Models by Speed Limit - 0.5 miles

Parameters_0.5 miles	< 45 mph		45 - 50 mph		> 50 mph	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
[Weekday=1]	✓	✓	✓	✓	✓	✓
[MPP=1]	✓	✓	✓	✓	✓	✓
[OPP=1]	✓	✓	✓	✓	✓	✓
[EPP=1]	✓	✓	✓	✓	✓	✓
Attached Residential						
Auto Dealer	✓		✓			✓
Bank						
Car Wash						
Church		✓	✓			
Commercial Service	✓			✓		✓
Convenience Store	✓			✓		
Daycare	✓	✓				
Department Store				✓		
Fast Food			✓			
Funeral Home	✓					
Government			✓			
Hospital		✓		✓		✓
Hotel / Motel			✓			
Industrial	✓		✓	✓	✓	
Industrial Lg						
Institutional					✓	
Manufactured Home Construction	✓	✓		✓		✓
Manufacturing	✓		✓	✓		✓
Medical			✓			✓
Multi-Family	✓			✓		
Office						
Parking Garage						
Recreational			✓			
Restaurant						
Retail						
School	✓	✓		✓		
Service Garage						
Shopping Mall		✓			✓	✓
Single-Family Residential						
Stadium /Arena		✓		✓		
Supermarket	✓			✓	✓	
Truck Terminal				✓	✓	
Utility			✓	✓		
Warehouse		✓				
Link_# of Lanes				✓	✓	
Link_SL (mph)	✓	✓	✓			✓
DS_# of Lanes						
DS_SL (mph)	✓	✓	✓			
US_# of Lanes						
US_SL (mph)			✓			
DS_Cross street_# of Lanes	✓			✓		
DS_Cross street_SL (mph)						
US_Cross street_# of Lanes	✓			✓	✓	
US_Cross street_SL (mph)		✓				
Intersection_# of Lanes	✓					
Intersection_SL (mph)		✓				

Table 34 Selected Predictor Variables to Develop Models by Speed Limit - 1 mile

Parameters_1-mile	< 45 mph		45 - 50 mph		> 50 mph	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
[Weekday=1]	✓	✓	✓	✓	✓	✓
[MPP=1]	✓	✓	✓	✓	✓	✓
[OPP=1]	✓	✓	✓	✓	✓	✓
[EPP=1]	✓	✓	✓	✓	✓	✓
Attached Residential						
Auto Dealer		✓	✓			✓
Bank						
Car Wash						
Church						
Commercial Service					✓	
Convenience Store	✓			✓		
Daycare		✓	✓			
Department Store	✓			✓		
Fast Food		✓				
Funeral Home	✓					
Government				✓		
Hospital				✓		
Hotel / Motel						
Industrial			✓	✓	✓	✓
Industrial Lg	✓	✓				
Institutional						✓
Manufactured Home Construction			✓	✓	✓	
Manufacturing						
Medical			✓			
Multi-Family	✓			✓		
Office		✓				
Parking Garage						
Recreational			✓			
Restaurant						
Retail						
School	✓	✓				
Service Garage			✓		✓	
Shopping Mall			✓		✓	✓
Single-Family Residential						
Stadium /Arena						
Supermarket			✓	✓		✓
Truck Terminal	✓					
Utility						
Warehouse		✓				
Link_# of Lanes						✓
Link_SL (mph)	✓	✓	✓		✓	
DS_# of Lanes		✓				
DS_SL (mph)			✓	✓		
US_# of Lanes						
US_SL (mph)			✓	✓		
DS_Cross street_# of Lanes	✓	✓				✓
DS_Cross street_SL (mph)					✓	
US_Cross street_# of Lanes		✓				
US_Cross street_SL (mph)				✓		
Intersection_# of Lanes		✓				
Intersection_SL (mph)	✓					

Table 35 Developed Models for 0.5 miles Buffer Width – Speed Limit < 45 mph

Parameters_0.5 miles_< 45 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	-0.121	0.121	0.319	0.896	0.102	<0.05	1.254	0.083	<0.05
[Weekday=1]	0.040	0.006	<0.05	0.040	0.008	<0.05	0.040	0.008	<0.05
[MPP=1]	0.019	0.008	<0.05	0.018	0.011	0.096	0.019	0.012	0.105
[OPP=1]	0.034	0.008	<0.05	0.034	0.011	<0.05	0.035	0.012	<0.05
[EPP=1]	0.068	0.009	<0.05	0.069	0.012	<0.05	0.069	0.012	<0.05
Attached Residential	-2.010E-04	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-3.269E-03	<0.001	<0.05	-9.374E-04	<0.001	<0.05	-	-	-
Bank	2.219E-04	<0.001	<0.05	-	-	-	-	-	-
Car Wash	1.333E-02	0.002	<0.05	-	-	-	-	-	-
Church	1.286E-04	<0.001	<0.05	-	-	-	-	-	-
Commercial Service	-2.524E-04	<0.001	<0.05	3.028E-04	<0.001	<0.05	-	-	-
Convenience Store	-	-	-	-	-	-	-	-	-
Daycare	-4.381E-03	<0.001	<0.05	-2.607E-03	<0.001	<0.05	-	-	-
Department Store	-3.051E-04	<0.001	<0.05	-	-	-	-	-	-
Fast Food	-	-	-	-	-	-	-	-	-
Funeral Home	-1.484E-03	<0.001	<0.05	-4.843E-03	<0.001	<0.05	-	-	-
Government	-	-	-	-	-	-	-	-	-
Hospital	8.641E-05	<0.001	<0.05	-	-	-	5.914E-05	<0.001	<0.05
Hotel / Motel	-5.230E-05	<0.001	<0.05	-	-	-	-	-	-
Industrial	-2.009E-03	<0.001	<0.05	-1.804E-03	<0.001	<0.05	-	-	-
Industrial Lg	-	-	-	-	-	-	-	-	-
Institutional	-7.359E-05	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-5.389E-02	0.005	<0.05	-3.709E-02	0.005	<0.05	-4.537E-02	0.005	<0.05
Manufacturing	-	-	-	-	-	-	-	-	-
Medical	-1.476E-04	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	7.454E-05	<0.001	<0.05	1.067E-04	<0.001	<0.05	-	-	-
Office	-	-	-	-	-	-	-	-	-
Parking Garage	8.831E-05	<0.001	<0.05	-	-	-	-	-	-
Recreational	-7.121E-04	<0.001	<0.05	-	-	-	-	-	-
Restaurant	1.290E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	-4.374E-04	<0.001	<0.05	-	-	-	-	-	-
School	1.578E-04	<0.001	<0.05	1.277E-04	<0.001	<0.05	7.742E-05	<0.001	<0.05
Service Garage	-9.013E-04	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	-2.454E-04	<0.001	<0.05	-	-	-	-4.409E-05	<0.001	<0.05
Single-Family Residential	-5.397E-05	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-	-	-	-	-	-	1.805E-04	<0.001	<0.05
Supermarket	2.511E-03	<0.001	<0.05	-7.077E-04	<0.001	<0.05	-	-	-
Truck Terminal	9.218E-04	<0.001	<0.05	-	-	-	-	-	-
Utility	-3.797E-03	<0.001	<0.05	-	-	-	-	-	-
Warehouse	2.788E-05	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-	-	-	-	-	-	-	-	-
Link_SL (mph)	0.021	0.003	<0.05	-0.010	0.003	<0.05	-0.018	0.002	<0.05
DS_# of Lanes	-	-	-	-	-	-	-	-	-
DS_SL (mph)	-0.004	<0.001	<0.05	-0.002	<0.001	<0.05	-0.002	<0.001	<0.05
US_# of Lanes	-0.025	0.004	<0.05	-	-	-	-	-	-
US_SL (mph)	-	-	-	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.030	0.003	<0.05	0.028	0.003	<0.05	-	-	-
DS_Cross street_SL (mph)	0.004	<0.001	<0.05	-	-	-	-	-	-
US_Cross street_# of Lanes	-0.023	0.003	<0.05	-0.009	0.004	<0.05	-	-	-
US_Cross street_SL (mph)	0.003	<0.001	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	-	-	-	0.039	0.006	<0.05	-	-	-
Intersection_SL (mph)	0.004	<0.001	<0.05	-	-	-	0.006	<0.001	<0.05
QIC	122.583			102.280			102.412		
QICC	118.660			101.107			98.832		
RMSE	0.657			0.584			0.644		
MAPE	19%			16%			17%		
MPE	-6%			-4%			-2%		

Note: Land use categories were considered in square feet.

Table 36 Developed Models for 1-mile Buffer Width – Speed Limit < 45 mph

Parameters_1-mile_ < 45 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.087	0.088	<0.05	1.278	0.098	<0.05	1.298	0.088	<0.05
[Weekday=1]	0.040	0.006	<0.05	0.040	0.009	<0.05	0.039	0.009	<0.05
[MPP=1]	0.018	0.008	<0.05	0.019	0.012	0.108	0.017	0.012	0.159
[OPP=1]	0.034	0.008	<0.05	0.035	0.012	<0.05	0.034	0.012	<0.05
[EPP=1]	0.067	0.009	<0.05	0.070	0.012	<0.05	0.069	0.013	<0.05
Attached Residential	8.398E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-7.447E-04	<0.001	<0.05	-	-	-	-1.107E-03	<0.001	<0.05
Bank	-3.273E-04	<0.001	<0.05	-	-	-	-	-	-
Car Wash	-1.417E-02	0.001	<0.05	-	-	-	-	-	-
Church	-1.627E-04	<0.001	<0.05	-	-	-	-	-	-
Commercial Service	-	-	-	-	-	-	-	-	-
Convenience Store	1.113E-02	<0.001	<0.05	-1.523E-03	<0.001	<0.05	-	-	-
Daycare	-	-	-	-	-	-	-4.639E-04	<0.001	<0.05
Department Store	-1.364E-04	<0.001	<0.05	-9.646E-05	<0.001	<0.05	-	-	-
Fast Food	-2.076E-03	<0.001	<0.05	-	-	-	5.372E-03	<0.001	<0.05
Funeral Home	-8.373E-03	<0.001	<0.05	-3.131E-03	<0.001	<0.05	-	-	-
Government	3.871E-05	<0.001	<0.05	-	-	-	-	-	-
Hospital	-1.412E-04	<0.001	<0.05	-	-	-	-	-	-
Hotel / Motel	1.664E-04	<0.001	<0.05	-	-	-	-	-	-
Industrial	-1.706E-03	<0.001	<0.05	-	-	-	-	-	-
Industrial Lg	-1.525E-03	<0.001	<0.05	-	-	-	-	-	-
Institutional	-	-	-	-	-	-	-	-	-
Manufactured Home Construction	-	-	-	-	-	-	-	-	-
Manufacturing	-2.977E-04	<0.001	<0.05	-	-	-	-	-	-
Medical	-	-	-	-	-	-	-	-	-
Multi-Family	5.092E-05	<0.001	<0.05	6.420E-05	<0.001	<0.05	-	-	-
Office	-4.158E-05	<0.001	<0.05	-	-	-	1.879E-05	<0.001	<0.05
Parking Garage	6.300E-05	<0.001	<0.05	-	-	-	-	-	-
Recreational	-5.772E-04	<0.001	<0.05	-	-	-	-	-	-
Restaurant	3.010E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	-3.356E-04	<0.001	<0.05	-	-	-	-	-	-
School	1.417E-04	<0.001	<0.05	8.063E-05	<0.001	<0.05	3.367E-05	<0.001	<0.05
Service Garage	-1.970E-04	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	-2.629E-04	<0.001	<0.05	-	-	-	-	-	-
Single-Family Residential	-2.446E-05	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-1.893E-04	<0.001	<0.05	-	-	-	-	-	-
Supermarket	6.830E-04	<0.001	<0.05	-	-	-	-	-	-
Truck Terminal	-	-	-	-	-	-	-	-	-
Utility	2.226E-03	<0.001	<0.05	-	-	-	-	-	-
Warehouse	1.701E-05	<0.001	<0.05	-	-	-	4.768E-06	<0.001	<0.05
Link_# of Lanes	0.024	0.010	<0.05	-	-	-	-	-	-
Link_SL (mph)	-0.020	0.002	<0.05	-0.030	0.003	<0.05	-0.026	0.002	<0.05
DS_# of Lanes	0.034	0.008	<0.05	-	-	-	-0.033	0.006	<0.05
DS_SL (mph)	-0.007	<0.001	<0.05	-	-	-	-	-	-
US_# of Lanes	-0.029	0.007	<0.05	-	-	-	-	-	-
US_SL (mph)	0.003	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.018	0.003	<0.05	0.043	0.003	<0.05	0.022	0.003	<0.05
DS_Cross street_SL (mph)	0.006	<0.001	<0.05	-	-	-	-	-	-
US_Cross street_# of Lanes	-0.015	0.003	<0.05	-	-	-	0.010	0.004	<0.05
US_Cross street_SL (mph)	-	-	-	-	-	-	-	-	-
Intersection_# of Lanes	-	-	-	-	-	-	0.062	0.007	<0.05
Intersection_SL (mph)	0.006	<0.001	<0.05	0.006	<0.001	<0.05	-	-	-
QIC	124.583			100.831			111.057		
QICC	124.024			98.406			109.730		
RMSE	0.747			0.585			0.685		
MAPE	23%			17%			19%		
MPE	-5%			-2%			-4%		

Note: Land use categories were considered in square feet.

Table 37 Developed Models for 0.5 miles Buffer Width – Speed Limit 45 to 50 mph

Parameters_0.5 miles_ 45to50 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	2.596	0.194	<0.05	3.985	0.127	<0.05	0.459	0.025	<0.05
[Weekday=1]	0.095	0.006	<0.05	0.096	0.008	<0.05	0.095	0.008	<0.05
[MPP=1]	0.041	0.008	<0.05	0.042	0.010	<0.05	0.043	0.010	<0.05
[OPP=1]	0.052	0.007	<0.05	0.054	0.010	<0.05	0.054	0.009	<0.05
[EPP=1]	0.135	0.010	<0.05	0.138	0.012	<0.05	0.136	0.011	<0.05
Attached Residential	-8.183E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-	-	-	-	-	-	-	-	-
Bank	-	-	-	-	-	-	-	-	-
Car Wash	4.844E-03	0.001	<0.05	-	-	-	-	-	-
Church	-	-	-	-1.823E-04	<0.001	<0.05	-	-	-
Commercial Service	-3.005E-04	<0.001	<0.05	-	-	-	-3.346E-04	<0.001	<0.05
Convenience Store	5.967E-03	<0.001	<0.05	-	-	-	8.581E-03	<0.001	<0.05
Daycare	-1.850E-03	<0.001	<0.05	-	-	-	-	-	-
Department Store	-5.769E-04	<0.001	<0.05	-	-	-	1.706E-04	<0.001	<0.05
Fast Food	-	-	-	1.992E-03	<0.001	<0.05	-	-	-
Funeral Home	1.182E-03	<0.001	<0.05	-	-	-	-	-	-
Government	-	-	-	-2.687E-04	<0.001	<0.05	-	-	-
Hospital	-7.725E-05	<0.001	<0.05	-	-	-	-4.213E-05	<0.001	<0.05
Hotel / Motel	9.494E-05	<0.001	<0.05	1.228E-04	<0.001	<0.05	-	-	-
Industrial	-3.983E-03	<0.001	<0.05	-6.207E-03	<0.001	<0.05	-2.666E-03	<0.001	<0.05
Industrial Lg	-2.118E-03	<0.001	<0.05	-	-	-	-	-	-
Institutional	-2.386E-04	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-2.775E-03	<0.001	<0.05	-	-	-	-1.204E-03	<0.001	<0.05
Manufacturing	-1.923E-04	<0.001	<0.05	-1.188E-04	<0.001	<0.05	-1.399E-04	<0.001	<0.05
Medical	1.224E-04	<0.001	<0.05	2.644E-04	<0.001	<0.05	-	-	-
Multi-Family	-2.076E-05	<0.001	<0.05	-	-	-	-3.215E-05	<0.001	<0.05
Office	-2.312E-05	<0.001	<0.05	-	-	-	-	-	-
Parking Garage	1.912E-04	<0.001	<0.05	-	-	-	-	-	-
Recreational	-	-	-	-1.119E-03	<0.001	<0.05	-	-	-
Restaurant	2.068E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	1.379E-04	<0.001	<0.05	-	-	-	-	-	-
School	-5.822E-05	<0.001	<0.05	-	-	-	-3.096E-04	<0.001	<0.05
Service Garage	-6.061E-04	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	-	-	-	-	-	-	-	-	-
Single-Family Residential	-4.850E-05	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-4.725E-04	<0.001	<0.05	-	-	-	-	-	-
Supermarket	5.492E-04	<0.001	<0.05	-	-	-	-	-	-
Truck Terminal	4.166E-04	<0.001	<0.05	-	-	-	-	-	-
Utility	-	-	-	2.774E-03	<0.001	<0.05	-	-	-
Warehouse	-	-	-	-	-	-	-	-	-
Link_# of Lanes	-0.090	0.011	<0.05	-	-	-	-0.064	0.007	<0.05
Link_SL (mph)	-0.043	0.004	<0.05	-0.076	0.003	<0.05	-	-	-
DS_# of Lanes	0.023	0.006	<0.05	-	-	-	-	-	-
DS_SL (mph)	-	-	-	0.003	<0.001	<0.05	-	-	-
US_# of Lanes	-0.028	0.009	<0.05	-	-	-	-	-	-
US_SL (mph)	0.002	<0.001	<0.05	-0.002	<0.001	<0.05	-	-	-
DS_Cross street_# of Lanes	0.032	0.004	<0.05	-	-	-	0.066	0.003	<0.05
DS_Cross street_SL (mph)	-	-	-	-	-	-	-	-	-
US_Cross street_# of Lanes	0.011	0.004	<0.05	-	-	-	0.008	0.004	<0.05
US_Cross street_SL (mph)	-0.002	<0.001	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	-	-	-	-	-	-	-	-	-
Intersection_SL (mph)	0.002	<0.001	<0.05	-	-	-	-	-	-
QIC	126.200			101.475			95.937		
QICC	121.106			101.518			96.071		
RMSE	0.443			0.381			0.403		
MAPE	20%			18%			20%		
MPE	-12%			-12%			-12%		

Note: Land use categories were considered in square feet.

Table 38 Developed Models for 1-mile Buffer Width – Speed Limit 45 to 50mph

Parameters_1-mile_ 45 to 50 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	3.123	0.203	<0.05	4.307	0.138	<0.05	0.687	0.032	<0.05
[Weekday=1]	0.095	0.007	<0.05	0.096	0.008	<0.05	0.096	0.009	<0.05
[MPP=1]	0.042	0.008	<0.05	0.043	0.010	<0.05	0.043	0.011	<0.05
[OPP=1]	0.052	0.007	<0.05	0.054	0.010	<0.05	0.055	0.011	<0.05
[EPP=1]	0.135	0.010	<0.05	0.138	0.012	<0.05	0.137	0.013	<0.05
Attached Residential	7.902E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-	-	-	-	-	-	-	-	-
Bank	-	-	-	-	-	-	-	-	-
Car Wash	-	-	-	-	-	-	-	-	-
Church	-	-	-	-	-	-	-	-	-
Commercial Service	-3.487E-04	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	5.324E-03	<0.001	<0.05	-	-	-	5.076E-03	<0.001	<0.05
Daycare	-1.647E-03	<0.001	<0.05	-7.602E-04	<0.001	<0.05	-	-	-
Department Store	-2.817E-04	<0.001	<0.05	-	-	-	1.222E-04	<0.001	<0.05
Fast Food	2.652E-03	<0.001	<0.05	-	-	-	-	-	-
Funeral Home	1.225E-03	<0.001	<0.05	-	-	-	-	-	-
Government	-4.150E-05	<0.001	<0.05	-	-	-	-9.464E-05	<0.001	<0.05
Hospital	-2.006E-04	<0.001	<0.05	-	-	-	-4.470E-05	<0.001	<0.05
Hotel / Motel	1.378E-04	<0.001	<0.05	-	-	-	-	-	-
Industrial	-2.914E-03	<0.001	<0.05	-2.862E-03	<0.001	<0.05	-2.757E-03	<0.001	<0.05
Industrial Lg	9.249E-04	<0.001	<0.05	-	-	-	-	-	-
Institutional	-1.122E-04	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-1.019E-03	<0.001	<0.05	-7.212E-04	<0.001	<0.05	-1.298E-03	<0.001	<0.05
Manufacturing	-6.089E-05	<0.001	<0.05	-	-	-	-	-	-
Medical	1.419E-04	<0.001	<0.05	5.987E-05	<0.001	<0.05	-	-	-
Multi-Family	-3.379E-05	<0.001	<0.05	-	-	-	-2.959E-05	<0.001	<0.05
Office	-2.756E-05	<0.001	<0.05	-	-	-	-	-	-
Parking Garage	1.227E-04	<0.001	<0.05	-	-	-	-	-	-
Recreational	-	-	-	-3.350E-04	<0.001	<0.05	-	-	-
Restaurant	1.027E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	-	-	-	-	-	-	-	-	-
School	1.244E-04	<0.001	<0.05	-	-	-	-	-	-
Service Garage	-	-	-	-	-	-	-	-	-
Shopping Mall	-1.723E-04	<0.001	<0.05	1.879E-04	<0.001	<0.05	-	-	-
Single-Family Residential	-3.523E-05	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-2.141E-04	<0.001	<0.05	-	-	-	-	-	-
Supermarket	-	-	-	-	-	-	5.068E-04	<0.001	<0.05
Truck Terminal	-2.766E-04	<0.001	<0.05	-	-	-	-	-	-
Utility	-	-	-	-	-	-	-	-	-
Warehouse	-1.511E-05	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	0.021	0.010	<0.05	-	-	-	-	-	-
Link_SL (mph)	-0.053	0.004	<0.05	-0.085	0.003	<0.05	-	-	-
DS_# of Lanes	-	-	-	-	-	-	-	-	-
DS_SL (mph)	-	-	-	0.002	<0.001	<0.05	0.001	<0.001	<0.05
US_# of Lanes	-0.071	0.010	<0.05	-	-	-	-	-	-
US_SL (mph)	0.002	<0.001	<0.05	-0.001	<0.001	<0.05	-0.002	<0.001	<0.05
DS_Cross street_# of Lanes	0.027	0.004	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	-	-	-	-	-	-	-	-	-
US_Cross street_# of Lanes	0.016	0.004	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.005	<0.001	<0.05	-	-	-	-0.004	<0.001	<0.05
Intersection_# of Lanes	-	-	-	-	-	-	-	-	-
Intersection_SL (mph)	0.003	<0.001	<0.05	-	-	-	-	-	-
QIC	126.092			99.465			111.585		
QICC	122.468			99.605			112.141		
RMSE	0.361			0.357			0.377		
MAPE	16%			17%			17%		
MPE	-8%			-10%			-10%		

Note: Land use categories were considered in square feet.

Table 39 Developed Models for 0.5 miles Buffer Width – Speed Limit > 50 mph

Parameters_0.5 miles_ >50 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	0.959	0.116	<0.05	0.586	0.026	<0.05	1.233	0.076	<0.05
[Weekday=1]	0.082	0.008	<0.05	0.084	0.009	<0.05	0.083	0.009	<0.05
[MPP=1]	0.006	0.007	0.386	0.006	0.008	0.432	0.007	0.009	0.451
[OPP=1]	-0.003	0.006	0.600	-0.002	0.007	0.729	-0.002	0.008	0.780
[EPP=1]	0.108	0.015	<0.05	0.111	0.017	<0.05	0.109	0.016	<0.05
Attached Residential	-	-	-	-	-	-	-	-	-
Auto Dealer	3.414E-03	<0.001	<0.05	-	-	-	-3.281E-04	<0.001	<0.05
Bank	-	-	-	-	-	-	-	-	-
Car Wash	-	-	-	-	-	-	-	-	-
Church	-	-	-	-	-	-	-	-	-
Commercial Service	6.152E-04	<0.001	<0.05	-	-	-	2.658E-04	<0.001	<0.05
Convenience Store	-	-	-	-	-	-	-	-	-
Daycare	1.184E-02	0.003	<0.05	-	-	-	-	-	-
Department Store	-	-	-	-	-	-	-	-	-
Fast Food	-	-	-	-	-	-	-	-	-
Funeral Home	-	-	-	-	-	-	-	-	-
Government	-	-	-	-	-	-	-	-	-
Hospital	2.199E-04	<0.001	<0.05	-	-	-	5.923E-04	<0.001	<0.05
Hotel / Motel	-	-	-	-	-	-	-	-	-
Industrial	1.724E-02	0.004	<0.05	-	-	-	-	-	-
Industrial Lg	5.829E-03	<0.001	<0.05	-	-	-	-	-	-
Institutional	1.568E-04	<0.001	<0.05	3.733E-05	<0.001	<0.05	-	-	-
Manufactured Home Construction	-	-	-	-	-	-	-1.711E-02	0.003	<0.05
Manufacturing	3.197E-04	<0.001	<0.05	-	-	-	3.919E-04	<0.001	<0.05
Medical	-	-	-	-	-	-	-	-	-
Multi-Family	-	-	-	-	-	-	-	-	-
Office	8.967E-05	<0.001	<0.05	-	-	-	-	-	-
Parking Garage	-	-	-	-	-	-	-	-	-
Recreational	-	-	-	-	-	-	-	-	-
Restaurant	-1.730E-02	0.004	<0.05	-	-	-	-	-	-
Retail	1.083E-03	<0.001	<0.05	-	-	-	-	-	-
School	-1.719E-04	<0.001	<0.05	-	-	-	-	-	-
Service Garage	-3.596E-03	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	1.159E-03	<0.001	<0.05	-	-	-	-2.135E-04	<0.001	<0.05
Single-Family Residential	-	-	-	-	-	-	-	-	-
Stadium /Arena	6.088E-04	<0.001	<0.05	-	-	-	-	-	-
Supermarket	-1.391E-03	<0.001	<0.05	-2.069E-03	<0.001	<0.05	-	-	-
Truck Terminal	3.538E-03	<0.001	<0.05	-	-	-	-	-	-
Utility	-	-	-	-	-	-	-	-	-
Warehouse	2.004E-04	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-	-	-	-0.154	0.007	<0.05	-	-	-
Link_SL (mph)	-0.068	0.015	<0.05	-	-	-	-0.023	0.001	<0.05
DS_# of Lanes	0.508	0.109	<0.05	-	-	-	-	-	-
DS_SL (mph)	0.020	0.008	<0.05	-	-	-	-	-	-
US_# of Lanes	-0.116	0.018	<0.05	-	-	-	-	-	-
US_SL (mph)	-	-	-	-	-	-	-	-	-
DS_Cross street_# of Lanes	-	-	-	-	-	-	-	-	-
DS_Cross street_SL (mph)	-	-	-	-	-	-	-	-	-
US_Cross street_# of Lanes	-	-	-	-0.087	0.012	<0.05	-	-	-
US_Cross street_SL (mph)	-	-	-	-	-	-	-	-	-
Intersection_# of Lanes	-	-	-	-	-	-	-	-	-
Intersection_SL (mph)	-	-	-	-	-	-	-	-	-
QIC	66.436			27.248			33.227		
QICC	59.197			24.950			31.209		
RMSE	1.334			0.176			0.188		
MAPE	76%			13%			14%		
MPE	-73%			-5%			-10%		

Note: Land use categories were considered in square feet.

Table 40 Developed Models for 1-mile Buffer Width – Speed Limit > 50 mph

Parameters_1-mile_ > 50 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	7.305	2.207	<0.05	1.237	0.071	<0.05	0.589	0.026	<0.05
[Weekday=1]	0.082	0.008	<0.05	0.083	0.009	<0.05	0.084	0.009	<0.05
[MPP=1]	0.006	0.007	0.391	0.007	0.009	0.450	0.006	0.007	0.416
[OPP=1]	-0.003	0.006	0.610	-0.002	0.008	0.756	-0.003	0.006	0.693
[EPP=1]	0.108	0.015	<0.05	0.109	0.016	<0.05	0.112	0.017	<0.05
Attached Residential	-	-	-	-	-	-	-	-	-
Auto Dealer	1.523E-02	0.005	<0.05	-	-	-	-	-	-
Bank	-	-	-	-	-	-	-	-	-
Car Wash	-1.183E-01	0.039	<0.05	-	-	-	-	-	-
Church	3.105E-03	0.001	<0.05	-	-	-	-	-	-
Commercial Service	-	-	-	2.159E-04	<0.001	<0.05	-	-	-
Convenience Store	-	-	-	-	-	-	-	-	-
Daycare	-	-	-	-	-	-	-	-	-
Department Store	1.320E-02	0.004	<0.05	-	-	-	-	-	-
Fast Food	-1.704E-02	0.005	<0.05	-	-	-	-	-	-
Funeral Home	-2.621E-02	0.009	<0.05	-	-	-	-	-	-
Government	-	-	-	-	-	-	-	-	-
Hospital	-	-	-	-	-	-	-	-	-
Hotel / Motel	-	-	-	-	-	-	-	-	-
Industrial	-	-	-	2.220E-03	<0.001	<0.05	1.701E-03	<0.001	<0.05
Industrial Lg	-6.184E-02	0.022	<0.05	-	-	-	-	-	-
Institutional	-	-	-	-	-	-	-	-	-
Manufactured Home Construction	-	-	-	-1.066E-02	0.001	<0.05	-	-	-
Manufacturing	-	-	-	-	-	-	-	-	-
Medical	1.236E-03	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	5.239E-05	<0.001	<0.05	-	-	-	-	-	-
Office	-	-	-	-	-	-	-	-	-
Parking Garage	-8.664E-05	<0.001	<0.05	-	-	-	-	-	-
Recreational	2.485E-03	<0.001	<0.05	-	-	-	-	-	-
Restaurant	-7.077E-03	0.002	<0.05	-	-	-	-	-	-
Retail	-	-	-	-	-	-	-	-	-
School	-	-	-	-	-	-	-	-	-
Service Garage	-6.331E-03	0.002	<0.05	-	-	-	-	-	-
Shopping Mall	8.132E-04	<0.001	<0.05	-5.095E-05	<0.001	<0.05	-7.194E-05	<0.001	<0.05
Single-Family Residential	-	-	-	-	-	-	-	-	-
Stadium /Arena	-5.838E-04	<0.001	<0.05	-	-	-	-	-	-
Supermarket	-	-	-	-	-	-	-1.113E-03	<0.001	<0.05
Truck Terminal	4.699E-03	0.002	<0.05	-	-	-	-	-	-
Utility	-	-	-	-	-	-	-	-	-
Warehouse	1.721E-04	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-	-	-	-	-	-	-0.155	0.006	<0.05
Link_SL (mph)	0.677	0.232	<0.05	-0.023	0.001	<0.05	-	-	-
DS_# of Lanes	0.388	0.128	<0.05	-	-	-	-	-	-
DS_SL (mph)	-0.146	0.041	<0.05	-	-	-	-	-	-
US_# of Lanes	-	-	-	-	-	-	-	-	-
US_SL (mph)	-0.664	0.230	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	-	-	-	-	-	-	-0.062	0.012	<0.05
DS_Cross street_SL (mph)	0.005	0.002	<0.05	-	-	-	-	-	-
US_Cross street_# of Lanes	-0.122	0.039	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.033	0.011	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	1.996	0.671	<0.05	-	-	-	-	-	-
Intersection_SL (mph)	-	-	-	-	-	-	-	-	-
QIC	74.271			27.998			29.974		
QICC	65.225			27.017			26.768		
RMSE	1.823			0.138			0.214		
MAPE	129%			10%			15%		
MPE	-101%			-6%			-9%		

Note: Land use categories were considered in square feet.

Table 41 Performance of Developed Models by Speed Limit - Summary

Buffer Width	Models	Parameters	Backward Elimination	Model 1	Model 2
0.5 Miles	< 45 mph	QIC	122.583	102.280	102.412
		QICC	118.660	101.107	98.832
		RMSE	0.657	0.584	0.644
		MAPE	19%	16%	17%
		MPE	-6%	-4%	-2%
	45 to 50 mph	QIC	126.200	101.475	95.937
		QICC	121.106	101.518	96.071
		RMSE	0.443	0.381	0.403
		MAPE	20%	18%	20%
		MPE	-12%	-12%	-12%
	> 50 mph	QIC	66.436	27.248	33.227
		QICC	59.197	24.950	31.209
		RMSE	1.334	0.176	0.188
		MAPE	76%	13%	14%
		MPE	-73%	-5%	-10%
1-Mile	< 45 mph	QIC	124.583	100.831	111.057
		QICC	124.024	98.406	109.730
		RMSE	0.747	0.585	0.685
		MAPE	23%	17%	19%
		MPE	-5%	-2%	-4%
	45 to 50 mph	QIC	126.092	99.465	111.585
		QICC	122.468	99.605	112.141
		RMSE	0.361	0.357	0.377
		MAPE	16%	17%	17%
		MPE	-8%	-10%	-10%
	> 50 mph	QIC	74.271	27.998	29.974
		QICC	65.225	27.017	26.768
		RMSE	1.823	0.138	0.214
		MAPE	129%	10%	15%
		MPE	-101%	-6%	-9%

8.4 Discussion related to the Developed Models by Speed Limit

For all the models by speed limit (Model 1 or Model 2), an increase in the speed limit of the selected link decreases the ATT (Table 42 and Table 43).

For links with the speed limit less than 45 mph, an increase in area with multi-family and school type land uses within 0.5 miles and 1-mile from a link increases the ATT (Table 42). However, an increase in area with auto dealer and daycare type land uses within 0.5 miles and 1-mile from a link decreases the ATT.

For links with the speed limit between 45 to 50 mph, an increase in area with convenience store, department store, and medical type land uses within 0.5 miles and 1-mile from a link increases the ATT (Table 43). However, an increase in area with industrial, manufactured home construction, multi-family, and recreational type land uses within 0.5 miles and 1-mile from a link decreases the ATT.

In addition, for links with the speed limit greater than 50 mph, an increase in area with commercial service within 0.5 miles and 1-mile increases the ATT. However, an increase in area with manufactured home construction, shopping mall, and supermarkets within 1-mile decreases the ATT (Table 44).

Further, the developed backward elimination model for links with the speed limit more than 50 mph with 0.5 miles and 1-mile buffer width dataset should not be used for estimating the ATT due to the high errors in the validation results (Table 41). Based on QIC, QICC, RMSE and MAPE, for all the speed limit categories, one-mile buffer was observed to be the better fit (lower QIC and QICC, lower difference between QIC to QICC, lower RMSE and MAPE) to explain the relationship between the land use developments and the ATT when compared to 0.5 miles buffer width. Further, for each speed limit category, Model 1 was observed to be the better fit to estimate the ATT compared to other models (Table 41).

Table 42 Comparison of Developed Models for Speed Limit < 45mph

Parameters_< 45 mph	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	N	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	P	P	P	P	P	P
[EPP=1]	P	P	P	P	P	P
Attached Residential	N			P		
Auto Dealer	N	N		N		N
Bank	P			N		
Car Wash	P			N		
Church	P			N		
Commercial Service	N	P				
Convenience Store				P	N	
Daycare	N	N				N
Department Store	N			N	N	
Fast Food				N		P
Funeral Home	N	N		N	N	
Government				P		
Hospital	P		P	N		
Hotel / Motel	N			P		
Industrial	N	N		N		
Industrial Lg				N		
Institutional	N					
Manufactured Home Construction	N	N	N			
Manufacturing				N		
Medical	N					
Multi-Family	P	P		P	P	
Office				N		P
Parking Garage	P			P		
Recreational	N			N		
Restaurant	P			P		
Retail	N			N		
School	P	P	P	P	P	P
Service Garage	N			N		
Shopping Mall	N		N	N		
Single-Family Residential	N			N		
Stadium /Arena			P	N		
Supermarket	P	N		P		
Truck Terminal	P					
Utility	N			P		
Warehouse	P			P		P
Link_# of Lanes				P		
Link_SL (mph)	P	N	N	N	N	N
DS_# of Lanes				P		N
DS_SL (mph)	N	N	N	N		
US_# of Lanes	N			N		
US_SL (mph)				P		
DS_Cross street_# of Lanes	P	P		P	P	P
DS_Cross street_SL (mph)	P			P		
US_Cross street_# of Lanes	N	N		N		P
US_Cross street_SL (mph)	P					
Intersection_# of Lanes		P				P
Intersection_SL (mph)	P		P	P	P	

Table 43 Comparison of Developed Models for Speed Limit between 45 to 50 mph

Parameters_ 45 to 50 mph	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	P	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	P	P	P	P	P	P
[EPP=1]	P	P	P	P	P	P
Attached Residential	N			P		
Auto Dealer						
Bank						
Car Wash	P					
Church		N				
Commercial Service	N		N	N		
Convenience Store	P		P	P		P
Daycare	N			N	N	
Department Store	N		P	N		P
Fast Food		P		P		
Funeral Home	P			P		
Government		N		N		N
Hospital	N		N	N		N
Hotel / Motel	P	P		P		
Industrial	N	N	N	N	N	N
Industrial Lg	N			P		
Institutional	N			N		
Manufactured Home Construction	N		N	N	N	N
Manufacturing	N	N	N	N		
Medical	P	P		P	P	
Multi-Family	N		N	N		N
Office	N			N		
Parking Garage	P			P		
Recreational		N			N	
Restaurant	P			P		
Retail	P					
School	N		N	P		
Service Garage	N					
Shopping Mall				N	P	
Single-Family Residential	N			N		
Stadium /Arena	N			N		
Supermarket	P					P
Truck Terminal	P			N		
Utility		P				
Warehouse				N		
Link_# of Lanes	N		N	P		
Link_SL (mph)	N	N		N	N	
DS_# of Lanes	P					
DS_SL (mph)		P			P	P
US_# of Lanes	N			N		
US_SL (mph)	P	N		P	N	N
DS_Cross street_# of Lanes	P		P	P		
DS_Cross street_SL (mph)						
US_Cross street_# of Lanes	P		P	P		
US_Cross street_SL (mph)	N			N		N
Intersection_# of Lanes						
Intersection_SL (mph)	P			P		

Table 44 Comparison of Developed Models for Speed Limit > 50 mph

Parameters_ > 50 mph	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	P	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	N	N	N	N	N	N
[EPP=1]	P	P	P	P	P	P
Attached Residential						
Auto Dealer	P		N	P		
Bank						
Car Wash				N		
Church				P		
Commercial Service	P		P		P	
Convenience Store						
Daycare	P					
Department Store				P		
Fast Food				N		
Funeral Home				N		
Government						
Hospital	P		P			
Hotel / Motel						
Industrial	P				P	P
Industrial Lg	P			N		
Institutional	P	P				
Manufactured Home Construction			N		N	
Manufacturing	P		P			
Medical				P		
Multi-Family				P		
Office	P					
Parking Garage				N		
Recreational				P		
Restaurant	N			N		
Retail	P					
School	N					
Service Garage	N			N		
Shopping Mall	P		N	P	N	N
Single-Family Residential						
Stadium /Arena	P			N		
Supermarket	N	N				N
Truck Terminal	P			P		
Utility						
Warehouse	P			P		
Link_# of Lanes		N				N
Link_SL (mph)	N		N	P	N	
DS_# of Lanes	P			P		
DS_SL (mph)	P			N		
US_# of Lanes	N					
US_SL (mph)				N		
DS_Cross street_# of Lanes						N
DS_Cross street_SL (mph)				P		
US_Cross street_# of Lanes		N		N		
US_Cross street_SL (mph)				N		
Intersection_# of Lanes				P		
Intersection_SL (mph)						

CHAPTER 9: CONCLUSIONS

Transportation and land use decisions are interconnected with each other. This research examined the influence of proximal land use developments within a selected distance from a link on travel time at link-level. In addition, the research investigates the influence of land use developments, by selecting the links by area type and by classifying the links based on the speed limit, on travel time at link-level. On a broader conclusion, land use developments within the proximity of a link influence the travel times.

Correlation between the land use developments and travel time measures were examined by considering before and after data. The correlation analysis investigates whether there exists a relationship between the land use developments and travel time measures or not. Statistical models were developed using data from different buffer widths to evaluate the influence of land use developments (predictor variables) on ATT (dependent variable). Further, statistical models were developed by area type (CBD, CBD Fringe / OBD, and urban area) and by classifying the links based on the speed limit (< 45 mph, 45 to 50 mph, and > 50 mph) using 0.5 miles and 1-mile buffer width datasets. A total of forty-eight models were developed in this research. In addition, network characteristics of the selected, upstream, downstream, upstream and downstream cross street, and intersecting links were also considered in the model development to address the spatial dependency. Log-link with Gamma distribution was observed to be the best-fit model for the data used in this research.

Models developed using 0.5 miles and 1-mile buffer width datasets were observed to perform better compared to models with 2 miles and 3 miles buffer width datasets based on the QIC, QICC, RMSE, and MAPE. In addition, MPE suggests whether the developed models under-predict or over-predict compared to the actual ATT. Each land use category within different buffer widths contributes differently to the ATT. Typically, in most of the cases, travel time on a link was observed to be higher during the evening peak period compared to the morning peak period and the afternoon off-peak period. While comparing the models by buffer width, in all the cases, the number of lanes and the speed limit on the selected link are negatively associated with the ATT. The area with single-family attached type land use within 0.5 miles, and 1-mile from a link contribute negatively to the ATT. However, the area with single-family attached type land use within 2 miles and 3 miles from a link is positively associated with the ATT. In addition, the area with supermarkets within 0.5 miles, 2 miles and 3 miles from a link contribute positively to the ATT. Likewise, the area with office within 0.5 miles, 1-mile, and 2 miles from a link contribute positively to the ATT. On the other hand, the area with daycare type land use within 0.5 miles, 2 miles and 3 miles from a link contribute negatively to the ATT. Likewise, the area with industrial type land use within 0.5 miles and 1-mile from a link contribute negatively to the ATT. Also, the area with large industrial type land use within 1-mile and 2 miles from a link contribute negatively to the ATT.

Similar to the models by buffer width, each land use category within 0.5 miles and 1-mile buffer width by area type (CBD, CBD Fringe/ OBD and urban area) and by classifying the links based on the speed limit contribute differently to the ATT. The results indicate that the influence of land use developments on the ATT varies by area type and speed limit.

Per DeRobertis et al. (2014), the typical solution in TIS is to increase the road capacity. However, the developed relationship between land use developments and ATT indicate that different land use developments have different (positive / negative) influence on the ATT. In addition, DeRobertis et al. (2014) stated that trip generation rates due to the future land use developments are assumed to be similar to the past developments and this needs to be readdressed. The proposed and adopted methodology in this research overcomes the assumption made in TIS.

The recommended solutions and strategies for TIS should be evaluated on links during weekday and the evening peak period, and in areas with high density of department store, government, and multi-family type land uses within 1-mile from a link in the CBD area to reduce congestion and improve the mobility. Likewise, the recommended solutions and strategies for TIS should be reviewed for areas with high density of daycare, multi-family, shopping mall, and supermarket type land uses within 1-mile from a link in the CBD fringe/ OBD area. Similarly, the recommended solutions and strategies for TIS should be reviewed for areas with high density of convenience store, department store, fast food, funeral home, multi-family, recreational, retail, and supermarket type land uses within 1-mile from a link in the urban area.

Based on the QIC, QICC, RMSE and MAPE, this research recommends the models by the speed limit, particularly Model 1 in each of the speed limit category for 1-mile buffer width, as the best-fitted models to forecast / predict the ATT. In other words, classifying the links by speed limit, capturing the land use developments within 1-mile from a link, and then developing the models would help better understand the relationship between the land use developments and the ATT. However, the developed backward elimination model for 0.5 miles buffer width is recommended while examining the influence of land use developments on the ATT by buffer width. Similarly, the developed Model 1 in each of the area type (CBD, CBD fringe / OBD, and urban) for 1-mile buffer width, are recommended while examining the influence of land use developments on the ATT by area type.

Based on the need, the developed models can be implemented to estimate the ATT on a link based on the type of land use within its proximity. In addition, the developed models suggest that the magnitude of connection between the land use developments and travel time vary over the space and time.

Individual influence of land use type, network characteristics, TOD and DOW on travel times based on the statistical models help professionals and planners in land use planning decisions and can proactively improve the mobility. In addition to the procedure followed in the TIS, the developed relationships could be helpful to quantify the influence of land use developments on the travel time based on the type of land use development, area type, and the speed limit of the link.

9.1 Limitations and Scope for Future Work

The land use developments and travel time data for the city of Charlotte, NC was used in this research. Similar studies should be conducted using data for other cities to investigate the relationship between land use developments and travel time. Considering more data over the years merits further investigation. In addition, inter-regional motorists, who are not regular commuters, could also influence the ATT due to the unfamiliarity of the route.

Demographic characteristics, socioeconomic characteristics, and non-recurrent events such as crashes, long weekend holiday, and adverse weather condition could also influence the ATT and should be considered in the model development procedure.

The influence of land use developments on the operational performance of transportation network could be quantified by collecting origin and destination patterns of every individual trip (home-to-work, home-to-recreational, work-to-recreational, work to home, and so on) using navigation applications. The land use development activities and the ATT should be collected over the years for such disaggregated analysis. While it is challenging to collect data at this level, examining the relationship between land use developments and the ATT by incorporating the origin and destination patterns merits an investigation.

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APPENDIX A: Correlation Tables

This section presents Pearson correlation matrices for each of the developed models. To avoid the multicollinearity, the predictor variables were selected based on these correlation coefficients.

Table A1 illustrates reference numbers for the dependent (ATT) and all the predictor variables used in the model development procedure. Table A2 to Table A17 present the Pearson correlation matrices for buffer widths, area type, and speed limit. Pearson correlation coefficients that were significant at a 95% confidence interval were classified into six categories. They are:

- High negative correlation (less than -0.5) represented as HN
- Moderate negative correlation (-0.5 to -0.3) represented as MN
- Low negative correlation (-0.3 to 0) represented as LN
- Low positive correlation (0 to +0.3) represented as LP
- Moderate positive correlation (+0.3 to +0.5) represented as MP
- High positive correlation (greater than 0.5) represented as HP

In addition, the dash symbol ("-") indicates that Pearson correlation coefficient is not significant at a 95% confidence interval between the two variables. Also, "1" indicates that the variable on the horizontal and corresponding vertical cell is the same.

Table A1 List of the Variables and Corresponding Reference Number for Correlation Analysis

Parameters	Reference Number for correlation tables	Parameters	Reference Number for correlation tables
ATT (minutes)	1	Recreational	25
Attached Residential	2	Restaurant	26
Auto Dealer	3	Retail	27
Bank	4	School	28
Car Wash	5	Service Garage	29
Church	6	Shopping Mall	30
Commercial Service	7	Single-Family Residential	31
Convenience Store	8	Stadium /Arena	32
Daycare	9	Supermarket	33
Department Store	10	Truck Terminal	34
Fast Food	11	Utility	35
Funeral Home	12	Warehouse	36
Government	13	Link_# of Lanes	37
Hospital	14	Link_SL (mph)	38
Hotel / Motel	15	DS_# of Lanes	39
Industrial	16	DS_SL (mph)	40
Industrial Lg	17	US_# of Lanes	41
Institutional	18	US_SL (mph)	42
Manufactured Home Construction	19	DS_Cross street_# of Lanes	43
Manufacturing	20	DS_Cross street_SL (mph)	44
Medical	21	US_Cross street_# of Lanes	45
Multi-Family	22	US_Cross street_SL (mph)	46
Office	23	Intersection_# of Lanes	47
Parking Garage	24	Intersection_SL (mph)	48

Table A2 Correlation Matrix – 0.5 miles Buffer Width

0.5 miles	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	LN	LP	1																																												
4	MP	MP	LN	1																																											
5	LN	LN	MP	LN	1																																										
6	MP	HP	LN	MP	LN	1																																									
7	LP	LP	LN	LP	MP	LP	1																																								
8	LN	LN	-	LN	LP	LN	LN	1																																							
9	LN	LN	-	LP	LP	LN	LP	LP	1																																						
10	LP	-	LN	LP	LN	LN	LN	LN	LN	1																																					
11	LN	LN	-	LN	LP	LN	LP	HP	LP	LN	1																																				
12	LN	-	MP	LN	LP	LN	LN	LP	LP	LN	LN	1																																			
13	HP	MP	LN	HP	-	MP	MP	LN	LP	LN	LN	LN	1																																		
14	LP	LP	LN	LP	LP	LP	MP	LN	LN	LN	LP	LP	LP	1																																	
15	MP	MP	LN	HP	LN	MP	LP	LN	LP	LP	LN	LN	HP	-	1																																
16	LN	LN	LN	LN	LP	LN	LN	LP	-	LN	LN	LN	LN	LN	LN	1																															
17	LN	LN	LN	LN	MP	LN	MP	LN	-	LN	-	LN	LP	-	-	-	1																														
18	MP	MP	LN	HP	-	MP	MP	LN	LN	LN	LN	LN	HP	LP	HP	LN	LN	1																													
19	LN	LN	-	LN	LP	LN	-	LP	LP	LN	LP	-	LN	LN	LN	-	-	LN	1																												
20	LP	LN	LN	LN	-	LN	LN	LP	LP	LN	LN	LN	LP	LN	-	LP	-	LN	LN	1																											
21	LP	LP	LN	LP	LP	LP	MP	-	LN	-	LP	LP	-	HP	LN	LN	LN	MP	LN	LN	1																										
22	MP	HP	LP	MP	-	MP	LP	LN	LP	-	LN	-	HP	LP	HP	LN	LN	MP	LN	LP	-	1																									
23	HP	HP	LN	HP	LN	HP	LP	LN	-	-	LN	LN	HP	LN	HP	LN	LN	HP	LN	LP	LN	HP	1																								
24	HP	HP	LN	HP	LN	HP	MP	MN	LN	LP	LN	LN	HP	MP	HP	LN	LN	HP	LN	-	LP	HP	HP	1																							
25	MP	MP	LN	MP	LN	LP	-	LN	LP	LN	LN	LN	HP	LN	HP	-	LN	LP	LN	LP	LN	HP	HP	HP	1																						
26	HP	HP	LN	HP	LN	MP	LP	LN	LP	LP	LP	LN	HP	LP	HP	LN	LN	HP	LN	LP	LP	HP	HP	HP	HP	1																					
27	MP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	-	LP	LP	MP	LN	LN	MP	LP	LP	LP	MP	MP	MP	LP	HP	1																				
28	LP	LP	-	LP	-	MP	LN	LN	LP	LN	-	LN	LP	LP	LP	LN	LN	LP	LP	LN	LP	LP	LP	LP	LP	LP	LP	1																			
29	LN	LN	LP	LN	LP	LN	LP	LP	-	LN	LP	LP	LN	LN	LN	LP	LP	LN	-	MP	LN	LN	LN	LN	LN	LN	LN	LN	1																		
30	-	-	LP	LP	LP	LN	LN	LP	LP	HP	MP	LP	LN	-	LN	LN	LN	LN	-	LN	LP	-	LN	LN	LN	LP	MP	LP	LN	1																	
31	LN	LP	LP	LN	LN	LP	LN	LN	-	LP	-	LP	MN	LP	MN	LN	LN	LN	LP	LN	LP	LN	MN	LN	LN	LN	LN	LP	LN	LP	1																
32	HP	HP	LN	HP	LN	MP	LP	LN	LN	LN	LN	LN	HP	LN	HP	LN	LN	MP	LN	LP	LN	HP	HP	HP	HP	HP	LP	LP	LN	LN	LN	1															
33	LP	LP	LP	LN	LN	LP	LN	LN	LP	MP	LP	-	LN	LP	LN	LN	LN	LN	LP	LN	LP	LP	LN	LN	LN	LP	LP	-	LN	MP	MP	LN	1														
34	LN	LN	LP	LN	LN	LN	LN	LP	LN	LN	-	LN	LN	LN	LN	LP	LP	LN	-	LP	LN	LN	LN	LN	LN	LN	LN	LN	HP	LN	LN	LN	LN	1													
35	LP	LP	LN	LP	LN	MP	LP	LN	LN	LN	-	LP	LP	HP	LP	LN	LN	LP	LN	-	MP	LP	LP	MP	-	MP	LP	LP	LN	LN	LP	LP	LP	LN	1												
36	LN	MN	LN	LN	LP	LN	LP	MP	-	LN	LP	LN	LN	LN	LN	LP	LP	LN	-	HP	LN	LN	LN	LN	LN	LN	LN	LN	HP	LN	MN	LN	LN	HP	LN	1											
37	MN	LN	LP	LP	-	LN	-	LP	-	LP	LN	LP	-	LN	LP	LP	-	-	LN	LN	LN	LN	LP	-	LN	LP	-	-	LP	LN	LN	-	LN	LP	LN	LP	1										
38	HN	MN	LP	LN	LP	LN	LN	LP	LP	-	LP	LP	LN	LN	LN	LP	LP	LN	LP	LN	LN	LN	LN	MN	LN	LN	LN	LN	LP	-	LN	LN	LN	LP	LN	LP	HP	1									
39	MN	LN	LP	LP	-	LN	-	LP	LP	LP	LN	LP	-	-	LP	LP	LP	LP	LN	-	LN	LP	LP	LP	LN	LP	-	LN	LP	LN	LN	-	LN	LP	-	LP	HP	HP	1								
40	MN	LN	LP	LN	-	LN	LN	LP	LP	-	LN	LP	LN	LN	-	-	LP	LN	LN	LN	LN	-	LN	LN	LN	-	LN	LN	LP	LN	LN	LN	-	LP	LN	LP	HP	HP	HP	1							
41	MN	LN	LP	LP	LN	LP	-	LP	-	LN	-	LP	LP	-	LP	-	-	LP	-	LN	LN	-	LP	LP	LN	LP	-	LP	LP	LN	LN	LP	LN	LP	LN	LP	HP	HP	HP	MP	1						
42	MN	LN	-	-	LN	LN	-	LP	LN	LN	LP	LP	LN	LN	-	LN	LP	-	-	LN	LN	LN	LN	LN	LN	LN	LN	LP	LP	LN	LN	-	-	-	LN	-	HP	HP	HP	MP	HP	1					
43	MP	LP	LP	LP	LP	LP	-	-	LP	LP	LP	LP	-	LP	-	LN	LN	LN	LN	LN	LP	LP	-	LP	LP	LP	LP	LP	LN	MP	LP	LN	LP	LN	LP	LN	MN	MN	MN	LN	MN	MN	1				
44	LN	LN	LP	LN	LP	LN	-	LP	LP	-	LP	LP	LN	LN	LN	LP	LP	LN	LP	LN	LN	LN	LN	LN	LN	LN	LN	LN	-	LP	LP	LN	LP	LP	LN	-	LN	LP	LP	LP	-	LN	LP	1			
45	LP	LP	LP	LP	LP	LP	LN	LN	-	LP	LN	LP	-	-	-	LN	LN	LN	-	LN	-	LP	LP	LP	LP	LP	LP	LP	LN	MP	MP	-	LP	LN	LP	MN	MN	MN	LN	LN	MN	MN	MP	LP	1		
46	MN	LN	LP	LN	-	LN	LN	LP	LN	-	-	LP	LN	LN	LN	LP	LN	MN	LP	LN	LN	LN	LN	MN	LN	LN	LN	LN	LP	LP	-	LN	LN	LP	LN	LP	LP	MP	LP	LP	LP	LP	LN	LP	LP	1	
47	MP	MP	-	LP	-	LP	LN	LN	LP	LP	LP	LN	LP	LP	LP	LN	LN	LP	-	LN	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LP	LP	-	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	MN	1
48	MP	LP	LP	LP	-	LP	LN	LN	LP	LP	LP	-	LP	LP	LP	-	LN	LP	-	-	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LP	LP	-	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	LN	HP

Table A3 Correlation Matrix – 1-mile Buffer

1-mile	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	LN	LN	1																																												
4	MP	HP	LN	1																																											
5	LP	LN	MP	LP	1																																										
6	MP	HP	LN	HP	LN	1																																									
7	LP	MP	LN	HP	HP	MP	1																																								
8	LN	MN	LP	LN	MP	LN	LN	1																																							
9	LN	LN	LP	LN	LP	LN	LP	LP	1																																						
10	LP	LP	LN	LP	LN	LN	LN	LN	LN	1																																					
11	LP	-	LP	LP	MP	-	LP	MP	MP	LN	1																																				
12	-	LP	HP	-	LP	LP	-	LP	LN	LN	LN	1																																			
13	MP	HP	LN	HP	LP	HP	HP	LN	LN	LN	LP	LP	1																																		
14	LP	MP	LN	HP	LP	HP	MP	LN	LN	LN	LP	LP	MP	1																																	
15	MP	HP	LN	HP	LP	HP	HP	LN	LN	-	LP	-	HP	MP	1																																
16	LN	MN	LN	LN	LP	LN	LP	LP	LP	LN	LN	LN	LN	LN	LN	1																															
17	LN	LN	LN	LN	MP	LN	MP	LN	LP	LN	LN	LN	LP	LN	LN	HP	1																														
18	MP	HP	LN	HP	LP	HP	HP	LN	LP	LN	-	LP	HP	MP	HP	LN	LN	1																													
19	LN	LN	-	LN	-	LN	LN	LP	LP	LN	LP	LN	LN	LN	LN	-	-	LN	1																												
20	LP	LP	LN	LP	LP	LP	LP	LP	LP	LN	LN	LN	MP	LN	MP	LP	LP	MP	LN	1																											
21	LP	MP	LN	HP	LP	HP	MP	LN	-	LN	LP	LP	MP	HP	LP	LN	LN	MP	LN	LN	1																										
22	MP	HP	-	HP	LP	HP	MP	LN	LP	LN	LP	LP	HP	LP	HP	LN	LN	HP	LN	MP	LP	1																									
23	MP	HP	LN	HP	-	HP	MP	LN	LN	-	LN	LP	HP	LP	HP	LN	LN	HP	LN	MP	LP	HP	1																								
24	MP	HP	LN	HP	-	HP	HP	LN	LN	LP	-	LP	HP	HP	HP	LN	LN	HP	LN	LP	HP	HP	HP	1																							
25	MP	HP	LN	HP	LP	HP	MP	LN	LP	LN	-	LN	HP	LP	HP	LN	LN	HP	LN	MP	LP	HP	HP	HP	1																						
26	MP	HP	LN	HP	LP	HP	HP	LN	LP	LP	LP	LP	HP	HP	HP	LN	LN	HP	LN	LP	HP	HP	HP	HP	HP	1																					
27	LP	MP	LP	MP	LP	LP	MP	LP	LP	LP	MP	LP	MP	LP	HP	LN	LN	HP	LN	LP	LP	HP	HP	HP	MP	HP	1																				
28	LP	HP	LN	HP	-	HP	LP	-	LP	LN	LP	LP	MP	MP	MP	LN	LN	HP	LN	-	MP	MP	MP	HP	MP	MP	MP	1																			
29	LN	LN	LP	LN	LP	LN	LP	MP	LP	LN	LP	LP	LP	LN	LP	LP	LP	LN	LP	MP	LN	LN	-	LN	LN	-	LN	LN	1																		
30	LN	LP	LP	-	LP	LN	LN	LP	LP	HP	LP	-	MN	LN	LN	LN	LN	LN	LN	MN	-	LN	LN	LN	LN	-	LP	LP	LN	1																	
31	LN	LP	LP	LN	LN	LP	LN	LN	LN	LP	-	LP	MN	LP	MN	MN	LN	MN	LP	HN	LP	LN	MN	LN	LN	LN	LN	LP	MN	MP	1																
32	MP	HP	LN	HP	LN	HP	MP	LN	LN	LN	LN	LP	HP	LP	HP	LN	LN	HP	LN	MP	LP	HP	HP	HP	HP	HP	MP	MP	-	MN	MN	1															
33	-	LP	LP	LP	-	LP	-	LN	LP	LP	MP	LP	LN	MP	LN	LN	LN	LN	LP	MN	MP	-	LN	LN	LN	-	LP	LP	LN	MP	HP	LN	1														
34	LN	MN	LN	LN	LP	LN	LP	LP	-	LN	LP	LN	LN	LN	LN	MP	MP	LN	LP	MP	LN	MN	LN	LN	LN	LN	MN	MN	HP	LN	MN	LN	LN	1													
35	LP	MP	LN	HP	LP	HP	MP	LN	LN	LN	LP	LP	MP	HP	MP	LN	-	MP	LN	LP	HP	LP	MP	HP	LP	MP	LP	MP	LN	LN	LP	MP	LP	LN	1												
36	LN	MN	LN	LN	LP	LN	LP	MP	LP	LN	LP	LN	LP	MN	LP	MP	LP	LN	LP	HP	MN	LN	-	LN	LN	LN	LN	LN	HP	LN	HN	LP	MN	HP	LN	1											
37	MN	LN	LP	-	-	LN	LN	LP	LP	-	LP	LP	-	LN	LP	-	LN	LP	LN	-	-	-	LP	-	LN	LP	-	-	LP	-	LN	LP	LN	LP	LN	LP	1										
38	HN	MN	LP	MN	-	MN	LN	LP	LP	LN	LP	-	MN	LN	LN	-	-	LN	LP	LN	LN	MN	LN	MN	MN	LN	LN	LN	LP	-	LN	MN	LN	LP	LN	LP	HP	1									
39	MN	LN	LP	LP	-	-	LN	LP	LP	LP	LP	LP	-	-	LP	LN	LN	LP	LN	-	LP	LP	LP	LP	-	LP	LP	-	LP	-	LN	-	LN	LP	-	LP	HP	HP	1								
40	MN	LN	LP	LN	-	LN	LN	LP	LP	-	LP	LP	LN	LN	-	LN	LN	LN	LN	LN	-	-	LN	LN	LN	-	-	LN	LP	-	LN	LN	-	LP	-	LP	HP	HP	HP	1							
41	MN	-	-	LP	LN	LP	-	LP	LP	LN	LP	LP	LP	-	LP	LN	LN	LP	-	-	LP	LP	LP	LP	-	LP	-	LP	LP	LN	LN	LP	LN	LP	LN	LP	HP	HP	HP	MP	1						
42	MN	LN	-	-	LN	LN	LN	LP	-	-	LP	LP	LN	LN	-	LN	LN	LN	LP	LN	-	LN	LN	LN	LN	LN	LN	LN	LP	-	LN	-	LN	LP	LN	-	HP	HP	HP	MP	HP	1					
43	MP	LP	LP	LP	LP	LP	LN	LN	LP	LP	LP	LP	LN	LP	LN	LN	LN	LN	LN	LN	LP	-	LN	-	-	-	LP	LP	LN	MP	MP	LN	LP	LN	LP	MN	MN	MN	MN	LN	MN	MN	1				
44	LN	LN	LP	LN	-	LN	LN	LP	LP	LP	LP	LP	MN	LN	LN	LP	LN	LN	LP	LN	LN	LN	MN	MN	LN	LN	LN	LN	-	LP	LP	MN	LP	LP	LN	-	LN	LP	LP	LP	-	LN	LP	1			
45	LP	LP	LP	-	LP	LP	LN	LN	LN	LP	LN	LP	LN	LN	LN	LN	LN	LN	-	LN	LN	LP	LN	LN	LP	LN	LP	LP	LN	LP	MP	LN	LP	LN	-	MN	MN	MN	LN	LN	MN	MN	MP	LP	1		
46	MN	LN	LP	MN	-	LN	LN	LP	LN	-	LP	-	LN	LN	LN	-	LN	MN	LP	LN	MN	LN	LN	MN	MN	MN	LN	LN	LP	LP	-	LN	LN	LP	LN	LP	LP	MP	LP	LP	LP	LP	LN	LP	LP	1	
47	MP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LN	-	LP	LP	LP	-	-	LP	LP	LN	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LP	LP	LN	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	MN	1
48	MP	LP	LP	LP	LP	LP	-	LN	LP	LP	-	-	-	-	-	LP	-	LP	LP	LN	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LP	LP	LN	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	LN	HP

Table A4 Correlation Matrix – 2 miles Buffer

2 miles	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	LN	LN	1																																												
4	MP	HP	MN	1																																											
5	-	LN	MP	LN	1																																										
6	MP	HP	MN	HP	LN	1																																									
7	LP	MP	MN	HP	LP	HP	1																																								
8	LP	LP	LP	LP	MP	LP	LP	1																																							
9	LN	LN	LP	LN	MP	LN	LP	MP	1																																						
10	-	MP	LN	LP	LN	LP	LN	MN	LN	1																																					
11	LP	LP	LP	LP	MP	LP	HP	HP	MP	LN	1																																				
12	LP	LP	LP	LP	LP	MP	LP	MP	LP	LN	LP	1																																			
13	MP	HP	MN	HP	LP	HP	HP	MP	-	LN	MP	LP	1																																		
14	MP	HP	LN	HP	LP	HP	HP	LP	LN	LN	MP	MP	HP	1																																	
15	MP	HP	MN	HP	LN	HP	HP	MP	-	LN	MP	LP	HP	HP	1																																
16	LN	MN	LN	LN	LP	MN	LP	LP	LP	LN	LP	MN	LP	LN	LP	1																															
17	LN	MN	LN	LN	LP	LN	MP	-	-	LN	LP	MN	LP	LN	-	HP	1																														
18	MP	HP	MN	HP	LN	HP	HP	MP	LP	LN	LP	MP	HP	HP	HP	LN	LN	1																													
19	LN	MN	LP	MN	LN	MN	MN	LN	LN	LN	LN	LN	LN	LN	MN	-	LN	LN	1																												
20	LP	-	MN	MP	LN	MP	MP	HP	LP	MN	LP	LP	HP	MP	HP	MP	LP	HP	LN	1																											
21	MP	HP	LN	HP	LP	HP	HP	LP	-	LN	LP	MP	HP	HP	HP	MN	LN	HP	LN	LP	1																										
22	MP	HP	LN	HP	LP	HP	HP	MP	LP	LN	MP	MP	HP	HP	HP	MN	LN	HP	MN	LP	HP	1																									
23	MP	HP	MN	HP	LN	HP	HP	MP	-	LN	MP	MP	HP	HP	HP	LN	LN	HP	MN	HP	HP	HP	1																								
24	MP	HP	MN	HP	LN	HP	HP	LP	LN	LN	LP	MP	HP	HP	HP	LN	LN	HP	MN	MP	HP	HP	HP	1																							
25	MP	HP	LN	HP	LP	HP	HP	MP	LP	LP	MP	LP	HP	HP	HP	LN	LN	HP	MN	LP	HP	HP	HP	HP	1																						
26	MP	HP	LN	HP	LP	HP	HP	MP	LP	LN	MP	MP	HP	HP	HP	LN	LN	HP	MN	MP	HP	HP	HP	HP	HP	1																					
27	MP	HP	LP	HP	LP	HP	HP	MP	MP	LN	HP	MP	HP	HP	HP	LN	LN	HP	MN	LP	HP	HP	HP	HP	HP	HP	1																				
28	LP	HP	LN	HP	-	HP	MP	MP	LP	-	MP	MP	HP	HP	HP	LN	LN	HP	MN	MP	HP	HP	HP	HP	HP	HP	HP	1																			
29	LN	LN	LN	LN	LN	-	LP	HP	LP	MN	-	LP	LP	LN	LP	MP	LP	LP	LP	HP	LN	LN	LP	LP	LN	LP	LN	LP	1																		
30	-	LP	MP	LP	LP	-	LN	LN	LP	HP	MP	LN	LN	LN	LN	LN	LN	LN	MN	MN	-	LP	LN	LN	LP	LP	LP	LP	MN	1																	
31	LP	HP	LP	LP	LN	MP	LN	LN	LN	HP	LN	LP	LN	LP	LN	HN	MN	LN	LN	HN	MP	LP	LN	LP	LP	LP	LP	MP	HN	MP	1																
32	MP	HP	MN	HP	LN	HP	HP	MP	-	LN	MP	MP	HP	HP	HP	LN	LN	HP	LN	HP	HP	HP	HP	HP	HP	HP	HP	HP	LP	LN	LN	1															
33	LP	HP	LP	MP	LP	MP	LP	LN	-	MP	LP	LP	LP	MP	LP	MN	LN	LP	LN	MN	HP	MP	LP	LP	MP	MP	MP	MP	MN	MP	HP	LP	1														
34	LN	HN	LN	MN	LN	LN	LN	LP	-	LN	LN	LN	LN	MN	LN	MP	LP	LN	LP	MP	MN	MN	LN	LN	MN	LN	MN	LN	HP	MN	MN	LN	HN	1													
35	MP	HP	MN	HP	LP	HP	HP	LP	LN	LN	MP	LP	HP	HP	HP	LN	LN	HP	MN	MP	HP	HP	HP	HP	HP	HP	HP	HP	LN	-	LP	HP	MP	LN	1												
36	LN	LN	LN	-	LN	LP	LP	HP	LP	MN	LP	-	MP	-	MP	HP	LP	LP	LP	HP	LN	LN	LP	LP	-	LP	-	LP	HP	MN	HN	MP	HN	HP	LP	1											
37	MN	LN	LP	LN	-	LN	LN	LP	-	LN	LN	LP	-	LN	LN	-	-	LP	LN	LP	LN	LN	LN	LN	LN	LN	LN	LP	LN	LN	-	LN	LP	LN	LP	LP	1										
38	HN	MN	LP	MN	-	MN	LN	LN	-	LN	LN	LN	MN	MN	MN	LP	LP	MN	LP	LN	MN	MN	MN	MN	MN	LN	MN	LP	-	LN	MN	LN	LP	MN	-	HP	1										
39	MN	LN	-	-	-	-	-	LP	LN	LN	-	LP	LP	-	LP	LP	-	LP	LN	LP	-	-	LP	-	LN	LP	-	-	LP	LN	LN	LP	LN	LP	-	LP	HP	HP	1								
40	MN	LN	LP	LN	-	LN	LN	LP	LN	LN	LN	LP	LN	LN	LN	-	LN	LN	-	-	LN	LN	LN	LN	LN	LN	LN	LN	LP	LN	LN	LN	LN	LP	LN	LP	HP	HP	HP	1							
41	MN	LN	LN	LP	LN	-	-	LP	LN	LN	LN	LP	LP	-	LP	LN	LN	LP	-	LP	-	-	LP	LP	LN	LP	-	-	LP	LN	LN	LP	LN	LP	-	LP	HP	HP	HP	MP	1						
42	MN	LN	-	LN	LN	LN	LN	-	LN	-	LN	LP	LN	LN	LN	-	LN	LN	LP	-	LN	LN	LN	LN	LN	LN	LN	LN	LP	LN	LN	LN	LN	LP	LN	-	HP	HP	HP	MP	HP	1					
43	MP	LP	LP	-	LP	LP	LN	LN	LP	LP	LN	-	LN	-	LN	LN	LN	LN	LN	MN	LP	LP	LN	LN	LP	-	-	LP	LN	LP	MP	LN	MP	LN	-	MN	MN	MN	MN	LN	MN	MN	1				
44	LN	LN	LP	MN	LP	LN	LN	LN	-	LP	LN	LN	MN	MN	LN	LP	LP	MN	LP	LN	LN	LN	MN	MN	LN	MN	LN	LN	-	LP	LP	MN	-	LP	LN	LN	LN	LP	LP	LP	-	LN	LP	1			
45	LP	LP	LP	-	LP	-	LN	LN	LN	LP	LN	-	LN	LN	LN	LN	LN	LN	LN	MN	-	LP	LN	LN	LP	LN	LP	-	LN	MP	MP	LN	LP	LN	LN	MN	MN	MN	LN	LN	MN	MN	MP	LP	1		
46	MN	MN	LP	MN	-	MN	MN	LN	LN	LP	LN	LN	MN	MN	LN	LP	-	MN	LP	LN	MN	MN	MN	MN	LN	MN	LN	MN	LP	-	LN	MN	LN	LP	LN	LP	LP	MP	LP	LP	LP	LP	LN	LP	LP	1	
47	MP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LN	-	LP	LP	LP	LN	LN	-	-	LN	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LP	LP	LN	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	MN	1
48	MP	LP	LP	LP	LP	LP	-	LN	LP	LP	-	-	-	LP	-	LN	LN	-	LP	LN	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LP	LP	LN	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	LN	HP

Table A5 Correlation Matrix – 3 miles Buffer

3 miles	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1
3	LN	LN	1
4	MP	HP	MN	1
5	LP	LP	MP	LP	1
6	MP	HP	MN	HP	LP	1
7	LP	LP	MN	HP	MP	HP	1
8	LP	LP	LN	MP	MP	HP	HP	1
9	LP	-	LP	LP	HP	LP	LP	HP	1
10	-	HP	LP	LP	LN	LP	LN	MN	MN	1
11	LP	MP	LN	HP	MP	HP	HP	HP	MP	LN	1
12	LP	LP	MP	MP	MP	MP	-	MP	LP	LN	LP	1
13	MP	MP	HN	HP	LP	HP	HP	HP	LP	LN	HP	LP	1
14	MP	HP	MN	HP	LP	HP	HP	MP	LP	LP	HP	MP	HP	1
15	LP	MP	HN	HP	LP	HP	HP	HP	LP	LN	HP	LN	HP	HP	1
16	LN	MN	MN	LN	LN	LN	MP	LP	LN	MN	LP	MN	LP	LN	MP	1
17	LN	MN	LN	LN	LN	LN	MP	LN	LN	LN	LP	LN	LP	LN	LP	HP	1
18	LP	MP	HN	HP	LP	HP	HP	HP	MP	MN	HP	LP	HP	HP	HP	LP	LN	1
19	LN	MN	LP	MN	LN	HN	MN	LN	LN	LN	LN	-	MN	MN	MN	LP	MP	LN	1
20	LP	LN	HN	MP	LN	MP	HP	HP	LP	MN	HP	LP	HP	MP	HP	HP	MP	HP	LN	1
21	MP	HP	LN	HP	LP	HP	MP	MP	LP	LP	MP	MP	HP	HP	MP	MN	MN	HP	MN	LP	1
22	MP	HP	-	HP	MP	HP	MP	HP	MP	LP	HP	MP	HP	HP	HP	MN	MN	HP	MN	LP	HP	1
23	MP	HP	MN	HP	LP	HP	HP	HP	LP	LN	HP	LP	HP	HP	HP	LP	LN	HP	MN	HP	HP	HP	1
24	MP	HP	MN	HP	LP	HP	HP	HP	LP	-	HP	MP	HP	HP	HP	LN	LN	HP	MN	HP	HP	HP	HP	1
25	MP	HP	LN	HP	LP	HP	HP	MP	LP	LP	HP	LP	HP	HP	HP	LN	LN	HP	HN	LP	HP	HP	HP	HP	1
26	MP	HP	MN	HP	LP	HP	HP	HP	MP	LN	HP	MP	HP	HP	HP	LN	LN	HP	HN	MP	HP	HP	HP	HP	HP	1
27	MP	HP	-	HP	MP	HP	HP	HP	HP	LN	HP	MP	HP	HP	HP	LN	LN	HP	MN	MP	HP	HP	HP	HP	HP	HP	1
28	MP	HP	LN	HP	LP	HP	MP	HP	LP	LP	HP	MP	HP	HP	HP	MN	MN	HP	HN	LP	HP	HP	HP	HP	HP	HP	HP	1
29	LN	LN	MN	LP	LN	LP	LP	HP	LP	MN	LP	LP	MP	LP	LP	MP	LP	MP	LP	HP	LN	-	LP	LP	-	LP	LP	LP	1
30	LP	HP	MP	MP	LP	MP	LP	LN	LP	HP	LP	-	LN	MP	LP	MN	MN	LN	MN	MN	MP	MP	LP	LP	MP	MP	MP	MP	MN	1
31	LP	HP	MP	LP	-	MP	LN	LN	LN	HP	LN	LP	LN	LP	LN	HN	MN	LN	LN	HN	MP	MP	LN	LP	MP	LP	LP	MP	HN	HP	1
32	MP	MP	MN	HP	LP	HP	HP	HP	LP	MN	HP	MP	HP	HP	HP	-	LN	HP	MN	HP	HP	HP	HP	HP	HP	HP	HP	HP	MP	LN	LN	1
33	LP	HP	MP	MP	MP	MP	LP	-	LP	MP	LP	MP	-	MP	LN	HN	MN	-	LN	MN	HP	HP	LP	LP	MP	MP	MP	MP	MN	HP	HP	LP	1
34	LN	HN	MN	LN	LN	LN	LP	MP	LP	MN	LP	LN	LP	LN	LP	HP	MP	LP	LP	HP	MN	MN	-	LN	MN	LN	LN	LN	HP	HN	HN	LP	HN	1
35	MP	HP	MN	HP	LP	HP	HP	MP	-	LP	HP	LP	HP	HP	HP	-	-	HP	HN	MP	HP	HP	HP	HP	HP	HP	HP	HP	LN	MP	LP	HP	MP	LN	1
36	-	LN	HN	LP	LN	LP	MP	HP	LP	MN	MP	-	HP	LP	HP	HP	MP	HP	LN	HP	LN	-	MP	MP	LP	MP	LP	LP	HP	MN	HN	HP	HN	HP	LP	1
37	MN	LN	-	LN	LN	LN	LN	LP	-	LN	LN	LP	LN	LN	LN	-	-	LP	LN	LP	LN	LN	LN	LN	LN	LN	LN	LN	LP	LN	LN	-	LN	LP	LN	LP	1
38	HN	MN	LP	MN	LN	MN	MN	LN	LN	LN	LN	LN	MN	MN	MN	LP	LP	MN	LP	LN	MN	MN	MN	MN	MN	MN	MN	MN	-	LN	LN	MN	LN	LP	MN	LN	HP	1
39	MN	LN	LN	-	-	LP	-	LP	LP	LN	-	LP	LP	-	LP	LP	-	LP	LN	LP	-	-	LP	LP	-	LP	-	-	LP	LN	LN	LP	LN	LP	-	LP	HP	HP	1
40	MN	LN	-	LN	-	LN	LN	-	-	LN	-	LP	LN	LN	LN	LP	LP	-	-	LP	LN	LN	LN	LN	LN	LN	LN	LN	LP	LN	LN	LN	LN	LP	LN	LP	HP	HP	HP	1
41	MN	LN	LN	-	LN	LP	LN	LP	-	LN	-	LP	LP	-	-	-	LN	LP	LN	LP	-	-	LP	LP	-	-	LN	-	LP	LN	LN	LP	LN	LP	LN	LP	HP	HP	HP	MP	1
42	MN	LN	LN	LN	LN	LN	LN	-	LN	LP	LN	LP	LN	LN	LN	-	LP	LN	LN	-	LN	LN	LN	LN	LN	LN	LN	LN	LP	LN	LN	LN	LN	-	LN	-	HP	HP	HP	MP	HP	1
43	MP	LP	LP	-	LP	-	LN	LN	-	LP	LN	-	LN	LN	LN	LN	LN	LN	LN	MN	LP	LP	LN	LN	LP	LN	-	-	LN	LP	MP	LN	MP	LN	LN	MN	MN	MN	MN	LN	MN	MN	1
44	LN	LN	LP	LN	-	MN	LN	LN	LN	LP	LN	LN	LN	LN	LN	LP	LP	LN	LP	LN	LN	LN	LN	MN	LN	LN	LN	LN	LN	LP	LP	LN	LN	-	LN	LN	LN	LP	LP	LP	-	LN	LP	1
45	LP	LP	MP	LN	LP	-	LN	LN	-	LP	LN	-	LN	LN	LN	MN	LN	MN	LN	MN	LP	LP	LN	LN	LP	LN	LP	LP	MN	MP	MP	LN	MP	MN	LN	MN	MN	MN	LN	LN	MN	MN	MP	LP	1
46	MN	LN	LP	MN	-	MN	LN	LN	LN	LP	LN	LN	MN	MN	LN	LP	LP	MN	LP	LN	MN	LN	MN	MN	MN	MN	LN	MN	-	-	LN	MN	LN	LP	LN	-	LP	MP	LP	LP	LP	LP	LN	LP	LP	1
47	MP	LP	LP	LP	LP	LP	LP	-	LP	LP	LP	LN	-	LP	-	LN	LN	-	-	LN	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	-	LP	LN	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	MN	1
48	MP	LP	LP	LP	LP	LP	LP	-	LP	LP	LP	-	-	LP	-	LN	LN	-	-	LN	LP	LP	-	LP	LP	LP	LP	LP	LN	LP	LP	-	LP	LN	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	LN	HP

Table A6 Correlation Matrix for CBD Area with 0.5 miles Buffer

0.5 miles_CBD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	-	-	1																																												
4	LP	LP	-	1																																											
5	LN	MN	-	LP	1																																										
6	MP	HP	-	HP	LN	1																																									
7	-	LN	-	MP	MP	LP	1																																								
8	LN	LN	-	MN	MP	MN	-	1																																							
9	LP	-	-	HP	MP	HP	MP	LN	1																																						
10	MP	HP	-	-	LN	LP	MN	-	LN	1																																					
11	LN	HN	-	LP	HP	LN	HP	LP	LP	MN	1																																				
12	LN	LN	-	MN	-	LN	-	MP	MN	-	-	1																																			
13	MP	MP	-	HP	-	HP	LP	MN	HP	LP	-	MN	1																																		
14	-	MN	-	LN	MP	-	HP	LP	LN	MN	HP	LP	LN	1																																	
15	HP	HP	-	HP	LN	HP	LP	HN	HP	MP	LN	MN	HP	LN	1																																
16	LN	LN	-	LN	-	LN	LN	MP	LN	LN	LN	MP	LN	LN	LN	1																															
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1																														
18	LP	LP	-	MP	MP	LP	MP	LP	MP	LN	MP	LN	LP	LP	LP	LN	-	1																													
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1																												
20	-	-	-	MN	LN	MN	HN	-	MN	LP	MN	-	MN	MN	MN	MP	-	HN	-	1																											
21	LP	MN	-	LN	MP	LN	HP	MP	-	MN	HP	LP	LN	HP	LN	LN	-	MP	-	MN	1																										
22	HP	HP	-	LP	MN	HP	LN	MN	LP	HP	MN	LN	HP	MN	HP	LN	-	-	-	-	MN	1																									
23	HP	HP	-	HP	MN	HP	LN	MN	MP	HP	MN	MN	HP	MN	HP	LN	-	LP	-	LN	MN	HP	1																								
24	HP	HP	-	HP	LN	HP	LP	MN	MP	MP	LN	MN	HP	-	HP	LN	-	LP	-	MN	-	HP	HP	1																							
25	HP	HP	-	MP	MN	HP	LN	MN	MP	HP	HN	LN	HP	MN	HP	LN	-	LP	-	-	MN	HP	HP	HP	1																						
26	HP	HP	-	HP	LN	HP	LP	MN	MP	MP	LN	MN	HP	-	HP	LN	-	LP	-	LN	LN	HP	HP	HP	HP	1																					
27	HP	HP	-	LP	LN	HP	LN	LN	LP	HP	LN	MN	HP	LN	HP	LN	-	LP	-	-	LN	HP	HP	HP	HP	HP	1																				
28	LP	LP	-	HP	MP	MP	LP	MN	HP	LN	-	MN	HP	-	LP	LN	-	MP	-	LN	-	LP	LP	LP	MP	LP	LP	1																			
29	LN	MN	-	MN	-	HN	MN	-	MN	LP	MN	LP	MN	MN	MN	MP	-	HN	-	HP	MN	-	MN	MN	LN	LN	LN	MN	1																		
30	LN	MN	-	LN	HP	LN	HP	MP	-	MN	HP	LP	LN	HP	LN	LP	-	LP	-	LN	HP	MN	MN	LN	MN	LN	LN	LN	LN	1																	
31	LN	MN	-	MN	LP	MN	MP	MP	MN	LN	MP	MP	HN	HP	HN	-	-	LP	-	LN	HP	MN	HN	MN	HN	MN	MN	LN	LN	HP	1																
32	HP	HP	-	MP	HN	HP	LN	MN	LP	HP	MN	MN	HP	MN	HP	LN	-	-	-	-	MN	HP	HP	HP	HP	HP	HP	-	LN	HN	HN	1															
33	LN	LN	-	LN	LP	LP	HP	-	LN	LN	MP	MP	LN	HP	LN	-	-	-	-	LN	HP	LN	LN	-	LN	-	LN	LN	LN	HP	HP	LN	1														
34	-	LP	-	LN	LP	-	MN	LP	LN	-	MN	LP	LN	LN	LN	HP	-	MN	-	HP	LN	-	-	LN	LP	-	-	LP	MP	LN	LN	LN	LN	1													
35	-	LP	-	LN	LP	LP	LP	-	LN	LN	LP	MP	-	HP	LN	LP	-	LN	-	-	MP	LN	LN	LP	-	LP	LN	-	LN	HP	MP	LN	HP	LP	1												
36	LN	-	-	MN	LN	MN	HN	LP	MN	LP	HN	MP	MN	MN	MN	HP	-	HN	-	HP	MN	-	LN	MN	LN	LN	-	MN	HP	LN	LN	-	LN	HP	-	1											
37	MN	LP	-	LP	-	LP	-	LN	LP	LN	LN	LP	LP	LN	LP	-	-	LN	-	-	LN	-	-	-	-	-	LN	LP	LN	LN	LN	LN	LN	LP	LP	LP	1										
38	HN	LN	-	LP	LP	LN	LP	-	LP	LN	LP	LN	LN	LN	LN	LN	-	-	-	-	LN	LN	LN	MN	LN	LN	MN	LP	LP	-	LN	LN	LN	-	LN	-	MP	1									
39	MN	LP	-	LP	LP	LP	LP	LN	LP	-	-	LN	LP	LN	LP	MN	-	LP	-	LN	LN	LP	LP	LP	-	LP	-	LP	LN	LN	LN	LP	-	LN	-	LN	HP	HP	1								
40	MN	-	-	LP	LP	LP	LP	MN	LP	-	LP	LN	LP	LN	LP	MN	-	-	-	LN	LN	LP	-	-	-	-	-	LP	-	LN	-	-	-	LN	-	LN	HP	HP	HP	1							
41	LN	LP	-	LP	LP	LP	LP	-	LP	LP	LP	LN	LP	-	LP	MN	-	LP	-	LN	LN	LP	LP	LP	-	LP	-	LP	LN	LN	LN	-	LN	-	-	LN	HP	MP	MP	MP	1						
42	MN	-	-	LP	LP	LP	LP	MN	LP	LN	LP	LN	-	-	-	HN	-	LP	-	LN	-	-	LN	-	LN	-	LN	LP	LN	LN	-	-	-	MN	LN	MN	MP	HP	HP	HP	MP	1					
43	HP	-	-	LP	LP	LP	LP	-	LP	-	LP	LP	MP	MP	MP	LP	-	LP	-	LN	MP	-	LP	MP	LP	LP	LP	LP	LN	MP	-	LP	LP	-	LP	LN	MN	HN	MN	LN	LN	MN	1				
44	LP	LP	-	LP	LP	LP	LP	-	LP	-	LP	LN	MP	LP	LP	-	-	LP	-	LN	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	-	LP	LP	-	-	LN	MN	LN	-	-	LN	LN	HP	1			
45	MP	LP	-	LP	-	LP	-	LN	LP	LP	LN	LN	MP	-	MP	LP	-	-	-	-	-	LP	MP	MP	MP	MP	MP	LP	-	-	LN	MP	-	LP	-	-	LN	MN	LN	LN	-	LN	MP	LP	1		
46	LN	LN	-	LP	-	LN	LN	LN	LP	LN	LN	LN	-	MN	-	-	-	MN	-	LP	MN	-	-	LN	-	-	LN	LP	LP	LN	LN	-	LN	LP	LN	LP	LP	MP	LP	LP	LP	LP	LN	LN	LP	1	
47	HP	LP	-	LP	LN	MP	-	LP	LP	LP	-	LP	MP	LP	LP	-	-	LP	-	LN	LP	LP	MP	MP	MP	MP	MP	LP	LN	LP	LN	LP	-	LP	LP	LN	LN	HN	MN	LN	LN	HN	HP	MP	LP	HN	1
48	HP	MP	-	LP	LN	LP	LN	LP	-	LP	LN	-	LP	-	LP	-	-	LP	-	LN	LP	LP	MP	MP	MP	MP	MP	LP	LN	LN	LN	LP	LN	-	-	LN	MN	HN	MN	MN	MN	HN	MP	LP	LP	MN	HP

Table A7 Correlation Matrix for CBD Area with 1-mile Buffer Width

CBD_1mile	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																												
3	-	-	1																																											
4	LP	HP	-	1																																										
5	LP	LP	-	HP	1																																									
6	LP	HP	-	HP	HP	1																																								
7	MP	HP	-	HP	HP	HP	1																																							
8	LN	MN	-	LN	-	LN	LN	1																																						
9	LP	MP	-	HP	HP	HP	HP	-	1																																					
10	LP	MP	-	-	MN	LP	LP	LN	LP	1																																				
11	LP	MP	-	HP	MP	HP	HP	-	HP	MP	1																																			
12	LN	-	-	-	LN	-	LN	LP	LN	LN	LN	1																																		
13	MP	HP	-	HP	HP	HP	HP	LN	HP	LP	MP	LN	1																																	
14	LN	-	-	HP	MP	MP	HP	LP	HP	-	HP	LP	LP	1																																
15	MP	HP	-	HP	MP	HP	HP	MN	HP	LP	MP	LN	HP	-	1																															
16	LN	MN	-	HN	LN	MN	MN	LP	MN	LN	MN	LP	HN	LN	HN	1																														
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1																													
18	MP	HP	-	MP	HP	MP	HP	LN	MP	LN	LP	-	HP	-	HP	MN	-	1																												
19	LN	MN	-	HN	MN	MN	MN	MP	MN	-	LN	LP	HN	LN	MN	MP	-	MN	1																											
20	LP	-	-	MN	LN	LN	MN	-	MN	LN	HN	LN	LN	HN	-	LP	-	LP	LP	1																										
21	LN	-	-	HP	MP	MP	HP	LP	HP	-	HP	LP	LP	HP	-	LN	-	-	LN	HN	1																									
22	MP	HP	-	LP	-	MP	LP	LN	LP	LP	-	LN	MP	LN	HP	LN	-	HP	LN	MP	MN	1																								
23	LP	HP	-	MP	LP	HP	MP	MN	MP	LP	-	LN	HP	LN	HP	MN	-	HP	MN	LP	LN	HP	1																							
24	LP	HP	-	HP	MP	HP	HP	LN	HP	MP	HP	-	HP	MP	HP	HN	-	HP	MN	LN	MP	HP	HP	1																						
25	LP	HP	-	LP	LP	MP	LP	MN	LP	LP	-	LN	HP	LN	HP	LN	-	MP	LN	MP	LN	HP	HP	MP	1																					
26	LP	HP	-	HP	MP	HP	HP	LN	HP	MP	HP	LN	HP	MP	HP	HN	-	MP	MN	LN	MP	MP	HP	HP	HP	1																				
27	LP	HP	-	MP	LP	HP	HP	LN	MP	HP	HP	MN	HP	LP	HP	MN	-	LP	LN	LN	LP	HP	HP	HP	HP	HP	1																			
28	LP	MP	-	HP	HP	HP	HP	-	HP	MN	LP	LN	HP	MP	MP	LN	-	HP	MN	-	MP	LP	LP	MP	LP	MP	-	1																		
29	LP	-	-	MN	LN	LN	LN	-	LN	LP	MN	LN	LN	HN	-	LP	-	-	MP	HP	HN	MP	LP	LN	LP	LN	LP	LN	1																	
30	LN	LN	-	MP	MP	MP	MP	LP	MP	LN	HP	MP	LP	HP	LN	-	-	LN	-	HN	HP	MN	MN	LP	MN	LP	-	LP	MN	1																
31	LN	LN	-	MP	LP	LP	LP	LP	LP	-	HP	LP	-	HP	LN	LN	-	MN	-	HN	HP	HN	MN	LP	HN	LP	-	LP	HN	HP	1															
32	LP	HP	-	LP	LN	LP	LP	MN	LP	MP	LN	-	MP	MN	HP	MN	-	MP	LN	MP	MN	HP	HP	MP	HP	MP	MP	-	MP	MN	HN	1														
33	LN	LN	-	MP	MP	MP	MP	LP	MP	-	HP	LP	LP	HP	-	LN	-	LN	LN	HN	HP	MN	MN	LP	MN	LP	LP	LP	HN	HP	HP	MN	1													
34	LN	LN	-	-	MP	LN	LN	LP	-	MN	MN	LP	-	MN	-	MP	-	LP	LP	HP	LN	-	LP	LN	LP	LN	LN	LP	MP	LN	MN	-	MN	1												
35	-	LP	-	HP	MP	MP	MP	-	MP	LN	MP	MP	LP	HP	LP	LN	-	LP	LN	MN	HP	LN	-	MP	LN	LP	-	MP	MN	HP	HP	LN	HP	-	1											
36	LN	LN	-	HN	HN	HN	HN	LP	HN	LN	HN	-	MN	HN	LN	MP	-	LN	MP	HP	HN	LP	-	HN	LP	HN	LN	MN	HP	HN	HN	LP	HN	MP	MN	1										
37	MN	LP	-	-	LN	LP	-	LN	-	LN	LN	MP	-	-	LP	-	-	LP	LP	LP	-	LP	LP	LP	LP	-	LN	-	LP	-	LN	LP	LN	LP	LP	LP	1									
38	HN	-	-	-	-	LP	-	LP	LP	-	-	-	-	LP	-	LN	-	-	LP	-	LP	-	LP	LP	-	LP	LP	-	-	LP	-	-	-	-	-	-	MP	1								
39	MN	LP	-	LP	-	LP	-	-	LP	LN	-	-	LP	-	LP	LN	-	LP	-	LP	-	LP	LP	LP	LP	LP	LP	LP	-	-	LN	LP	-	-	LP	-	HP	HP	1							
40	MN	LP	-	LP	-	MP	LP	-	MP	LP	LP	LN	LP	LP	LP	LN	-	LP	LN	-	LP	LP	LP	MP	LP	LP	LP	LP	-	LP	-	LP	LP	LN	LP	LN	HP	HP	HP	1						
41	LN	MP	-	MP	LP	LP	LP	-	MP	-	-	LP	MP	LP	LP	LN	-	MP	LN	-	LP	LP	LP	MP	LP	LP	LP	LP	LN	-	-	LP	-	-	LP	LN	HP	MP	MP	MP	1					
42	MN	LP	-	LP	-	LP	LP	LN	LP	LP	LP	LN	LP	LP	LP	MN	-	LP	LN	LN	LP	LP	LP	MP	-	MP	MP	-	LN	LP	-	LP	-	LN	-	LN	MP	HP	HP	HP	MP	1				
43	HP	LP	-	MP	MP	LP	MP	-	MP	LP	MP	-	LP	LP	LP	LP	-	LP	LN	LN	LP	-	-	LP	-	LP	LP	LP	LN	LP	LP	LN	LP	-	LP	MN	MN	HN	MN	LN	LN	MN	1			
44	LP	LP	-	MP	LP	LP	MP	LN	LP	LP	MP	LN	LP	LP	MP	LP	-	LP	LN	LN	LP	LP	LP	LP	-	LP	LP	LP	LN	LP	LP	LP	LP	-	LP	LN	MN	LN	-	-	LN	LN	HP	1		
45	MP	MP	-	LP	MP	LP	LP	-	LP	-	LP	LN	MP	LN	LP	-	-	LP	LN	LP	-	LP	LP	LP	LP	LP	LP	MP	LP	LN	LN	LP	LN	LP	-	LN	LN	MN	LN	LN	-	LN	MP	LP	1	
46	LN	-	-	LN	-	-	-	LP	-	LP	-	LN	LN	LN	LN	LP	-	-	LP	LP	LN	LP	LN	LN	LN	-	LP	-	LP	LN	LN	-	LN	LP	MN	LP	LP	MP	LP	LP	LP	LP	LN	LN	LP	1
47	HP	LP	-	LP	LP	LP	LP	LN	LP	-	-	LP	LP	-	LP	LP	-	MP	LN	-	-	-	-	LP	-	-	LN	LP	LN	-	-	-	-	-	LP	LN	LN	HN	MN	LN	LN	HN	HP	MP	LP	HN	1
48	HP	LP	-	-	LP	-	LP	LN	LN	LN	LN	-	LP	LN	LP	LP	-	MP	MN	LP	LN	-	LP	-	-	LN	LN	LP	LN	LN	LN	LP	LN	-	-	-	MN	HN	MN	MN	MN	HN	MP	LP	LP	MN	HP

Table A8 Correlation Matrix for CBD Fringe / OBD Area with 0.5 miles Buffer Width

0.5 miles_OBD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	LN	LN	1																																												
4	LP	MP	LN	1																																											
5	LN	LN	LP	LN	1																																										
6	LP	HP	LN	LN	LN	1																																									
7	-	-	LN	LN	MP	-	1																																								
8	-	-	LP	LN	LP	LP	-	1																																							
9	LN	LN	-	LN	LP	LN	LP	-	1																																						
10	LP	LP	LN	HP	LN	LN	LN	LN	LN	1																																					
11	LP	LP	LP	-	MP	LP	MP	HP	LP	LN	1																																				
12	-	LP	LN	LN	LN	LP	-	LP	LN	LN	LN	1																																			
13	-	LN	LN	LN	LP	LN	MP	LP	LP	LN	LP	LN	1																																		
14	LP	HP	LN	-	LN	MP	LP	LN	LN	LN	-	MP	LN	1																																	
15	LN	LN	MP	LP	-	LN	LN	LP	LP	LP	LP	LN	LN	LN	1																																
16	LN	LN	LN	LN	LP	LN	LP	LP	-	LN	LN	LP	LP	LN	LN	1																															
17	LN	LN	-	-	HP	LN	HP	LN	LP	-	LP	LN	MP	LN	LN	LP	1																														
18	-	-	LN	-	LP	-	-	-	-	LN	LP	LP	LN	LP	LP	LN	-	1																													
19	LN	LN	HP	LN	LP	LN	LN	LP	LN	LN	LP	LN	LN	LN	MP	LN	LN	LP	1																												
20	-	LN	LP	LN	LP	LN	LN	MP	MP	LN	-	LP	-	LN	-	HP	LN	-	LN	1																											
21	LP	HP	LN	LP	-	LP	LP	-	LN	-	LP	MP	LN	HP	LN	LN	LN	MP	LP	LN	1																										
22	MP	MP	LN	LP	-	LP	LP	LP	LP	-	MP	-	LP	LP	-	LN	LN	LP	LN	LP	LP	1																									
23	-	LP	LP	MP	LN	LN	-	LP	MP	MP	LP	-	MN	-	HP	LN	LN	-	LN	-	LP	LP	1																								
24	MP	HP	LN	HP	LN	LP	LP	LN	LN	MP	-	LP	LN	HP	-	LN	LN	LP	LN	LN	HP	MP	MP	1																							
25	-	-	LN	-	LP	LN	LN	LP	MP	LN	LP	LN	-	LN	LN	LP	-	LN	LN	LP	LN	LP	-	LN	1																						
26	LP	MP	-	MP	-	LP	LP	LP	LP	MP	HP	-	MN	MP	LP	LN	LN	MP	-	LN	MP	MP	HP	HP	-	1																					
27	LP	-	MP	LP	LP	LN	LP	LP	LP	LP	HP	LN	LN	-	LP	LN	LN	MP	LP	LP	LP	MP	LP	LP	-	HP	1																				
28	LN	LP	LN	LN	LN	MP	LN	LN	LN	LN	MN	-	LN	LP	MN	LN	LN	-	LN	LN	LP	LN	LN	LP	LN	LN	LN	1																			
29	-	LN	LP	MN	MP	LN	LP	MP	LP	MN	LP	LP	LP	LN	LN	HP	LP	-	LN	HP	LN	LP	LN	MN	LP	LN	LP	LN	1																		
30	MP	LP	-	HP	LN	LN	LN	-	LN	HP	LP	LN	LN	LN	LP	LN	LN	-	LN	LN	-	LP	MP	MP	-	HP	MP	LN	LN	1																	
31	LP	HP	LN	LP	LN	HP	LN	-	LN	-	LN	LP	LN	MP	MN	LN	LN	LP	LN	LN	HP	LP	LN	MP	-	LP	LN	HP	MN	LP	1																
32	LN	LN	LN	LN	LP	LN	-	LP	LN	LN	-	-	LN	-	LN	-	-	LP	LN	LP	-	-	-	LN	MP	LP	-	-	LP	LN	-	1															
33	HP	HP	LN	HP	LN	LP	-	LN	LN	HP	LP	LP	LN	MP	LN	LN	LN	LN	MN	LN	LP	MP	LP	HP	LN	HP	LP	-	LN	MP	MP	-	1														
34	LN	LN	-	LN	LP	LN	LP	LP	-	LN	-	LP	-	LN	LP	HP	LP	LN	LN	HP	LN	LN	-	LN	-	LN	LN	LN	HP	LN	LN	-	LN	1													
35	LP	MP	LN	LN	LN	MP	LP	LP	LN	LN	LP	HP	LN	HP	LN	-	LN	-	LN	LN	HP	-	LP	HP	MN	LP	LN	LP	-	LN	MP	LN	MP	-	1												
36	LN	MN	LP	MN	MP	LN	LP	MP	LP	MN	LP	LP	MP	MN	-	HP	LP	LN	LN	HP	MN	LP	LN	MN	LP	MN	-	MN	HP	MN	MN	-	MN	HP	LN	1											
37	HN	LN	LP	LP	-	LN	-	-	LP	LP	LN	LN	LN	LN	LP	LN	-	LP	LP	-	LN	LN	LP	-	LN	-	LP	-	LN	-	MN	LP	LN	LN	LN	-	1										
38	HN	MN	LP	-	-	MN	LP	LP	LP	-	-	LN	-	LN	MP	LN	-	LP	LP	LN	LN	LN	LP	LN	LN	-	-	-	LN	LN	MN	LP	MN	LN	LN	-	HP	1									
39	HN	MN	-	-	LP	LN	LP	LP	LP	LP	-	LN	-	-	LP	-	LP	LP	-	LP	LN	LN	LP	-	LN	LP	LP	LN	-	-	LN	LP	LN	LP	LN	LP	HP	HP	1								
40	MN	MN	LP	-	LP	LN	LP	LP	LP	-	LP	LN	LP	LN	LP	-	LP	LP	LP	-	-	LN	LP	LN	-	-	LP	LN	-	-	MN	LP	LN	-	LN	LP	HP	HP	HP	1							
41	MN	LN	LN	LN	LN	LN	LP	LN	MP	LN	LN	-	-	-	-	-	-	LP	LN	LP	-	LN	LP	-	LN	-	LN	LP	-	LN	LN	LP	LN	LN	LN	-	HP	HP	HP	MP	1						
42	MN	LN	LN	-	LP	LN	LP	LN	LP	-	-	LN	LP	LN	LP	-	LP	LP	LN	LN	LN	LN	LP	LN	LN	-	LN	-	LN	LN	LN	LP	LN	LN	LN	-	HP	HP	HP	MP	HP	1					
43	HP	MP	-	MP	-	-	LN	-	LN	MP	LP	-	LN	LP	LP	LN	LN	LP	-	LN	LP	LP	LP	MP	-	MP	LP	LN	LN	HP	MP	LN	MP	LN	LP	LN	MN	MN	MN	MN	MN	MN	1				
44	-	LN	LP	-	-	LN	LP	LN	LP	-	-	-	LP	LN	LP	-	LP	LN	LP	LN	LN	LN	LP	LN	LN	LN	-	LN	-	LP	LN	HN	LN	LP	LN	LP	-	LP	-	LP	-	-	LP	1			
45	MP	MP	-	MP	LN	LP	LN	LP	LN	MP	LP	LN	LN	LP	LN	LP	LN	LN	LN	LN	-	-	-	LP	LN	LP	LP	LN	LN	HP	MP	MN	MP	-	LP	LN	MN	MN	LN	LN	MN	MN	MP	-	1		
46	MN	LN	LP	LN	LP	LN	-	LP	LN	-	LN	LN	LP	LN	LP	-	LP	LN	LP	LN	LN	MN	LN	LN	LN	LN	LN	-	-	-	LN	LN	MN	LP	LN	LP	LP	MP	MP	LP	LP	LP	MN	LP	-	1	
47	HP	MP	LN	MP	LN	LP	LN	-	-	LP	LP	LP	LN	LP	LN	-	LN	-	LN	LP	LP	MP	LP	MP	LP	MP	LP	LN	LP	MP	LP	LN	MP	LN	LP	LN	MN	HN	MN	LN	MN	MN	HP	-	HP	HN	1
48	HP	MP	LN	LP	-	LP	LN	LP	LP	LP	LP	LP	LN	LP	LN	LP	LN	-	LN	LP	LP	MP	LP	MP	LP	MP	LP	LN	LP	MP	LP	LN	MP	LN	LP	LN	MN	HN	MN	LN	MN	HN	HP	-	HP	HN	HP

Table A9 Correlation Matrix for CBD Fringe / OBD Area with 1-mile Buffer Width

OBD_1mile	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1
3	LN	LN	1
4	LP	MP	LN	1
5	LN	LN	MP	LP	1
6	LP	HP	LN	LP	-	1
7	-	LP	LN	LP	MP	MP	1
8	LN	LN	LP	LN	HP	-	-	1
9	LN	MN	LP	LN	LP	MN	-	-	1
10	LP	LP	-	MP	LN	MN	LN	MN	LN	1
11	LP	LN	MP	-	HP	LP	MP	MP	LP	LN	1
12	-	HP	LN	-	LN	HP	LP	LN	MN	LN	LN	1
13	LP	LP	LN	MP	LP	MP	HP	-	LN	MN	MP	MP	1
14	LP	HP	LN	HP	-	HP	HP	LN	LN	LN	LP	MP	MP	1
15	LN	LN	MP	LP	MP	LN	LP	LP	-	LP	LP	-	-	LN	1
16	LN	LN	LN	LN	-	LN	LN	-	-	LN	-	-	LN	LN	LN	1
17	LN	LN	LN	LN	MP	LN	MP	LN	-	LN	LN	LN	LP	LN	LN	-	1
18	LN	LP	LN	LP	LN	MP	MP	LN	MP	LN	-	MP	MP	MP	LP	LN	LN	1
19	MN	MN	LP	MN	LP	LN	LP	-	MP	LN	-	-	LN	LN	LP	-	LP	LP	1
20	LN	MN	-	MN	LP	-	-	MP	LP	MN	-	LP	LP	MN	LP	HP	LP	-	LP	1
21	LP	HP	LN	HP	LP	HP	HP	LN	LN	LN	LP	MP	MP	HP	-	LN	LN	MP	-	MN	1
22	LP	LP	LN	-	-	LP	LP	LP	LP	LN	LP	LP	MP	-	-	-	LN	LP	LN	MP	LP	1
23	-	LP	LN	LP	LN	LP	-	LN	LN	LP	LN	MP	LP	LN	MP	-	LN	MP	-	LP	-	MP	1
24	LP	HP	MN	HP	LN	HP	MP	MN	MN	MP	LN	HP	MP	HP	LP	LN	LN	MP	LN	LN	HP	LP	HP	1
25	-	LP	LN	LN	LN	-	MN	LP	LP	LN	LN	LP	-	LN	LN	MP	LN	-	LN	MP	LN	MP	LP	LN	1
26	LP	MP	LN	HP	LP	MP	HP	-	LP	-	MP	LP	MP	MP	MP	LN	LN	HP	-	LN	HP	MP	MP	HP	-	1
27	-	LN	MP	-	MP	LN	LP	LP	MP	-	HP	LN	-	LN	MP	-	LN	MP	MP	-	LP	MP	LP	-	-	HP	1
28	LP	HP	MN	MP	LN	HP	LP	LN	LN	LN	-	HP	LP	HP	LN	LN	LN	MP	LN	LN	HP	LP	LP	MP	MP	MP	LN	1
29	LN	MN	-	MN	LP	LN	LP	MP	-	MN	LP	LP	LP	MN	-	MP	MP	LN	MP	HP	MN	MP	LP	MN	LP	LN	LP	LN	1
30	LP	LP	LP	MP	-	MN	LN	LN	-	HP	-	MN	MN	LN	MP	LN	LN	LN	LN	MN	LN	LN	LP	LP	LN	LP	LP	LN	MN	1
31	MP	HP	LN	MP	LN	HP	LP	LN	MN	LP	-	LP	-	HP	LN	MN	LN	-	MN	HN	HP	-	LN	HP	LP	MP	LN	HP	HN	LP	1
32	-	LP	LN	-	LN	MP	LP	LP	LN	LN	-	HP	HP	LP	LP	-	LN	LP	-	LP	LP	HP	HP	MP	LP	MP	LP	LP	LP	MN	-	1
33	MP	HP	LN	MP	-	HP	MP	LN	LN	LP	MP	LP	MP	HP	LN	LN	LN	-	LN	MN	HP	MP	-	MP	LN	MP	LP	MP	LN	LP	HP	LP	1
34	LN	LN	LN	LN	LP	-	LP	-	LN	LN	LN	LP	LP	LN	-	LP	HP	-	LP	HP	LN	-	LP	LN	LP	LN	LN	LN	HP	LN	MN	-	MN	1
35	LP	MP	-	LP	LP	HP	LP	-	MN	LN	LP	MP	LP	HP	LP	-	LN	LP	LN	-	MP	LN	LP	MP	LN	LP	LN	MP	LN	LN	MP	-	LP	-	1
36	LN	MN	LP	HN	LP	LN	LN	MP	LP	MN	LP	-	LP	MN	LP	MP	LP	LN	LP	HP	MN	LP	LP	MN	LP	MN	-	MN	HP	MN	HN	LP	MN	HP	-	1
37	HN	LN	-	-	-	LN	LN	-	LP	-	LN	-	LN	LN	LP	LN	-	LP	MP	-	-	-	-	-	LN	-	LP	LN	-	LN	LN	LP	LN	-	LN	LP	1
38	HN	MN	LP	LN	LP	MN	LN	LP	LP	LN	-	LN	LN	MN	LP	LN	-	LP	MP	LN	LN	LN	LN	MN	LN	LN	LP	LN	LN	-	MN	LN	MN	LN	LN	LP	HP	1
39	HN	LN	-	-	LP	LN	LP	LP	-	-	-	-	LN	LN	LP	-	LP	LP	LP	-	-	-	-	-	LN	LP	LP	LN	LP	-	LN	-	LN	LP	LN	LP	HP	HP	1
40	MN	MN	LP	LN	LP	LN	LP	LP	LP	LN	LP	LN	-	LN	LP	-	LP	LP	LP	LP	-	LP	-	LN	-	-	MP	MN	LP	-	MN	-	LN	-	LN	LP	HP	HP	HP	1
41	MN	LN	LN	LN	LN	LN	-	-	LP	LN	LN	LP	-	LN	LP	-	-	MP	LP	LP	-	LP	LP	-	LN	-	-	-	-	LN	LN	LP	LN	-	LN	LP	HP	HP	HP	MP	1
42	MN	LN	LN	-	LP	LN	LP	-	LP	-	-	LN	-	LN	LP	-	LP	-	LP	-	-	LN	LN	LN	LN	LN	-	LN	-	-	LN	-	LN	-	LN	-	HP	HP	HP	MP	HP	1
43	HP	MP	-	MP	LN	-	LN	LN	LN	MP	-	-	LN	LP	LP	MN	LN	-	LN	MN	LP	LN	LP	LP	LN	LP	-	LP	MN	MP	MP	LN	MP	LN	LP	MN	MN	MN	MN	MN	MN	MN	1
44	-	LN	LP	MN	-	LN	LN	LN	LP	LP	-	-	LN	LN	LP	LP	LP	-	MP	LP	LN	LN	LP	LN	LN	LN	-	MN	LP	LP	LN	LN	LN	LP	LN	LP	-	LP	-	LP	-	-	LP	1
45	MP	MP	LP	MP	LN	LP	LN	LN	MN	MP	-	-	LN	LP	-	-	LN	LN	MN	LN	-	LN	-	LP	-	LP	LN	LP	LN	MP	MP	LN	LP	LN	LP	LN	MN	MN	LN	LN	MN	MN	MP	-	1
46	MN	LN	LP	LN	LP	LN	LN	LP	LN	LP	-	LN	LN	MN	LP	-	LP	LN	LP	LP	MN	LN	-	LN	LN	LN	-	LN	LP	LP	LN	-	MN	LP	-	LP	LP	MP	MP	LP	LP	LP	MN	LP	-	1
47	HP	MP	LN	LP	LN	LP	-	LN	-	LP	LP	LP	-	LP	LN	-	LN	-	MN	LN	LP	LP	LP	MP	-	MP	-	LP	LN	LP	MP	-	MP	LN	LP	LN	MN	HN	MN	LN	MN	MN	HP	-	HP	HN	1
48	HP	MP	LN	LP	LN	LP	-	LN	-	LP	LP	LP	LP	LP	LN	-	LN	-	MN	LN	LP	LP	-	LP	LP	LP	-	LP	LN	LP	MP	-	MP	LN	LP	LN	MN	HN	MN	LN	MN	HN	HP	-	HP	HN	HP

Table A10 Correlation Matrix for Urban Area with 0.5 miles Buffer Width

0.5 miles_Urban	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	LP	1																																													
3	LN	LP	1																																												
4	LP	LP	LN	1																																											
5	LP	-	MP	LP	1																																										
6	-	MP	LN	LP	LN	1																																									
7	LP	LN	-	LP	HP	LN	1																																								
8	LP	LN	LN	LP	LP	LN	-	1																																							
9	-	LP	LN	MP	LP	LN	LP	LP	1																																						
10	LP	LP	-	LP	LP	LN	LN	LP	LP	1																																					
11	LP	-	-	MP	LP	LN	LP	HP	LP	LP	1																																				
12	LP	LP	MP	LN	LP	LN	-	LP	LP	LN	LN	1																																			
13	LP	LN	LN	LP	MP	LN	HP	-	-	LN	LP	LN	1																																		
14	-	LN	LN	LN	-	-	-	LN	-	LN	LN	-	-	1																																	
15	LN	LN	LN	LP	LN	LN	LP	LN	-	LN	LP	LN	LP	LP	1																																
16	LN	LN	LN	LN	-	LN	-	LN	LN	LP	LN	LN	LP	-	LP	1																															
17	LN	LN	LN	LP	LP	LN	MP	LN	LN	LN	LN	LN	MP	LP	LP	-	1																														
18	LN	LN	LN	-	LN	-	-	-	LN	LN	LN	-	LP	LP	-	LP	LP	1																													
19	LN	-	LN	LP	LP	LP	LP	LP	LP	LP	LP	-	-	-	-	LN	-	LN	1																												
20	-	LN	LN	LP	LN	LN	LP	LP	LP	LN	LP	LN	LP	-	LP	LP	LP	LN	LN	1																											
21	LP	LP	LN	MP	-	LP	LN	-	LP	LP	LP	LP	LN	-	LN	LN	LN	LN	-	-	1																										
22	LP	MP	MP	LP	LP	LP	LN	-	MP	LP	LP	LP	LN	-	LN	LN	LN	LN	-	-	LP	1																									
23	-	LP	LP	LP	-	LP	-	LN	MP	LN	LN	LP	-	MP	MP	LP	LP	-	LN	LP	LP	MP	1																								
24	LP	MP	LN	LP	LP	LP	LP	LN	MP	LN	LN	LN	LP	LP	LP	-	LP	-	LN	LP	LP	LP	HP	1																							
25	LP	LP	LN	LP	LP	LN	LP	LN	MP	LP	LP	LN	LP	-	-	LP	-	LN	-	LP	-	MP	LP	LP	1																						
26	LP	LP	LP	LP	LP	LN	LN	MP	LP	LP	MP	LP	LN	LN	LP	LN	LN	LN	-	LP	LP	MP	LP	LN	LP	1																					
27	LP	LP	MP	LP	MP	LN	LP	LP	LP	LP	MP	LP	LN	LN	LN	-	LN	LN	LP	-	-	MP	LP	LN	LP	HP	1																				
28	LP	LP	LP	LP	LP	LP	LN	-	LP	LP	LP	-	LN	LN	LN	LN	LN	-	LP	LN	LP	LP	LN	LN	-	LP	LP	1																			
29	LN	LN	LP	LN	LP	MN	LP	LP	LN	-	LP	LP	LP	LN	MP	LP	LP	LN	-	LP	LN	LN	LN	LN	LN	LP	-	LN	1																		
30	LP	LP	MP	MP	LP	LN	LN	LP	LP	MP	HP	LP	LN	LN	LN	LN	LN	LN	-	LP	LP	MP	LP	LN	LP	HP	HP	HP	LN	1																	
31	LP	HP	-	LP	LN	HP	LN	MN	-	LP	LN	-	LN	LN	MN	LN	LN	LN	LP	LN	LP	LP	-	LP	LP	LN	-	MP	MN	LP	1																
32	LP	LP	-	LP	-	-	-	LP	LP	LP	LP	LP	-	-	-	LN	-	LP	-	LP	LP	-	LP	-	LP	LP	LP	LP	-	MP	-	1															
33	LP	MP	LP	MP	-	LP	LN	LN	LP	LP	MP	LN	LN	LN	LN	LN	LN	LN	LP	LN	MP	MP	LP	LP	LP	LP	LP	LP	LN	LP	MP	LP	1														
34	-	LN	-	LN	LN	LN	LP	LP	LN	LN	-	LN	LP	-	LP	LP	LP	LN	LN	LP	LN	LN	-	-	LN	LP	LN	LN	HP	LN	LN	-	LN	1													
35	-	-	-	LN	LN	LP	LN	LN	LN	LN	LN	LN	-	LP	LP	LP	LN	LP	-	LN	LP	-	MP	LP	LP	LN	LN	LN	LN	LN	-	-	LP	LN	1												
36	LN	MN	LN	-	LP	LN	LP	MP	LN	-	LP	LN	MP	LN	MP	LP	LP	LP	-	MP	LN	MN	LN	LN	LN	LP	LN	LN	HP	LN	MN	LP	LN	HP	LN	1											
37	HN	LN	LP	LN	-	LN	LN	LP	LN	LN	-	LP	LN	-	LP	LP	-	-	LN	LN	LN	LN	LN	LN	LN	LP	-	LN	LP	LN	MN	-	LN	LP	LN	LP	1										
38	HN	LN	LP	LN	-	LN	-	LP	LN	LN	-	LP	LN	-	LP	-	LP	LN	LP	LN	-	LN	-	LN	LN	-	LN	LN	LP	LN	LN	LN	-	-	LN	LP	HP	1									
39	MN	LN	LP	LN	LN	-	LN	LP	-	LN	LN	LP	LN	LP	LP	LP	-	-	LN	LN	-	LP	LP	-	LN	LP	LN	LN	LP	LN	LN	LN	LN	LP	-	LP	HP	HP	1								
40	MN	LN	LP	LN	LN	LP	LN	LP	LN	LN	LN	LP	LN	LP	LP	LP	LP	-	LN	LN	-	LP	LP	-	LN	-	LN	LN	LP	LN	LN	-	-	LP	LN	LP	HP	MP	HP	1							
41	MN	LN	LP	LN	LN	-	LN	LP	LN	LN	-	LP	LN	-	LP	-	-	LP	-	LN	LN	LN	LN	LN	LN	-	-	-	LP	LN	LN	LP	LN	LP	LN	LP	HP	HP	HP	MP	1						
42	MN	LN	-	LN	LN	-	LN	LP	LN	LN	LP	LP	LN	-	-	LN	LP	-	-	LN	-	LN	LN	LN	LN	LN	LN	-	LP	-	LN	LP	LP	-	LN	LP	HP	HP	MP	MP	HP	1					
43	MP	MP	LP	LP	LP	LP	LP	LN	LP	LP	-	LP	LN	LN	LN	LN	LN	LN	LN	LN	LP	LP	LN	LP	LP	LP	LP	LP	LN	LP	LP	LN	LP	LN	-	LN	MN	MN	MN	MN	LN	LN	1				
44	-	LP	LP	-	LP	LP	LP	LP	-	LP	LP	LP	LP	-	LN	-	LP	LN	LP	LN	LP	LP	LP	LP	-	LP	LP	LP	LN	LP	LP	LP	LP	-	-	-	LP	LP	LP	LP	-	LN	LP	1			
45	MP	MP	LP	LP	LP	LP	LN	LN	LP	LP	LN	LP	LN	-	LN	LN	LN	LN	LN	LN	LP	MP	LP	LP	LP	LP	LP	LP	MN	LP	MP	LN	LP	LN	LP	HN	MN	MN	LN	LN	MN	MN	MP	LP	1		
46	LN	-	LP	LN	LN	LP	LN	LP	LN	-	-	LP	LN	-	-	-	LN	-	LP	LN	LN	-	-	-	LN	LP	LN	LN	-	-	LN	-	LP	LP	-	-	MP	MP	LP	LP	LP	LP	LN	LP	-	1	
47	MP	LP	LP	LP	-	LP	LN	LN	LP	LP	-	LN	LN	LP	LN	LN	LP	-	-	LN	LP	LP	LP	LP	LP	-	LP	LP	LN	LP	MP	-	LP	-	LP	LN	HN	HN	MN	LN	MN	MN	MP	LP	LP	LN	1
48	MP	LP	LP	LP	-	LP	-	LN	LP	LP	LP	LN	-	LP	LN	-	-	-	-	-	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LP	MP	-	LP	LN	HN	HN	MN	LN	MN	MN	MP	LP	LP	LN	HP

Table A11 Correlation Matrix for Urban Area with 1-mile Buffer Width

Urban_1mile	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	LP	1																																													
3	-	LP	1																																												
4	LP	MP	LN	1																																											
5	LP	LN	MP	LN	1																																										
6	-	MP	LN	LP	LN	1																																									
7	-	LN	-	-	HP	LN	1																																								
8	-	MN	LP	LN	MP	LN	-	1																																							
9	-	-	LP	LN	MP	LN	LP	LP	1																																						
10	LP	MP	LN	HP	LN	LP	LN	LN	LN	1																																					
11	LP	LN	LP	LP	LP	LN	LP	HP	MP	LN	1																																				
12	-	-	HP	LN	LP	LN	LN	LP	LP	LN	-	1																																			
13	-	LN	LN	LP	MP	LN	HP	LP	LP	LN	LP	LN	1																																		
14	LP	MP	LN	MP	LN	MP	-	LN	LN	LP	LN	LN	LN	1																																	
15	LN	LN	LN	LP	LP	LN	HP	-	LP	LP	LP	LN	HP	-	1																																
16	LN	MN	LN	LN	LP	LN	MP	-	LP	LN	-	LN	MP	LN	HP	1																															
17	-	MN	LN	-	MP	LN	HP	LN	LP	LN	LN	LN	HP	-	MP	HP	1																														
18	-	LP	LN	LP	LN	LP	LP	LP	LP	LN	LP	-	LP	LP	LP	LP	LP	1																													
19	-	-	LN	LN	-	LN	-	LP	-	LN	LP	LN	-	LN	LN	LN	LN	LN	1																												
20	-	MN	LN	LN	-	LN	LP	LP	LP	LN	LP	LN	MP	LN	LP	MP	LP	LP	LN	1																											
21	LP	MP	-	MP	LN	MP	LN	LN	-	-	-	-	LN	HP	LN	LN	LN	LP	LN	LN	1																										
22	LP	MP	MP	LP	LP	LP	LN	LP	MP	LP	LP	MP	LN	LP	LN	LN	LN	MP	LN	LN	LP	1																									
23	-	LP	-	MP	-	LP	LP	LP	LP	LP	LP	LP	LP	LP	HP	LP	LP	HP	LN	LP	LP	MP	1																								
24	LP	MP	LN	HP	LN	MP	LP	LN	-	HP	-	LN	LP	HP	MP	-	LP	MP	LN	LP	MP	LP	HP	1																							
25	LP	LP	LN	LP	LP	LP	-	LN	MP	LP	LP	LN	-	LP	-	LP	LP	LP	LN	LN	LP	MP	LP	LP	1																						
26	LP	LP	LP	MP	MP	-	LP	MP	LP	LP	MP	-	LP	LP	MP	LP	LP	LP	LN	LP	LP	MP	MP	MP	LP	1																					
27	LP	LP	HP	LP	MP	LN	-	LP	LP	LP	MP	LP	LN	-	-	LN	LN	LP	LP	LN	-	MP	LP	LP	LP	HP	1																				
28	-	LP	LN	LP	-	MP	LN	LP	LP	LP	LP	-	LN	MP	LN	-	LN	MP	LP	LN	MP	LP	LP	LP	MP	LP	LP	1																			
29	LN	MN	LP	LN	LP	LN	LP	MP	LP	LN	LP	LP	LP	LN	MP	LP	LP	-	-	MP	LN	LN	-	LN	LN	LP	-	LN	1																		
30	LP	MP	LP	HP	LP	LP	LN	LP	LP	HP	MP	LP	LN	LP	-	LN	LN	LP	LN	LN	LP	MP	LP	MP	MP	HP	HP	MP	LN	1																	
31	LP	HP	LP	MP	MN	HP	MN	MN	LN	LP	LN	-	MN	MP	MN	MN	MN	LN	-	MN	MP	MP	-	LP	LP	LN	LP	LP	MN	LP	1																
32	LP	LP	LN	LP	LN	LP	-	LP	LP	-	LP	-	LP	-	LP	LP	LN	HP	LN	LP	-	MP	HP	MP	LP	LP	LP	LP	LP	LP	-	1															
33	LP	MP	LP	MP	LN	LP	LN	LN	LP	LP	MP	-	LN	LP	LN	MN	LN	LN	LP	MN	MP	MP	LP	LP	LP	LP	LP	LP	LN	MP	HP	LN	1														
34	LN	MN	LN	LN	LP	LN	MP	LP	-	LN	LP	LN	MP	LN	HP	MP	LP	LN	-	HP	LN	MN	LN	LN	LN	LP	LN	MN	HP	LN	MN	LN	LN	1													
35	-	LP	-	LP	LN	MP	LP	LN	LN	-	LN	LP	LP	HP	LP	LP	LP	LP	LN	-	HP	-	LP	MP	LP	-	-	LP	LN	-	LP	LN	LP	LN	1												
36	LN	HN	LN	LN	LP	LN	MP	HP	LP	LN	LP	LN	MP	LN	MP	MP	LP	LP	-	HP	LN	MN	LP	-	LN	LP	LN	LN	HP	LN	HN	LP	MN	HP	LN	1											
37	HN	LN	LP	LN	LP	-	LN	LP	-	LN	LP	LP	-	LN	LP	-	LN	LN	LN	LN	-	LN	LN	LN	LN	LP	LN	LP	LP	-	LN	LN	LN	LP	LN	LP	1										
38	HN	LN	LP	LN	-	-	-	LP	LN	LN	LP	LP	-	LN	LP	LN	LN	LN	-	LN	LN	LN	LN	LN	LN	-	LN	LN	LP	LN	LN	LN	-	LP	LN	LP	HP	1									
39	MN	LN	LP	-	LN	-	LN	LP	LP	-	LP	LP	LN	-	LP	LN	LN	-	LN	LN	-	-	LP	-	LN	LP	LN	-	LP	-	LN	LN	LN	LP	-	LP	HP	HP	1								
40	MN	LN	LP	-	LN	-	LN	LP	-	-	-	LP	LN	-	-	LN	LN	-	LN	-	LP	-	LP	-	LN	LP	LN	LN	LP	LN	LN	-	LN	LP	-	LP	HP	MP	HP	1							
41	MN	LN	LP	-	LN	LP	LN	LP	LN	-	LP	LP	LN	-	LP	LN	LN	-	-	-	-	LN	-	-	LN	LP	LN	LP	LP	LP	LN	LP	LN	LP	LN	LP	HP	HP	HP	MP	1						
42	MN	LN	LP	LN	LN	LP	LN	LP	LN	-	LP	LP	LN	LN	-	LN	LN	LN	LP	-	-	LN	LN	LN	LN	-	LN	LP	LP	-	-	-	LN	LP	LN	-	HP	HP	MP	MP	HP	1					
43	MP	MP	LP	LP	LP	LP	LN	LN	LP	LP	-	LP	LN	LP	LN	LN	LN	LN	LN	LN	LP	MP	LN	-	LP	LP	LP	LP	LN	LP	MP	LN	LP	MN	LP	MN	MN	MN	MN	MN	LN	LN	1				
44	-	LP	LP	-	LN	LP	LN	LP	LP	-	LP	LP	LN	-	LN	LN	LN	-	LP	LN	-	LP	LP	-	-	LP	LP	LP	LN	LP	LP	LP	LP	LN	-	LN	LP	LP	LP	LP	-	LN	LP	1			
45	MP	MP	MP	LP	LP	LP	LN	LN	LP	LP	LN	LP	MN	LP	LN	LN	LN	LN	LN	MN	LP	MP	-	-	MP	LP	LP	LP	MN	MP	MP	LN	LP	MN	LP	HN	MN	MN	LN	LN	MN	MN	MP	LP	1		
46	LN	-	LP	LN	LN	-	LN	LP	-	LN	LP	LP	LN	LN	LN	LN	LN	LN	LP	LN	LN	-	-	LN	LN	LN	-	LN	-	LN	LN	LN	LP	-	LN	LN	MP	MP	LP	LP	LP	LP	LN	LP	-	1	
47	MP	MP	LP	LP	LP	LP	-	LN	LP	LP	LN	LN	LN	LP	LN	-	-	LP	LP	LN	LP	LP	LP	LP	LP	LP	LP	-	LN	LP	MP	-	LP	LN	LP	LN	HN	HN	MN	LN	MN	MN	MP	LP	LP	LN	1
48	MP	MP	LP	LP	LP	LP	-	LN	LP	LP	-	LN	LN	LP	-	-	-	LP	LP	LN	LP	LP	LP	LP	LP	LP	LP	-	LN	LP	LP	LP	LP	LN	LP	LN	HN	HN	MN	LN	MN	MN	MP	LP	LP	LN	HP

Table A12 Correlation Matrix for Speed Limit < 45 mph with 0.5 miles Buffer Width

0.5miles_<45 mph	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	LN	LN	1																																												
4	HP	MP	LN	1																																											
5	-	LN	LP	LN	1																																										
6	MP	HP	LN	HP	LN	1																																									
7	LP	LP	LN	LP	MP	LP	1																																								
8	LN	MN	LP	MN	LP	MN	LN	1																																							
9	-	LN	-	LP	LP	LN	-	LP	1																																						
10	LN	-	-	LP	LN	LN	LN	LN	LN	1																																					
11	LN	LN	-	LN	LP	LN	MP	HP	LP	LN	1																																				
12	LN	LN	LN	LN	-	-	-	LP	LN	LN	-	1																																			
13	HP	HP	LN	HP	-	HP	MP	MN	LP	LN	LN	LN	1																																		
14	LP	LP	LN	-	LP	LP	HP	LN	LN	LN	LP	MP	-	1																																	
15	HP	HP	-	HP	LN	HP	LP	MN	LP	-	LN	LN	HP	LN	1																																
16	LN	MN	LP	LN	LP	LN	LN	LP	LP	LN	-	-	LN	LN	LN	1																															
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1																														
18	MP	MP	LN	MP	LP	MP	MP	LN	LN	LN	LN	LN	HP	LP	MP	LN	-	1																													
19	LN	LN	-	LN	LP	LN	LN	LP	-	LN	LP	LP	LN	LN	LN	LP	-	LN	1																												
20	-	LN	LP	LN	LP	LN	LN	LP	LP	LN	LN	LP	-	LN	LN	LP	-	LN	LN	1																											
21	-	LP	LN	-	LP	LP	MP	-	LN	-	LP	LP	LN	HP	LN	LN	-	MP	LP	LN	1																										
22	HP	HP	LN	MP	LN	MP	LP	LN	LP	-	LN	LN	HP	LN	HP	LN	-	MP	LN	LP	LN	1																									
23	HP	HP	LN	HP	LN	HP	LP	MN	-	-	MN	LN	HP	LN	HP	LN	-	HP	LN	-	LN	HP	1																								
24	HP	HP	LN	HP	LN	HP	MP	MN	LN	-	LN	LN	HP	LP	HP	LN	-	HP	LN	LN	LP	HP	HP	1																							
25	MP	HP	LN	HP	LN	MP	-	LN	LP	-	LN	LN	HP	LN	HP	LP	-	MP	LN	LP	LN	HP	HP	HP	1																						
26	HP	HP	LN	HP	LN	HP	LP	LN	-	LP	-	LN	HP	LP	HP	LN	-	MP	LN	-	LP	HP	HP	HP	HP	1																					
27	MP	MP	-	MP	LP	LP	LP	LP	LP	LP	LP	LN	MP	-	MP	LN	-	MP	LN	LP	-	HP	HP	HP	MP	HP	1																				
28	LP	LP	LN	MP	LN	MP	LN	LN	-	LN	-	LN	LP	LP	LP	LN	-	LP	LN	LN	LP	-	LP	LP	LP	LP	-	1																			
29	LN	LN	HP	LN	LP	LN	-	LP	-	LN	-	LP	LN	LN	LN	LP	-	LN	LP	HP	LN	LN	LN	LN	LN	LN	LN	LN	1																		
30	LN	LN	-	-	-	MN	LN	LP	-	HP	MP	LN	MN	-	LN	-	-	MN	LN	LN	-	LN	LN	LN	LN	-	LP	LP	LN	1																	
31	MN	LP	-	LN	LN	LP	LN	-	LN	LP	-	LP	MN	LP	MN	LN	-	MN	LP	LN	LP	MN	MN	MN	MN	LN	LN	LP	LN	LP	1																
32	HP	HP	LN	HP	LN	MP	LP	LN	-	LN	LN	LN	HP	LN	HP	LN	-	MP	LN	LP	LN	HP	HP	HP	HP	HP	MP	LP	LN	LN	MN	1															
33	LN	LP	LN	LN	LN	-	LP	LN	-	MP	LP	LP	MN	MP	LN	LN	-	LN	LN	LN	LP	LN	LN	LN	LN	LP	LP	-	LN	HP	MP	LN	1														
34	LN	LN	HP	LN	-	LN	-	LP	-	LN	LN	-	LN	LN	LN	LP	-	LN	-	MP	LN	LN	LN	LN	LN	LN	LN	LN	HP	-	LN	LN	LN	1													
35	LP	LP	LN	-	-	LP	MP	LN	LN	LN	LP	MP	LP	HP	-	LN	-	LP	LN	LN	MP	LP	LP	MP	LN	LP	LP	LP	LN	LN	LP	-	MP	LN	1												
36	LN	MN	MP	LN	LP	MN	LN	MP	LP	LN	LP	LP	LN	LN	LN	MP	-	MN	-	HP	LN	LN	LN	MN	LN	LN	-	LN	HP	-	MN	LN	LN	HP	LN	1											
37	LP	MP	-	MP	LN	MP	LP	LN	LN	LP	LN	LP	MP	LP	MP	LN	-	LP	LN	LP	LP	MP	MP	MP	LP	MP	MP	LP	-	-	LN	MP	-	LP	LP	-	1										
38	LN	LP	LP	LN	-	LN	LN	LP	LP	LP	LP	-	LN	LN	LN	LN	-	LN	LP	-	LP	-	LN	LN	-	-	-	-	LN	LP	MP	-	LP	LN	LN	-	LN	1									
39	LP	LP	LP	LP	LN	LP	-	LN	-	LP	LN	LP	LP	LP	LP	LN	-	LP	LN	LP	LP	LP	LP	MP	LP	MP	LP	LP	-	-	LN	LP	LP	LP	LP	-	HP	-	1								
40	LN	LP	LP	-	LN	LP	LN	-	LP	LP	-	LP	-	LP	LP	LN	-	LP	-	LP	LP	LP	LP	LP	LN	LP	LP	-	-	-	-	-	LP	-	LP	-	MP	LP	HP	1							
41	LP	MP	-	LP	LN	MP	LP	LN	LN	LN	LP	-	MP	LP	LP	LN	-	MP	MN	-	LP	LP	MP	MP	LP	MP	LP	LP	LN	-	-	LP	-	-	LP	LN	HP	-	LP	LP	1						
42	LP	MP	-	LP	LN	LP	LP	LN	LN	LN	LP	LN	LP	LP	LP	LN	-	LP	MN	LN	LP	LP	LP	LP	-	LP	LP	LP	LN	LP	LP	LP	LP	-	LP	LN	MP	LP	LP	LP	HP	1					
43	-	-	-	LP	MP	LN	LP	-	LP	LP	LP	LN	-	LP	-	LP	-	LN	LP	LN	LP	LN	LN	-	LN	-	LN	-	LN	LP	LP	LN	LP	LN	LP	LN	LN	LP	LN	LN	LN	LN	1				
44	LN	LN	LP	LN	LP	LN	LN	LP	LP	-	LP	LN	LN	LN	LN	LP	-	MN	MP	-	-	LN	LN	LN	-	LN	LN	-	LP	LP	LP	LN	LP	LP	LN	LP	LN	LP	LN	-	LN	LN	LP	1			
45	-	-	-	LP	-	-	LN	LN	-	MP	LN	LN	LP	-	LP	LP	-	LN	LN	LN	LN	-	LP	LP	LP	LP	-	-	LN	LP	LP	-	LP	LN	-	LN	-	-	-	-	-	LN	LP	LP	1		
46	LN	LN	LP	LN	LP	LN	LN	-	LP	LP	LN	LN	LN	LN	LN	LP	-	MN	LP	LP	LN	LN	LN	MN	-	LN	LN	-	LP	LP	LP	LN	-	-	LN	LP	LN	LP	LN	LN	LN	LN	LP	LP	MP	1	
47	LP	LP	-	LP	LP	LP	LP	-	LP	LP	LP	-	LP	LP	LP	-	-	LP	LN	LN	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LN	LP	LP	-	LP	LN	LP	-	LP	LP	LP	-	LP	LP	-	LN	1
48	LP	LP	-	LP	-	-	-	-	LP	LP	LP	-	LP	LN	LP	-	-	LP	LP	LN	LP	LP	LP	LP	LP	LP	LP	LP	-	-	LP	LN	LP	-	LP	-	LP	LP	-	LP	LP	-	-	-	LP	-	LN	HP

Table A13 Correlation Matrix for Speed Limit < 45 mph with 1-mile Buffer Width

1-mile_<45mph	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	LN	LN	1																																												
4	HP	HP	LN	1																																											
5	LP	LN	LP	LP	1																																										
6	MP	HP	LN	HP	LP	1																																									
7	MP	MP	LN	HP	HP	HP	1																																								
8	LN	MN	MP	LN	MP	LN	LN	1																																							
9	LN	LN	LP	LN	MP	LN	LN	MP	1																																						
10	LN	-	LP	LP	LN	MN	LN	LN	LN	1																																					
11	LP	-	LP	LP	MP	LP	MP	MP	LP	LN	1																																				
12	-	LP	LN	LP	LN	MP	LP	LN	MN	LN	LN	1																																			
13	HP	HP	LN	HP	LP	HP	HP	LN	-	LN	LP	LP	1																																		
14	-	MP	LN	HP	LP	HP	MP	LN	LN	LN	MP	MP	LP	1																																	
15	HP	HP	LN	HP	LP	HP	HP	LN	LN	LN	-	LP	HP	LP	1																																
16	LN	HN	LP	MN	LP	MN	LN	LP	LP	LN	-	LN	MN	LN	MN	1																															
17	LN	MN	LN	LN	LP	LN	LP	-	LP	LN	LN	LN	LN	LN	LN	HP	1																														
18	HP	HP	LN	HP	LP	HP	HP	LN	LN	LN	-	MP	HP	LP	HP	LN	LN	1																													
19	MN	MN	LP	MN	-	MN	MN	LP	LP	LN	-	LN	MN	LN	MN	MP	LP	MN	1																												
20	LP	-	LP	-	LP	LP	-	MP	LP	LN	LN	LP	LP	MN	MP	LP	LN	MP	-	1																											
21	-	MP	LN	HP	LP	HP	MP	LN	LN	LN	MP	MP	LP	HP	LP	LN	LN	LP	LN	MN	1																										
22	HP	HP	LN	HP	-	HP	MP	LN	-	LN	LP	LP	HP	-	HP	MN	LN	HP	MN	MP	-	1																									
23	HP	HP	LN	HP	LP	HP	MP	LN	LN	LN	LN	LP	HP	-	HP	MN	LN	HP	MN	MP	LP	HP	1																								
24	HP	HP	LN	HP	LP	HP	HP	LN	LN	LN	-	MP	HP	MP	HP	MN	LN	HP	MN	LP	MP	HP	HP	1																							
25	MP	HP	LN	MP	LP	MP	LP	LN	LP	LN	LN	-	HP	LN	HP	LN	LN	HP	MN	MP	LN	HP	HP	HP	1																						
26	HP	HP	LN	HP	LP	HP	HP	LN	LN	-	LP	LP	HP	MP	HP	MN	LN	HP	MN	LP	MP	HP	HP	HP	HP	1																					
27	MP	HP	-	HP	LP	HP	MP	LP	LP	-	MP	-	HP	LP	HP	LN	LN	HP	MN	MP	LP	HP	HP	HP	HP	HP	1																				
28	LP	MP	LN	MP	LP	HP	LP	-	-	LN	LP	LP	MP	MP	LP	LN	LN	MP	MN	-	MP	LP	LP	MP	LP	MP	LP	1																			
29	-	LN	MP	LN	LP	LN	-	MP	LP	LN	-	LP	-	MN	-	LP	LP	LN	MP	HP	MN	LP	-	LN	LP	LN	-	LN	1																		
30	LN	LN	MP	LN	LP	MN	LN	LP	LP	HP	MP	MN	MN	-	LN	-	LN	MN	-	MN	-	MN	MN	LN	MN	LN	-	LN	LN	1																	
31	MN	LP	-	LN	LN	LP	LN	LN	LN	MP	LP	LN	MN	MP	MN	LN	LN	MN	LP	HN	MP	MN	MN	LN	MN	LN	MN	LP	MN	MP	1																
32	HP	HP	LN	HP	-	HP	MP	LN	LN	LN	LN	LP	HP	-	HP	MN	LN	HP	MN	MP	-	HP	HP	HP	HP	HP	HP	LP	-	MN	MN	1															
33	LN	LP	LN	LP	-	LP	LP	LN	-	LP	MP	-	LN	HP	LN	LN	LN	LN	-	MN	HP	LN	MN	LN	MN	-	-	LP	MN	MP	HP	LN	1														
34	LN	MN	MP	LN	LP	LN	-	LP	-	LN	LN	LP	LN	LN	LN	MP	LP	LN	MP	MP	LN	LN	LN	LN	LN	LN	LN	LN	HP	LN	LN	LN	LN	1													
35	LP	MP	-	MP	LP	HP	MP	LN	LN	LN	LP	MP	LP	HP	LP	LN	LN	MP	LN	LN	HP	LP	LP	MP	LP	MP	LP	MP	LN	LN	LP	LP	LP	LN	1												
36	LN	MN	LP	MN	LP	MN	LN	HP	LP	LN	LP	LP	LN	HN	LN	MP	LP	LN	MP	HP	HN	-	LN	MN	-	LN	LN	LN	HP	LN	HN	-	MN	HP	MN	1											
37	LP	MP	-	MP	LP	MP	LP	LN	LN	LP	LN	LP	MP	LP	MP	LN	LN	MP	LN	LP	LP	MP	MP	MP	MP	HP	MP	LP	LP	LN	LN	MP	-	-	LP	-	1										
38	LN	LP	LP	LN	LN	-	LN	LP	LP	-	LP	LN	LN	-	LN	LN	LN	LN	LP	LN	LP	LN	LN	LN	LN	LN	-	-	LN	LP	MP	LN	MP	LN	LN	LN	LN	1									
39	LP	LP	LP	LP	-	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	MN	LN	LP	LN	LP	LP	MP	LP	LP	LP	MP	MP	LP	LP	-	LN	LP	LP	LP	LP	LP	HP	-	1								
40	LN	LP	LP	LP	LN	LP	LN	LP	LP	LP	LP	LP	LP	LP	LP	MN	MN	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	-	-	-	-	LP	LP	-	LP	-	MP	LP	HP	1							
41	LP	MP	-	MP	-	MP	LP	-	LN	LN	LP	LP	MP	LP	MP	MN	MN	MP	LN	LP	LP	MP	MP	MP	LP	MP	MP	MP	-	LN	-	MP	-	LN	LP	LN	HP	-	LP	LP	1						
42	LP	MP	-	MP	LN	LP	LP	-	LN	-	LP	LP	LP	LP	LP	MN	HN	LP	LN	-	LP	LP	LP	LP	LP	MP	MP	LP	-	LP	LP	LP	LP	LN	LP	LN	MP	LP	LP	LP	HP	1					
43	-	-	LP	LP	MP	LN	LP	LN	LP	LP	LP	LN	LN	LP	LN	LP	LP	LN	LP	MN	LP	LN	LN	LN	LN	LN	LN	-	LN	LP	LP	LN	LP	-	LP	LN	LN	LP	LN	LN	LN	LN	1				
44	LN	MN	LP	LN	LP	MN	LN	LP	MP	LP	LP	LN	MN	LN	MN	MP	LP	MN	MP	LN	LN	MN	MN	MN	LN	MN	LN	LN	LP	MP	LP	MN	LP	LP	LN	LP	LN	LP	LN	-	LN	LN	LP	1			
45	-	-	LP	LP	LP	-	LN	LN	LN	MP	LN	LN	LN	-	LN	-	-	LN	LN	LN	-	LN	LN	LN	LN	LN	LN	LP	LN	LP	LP	LN	LP	LN	-	LN	-	-	-	-	-	LN	LP	LP	1		
46	LN	LN	LP	MN	LP	MN	LN	LP	LP	LP	LP	MN	MN	LN	MN	LP	LP	MN	LP	LN	LN	LN	MN	MN	LN	MN	LN	LN	-	LP	LP	MN	-	LP	MN	LP	LN	LP	LN	LN	LN	LN	LP	LP	MP	1	
47	LP	LP	-	LP	LP	LP	LP	LN	-	LP	LN	LP	LP	LP	LP	LN	-	LP	LN	-	LP	LP	LP	LP	-	LP	-	LP	LN	-	-	-	LP	-	LP	LN	LP	-	LP	LP	LP	-	LP	LP	-	LN	1
48	LP	LP	-	LP	LP	-	LP	LN	-	LP	LN	LP	LP	LN	LP	-	LP	LP	LP	LP	LN	LP	LP	LP	LN	-	LN	-	LP	-	LN	-	-	LP	LN	LP	LP	-	LP	LP	-	-	-	LP	-	LN	HP

Table A14 Correlation Matrix for Speed Limit between 45 - 50 mph with 0.5 miles Buffer

0.5 miles_ 45 to 50 mph	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	-	1																																													
3	LN	LP	1																																												
4	LP	LP	LN	1																																											
5	-	-	MP	LN	1																																										
6	LN	MP	LN	-	LN	1																																									
7	LN	LN	-	-	MP	LN	1																																								
8	LP	LN	LN	-	LP	LN	-	1																																							
9	-	-	LN	-	LP	LN	-	LP	1																																						
10	LP	-	LN	HP	LN	LN	-	LN	LN	1																																					
11	LP	LN	-	LP	LP	LN	LP	HP	LP	-	1																																				
12	LP	LP	MP	LN	LP	-	-	LP	LP	LN	LN	1																																			
13	LN	-	LN	LN	LP	LN	HP	-	LN	LN	LP	LN	1																																		
14	LN	-	LN	LP	LP	LP	-	-	-	LP	-	-	-	1																																	
15	LP	LN	LN	MP	LN	LN	LP	LN	LP	MP	LP	LN	LN	-	1																																
16	LN	LN	LN	LN	-	LN	-	LN	LN	-	LN	LN	-	-	LP	1																															
17	LN	LN	LN	-	MP	LN	HP	LN	-	-	-	-	HP	-	LN	-	1																														
18	LN	LN	LN	LP	-	LN	LP	LN	-	-	LP	LN	LP	HP	MP	-	-	1																													
19	LN	-	LN	-	LP	LP	LP	LP	LP	-	LP	-	-	LN	-	-	-	LN	1																												
20	LN	LN	LN	-	LN	LN	-	LP	LP	LN	-	LN	LP	LP	LP	LP	-	LP	LN	1																											
21	LP	LP	LN	LP	-	LP	LP	-	-	LP	LP	-	LN	LP	LP	LN	LN	MP	-	LN	1																										
22	-	HP	MP	LP	LP	LP	LN	-	MP	-	LP	LP	LN	LP	LN	LN	LN	LP	LN	LP	LP	1																									
23	-	MP	-	MP	-	-	-	LN	LP	MP	LN	-	LP	LP	MP	LP	-	LP	LN	MP	LP	MP	1																								
24	-	MP	LN	HP	LN	LP	-	LN	-	HP	LN	LN	LP	MP	MP	LN	-	LP	LN	LP	LP	MP	HP	1																							
25	LN	LP	LN	LP	LP	LN	-	-	HP	LN	LP	LN	LN	LP	-	-	-	LP	-	LP	LP	MP	LP	LP	1																						
26	LP	LP	-	HP	LP	LN	LP	LP	LP	MP	MP	-	-	MP	HP	LN	LN	HP	LN	LP	MP	MP	HP	MP	LP	1																					
27	LP	-	LP	LP	MP	LN	LP	LP	LP	LP	MP	LP	LN	LP	MP	LN	LN	MP	LP	LP	LP	LP	LP	LP	LP	HP	1																				
28	LN	LP	LP	LN	LP	LP	LN	-	LP	LN	LP	-	LN	LP	MN	LN	LN	-	LP	LN	-	LP	LN	LN	LP	LN	LN	1																			
29	LN	LN	LP	LN	LP	LN	LP	MP	-	LN	MP	LP	LP	-	LP	LP	-	-	-	LP	LN	LN	LN	LN	LN	-	LP	LN	1																		
30	LP	LP	LP	HP	LP	LN	-	LP	LP	HP	MP	LP	LN	-	MP	LN	LN	LP	-	LN	LP	MP	LP	MP	LP	HP	HP	LP	LN	1																	
31	LN	MP	-	LP	LN	MP	LN	LN	-	-	-	-	LN	LP	MN	LN	LN	LN	LP	LN	LP	LP	LN	-	LP	LN	LN	MP	MN	LP	1																
32	LN	LP	LN	LN	LP	LP	LP	LN	LN	LN	LN	-	LP	LP	LN	LN	-	LP	LN	LP	LP	LP	MP	MP	LP	LP	LP	LP	-	LN	LN	1															
33	LP	MP	LP	MP	LN	LP	LN	LN	-	LP	LP	LN	LN	LP	-	LN	LN	LN	-	LN	MP	LP	LP	LP	LP	-	LN	LP	LN	LP	MP	LN	1														
34	-	LN	LN	LN	LN	LN	-	LP	LN	LN	LP	LN	LP	-	LP	LP	LP	LN	-	-	LN	LN	LN	LN	LN	LN	LN	LN	HP	LN	LN	-	-	1													
35	LN	LP	LN	-	-	LP	-	-	LN	LN	LN	LN	LP	-	-	LP	LN	-	LN	LP	-	LP	MP	LP	LP	LP	-	LN	LN	-	-	LP	-	-	1												
36	LN	MN	LN	LN	LP	LN	LP	MP	-	LN	MP	LN	MP	-	LP	LP	LP	-	-	HP	LN	LN	-	LN	-	-	LP	LN	HP	LN	MN	LP	LN	MP	LP	1											
37	LN	LN	LP	LP	LP	LN	-	-	-	LP	-	LP	LP	LP	LP	-	-	LP	LN	LP	-	LP	LP	LP	-	LP	LP	-	LP	LP	MN	LP	-	LN	LP	LP	1										
38	MN	LP	LP	LN	LP	LP	-	LN	LN	LN	LN	LP	LP	MP	LN	LN	-	LP	LN	LP	LN	LP	LP	LP	-	LP	LP	LP	-	LN	LN	MP	LN	LN	LP	-	MP	1									
39	LN	LP	LP	LP	LP	-	LP	-	LP	LP	LN	LP	LP	LP	LP	LP	LP	LP	MN	-	LP	LP	MP	MP	LP	LP	LP	LN	LN	LP	LN	MP	-	LN	LP	LN	HP	MP	1								
40	-	LP	-	-	LP	-	LP	LP	-	LN	LN	LP	LP	LP	-	LP	LP	LP	MN	LN	LP	LP	LP	LP	LP	LP	-	LN	-	-	LN	LP	-	-	LP	-	LP	LP	HP	1							
41	LN	LN	-	-	LN	-	-	-	LP	-	LN	LP	LP	LP	LP	-	-	LP	LN	LP	LN	LP	LP	LP	-	-	-	LP	LP	LN	LN	LP	LN	-	LP	LP	HP	MP	MP	LP	1						
42	LN	LN	LN	LP	LN	LP	LP	LP	-	-	LN	LP	LP	LP	-	LN	LP	LP	-	LP	-	-	LP	LP	LN	LN	LN	LP	-	LN	-	LP	-	LN	LP	-	MP	LP	MP	LP	HP	1					
43	MP	LP	LP	LP	LP	LP	-	-	-	LP	-	LP	LN	LN	LP	LN	LN	-	LN	LN	MP	LP	-	-	-	LP	LP	LP	LN	MP	LP	LN	LP	LN	LN	LN	LN	MN	-	-	LN	-	1				
44	MP	-	LP	LP	LP	-	LP	LP	LP	LP	LP	LP	-	MN	LN	-	LP	LN	LP	LN	LP	-	LN	LN	LN	LN	LP	LP	LN	LP	LP	MN	LP	-	LN	LN	MN	HN	LN	LN	LN	LN	HP	1			
45	LP	LP	MP	LP	LP	LP	LN	-	-	-	-	LP	MN	LN	LN	LN	LN	LN	-	LN	-	LP	LN	LN	LN	LN	LP	LP	LN	MP	MP	LN	LP	LN	-	MN	LN	LN	LN	-	MN	LN	LP	MP	1		
46	LN	LP	LP	LN	LP	LP	-	LP	LN	LN	-	LP	LP	-	LN	LN	LP	LN	LP	LN	MN	-	LN	LN	MN	LN	LN	-	LP	-	-	LN	-	LP	-	-	LN	LP	-	-	LN	LN	LN	LP	LP	1	
47	MP	LP	LP	LP	-	LP	LN	LN	LP	-	LP	LN	MN	LN	LP	LP	LN	LN	LP	LN	LP	LP	LN	LN	LP	-	LP	LP	-	LP	MP	LN	MP	LP	LN	LN	LN	MN	LN	-	LN	LN	MP	MP	LP	LN	1
48	LP	LP	LP	-	-	-	LN	-	LP	LN	LP	-	LN	LN	-	LP	LN	LN	LP	LN	LP	LP	LN	LN	LP	-	LP	-	-	LP	LP	LN	MP	LP	LN	LN	LN	MN	LN	LP	LN	LN	MP	MP	LP	LN	HP

Table A15 Correlation Matrix for Speed Limit between 45 - 50 mph with 1-mile Buffer Width

1-mile_45to50mph	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	-	1																																													
3	-	LP	1																																												
4	LN	MP	LN	1																																											
5	-	LN	MP	-	1																																										
6	LN	MP	LN	LP	LN	1																																									
7	LN	LN	LN	LP	HP	LN	1																																								
8	LP	LN	LP	LN	HP	LN	LP	1																																							
9	-	-	LP	LN	LP	MN	LP	LP	1																																						
10	LP	MP	LN	HP	LN	-	LN	LN	LN	1																																					
11	LP	LN	LP	LN	MP	LN	LP	MP	MP	LN	1																																				
12	-	LP	HP	LN	LP	-	LN	LP	LP	LN	-	1																																			
13	MN	LP	LN	HP	LP	LP	HP	-	-	LN	LN	-	1																																		
14	-	MP	LN	MP	-	LP	LP	LP	-	LP	LP	-	LP	1																																	
15	LN	LP	LN	HP	LP	LP	MP	-	LP	LP	-	LN	HP	-	1																																
16	LN	MN	LN	LN	LP	LN	MP	-	-	LN	LN	LN	LP	LN	LP	1																															
17	LN	MN	LN	LN	MP	LN	HP	LN	-	LN	LN	LN	MP	-	LP	HP	1																														
18	LN	LP	LN	MP	LN	LP	LP	LN	MP	LN	LN	-	HP	LP	HP	LN	-	1																													
19	-	LN	LN	LN	-	LN	-	LP	-	LN	LP	LN	LN	LN	LN	LN	LN	LN	1																												
20	LN	LN	LN	LP	-	LN	LP	LP	LP	LN	LN	LN	MP	LN	LP	LP	LP	LP	-	1																											
21	-	LP	LN	MP	LP	LP	LP	LP	LP	-	LP	-	LP	HP	LP	LN	LN	MP	LN	LN	1																										
22	LN	HP	MP	MP	LP	LP	LN	LP	MP	-	LP	MP	LP	LP	LP	LN	LN	MP	LN	LN	LP	1																									
23	LN	MP	LN	HP	LN	LP	LP	LN	LP	LP	LN	LP	HP	LP	HP	LN	LN	HP	LN	LP	LP	HP	1																								
24	LN	HP	LN	HP	LN	LP	LP	LN	LN	MP	LN	-	HP	MP	HP	LN	LN	HP	LN	LP	LP	MP	HP	1																							
25	LN	MP	LN	MP	LP	MP	LP	LN	LP	LP	LP	LN	LP	MP	LP	LP	LP	MP	LN	-	LP	MP	MP	MP	1																						
26	LP	MP	-	HP	MP	-	MP	LP	MP	LP	LP	-	MP	LP	HP	LN	-	HP	LN	LP	MP	MP	HP	HP	MP	1																					
27	LP	LP	MP	LP	MP	LN	LP	LP	LP	-	MP	LP	-	LP	LP	LN	LN	LP	-	LN	LP	MP	LP	LP	LP	HP	1																				
28	LN	MP	LN	MP	LP	MP	LP	LP	LP	-	LP	-	LP	MP	LP	-	LN	LP	LP	LN	MP	MP	LP	MP	HP	MP	LP	1																			
29	LN	MN	LP	LN	MP	LN	MP	HP	LP	LN	LP	LP	LP	LN	LP	LP	LP	LN	-	MP	LN	LN	LN	LN	LN	LP	-	LN	1																		
30	LP	MP	LP	MP	LP	LN	LN	LP	LP	HP	LP	LP	LN	LP	LP	LN	LN	LN	LN	MN	LP	LP	LP	LP	LP	HP	HP	LP	LN	1																	
31	-	HP	LP	LP	LN	MP	MN	LN	LN	LP	-	LP	MN	LP	LN	MN	MN	LN	-	HN	LP	LP	LN	-	LP	LN	LN	MP	MN	LP	1																
32	LN	MP	LN	HP	-	MP	LP	-	LN	LN	LN	LP	HP	LP	HP	LN	LN	HP	LN	MP	LP	MP	HP	HP	MP	MP	LP	LP	-	LN	LN	1															
33	LP	LP	LP	LP	LN	LP	LN	-	LP	LP	MP	LP	LN	LP	LN	LN	LN	LN	LP	MN	LP	LP	LN	-	-	-	LP	LP	LN	LP	HP	LN	1														
34	LN	MN	LN	LN	LP	LN	LP	LP	LN	LN	LP	LN	LP	LN	LP	LP	MP	LN	LP	MP	LN	MN	LN	LN	LN	-	LN	LN	HP	LN	MN	LN	LN	1													
35	-	MP	-	LP	-	MP	-	LP	LN	-	-	LP	LP	MP	MP	LP	LP	LP	LN	LP	LP	LP	MP	MP	MP	MP	LP	MP	LN	LP	LP	MP	LP	LN	1												
36	LN	MN	LN	LN	LP	LN	MP	MP	LP	LN	LP	LN	MP	LN	LP	MP	MP	LP	LP	HP	LN	MN	LP	-	LN	LP	-	LN	HP	LN	HN	LP	MN	HP	-	1											
37	LN	-	LP	MP	LP	LP	LP	LP	LP	-	-	LP	MP	-	LP	LP	LP	LP	LN	LP	LP	MP	MP	MP	LP	LP	LP	LP	LP	LP	LN	MP	LN	-	LP	LP	1										
38	MN	LP	LP	MP	LP	LP	LP	LP	LN	LN	LN	LP	HP	LP	MP	LN	LN	MP	LN	LP	LP	MP	HP	MP	LP	LP	LP	LP	-	LN	LN	HP	LN	LN	LP	LP	MP	1									
39	LN	LP	LP	MP	LP	-	LP	LP	LP	LP	-	LP	LP	LP	LP	LP	LP	LP	LN	-	LP	MP	MP	MP	MP	LP	LP	LP	-	LP	LN	LP	LN	LN	LP	LN	HP	MP	1								
40	-	LP	LP	LP	LP	-	-	LP	-	LP	-	LP	LP	LP	LP	-	-	LP	LN	-	LP	LP	LP	LP	LP	LP	-	-	-	LP	LN	LP	LN	LP	LP	-	LP	LP	HP	1							
41	LN	-	-	LP	-	LP	LP	LP	LP	-	LN	LP	MP	-	LP	LP	LP	MP	-	LP	LP	LP	MP	MP	LP	LP	-	LP	LP	-	LN	MP	LN	-	LP	LP	HP	MP	MP	LP	1						
42	LN	LN	LN	LP	LN	LP	LP	LN	-	LP	LN	LP	LP	-	LP	-	LP	LP	-	LP	-	-	LP	LP	LP	-	LN	LP	-	LN	-	LP	LN	LP	LP	-	MP	LP	MP	LP	HP	1					
43	MP	LP	LP	LN	-	LP	LN	-	LP	LP	LP	LP	MN	-	LN	MN	LN	LN	LN	MN	LP	LP	LN	LN	-	LP	LP	-	LN	MP	MP	MN	MP	MN	-	MN	LN	MN	-	-	LN	-	1				
44	MP	-	LP	MN	LN	LN	MN	LN	LP	LP	LP	LP	HN	LN	MN	LN	LN	LN	LP	LN	LN	LN	MN	MN	LN	LN	LP	LN	LN	LP	LP	MN	MP	LN	LN	LN	MN	HN	LN	LN	LN	LN	HP	1			
45	LP	LP	MP	LN	LP	LP	LN	LN	-	-	-	LP	MN	LN	MN	LN	LN	MN	-	MN	LN	LP	LN	MN	-	LN	LP	-	LN	LP	MP	MN	LP	LN	LN	MN	LN	LN	LN	-	MN	LN	LP	MP	1		
46	LN	LP	LP	LN	LP	LP	LN	LP	LN	LN	-	LP	LP	LN	LN	LN	LN	LN	LP	-	MN	-	-	LN	LN	LN	LN	LN	LP	LN	-	LP	-	LP	-	-	LN	LP	-	-	LN	LN	LN	LP	LP	1	
47	MP	LP	LP	LN	LN	-	LN	LN	LP	LP	LP	LN	MN	-	LN	-	LN	LN	LP	MN	-	-	LN	LN	-	LN	-	LN	LN	LP	MP	MN	MP	LN	-	LN	LN	MN	LN	-	LN	LN	MP	MP	LP	LN	1
48	LP	LP	LP	LN	LN	LN	LN	-	LP	LP	LP	-	MN	-	LN	LP	LN	LN	LP	MN	-	-	LN	LN	-	LN	-	LN	LN	LP	LP	MN	LP	LN	-	LN	LN	MN	LN	LP	LN	LN	MP	MP	LP	LN	HP

Table A16 Correlation Matrix for Speed Limit > 50 mph with 0.5 miles Buffer Width

0.5 miles_ >50mph	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	LP	1
3	LN	-	1
4	LP	HP	LN	1
5	MP	LP	-	MP	1
6	-	HP	LN	HP	LP	1
7	MP	MP	LN	MP	HP	LP	1
8	LN	LN	MP	LN	-	LP	LN	1
9	LN	LP	LN	MP	LP	-	MP	LN	1
10	LN	LN	-	LN	LN	LN	LP	LN	HP	1
11	-	LP	-	MP	MP	MP	MP	MP	MP	LP	1
12	LN	LN	-	LN	LN	LP	MN	LP	LN	LN	LN	1
13	LP	HP	LN	HP	HP	MP	HP	LN	LP	LN	LP	LN	1
14	MP	LN	-	-	-	-	-	-	LN	-	-	LN	-	1
15	LP	HP	LP	HP	LP	MP	MP	-	LP	LP	HP	MN	HP	LP	1
16	LN	LN	-	LN	-	LN	LN	-	LN	LN	LN	LN	LN	-	-	1
17	HP	LN	LN	-	HP	LN	MP	LN	-	LN	-	LN	LP	LP	-	-	1
18	LP	HP	LN	HP	MP	HP	MP	MN	LP	LN	LP	-	HP	-	MP	LN	LN	1
19	LN	LN	-	LN	LP	-	-	MP	LN	-	MP	LP	LN	LN	LN	LP	-	LN	1
20	MP	-	-	LN	-	LN	LN	-	MN	LN	LN	LN	LN	LP	-	-	LP	LN	LN	1
21	LP	MP	LN	HP	LP	HP	LP	LN	LP	LN	MP	LN	MP	-	LP	-	LN	MP	LN	LN	1
22	LP	HP	LN	HP	LP	MP	MP	LN	LP	-	LP	LN	HP	-	HP	-	LN	HP	MN	LN	LP	1
23	LP	HP	-	HP	LP	HP	MP	LN	MP	-	MP	LN	HP	-	HP	LN	-	HP	LN	LN	LP	HP	1
24	LP	HP	LN	HP	LP	HP	HP	LN	MP	-	MP	LN	HP	-	HP	LN	LN	HP	LN	LN	MP	HP	HP	1
25	LP	LP	LP	LP	HP	LN	MP	-	LP	-	LP	MN	HP	-	MP	-	LP	-	LN	LP	LN	LP	LP	LP	1
26	LN	HP	-	HP	-	MP	MP	-	HP	MP	HP	MN	MP	-	HP	-	LN	MP	LN	LN	MP	HP	HP	HP	LP	1
27	-	HP	LP	MP	-	-	MP	LN	HP	HP	MP	MN	LP	LN	HP	LN	LN	MP	LN	-	LP	MP	HP	HP	LP	HP	1
28	LN	MP	LN	MP	-	LP	LP	MN	HP	MP	-	-	LP	LN	-	-	MN	HP	LN	MN	MP	MP	LP	MP	LN	MP	MP	1
29	-	LN	MP	LN	LP	MN	-	MP	LN	LN	-	-	-	-	LN	MP	LP	LN	-	LP	LN	LN	LN	LN	LP	LN	LN	LN	1
30	LN	LN	LN	LN	LN	-	-	-	MP	MP	LP	LN	-	-	MP	LP	LN	LN	LN	-	LP	-	LP	-	LP	MP	LP	MP	LN	1
31	LN	-	LN	LN	MN	LP	MN	LP	MN	LN	LN	HP	LN	LN	MN	LN	MN	-	MP	LN	LN	-	LN	LN	LN	MN	MN	-	LN	-	1
32	LP	HP	LN	HP	LP	LP	LP	MN	LP	LN	LP	LN	HP	-	LP	LN	LN	HP	LN	MP	MP	HP	MP	HP	-	MP	MP	MP	-	LN	LN	1
33	LN	LN	LN	LN	-	LP	LN	MP	-	-	MP	-	LN	-	-	LP	LN	LN	HP	LN	-	LN	LN	LN	-	-	LN	-	-	LP	MP	LN	1
34	-	LN	HP	LN	-	LN	LN	MP	LN	LN	-	-	LN	LP	LN	LP	LP	LN	LN	-	LN	LN	LN	LN	-	-	LN	LN	HP	LN	LN	LN	LN	1
35	MP	-	-	-	-	MP	-	LP	LN	LN	LP	LN	-	MP	HP	LN	LN	-	LN	LP	-	LP	LP	LP	-	LP	-	LN	LN	LP	LN	-	-	-	1
36	-	MN	MP	MN	LP	LN	-	HP	LN	LN	LP	-	LN	-	LN	MP	LP	MN	LP	LP	LN	MN	MN	MN	LP	LN	MN	MN	HP	-	LN	LN	MP	MP	LP	1
37	HN	MN	-	MN	MN	LN	MN	LP	-	LP	LN	MP	MN	LN	MN	LP	MN	LN	LP	HN	-	LN	LN	LN	MN	-	LN	LP	-	LP	MP	MN	LP	LP	MN	-	1
38	MN	MN	-	LN	LN	MN	-	LN	MP	HP	LN	LN	MN	LN	LN	LP	LN	MN	-	LN	LN	LN	LN	LN	MN	LP	LP	LP	LP	LP	LN	LN	-	LP	MN	-	HP	1
39	HN	MN	-	LN	HN	LN	MN	LP	LP	LP	LN	MP	MN	LN	MN	LP	HN	LN	-	MN	LN	LN	LN	LN	HN	-	LN	LP	LP	LP	LP	LN	-	LP	LN	LN	HP	HP	1
40	HN	MN	LP	LN	MN	LN	LN	-	LP	MP	LN	-	LN	LN	LN	LP	MN	LN	-	HN	-	LN	LN	LN	MN	LP	LP	LP	-	LP	-	MN	-	LP	MN	LN	HP	HP	HP	1
41	HN	LN	-	LN	MN	-	LN	LP	LP	LP	-	MP	LN	LN	LN	LP	HN	-	LP	HN	-	-	-	-	MN	LP	-	LP	-	LP	MP	MN	LP	-	MN	LN	HP	HP	HP	HP	1
42	HN	LN	-	LN	HN	LN	MN	-	LP	HP	LN	-	MN	LN	LN	LP	MN	LN	LN	LN	LN	LN	LN	LN	MN	LP	LP	MP	-	MP	LN	LN	-	LP	LN	LN	HP	HP	HP	HP	HP	1
43	-	-	LP	LN	-	LN	LN	-	LN	-	LN	-	LN	LP	LN	LN	LP	LN	LN	LP	MN	-	LN	LN	-	LN	LN	LN	LN	LN	-	LN	LN	-	LN	-	LN	LN	LN	-	LN	-	1
44	LN	MN	-	HN	-	MN	LN	LP	LN	-	MN	LP	MN	-	LN	LP	LP	MN	LP	-	HN	LN	LN	MN	-	MN	LN	MN	LP	LN	LP	MN	-	-	LN	LP	LP	-	LP	-	LP	-	MP	1
45	LN	MP	MP	LP	LN	LP	MN	LP	-	LP	-	LN	-	-	LP	LN	MN	LP	LN	-	LN	LP	-	-	LN	LP	MP	LP	LN	-	LP	LP	-	LN	-	MN	-	-	-	LP	-	LP	HP	-	1
46	MN	LN	-	LN	HN	LP	HN	LP	LN	LP	LN	LP	MN	-	LN	-	HN	LN	LN	LN	-	-	LN	LN	MN	-	-	LP	LN	LP	MP	LN	LP	-	-	LN	MP	LP	MP	HP	MP	HP	LP	LN	MP	1
47	MP	LN	LN	-	LN	LN	LN	LN	LN	LN	LN	LN	LN	MP	-	-	HP	-	LN	LP	LN	-	-	-	-	LN	LN	LN	LN	LN	LN	LN	-	LP	-	-	MN	LN	MN	-	MN	LN	MP	-	-	LP	1
48	MP	LN	LN	-	LN	LN	LN	LN	LN	LN	LN	LN	LN	MP	-	-	HP	-	LN	LP	LN	-	-	-	-	LN	LN	LN	LN	LN	LN	LN	-	LP	-	-	MN	LN	MN	-	MN	LN	MP	-	-	LP	HP

Table A17 Correlation Matrix for Speed Limit > 50 mph with 1-mile Buffer Width

1-mile _ >50mph	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	LP	1																																													
3	LN	LN	1																																												
4	LP	HP	LN	1																																											
5	MP	-	LP	LP	1																																										
6	LP	HP	LN	HP	-	1																																									
7	HP	MP	LN	HP	HP	MP	1																																								
8	LN	MN	MP	MN	-	LN	HN	1																																							
9	LN	-	LN	LP	-	LN	LP	MN	1																																						
10	LN	-	LP	-	-	LN	LP	MN	MP	1																																					
11	LN	-	LP	LP	LP	-	-	LP	MP	LP	1																																				
12	LN	LP	LN	-	LN	MP	LN	MP	LN	LN	MN	1																																			
13	MP	HP	MN	HP	LP	HP	HP	MN	-	LN	-	-	1																																		
14	LP	HP	LN	HP	LP	HP	HP	LN	LP	-	LP	-	HP	1																																	
15	LP	HP	LP	HP	LP	HP	HP	MN	LP	LP	MP	LN	HP	HP	1																																
16	MP	MN	LN	LN	MP	LN	LP	LN	LP	LN	LP	MN	LN	LN	-	1																															
17	HP	LN	LN	LN	HP	LN	HP	LN	LP	LN	LN	LN	LP	LN	-	HP	1																														
18	LP	HP	LN	HP	LN	HP	MP	HN	MP	MP	-	LP	HP	HP	HP	LN	LN	1																													
19	MN	MN	-	MN	LN	LN	LN	MP	LP	LP	LP	LP	MN	MN	MN	LN	LN	LN	1																												
20	HP	LP	LN	LP	HP	-	HP	MN	LN	LN	-	MN	MP	LP	MP	HP	HP	-	HN	1																											
21	LP	HP	LN	HP	-	HP	HP	MN	LP	LP	LP	-	HP	HP	HP	LN	LN	HP	LN	-	1																										
22	LP	HP	LN	HP	-	HP	MP	MN	-	LP	LP	-	HP	HP	HP	MN	LN	HP	MN	LP	HP	1																									
23	LP	HP	LN	HP	-	HP	HP	MN	-	-	-	-	HP	HP	HP	LN	LN	HP	MN	LP	HP	HP	1																								
24	LP	HP	LN	HP	-	HP	HP	MN	-	-	-	-	HP	HP	HP	LN	LN	HP	MN	LP	HP	HP	HP	1																							
25	LP	HP	LN	HP	LP	HP	HP	MN	LP	-	LP	LN	HP	HP	HP	LN	LN	HP	MN	MP	HP	HP	HP	HP	1																						
26	LP	HP	LN	HP	LP	HP	HP	MN	MP	LP	LP	LN	HP	HP	HP	LN	-	HP	MN	LP	HP	HP	HP	HP	HP	1																					
27	-	HP	-	HP	-	MP	MP	MN	MP	HP	LP	LN	MP	MP	HP	MN	LN	HP	LN	-	HP	HP	HP	HP	HP	HP	1																				
28	LN	HP	MN	HP	LN	HP	-	LN	LP	-	-	HP	MP	HP	LP	MN	MN	HP	-	MN	HP	HP	MP	HP	MP	MP	MP	1																			
29	LN	LN	MP	LN	LN	LN	LN	LP	LN	LN	-	LN	LN	LN	LN	LP	-	MN	LP	LN	LN	MN	LN	LN	LN	LN	MN	MN	1																		
30	LN	LN	LP	-	-	LN	LN	LP	MP	MP	HP	LN	LN	LN	LP	LN	LN	LP	-	LN	-	-	-	LN	LP	-	MP	LP	LN	1																	
31	MN	LP	LN	LP	HN	MP	HN	MP	LN	LN	-	HP	-	LP	LN	MN	HN	-	MP	HN	LP	LP	-	LP	-	LN	LN	HP	-	-	1																
32	LP	HP	LN	HP	LN	HP	MP	MN	LN	-	-	LP	HP	HP	HP	LN	LN	HP	MN	LP	HP	HP	HP	HP	HP	HP	HP	MP	LN	LN	LP	1															
33	LN	LP	LP	LP	-	-	LN	MP	LP	-	HP	LN	-	LP	LP	-	LN	-	MP	LN	LP	LP	-	LP	LP	LP	-	LN	LP	LP	MP	-	1														
34	-	MN	LP	LN	LP	MN	LP	LP	LP	LN	LP	MN	LN	LN	LN	HP	MP	MN	LP	LP	LN	MN	MN	LN	LN	LN	HN	HN	HP	MN	LN	MN	LP	1													
35	MP	HP	-	HP	MP	MP	MP	LN	-	-	LP	LN	HP	HP	HP	-	-	MP	MN	HP	HP	HP	HP	HP	HP	HP	MP	-	LN	-	LN	MP	-	LN	1												
36	LP	HN	LP	HN	LP	MN	LN	MP	LN	MN	-	-	MN	HN	MN	MP	LP	HN	LP	LP	HN	HN	HN	HN	MN	HN	HN	HN	HP	LN	LN	MN	LN	MP	-	1											
37	HN	MN	-	MN	HN	LN	HN	LP	LP	LP	LN	MP	HN	LN	HN	LN	MN	LN	MP	HN	LN	MN	MN	MN	HN	MN	LN	LP	LP	LP	MP	MN	LP	-	HN	LN	1										
38	MN	MN	LP	LN	MN	MN	LN	LN	MP	HP	-	LN	MN	LN	LN	-	LN	-	LP	HN	LN	MN	MN	LN	MN	LN	LP	-	LP	LP	LN	LN	-	LP	HN	LN	HP	1									
39	HN	LN	-	LN	HN	LN	HN	LP	-	LP	LN	LP	MN	LN	MN	LN	HN	LN	LP	HN	LN	LN	MN	LN	MN	MN	LN	LP	LP	-	MP	LN	-	-	HN	LN	HP	HP	1								
40	HN	MN	LP	LN	MN	LN	MN	-	MP	MP	-	-	MN	LN	MN	LN	MN	-	LP	HN	-	MN	MN	LN	MN	LN	-	LP	LP	LP	LP	MN	LP	-	MN	LN	HP	HP	HP	1							
41	HN	-	-	LN	HN	-	HN	LP	LP	LP	LN	MP	MN	-	MN	MN	HN	LP	MP	HN	-	LN	LN	LN	MN	LN	LN	MP	LP	-	HP	-	LP	LN	MN	LN	HP	HP	HP	HP	1						
42	HN	LN	LP	LN	HN	LN	MN	LN	LP	HP	-	LN	MN	LN	LN	LN	MN	-	LP	HN	LN	LN	LN	LN	LN	LN	LP	-	LP	LP	-	LN	-	-	LN	LN	HP	HP	HP	HP	HP	1					
43	-	LN	-	LN	LP	LN	-	LP	-	LN	LN	LN	LN	LN	LN	-	LP	LN	-	LP	LN	LN	LN	LN	LN	LN	LN	LN	LN	-	LN	LN	LN	-	-	-	LN	LN	LN	-	LN	-	1				
44	LN	MN	-	MN	-	MN	LN	LP	-	-	LN	LP	MN	HN	MN	LP	LP	LN	LP	-	HN	MN	MN	MN	MN	MN	MN	LN	LP	LN	-	LN	LN	LP	LN	MP	LP	-	LP	-	LP	-	MP	1			
45	LN	LP	MP	LP	-	-	LN	LP	LN	LP	LP	LN	-	-	LP	MN	MN	-	LN	-	LP	LP	LP	LP	LP	LP	MP	LP	LN	MP	LP	-	LP	MN	LP	LN	-	-	-	LP	-	LP	HP	-	1		
46	MN	LN	LP	LN	MN	-	HN	LP	-	LP	-	LP	MN	LN	LN	MN	HN	-	LP	MN	LN	-	LN	LN	LN	MN	-	LP	LN	LP	MP	LN	-	LN	-	-	MP	LP	MP	HP	MP	HP	LP	LN	MP	1	
47	MP	LN	LN	-	MP	-	HP	LN	LP	LN	LN	LN	LP	-	-	MP	HP	-	LN	MP	LN	LN	-	LN	-	-	LN	LN	LN	LN	MN	LN	LN	LP	LP	LP	MN	LN	MN	-	MN	LN	MP	-	-	LP	1
48	MP	LN	LN	-	MP	-	HP	LN	LP	LN	LN	LN	LP	-	-	MP	HP	-	LN	MP	LN	LN	-	LN	-	-	LN	LN	LN	LN	MN	LN	LN	LP	LP	LP	MN	LN	MN	-	MN	LN	MP	-	-	LP	HP