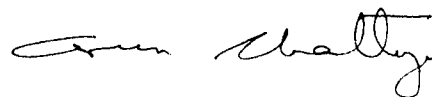


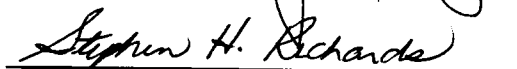
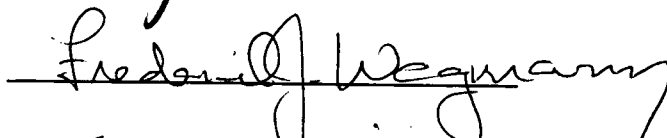
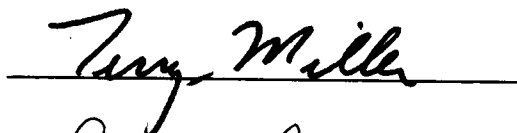
To the Graduate Council:

I am submitting herewith a dissertation written by Richard Anthony Margiotta entitled "Improved Vehicle Speed Estimation Procedures for Air Quality and Planning Applications." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Civil Engineering.

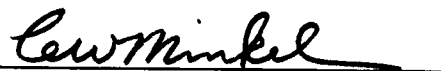


Arun Chatterjee, Major Professor

We have read this dissertation
and recommend its acceptance:



Accepted for the Council:



Associate Vice Chancellor and
Dean of The Graduate School

**IMPROVED VEHICLE SPEED ESTIMATION PROCEDURES
FOR AIR QUALITY AND PLANNING APPLICATIONS**

A Dissertation
Presented for the
Doctor of Philosophy Degree
The University of Tennessee, Knoxville

Richard Anthony Margiotta
December 1996

DEDICATION

For my family, especially my Dad.

ACKNOWLEDGEMENTS

I would like to thank several people who provided support and encouragement to me throughout this research. First, Dr. Arun Chatterjee provided superb guidance throughout the work and his suggestions were extremely helpful in maintaining the focus of the work. My good friend, Harry Cohen, provided many positive ideas when the research seemed to face the intractable. Rob Morris and Andy Dixson provided great support throughout the research and Sherry Atkins provided the best graphics support known to humans.

ABSTRACT

Estimation of vehicle speeds under various traffic and highway conditions is a high priority for transportation analysts. Speeds are used directly in air quality models to estimate vehicle emissions. Other measures such as vehicle delay and travel rate can be derived from speed estimates and are commonly used as the fundamental measures of urban area congestion. However, most prior research has focused on speed estimation for uncongested (i.e., unsaturated) traffic conditions. Further, the estimation process is more tenuous for transportation planning applications where very little input data are available.

This research focuses on the development, calibration, and application of a new methodology for estimating vehicle speeds for air quality and other transportation planning applications. The methodology uses data that are readily available to transportation planners and embodies several theoretical and practical concepts missing from traditional speed estimation methodologies. The main features of the approach include: the use of temporal distributions as a basis for developing hourly traffic estimates; accounting for daily variation in traffic by allowing hourly traffic estimates to vary stochastically; use of a capacity drop on freeways after flow has broken down; separate functions to estimate speeds in queuing and free flow conditions; and the use of highway capacity concepts to determine when traffic operates under free flow and queuing conditions as well as a basis for estimating free flow speeds and the extent of queuing. The new methodology has been developed in two forms: (1) a set of simple equations that can be applied to individual highway segments or network links and (2) a detailed method for tracking the speed characteristics of highway segments over time and space.

Application of the methodology at both the network and corridor levels leads to several

conclusions. The main conclusion is that as the extent of congestion grows (as defined by traffic in queues), the methodology predicts lower speeds than traditional methods; the more extensive queuing is, the larger this difference. Other conclusions include: traditional speed estimation methodologies produce a wide range of results and do not explicitly consider the effects of queuing; congestion is more appropriately related to AADT/C rather than to V/C; on signalized arterials, signal density and progression were found to be strong determinants of speeds.

TABLE OF CONTENTS

1. INTRODUCTION	1
1.1 Research Background	1
1.2 Purpose of the Research	1
1.2.1 Improved Speed Estimates for Air Quality Modeling	1
1.2.2 Other Transportation Planning Applications Requiring Speed Estimation	7
1.3 Requirements of Speed Estimation Procedures for Planning Applications	13
1.4 Overview of Dissertation	14
2. LITERATURE REVIEW OF COMMON SOURCES	20
2.1 Introduction	20
2.2 Summary of Literature Review	20
2.3 The Author's Previous Work on Speed Modeling	25
3. DISSERTATION METHODOLOGY	38
3.1 Introduction	38
3.2 Procedures for Validation Against Field Data	39
3.3 Adaptation of the Methodology to a Post-Processor for Travel Forecasting Models	40
3.4 Case Study Comparisons	43
4. SPEED MODEL (QSIM) DEVELOPMENT AND VALIDATION	48
4.1 Verification of the QSIM Model With Field Data	48
4.1.1 Introduction	48
4.1.2 Comparison of The QSIM Model With Freeway Data	48
4.1.3 Comparison of The QSIM Model With Arterial Data	56
4.2 Final QSIM Results	66
4.2.1 Introduction	66
4.2.2 Curve Fitting Procedure and Final Equations	71
5. APPLICATION OF THE SPEED MODELING PROCEDURE	82
5.1 Introduction	82
5.2 Application of the Equations to the Knoxville Planning Network	82
5.2.1 Background	82
5.2.2 Results and Implications for Congestion Management	86
5.2.3 Results and Implications for Air Quality Planning	89
5.3 Application of the Queuing Procedure to Test Corridors (QNET)	91
5.3.1 Background	91
5.3.2 Results and Implications for Congestion Management and Air Quality	94

6. CONCLUSIONS AND RECOMMENDATIONS	104
6.1 Conclusions	104
6.2 Recommendations	110
REFERENCES	112
APPENDICES	115
APPENDIX A: DETAILED LITERATURE REVIEW	116
APPENDIX B: TEMPORAL TRAFFIC DISTRIBUTIONS AND PEAK SPREADING PROCEDURE USED IN THE RESEARCH	133
APPENDIX C: QSIM RESULTS FOR FREEWAYS AND ARTERIALS	141
APPENDIX D: COMPARISONS OF QSIM RESULTS WITH FIELD DATA FOR CONGESTED FREEWAYS	185
APPENDIX E: KNOXVILLE NETWORK LINK COMPARISONS OF SPEEDS AND EMISSIONS	195
APPENDIX F: QSIM COMPUTER CODE (FREEWAYS)	210
VITA	214

LIST OF TABLES

TABLE	PAGE
Table 1.1. Potential Measures of Roadway Congestion	11
Table 2.1. AADT/C Levels and Corresponding AADT Values	28
Table 3.1. 1993 HPMS Data for I-25 (Denver) and I-4 (Orlando)	39
Table 3.2. Test Network for Freeways	45
Table 3.3. Test Network for Signalized Arterials	46
Table 4.1. 1993 HPMS Data for I-25 (Denver) and I-4 (Orlando)	50
Table 4.2. Queue Speeds from Denver and Orlando Freeway Data	52
Table 4.3. Application of NETSIM to N.J. Route 10 Dataset	61
Table 4.4. Effect of Progression on Vehicle Speeds	66
Table 4.5. Coefficients for Freeway Delay Equations	72
Table 4.6. Coefficients for Arterial Delay Equations	75
Table 4.7. VMT Proportions for Freeways	80
Table 4.8. VMT Proportions for Arterials	81
Table 5.1. Test Network for Freeways	92
Table 5.2. Test Network for Signalized Arterials	93
Table A.1. Capacity Reductions from the CA/T Project Analysis	121
Table B.1. Weekday Temporal Distributions	134
Table B.2. Final Weekend/Holiday Temporal Distributions	136
Table B.3. Modification Procedures for Temporal Distributions	138
Table B.4. Application of Smoothing Procedure to Selected AADT/C Ratios, Morning Peak Direction	140

LIST OF FIGURES

FIGURE	PAGE
Figure 1.1. The Air Pollution Modeling Process	3
Figure 1.2. Emissions vs. Speed (grams/mile for all vehicles) MOBILE5a	5
Figure 1.3. Forecasted Network Link Volumes vs. Reality	16
Figure 1.4. Hierarchy of Speed Estimation Procedures Used in this Dissertation	18
Figure 2.1. Overview of the QSIM Modeling Procedure	26
Figure 2.2. Average Coefficients of Variation from Urban ATR Sites	31
Figure 2.3. Original Uncongested Delay Functions from Reference (22)	34
Figure 3.1. Application of the Speed Methodology to Consider Queue Spillbacks	42
Figure 4.1. Comparison of QSIM's Uncongested Speed Function and Freeway Surveillance Data	49
Figure 4.2. Use of Freeway Surveillance Data in Model Calibration -- Congested (Oversaturated) Conditions	53
Figure 4.3. Example Speed Contour Plot: Orlando (I-4, Northbound)	54
Figure 4.4. Denver (I-25) Speed Data	57
Figure 4.5. Orlando (I-4) Speed Data	58
Figure 4.6. Comparison of QSIM Arterial Speed Function With Field Data	60
Figure 4.7. Comparison of Original and Revised NETSIM Runs	62
Figure 4.8. Arterial Speed Results, FFS=40	64
Figure 4.9. Arterial Speed Results, FFS=50	65
Figure 4.10. QSIM Results for Freeways (Combined All Days and Both Directions)	67
Figure 4.11. QSIM Results for Signalized Arterials (Combined All Days and Both Directions)	68
Figure 5.1. Basic Characteristics of the Knoxville Network, Year 2020	84
Figure 5.2. Volume-to-Capacity Ratios for the Knoxville Network, Year 2020	85
Figure 5.3. Example of Knoxville Link-by-Link Comparisons	87
Figure 5.4. Peak Hour Speed Post-Processing, Knoxville 2020 MINUTP Network	88
Figure 5.5. Emission Factor Equations Used for the Emissions Comparisons	90
Figure 5.6. Application of QNET Procedure to Test Network	95
Figure 5.7. Application of QNET Procedure to Freeway Test Corridor	96
Figure 5.8. QNET vs. BPR Speeds for a Highly Congested Freeway Corridor (Peak Direction)	99
Figure 5.9. Application of QNET Procedure to Arterial Test Corridor	100
Figure 5.10. QNET vs. HCM Speeds for a Highly Congested Arterial Corridor (Peak Direction)	102
Figure A.1. Comparison of Selected Arterial Speed Functions	127
Figure A.2. Speeds Produced By The BPR Function and Its Variants	130
Figure B.1. Example Temporal Distribution Used in the Study	137

1. INTRODUCTION

1.1 Research Background

In recent years there has been a great deal of interest in improving procedures for speed determination. Traditionally, transportation engineers and planners have been interested in traffic volume alone. However, the requirements of air quality models and other planning initiatives such as congestion management have forced a re-examination of the procedures for speed determination. Specifically, a real need exists for simplified methods of speed estimation for planning studies. These studies typically have very little base data available from which to make speed estimates. This dissertation is concerned with exactly such cases.

1.2 Purpose of the Research

1.2.1 Improved Speed Estimates for Air Quality Modeling

The focus of this research is to improve vehicle speed estimates that are used as inputs to the MOBILE¹ model maintained by the U.S. Environmental Protection Agency (EPA). Because speed estimation is required for many other transportation planning applications, the methodology and results are also applicable to them. Air quality planning requirements for speed estimation are covered in this section; other applications are discussed in the next section.

Public concern over the health problems associated with air pollution coupled with the legislative mandate of the Clean Air Act Amendments of 1990 (CAAA) have made air quality an issue of national significance. As part of the process for developing emission control and abatement strategies, a complex modeling process is used to estimate and forecast air quality

¹The MOBILE model has continuously undergone revision since its original development. MOBILE5.1 is the most recent release.

in urban areas. The emissions from mobile sources (vehicles) are major contributors to air pollution and in many urban areas mobile sources are the leading contributor. In particular, ozone air pollution in many urban areas is largely attributable to emissions of hydrocarbons and nitrogen oxides from vehicles. Areawide air quality studies and State Implementation Plans (SIPs) require accurate information on the temporal and spatial distribution of emissions (Figure 1.1). The modeling of mobile sources occurs as follows:

- Mobile source emission factors (grams of pollutant per mile driven) are obtained for different types of vehicles. The MOBILE model is used to estimate these factors -- expressed in grams of pollutant per vehicle-mile traveled. The pollutants covered by MOBILE are hydrocarbons (HC), carbon monoxide (CO), and nitrous oxides (NO_x). MOBILE takes into account climate, the current year (important because of the effect of vehicle age on emissions), traffic characteristics, vehicle factors, and fuel volatility. Emission factors for eight vehicle types are output from MOBILE as well as a composite factor which is a weighted average of the eight vehicle type factors, where the weights are the assumed percentage of vehicles in the traffic stream.
- The emission factors are multiplied by vehicle-miles of travel (VMT) for each vehicle type to obtain the emissions from mobile sources (grams of pollutant) by time of day and geographic location.
- The emissions from area and point sources are combined with mobile sources to obtain total areawide emissions. These total emissions are then input to a dispersion model that predicts pollutant concentrations by time of day and geographic location.

To date, an extensive amount of work has gone into the development and refinement of MOBILE and the dispersion models. However, the basic inputs to these models have not received much attention, calling into question the validity of their application. Specifically, the

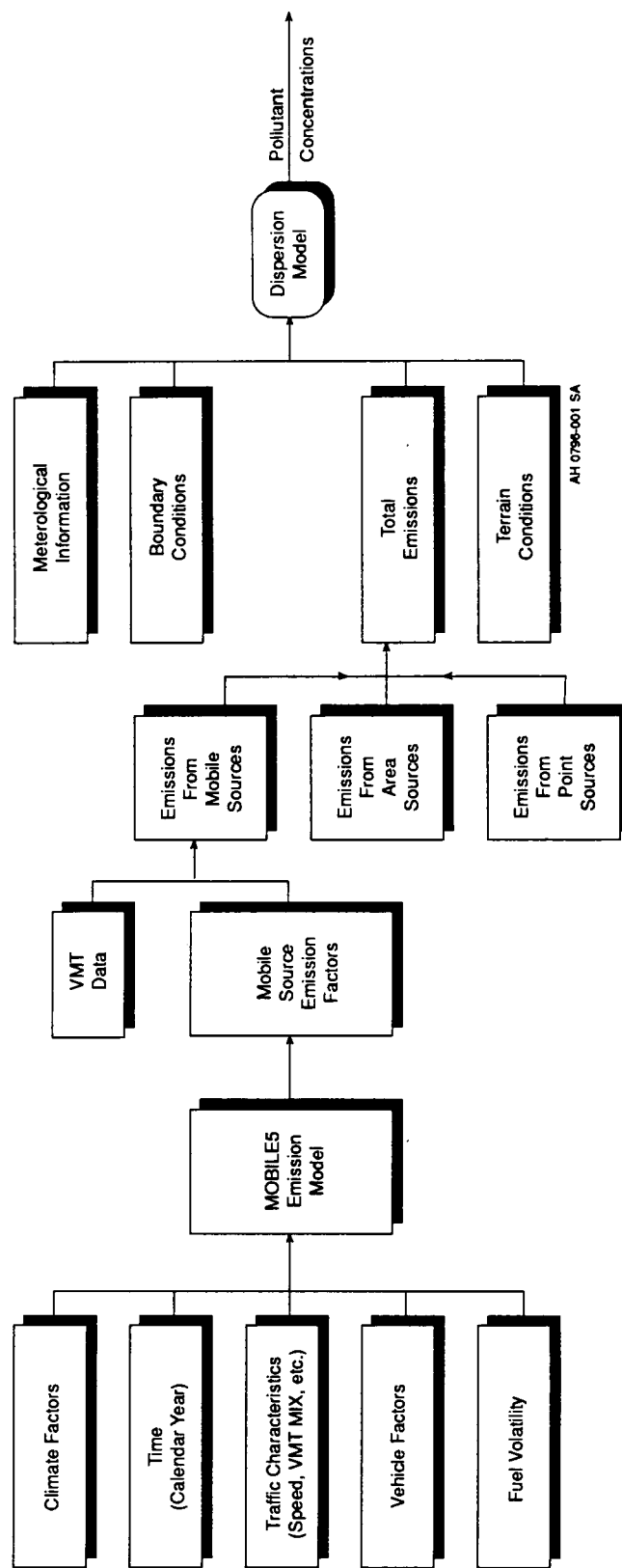


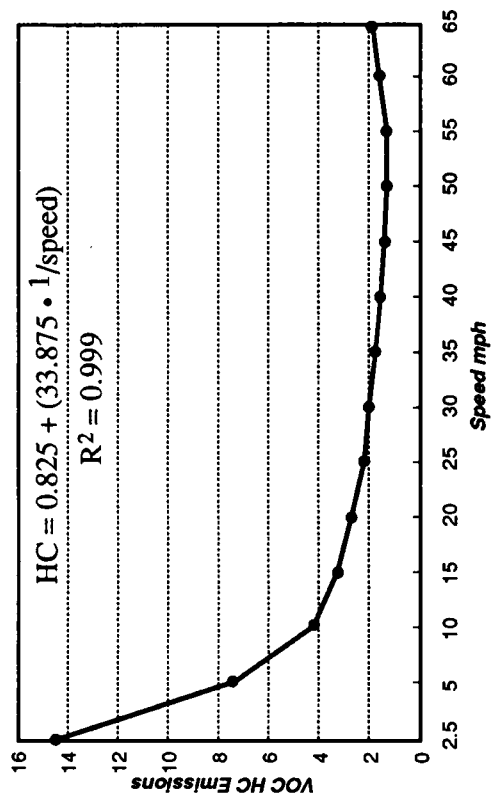
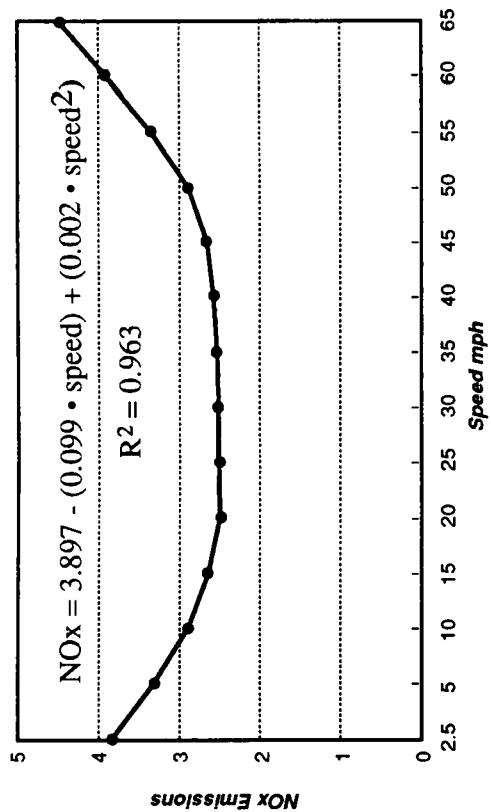
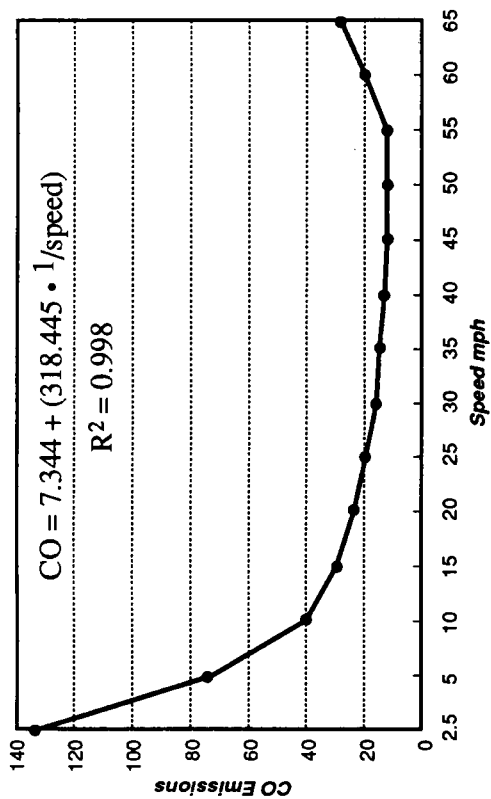
Figure 1.1. The Air Pollution Modeling Process

transportation inputs to air quality models are inadequate for preparing high resolution emission inventories for several reasons:

- The default values supplied by EPA are based on outdated and limited studies (for example, the default speed is based on the Federal Test Procedure {FTP} for approximating urban travel for fuel economy estimation);
- A tendency exists among analysts to use defaults in lieu of developing area-specific inputs;
- Time of day is seldom considered, thus, peak hour conditions are not separated from other time periods; and
- Even if analysts wanted to override the defaults with local data, almost no guidance exists to help them do so.

The time-of-day criticism is particularly germane given the level of detail in the dispersion models which require hour-by-hour estimates of pollutants by geographic location. Currently, the procedures to produce this level of detail are based on inadequate information.

MOBILE's results are particularly sensitive to speeds found under congested traffic conditions. The basic relationships for the major pollutant groups are shown in Figure 1.2. The functional form of the relationships for CO and HC is the same, i.e., emissions vary inversely with speed up to 55 mph and increase linearly between 55 and 65 mph. In the range of speeds typically found on uncongested facilities (e.g., 25 to 50 mph, which covers uncongested conditions on both freeways and signalized highways), CO, HC, and NO_x emissions are all relatively insensitive to changes in speed. However, below 20 mph, the effect of speed on emissions is strong: as speeds decrease from 20 to 5 mph, CO and HC emissions almost quadruple and NO_x emissions increase by about 40 percent. *Therefore, for air quality purposes, accurate estimation of speeds under congested traffic conditions is extremely important.*



Year = 1996
RVP = 7.8
Ambient Temperature = 75°F

Note: CO and HC equations valid for speeds ≤ 55 mph.

Figure 1.2. Emissions vs Speed (grams/mile for all vehicles) MOBILE5A

Because mobile sources are a major contributor to urban air pollution, transportation improvements can have a major impact on areawide emissions. In the course of identifying needed improvements, transportation planning generates much data that are directly applicable to air quality. Specifically, the travel forecasting process provides a base for estimating some of the transportation data needed by air quality models. This process is almost always based on forecasting travel on a network representation of the area's highway system, and thus can provide information on areawide VMT. Also, network assignments can be used to estimate vehicle speeds, but it is generally held that the speeds used to assign traffic are too crude for air quality analysis purposes, especially under congested flow (1 and 2.) There has been some discussion about integrating traffic simulation models with travel forecasting models to provide the desired level of precision, but this integration is hampered by intensive data requirements of the simulation models and the limitations of computers to simulate entire urban networks. (Simulation models are usually applied to small subnetworks.)

Highway traffic assignment procedures provide two major outputs for each link in the highway network: predicted volumes and speeds. Traditionally, the major purpose of the assignment process for transportation planners has been to obtain volumes for each highway facility; the corresponding speeds tend to be treated only as intermediate variables required to obtain realistic volumes. Modifications have been made, mainly on an *ad hoc* basis by local planners, to improve the speed estimation process. These take the form of either using alternative link speed functions to perform traffic assignment or "post-processing" the results of the final traffic assignment step to refine speed estimates. The standard traffic assignment process places significant limitations on the level of enhancement that is possible in volume-speed functions to be used in these processes. As outlined in (3), these limitations include:

- Because trips are assigned over distance but not over time, the dynamics of queues --

their build-up and dissipation over the peak period -- cannot be reflected in the required functions.

- Currently used assignment procedures are set up to use only the volume and characteristics of a given link to estimate its speed or travel time. The influence of queues "spilling back" from adjacent (downstream) links is not considered. In other words, links are considered in isolation from the dynamic traffic processes that operate in the field.
- The number of link descriptors is typically limited to no more than four to eight. This number typically places a significant restriction on the ability to represent important variables, such as trucks, as a percentage of total travel, grade, green time at intersections, parking, and pedestrian cross-traffic.

Within these limitations, however, many agencies have found improved parameters or functions for use in volume-speed relationships. In most cases, the parameters of the "standard" Bureau of Public Roads (BPR) function are changed while retaining its basic functional form (refer to Appendix A for a full description of the BPR function and its variants). BPR-based functions may be used for either traffic assignment or as post-processors of link information. The *Highway Capacity Manual (HCM)* (4) is also used as a basis for speed post-processors. The post-processing approach is taken as the basis for this research.

1.2.2 Other Transportation Planning Applications Requiring Speed Estimation

With the passage of the Intermodal Surface Transportation Efficiency Act (ISTEA), transportation planning has been given a much stronger emphasis than in the past. Not since the institution of the so-called "3C" process in the early 1960s have planners been faced with such wide-ranging challenges. Examples of the requirements facing state and local planners

include:

- mandated management systems for pavements, bridges, congestion, safety, intermodal, public transit, and traffic monitoring² at the state level and congestion management systems for large urban areas;
- statewide planning requirements, including a set of criteria that must be addressed in the plan; and
- an increased role of Metropolitan Planning Organizations (MPOs) in the programming of state-level projects.

Many of the new requirements relate directly to the estimation of speed and related measures of performance such as delay and travel time. An assessment of how speed estimation is used by specific planning applications follows.

Long-Range Transportation Planning

The long-range planning process is required by Federal regulations to ensure that transportation investments are based on expected needs. The foundation of long-range planning is the use of travel forecasting models which predict future traffic on a transportation network as a function of expected changes in land use and demographic patterns. Vehicle speeds on the network are used at two distinct phases of the travel forecasting process. First, predicted trips that are "produced" in one subarea (traffic zone) and "attracted" to another are distributed based on travel times between the traffic zones. Second, once the trip demand between zones is estimated, they are assigned to the network based on mathematical optimization techniques. For simplicity, trip distribution is usually based on the free flow travel time between zones while traffic assignment uses various methods to account for traffic congestion's effect on speeds as

²Traffic monitoring is not usually included in discussions of the other six management systems because it appears in a different part of the legislation.

traffic is built up in the network. This latter process is referred to as "capacity restraint" and is based on a formula that relates link volume-to-capacity (V/C) ratio to speeds. (For example, the BPR function referred to earlier; a full discussion of various formulas that have been suggested for the relationship appears in Appendix A.)

Many problems have been noted with travel forecasting models over the years regarding their ability to predict traffic accurately. One of the problems is link oversaturation: the prediction of link flows far in excess of link capacity, even with capacity restraint instituted. In reality, links that are predicted to experience very high V/C ratios (e.g., over 1.4) will never actually reach that level since trips will divert away from that link in both time ("peak spreading") and space (route diversion). If congestion is chronic, changes in land use development patterns may also occur. To compensate for this phenomenon, an approach that is now being used is the so-called "speed feedback" technique, where the results of a traffic assignment run are used to re-estimate speeds for trip distribution. This feedback process is based on the refinement of speeds from the assignment process. Since speeds estimated after a pass through the assignment process account for congestion, congested speeds rather than free flow speeds are used to distribute trips in the next iteration. In some cases, the same formula used to perform the assignment is used. However, this step offers the opportunity to improve speed estimation substantially through a separate "post-processor". The results of the proposed research will be extremely valuable in producing a workable model for post-processing speeds as part of the feedback process. Even without the feedback process, the post-processing of speeds after a single pass through the travel forecasting process will lead to improved estimates for a variety of purposes including air quality analyses. Finally, the newly emerging technique of dynamic traffic assignment requires the ability to predict speeds in congested networks.

Congestion Management

The needs of these three applications are closely related: a measure of system efficiency is needed in order to determine the magnitude of problems and to develop solutions. Of the ISTEA-mandated management systems, congestion management systems (CMSs) are the most relevant for the proposed work. Intermodal and growth management needs can be well-served by speed estimation techniques developed for CMSs. The key for intermodal management is to ensure that the performance measures for highways are compatible with those from the other modes. Growth management is mainly concerned with the traffic carrying abilities of various road designs, especially as they relate to planned developments. In both cases the ability to predict speeds and other related measures are roughly the same as for CMSs.

As defined in the final Federal rule, a CMS is a systematic process that provides information on transportation system performance and alternative strategies to alleviate congestion and enhance mobility of persons and goods. Performance measures are an integral part of a CMS and define the extent of congestion and permit the evaluation of the effectiveness of congestion reduction and mobility enhancement strategies. Thus, performance measures fall into two categories: those that relate to congestion (interference from traffic as it affects systems performance) and mobility (the ability to complete desired trips). The two are somewhat related but mobility is a much broader definition that accounts for accessibility. Accessibility implies that the whole system in which transportation takes place must be considered, for example, the land use pattern that results in desired travel patterns. In contrast, congestion is more narrowly focused on facility performance.

These new requirements have spurred a vigorous national debate over what standard measures should be used. A profusion of candidate measures have been advanced, but there is still little agreement since no single term can provide the full range of impacts (Table 1.1).

Table 1.1. Potential Measures of Roadway Congestion

Measure of Effectiveness	Application			Ability to Forecast Congestion
	Spot	Corridor	Areawide	
Level of Service	x			
Lane-miles of LOS "X"		x	x	
VTM of LOS "X"		x	x	
Average Travel Speed		x		
Average Spot Speed	x			
Average Travel Time		x		x
Average Travel Rate		x	x	x
Travel Time Contours			x	x
Total Delay	x			
Excess Delay	x	x	x	
Average Delay per Vehicle/Person	x			
Delay/Trip		x		
Delay/VTM		x		
Minute-Miles of Delay		x		
Delay due to Construction	x	x		
Delay/Incident	x			
Volume, Flow rate	x			
Intersection V/C Ratio	x			
Midblock VC Ratio	x			
Roadway Congestion Index		x	x	x
Volume/"Acceptable Flow Rate"	x			
Suggested Congestion Index		x	x	x
Detector Occupancy	x			
Queue Length and Duration	x			
Acceleration Noise		x		
Accident Rates	x	x	x	
Percent VMT by Functional Class		x	x	
VMT/Lane-mile		x	x	
Persons/Hour or Vehicles/Hour	x			
Persons/Vehicle	x	x	x	

Source: (5)

The on-going NCHRP Project 7-13 ("Quantifying Congestion") is wrestling with this problem. Based on their preliminary report, it is likely that **travel rate** (minutes per mile) will emerge as the main congestion measure. Some of the reasons put forth in favor of travel rate are: it measures congestion in both time and space over routes; it can be statistically summarized; it can now be measured with the widely accepted "floating car method"; and ITS technologies will allow more extensive data collection in the future. Other measures from Table 1.1 include speed, metrics based on the *HCM*, and delay. *HCM* procedures are so widely recognized and applied that many agencies are now using them as a basis for CMS performance measures. *However, as will be discussed later in this research, the HCM procedures have serious shortcomings when they are applied to congested conditions.* The research presented here is meant to address these shortcomings specifically and offer a practical alternative to using the *HCM* procedures.

Major Investment Studies

Major investment studies are in-depth investigations of large-scale transportation projects. They are an outgrowth of traditional benefit/cost (B/C) analyses conducted for highway projects but they are usually multimodal in nature. For example, the study of a proposed new commuter rail line will include the impacts on both rail and highway users. Also, the scope of a major investment study is larger and includes impacts beyond those that strictly accrue to the transportation system (e.g., financing and social issues). In both major investment studies and traditional B/C, determining vehicle speeds for each alternative is essential for:

- estimating travel time savings, which can be half or more of the total transportation-related benefits of the project;
- providing a basis for calculating vehicle operating costs; and
- estimating the externalities of pollutant emissions and noise impacts.

Based on the preliminary findings of an on-going NCHRP project on User Cost Estimation, a set of improved procedures for speed estimation is essential for major investment studies. A major conclusion of this study is that speed estimation procedures as applied to user costs are highly flawed, especially for oversaturated conditions. The study notes the high degree of sensitivity of user costs to speeds and that results can vary widely if based on flawed speed estimation methods.

1.3 Requirements of Speed Estimation Procedures for Planning Applications

Based on the preceding discussion, speed estimation procedures for transportation planning applications -- including air quality analyses -- should have the following characteristics:

- Ease of Use. The procedure should be able to be applied in a simple fashion and require only a few, easily obtainable input data items. Ideally, the data items should be generally available to planners or collected as part of routine planning studies.
- Consideration of Saturated Conditions. Nearly all of the highway capacity research to date has focused on parameters (speed, flow, and density) for unsaturated traffic conditions (the so-called "stable flow regime"). However, a major concern of practicing engineers and planners is what occurs after oversaturation (i.e, standing queues)³ has occurred. Therefore, a significant contribution can be made to the field if speed estimation procedures can address oversaturated conditions. Specifically, the procedures should be able to account for the spatial and temporal effects of oversaturation; the spatial effects relate to the physical growth of queues upstream from a bottleneck and

³For the purpose of this research, the terms "oversaturation" and "congestion" are used equivalently and indicate what traffic engineers call "forced flow", that is, the traffic flow that occurs after capacity is exceeded (Level of Service F).

temporal effects relate to queues building and dissipating over time. (Current procedures, such as those in the *HCM*, consider only a single hour.)

- Use of *HCM* concepts and methods as a foundation. The *HCM* provides a useful starting point not only because it is widely accepted but the delineation of capacity divides the two flow regimes (stable and unstable). Also, because many factors go into the determination of capacity (e.g., lane width and truck mix), it can be used as a single surrogate for many other factors influencing speed.
- Application to Travel Forecasting Models. Travel forecasting (network) models are used to develop data for air quality estimation as well as many other planning applications. Therefore, the information provided by travel forecasting models should be the basis for the speed prediction procedures.

1.4 Overview of Dissertation

A detailed description of the background to the dissertation is given in Section 2.5 (part of the Literature Review). Chapter 3 discusses the specifics of the methodology used in the research. The basic tenet of the research is to develop a model that is capable of satisfying the requirements listed above in Section 1.3. The model can be applied in a series of experiments to produce information on speeds for various traffic conditions in table form; the data in the tables then can be used to fit a series of equations that predict speeds as a function of traffic level and other easily obtainable highway characteristics (e.g., signal density).

A key feature of the model must be the ability to simulate the growth of queues over space (highway distance) and time; this is the major shortcoming of all existing planning methods for speed estimation. For example, consider a short four-lane freeway section with the following basic characteristics:

- Average Annual Daily Traffic (AADT) = 74,000 vehicles per day;
- Percent of Daily Traffic Occurring in the Peak Hour (K-Factor) = 10 percent;
- Peak Hour Directional (D-) Factor = 60 percent;
- 12 foot lanes, 8 foot shoulders; and
- 10 percent trucks.

Using the *HCM*, the peak hour capacity is 4,004 vehicles per hour for two lanes of traffic in one direction; this is based on an ideal capacity 2,200 passenger cars per hour per lane (pcphpl) factored downward for 10 percent trucks. The corresponding peak hour volume is 4,400 resulting in a volume-to-capacity (V/C) ratio of 1.1, indicating that traffic flow will break down during the peak hour and a queue will form. Existing methods (described in Chapter 2) deal with the consequences of this oversaturated condition only on this short section for the peak hour only. In reality, the queue will not only affect speeds in the peak hour but it will also affect at least the next hour, and maybe more, depending on how long it takes to dissipate. Further, the queue may spill back onto upstream freeway sections that the static *HCM* analysis might indicate have V/C ratios less than 1.0. In this situation, traditional speed estimation methods will predict higher speeds but in reality these upstream sections are influenced by the queue that has formed downstream of them. Therefore, the primary thrust of the research is the incorporation of queuing effects into an easy to use speed estimation methodology for planning applications. Once this method is developed, it is applied to typical highway networks and compared to results obtained by traditional methods.

The situation is exacerbated when travel forecasting (network) models are used as the basis for estimating speeds. Within the structure of network models, the basic problem is illustrated in Figure 1.3. Network models routinely predict volumes well in excess of link capacity due to the way in which the internal algorithms work. While some traffic will be

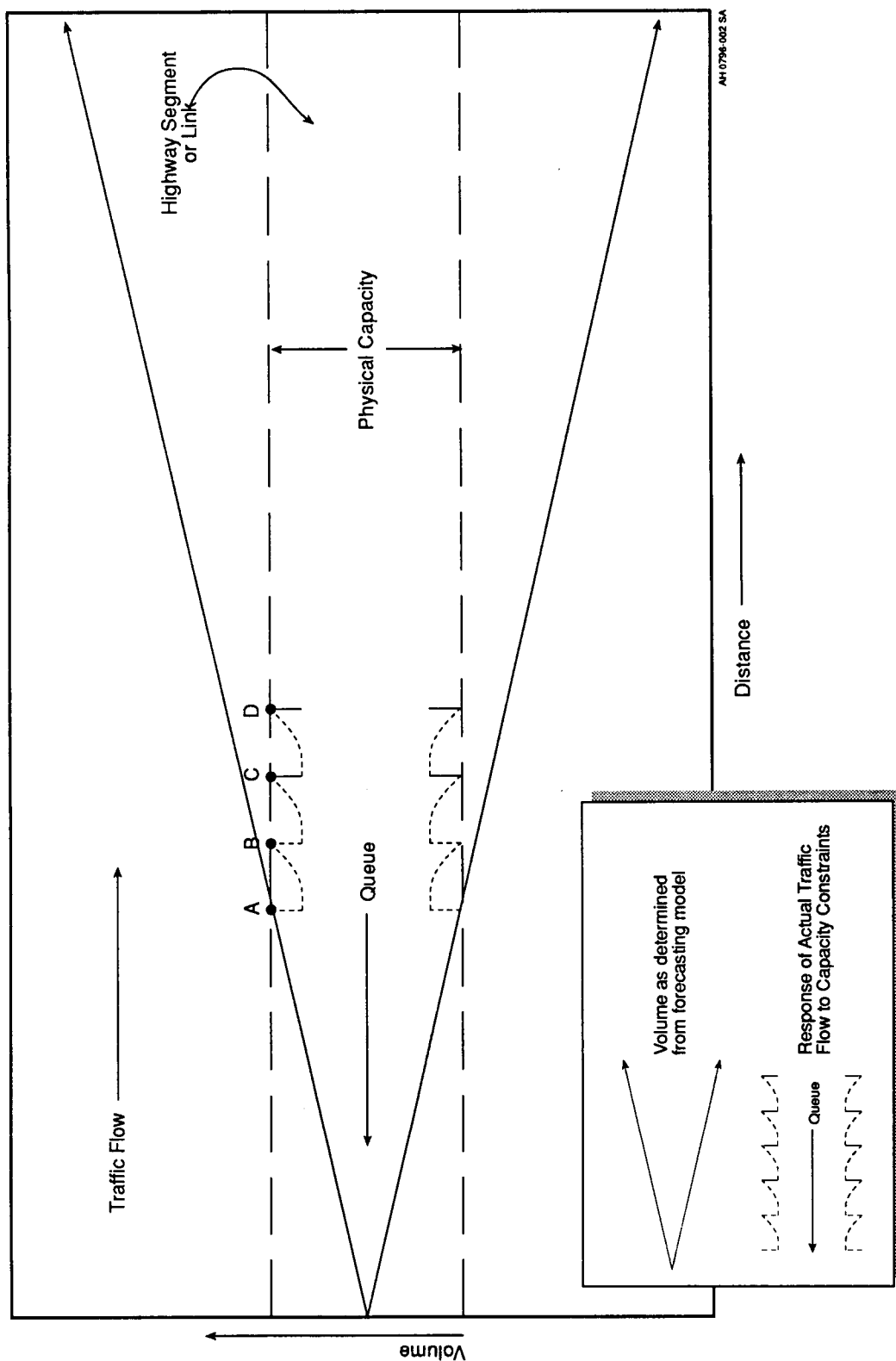


Figure 1.3. Forecasted Network Link Volumes vs. Reality

diverted off of congested facilities during the assignment process, it is still common for assigned volumes to exceed link capacities, sometimes by 50 percent or more when future year forecasts are made. (This is shown in Figure 1.3 as the divergent solid lines.) By definition, it is never possible to observe volumes in excess of capacity in the field; traffic will grow up to the physical capacity at which point flow will break down and a queue will form upstream (backward) from this location. (This is shown at Point A in Figure 1.3.) If the link is a freeway, prior research has shown that volumes will actually drop to less than capacity after flow has "broken down". Traffic may again build back up on the link due to volumes from intersecting links, but when it hits the physical capacity, a queue will form once again (Points B through D). It is precisely this condition that the speed estimation procedure developed here addresses.

Figure 1.4 shows a hierarchy, in terms of analytic sophistication and reliability, of the speed estimation procedures considered by this research. The crudest speed estimates are those taken directly from the final traffic assignment step in travel forecasting models. More sophisticated techniques are based on post-processing the output from travel forecasting models, namely, related forecasted volumes and capacities to speed (e.g., the BPR functions and *HCM* procedures). As shown in Figure 1.4, the original QSIM model developed by the author as part of previous research attempts to replicate the queuing situation. This dissertation offered the opportunity to extend the QSIM model in two ways. First, additional features and calibration of QSIM⁴ against available field data were performed (Chapter 4). Second, a more detailed procedure, QNET,⁵ was developed to handle the problem of queue spillbacks onto other links

⁴The model was named "QSIM" for its ability to simulate the growth and dispersion of queues.

⁵The name "QNET" was used because of the procedure's ability to simulate queues over a network rather than a single link.

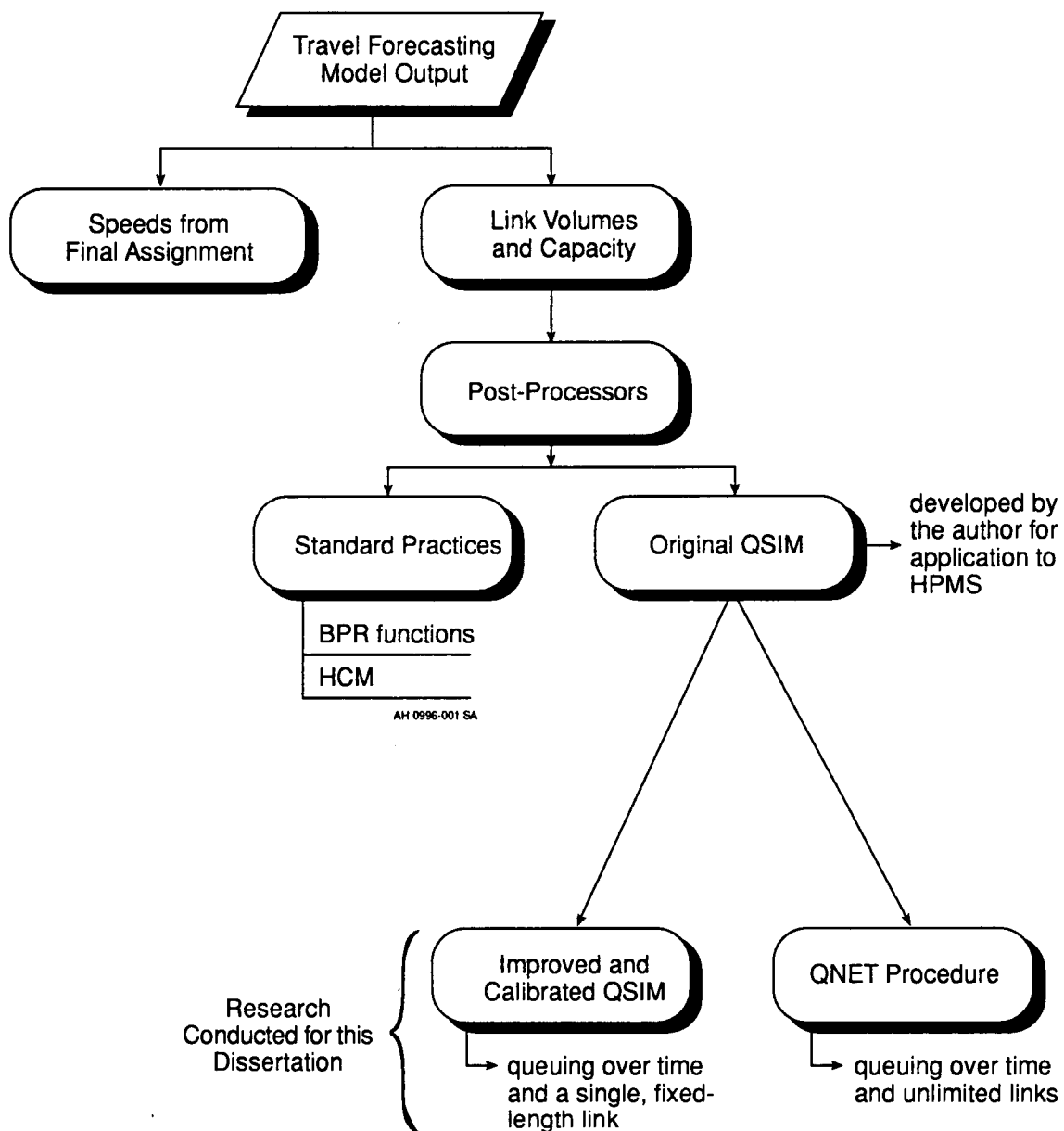


Figure 1.4. Hierarchy of Speed Estimation Procedures Used in this Dissertation

(Chapter 5). This extension of the QSIM model is needed because the current version takes its speed measurements of fixed link lengths. (Actually, the model can be set up to measure speeds over **any** link length, but since the goal was develop easily applied equations from the model output, fixed link lengths had to be established.) Once the improved QSIM model and the QNET procedure are developed, they are compared to results obtained by using standard speed estimation practices (Chapter 5).

2. LITERATURE REVIEW OF COMMON SOURCES

2.1 Introduction

The literature reviewed for this research focuses on the effects of urban congestion, therefore, a substantial number of studies related to speed estimation on nonurban highways have been excluded (e.g., those for rural two-lane highways). A summary of the literature review appears in Section 2.2; a full discussion of the literature appears in Appendix A. Section 2.3 of this Chapter discusses the speed model developed by the author as part of past research projects; it is this model that serves as the starting point for the research conducted specifically for this dissertation. Urban freeways and arterial highways with signals are the focus of the research; unsignalized arterials are not covered because they are not usually considered to experience a substantial amount of congestion. *The term "arterials" is used throughout this dissertation to mean highways with traffic signals present to distinguish them from freeways which have no such restrictions on traffic flow. The term "congested" is meant to indicate traffic flow that is in the so-called unstable (forced flow) operating regime, Level of Service "F" in HCM terms.*

2.2 Summary of Literature Review

The Highway Capacity Manual (*HCM*) serves as a focal point for research on highway capacity and the relationships between highway congestion and speed (4). It is the basic reference document used by traffic engineers in planning, designing, and analyzing highways. Researchers frequently compare their data on traffic volumes and speeds with the tables and curves in the *HCM*. Also, much past and ongoing research by NCHRP and FHWA has as an explicitly stated objective the development of findings and procedures for inclusion in the next

edition of the *HCM*.

A review of the recent literature on traffic flow theory indicates several important areas where the speed-flow relationships for freeways and multilane highways presented in the 1994 *HCM* have been challenged:

- There is evidence for a "two-capacity" hypothesis under which the occurrence of bottlenecks on a section creates a metered flow that is less than the free-flow capacity of the section. For example, Hall and Agyemang-Duah found that the queue discharge rate on a section of the Queen Elizabeth Highway in Ontario was 6 percent less than the free-flow capacity of the section (7). The lowering of capacity under breakdown conditions is acknowledged in Chapter 3 of the 1994 *HCM*. Chapter 3 now notes that the reduction is highly dependent on local conditions and can range from no appreciable drop in capacity to as much as a 25 percent decrease. Chapter 3 also presents a simple method for examining queues.
- Perhaps the most important issue to be addressed in developing improved speed estimation procedures for planning applications is how to estimate the consequences of queuing which result when the number of vehicles attempting to use a section exceeds its capacity. The 1994 *HCM* procedures provide an excellent basis for determining capacities and speeds when flows are under capacity. However, little guidance is provided on what speeds are like under saturated traffic conditions. For planning applications, the speeds in saturated conditions are extremely important because models will typically produce volume estimates in well in excess of capacity. For example, travel forecasting models routinely predict link volume-to-capacity (V/C) ratios of 1.3 and higher.

I believe that the failure to address queuing is the major shortcoming of existing procedures and any methods proposed for speed estimation must consider it.

The *HCM* also provides procedures for estimating the capacities of signalized intersections, delays at intersections, and average speeds on arterials with signalized intersections. Two procedures are provided in Chapter 9 of the *HCM* for determining the capacities of signalized intersections: an operational analysis procedure and a planning analysis procedure. The operational analysis procedure is very detailed and requires extensive inputs. Even the planning analysis procedure, which provides much more approximate estimates of intersection capacity, requires input information that may not be widely available for planning applications.

When intersection demand volumes exceed capacity, it is difficult to estimate delays accurately since spillbacks may extend to adjacent intersections. The *HCM* states that the procedure for estimating intersection delays can be used with caution for ratios of demand volume to capacity of 1.2 or less.

Another class of models to consider as an alternative to the *HCM* procedure is arterial signal timing models such as PASSER II and TRANSYT-7F. Both models generally achieve improved accuracy over the *HCM* arterial methodology through a much more detailed treatment of the propagation of traffic along an arterial route. The *HCM* relies on a simple categorization of arrival type from 1 to 6, i.e., the progression design is not realistically considered. The other class of models is traffic simulation models, such as TRAF-NETSIM. (Simulation models are discussed below.)

However, the results of recent field studies casts suspicion on the validity of all analytical models, including the *HCM* and its competitors. For example, two studies within the

past four years suggest that the *HCM* arterial methodology substantially underestimates speeds (14, 15). In particular, Courage, Showers, and McLeod developed adjustment factors to be applied to the incremental and uniform delay components of the *HCM* arterial methodology to achieve a better match predicted and observed speeds, as measured with the floating car method (15). They found that the floating car has a distinct advantage in systems that have a degree of progression as compared to the "average vehicle". That is, once the floating car is in the system, it receives all of the advantage of progression that does not accrue to all vehicles.

Dowling and Skabardonis developed a procedure for predicting the effects of queues on travel speeds (9). Their procedure was developed as part of a traffic assignment output "post-processor" to provide improved speeds for air quality impact analysis. The procedure recommended by Dowling and Skabardonis allows for the consideration of the growth and dissipation of queues over time and thus satisfies the main requirements of the model outlined in Chapter 1. A highly modified and enhanced version of the procedure was adopted by the author for use in this research.

Simpler procedures have also been used to represent speeds under queuing. The traffic assignment component of urban travel forecasting models uses a link speed function to develop minimum time paths through a network. Several link speed functions have been developed over the years, most of which are based on the original formulation from the Bureau of Public Roads (BPR; 18). These functions relate speed to link volume and capacity. The fundamental problem with any variant of the BPR curve is that they do not account directly for the effects of queuing. The curves have not been calibrated on any data where volumes exceed capacity and any match to predicted speeds in oversaturated conditions is purely coincidental. Further, the temporal and spatial aspects of congestion (queues) are not accounted for in any fashion; in the field, queues built up in one hour will affect traffic in successive hours and queues from

one link will "spill back" onto upstream links.

Traffic simulation models are another method for determining speeds as a function of highway and traffic conditions. FHWA has been developing a family of microscopic traffic simulation models collectively known as TRAF since the 1970s. Separate microscopic models were developed to handle different facility types: ROADSIM (rural two-lane roads), NETSIM (urban arterials), and FRESIM (freeways).⁶ These models are dubbed "microscopic" because they track the movements of individual vehicles, including the influences of driver behavior, second-by-second as they proceed through a network. (The so-called "macroscopic" models do not model vehicles in this way but rely on deterministic traffic flow relationships instead.) One of the key underpinnings of the microscopic models is their stochastic (random) handling of certain features including the assignment of vehicle types, driver types, and turning movements. The simulation proceeds second-by-second on a highly detailed network given by the user. In the case of NETSIM, intersection geometry and signal characteristics are coded. In the case of FRESIM, lane configuration and ramp junctures are designated. Vehicles then enter into the network via random generation at "source" nodes so as to match user-specified volumes for the simulation period (typically one hour).

Since the models monitor the movement of vehicles every second, both NETSIM and FRESIM explicitly account for the growth and decline of queues over time, including the effect of "spillbacks" onto upstream links. Additionally, because traffic can be varied by time period, the cumulative effect of congestion over the course of a day can be simulated. This feature -- the ability to handle traffic in oversaturated conditions -- distinguishes the microscopic models from many other analytic techniques (21).

⁶FHWA is now developing the CORSIM model which integrates NETSIM and FRESIM into a single framework.

2.3 The Author's Previous Work on Speed Modeling

The Base Model for speed estimation used in this research has been evolving over the past three years as a result of several FHWA research projects lead by the author. *The model is referred to as "QSIM" for its ability to simulate the growth and dispersion of queues over time.* The first of these was geared toward developing improved speed models for the HPMS Analytical Process and Highway Economic Requirements System (HERS), the battery of models used by FHWA to estimate the effect of national highway and traffic conditions on user costs (22). The model was revised based on another research project which developed improved temporal distributions, a key input to the QSIM model structure (23). QSIM was recently extended and adapted for general use in air quality planning procedures as part of a third project (24). A full description of the methods developed in those studies and how they apply to the proposed work follows.

A complete overview of the speed modeling process undertaken by this research is shown in Figure 2.1. **The basic approach identifies a framework that is used to develop a set of general speed relationships. These relationships can then be used to predict speed on individual highway segments or over entire networks given only a few input data items.**

The major steps in the process are identified by the numbers in the upper right corner of the flow chart boxes of Figure 2.1. As explained below, the procedure is stochastic in that it allows traffic to vary from day-to-day; a total of 1,000 "days" are simulated. The final speeds are then a composite average for these 1,000 days and account for the natural variability in daily traffic. It is believed by the author that this procedure produces more reliable results than relying on K- and D-factors to derive peak hour traffic

1. Select AADT/C Level. A specific requirement of the author's approach is that the full effect of congestion over the course of an entire day has to be assessed; this implies that

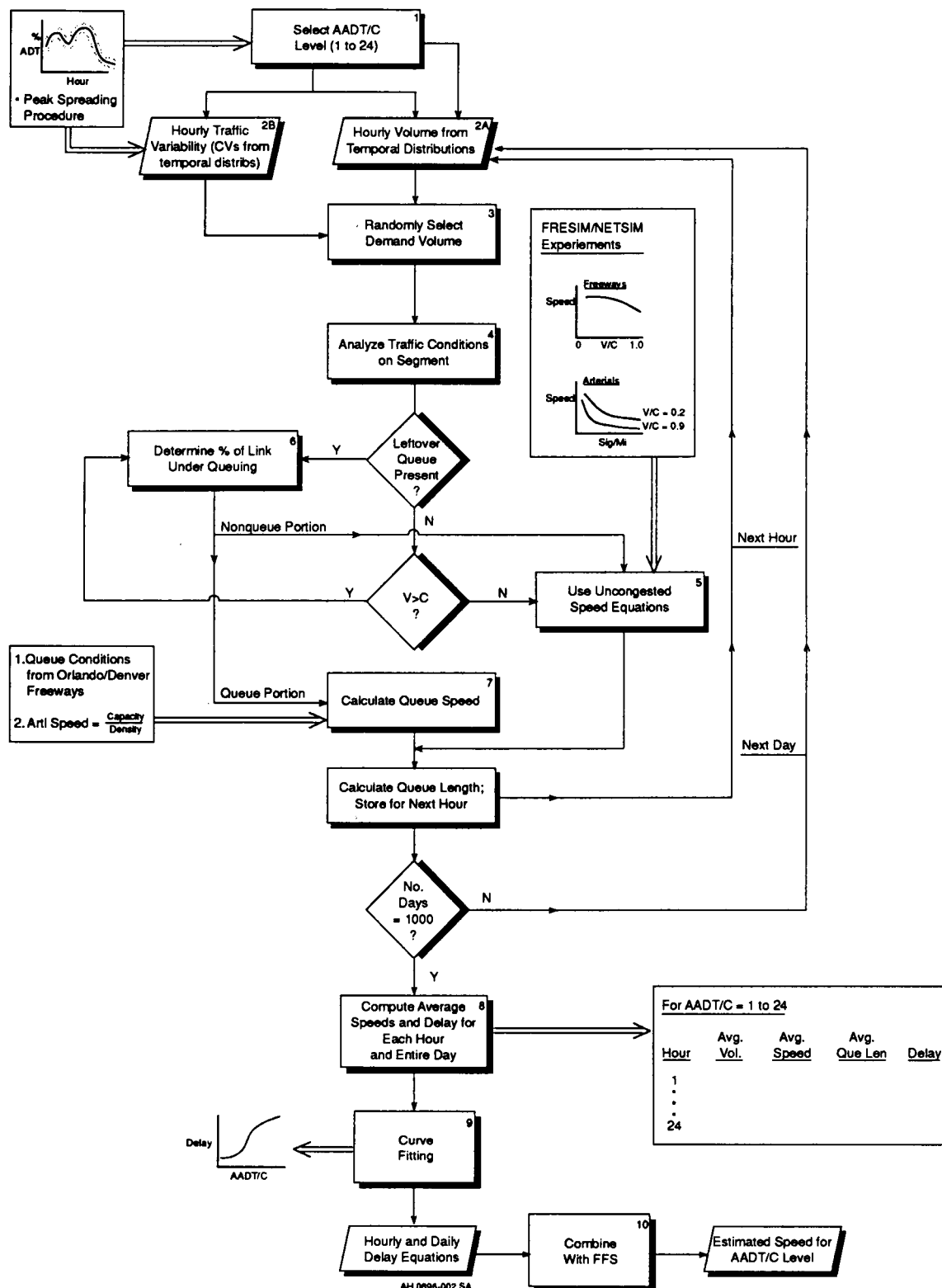


Figure 2.1. Overview of the QSIM Modeling Procedure

queuing in oversaturated conditions has to be explicitly considered. Because most analytical methods consider only the effect of peak hour congestion (such as the *HCM's* V/C ratio), a new measurement of daily congestion was developed: the Average Annual Daily Traffic-to-Capacity (AADT/C) ratio, where capacity is the two-way hourly capacity. For reference, the AADT values that result from various AADT/C ratios for typical situations are provided in Table 2.1. The model studies AADT/C levels from 1 to 24, although in practice, very high AADT/C levels (above 15-16) are almost never observed. (An AADT/C level of 24 implies that both directions of the facility operate over capacity for the entire day.)

2A. Determine Hourly Volumes from Temporal Distributions. Analysis of congested conditions is more complicated than uncongested conditions. Because the effects of queuing had to be explicitly considered, multiple consecutive hours had to be studied. In order to develop default relationships -- assuming that temporal distributions for specific facilities are not available -- generalized or average values for traffic volumes by hour are required. Fortunately, detailed temporal traffic distribution data were available from one of the previous studies completed by the author (23). This study examined how urban temporal distributions change with conditions such as facility type, area type, and traffic level. The final distributions were developed on data from 713 automatic traffic recorder (ATR) sites around the country (presented in Appendix B) and represent a combination of the following factors:

- weekdays and weekend/holidays;
- freeways and nonfreeways;
- three separate AADT/C levels; and
- weekday peak direction orientation (whether a certain direction "peaks" in the morning or afternoon; this distinction is not made for weekends based on the temporal distributions in Appendix B).

Table 2.1. AADT/C Levels and Corresponding AADT Values

	Freeways (10% Trucks)		Signalized Arterials (8% trucks) ³
	4-Lanes ¹	6-Lanes ²	
AADT/C	AADT⁴	AADT⁴	AADT⁴
9	72,000	113,000	30,000
10	80,000	126,000	33,000
11	88,000	138,000	37,000
12	96,000	151,000	40,000
13	104,000	163,000	43,000
14	112,000	176,000	47,000
15	120,000	188,000	50,000

¹Ideal Capacity = 2,200 pcphpl

²Ideal Capacity = 2,300 pcphpl

³Ideal Capacity = 900 pcphpl (based on a saturation flow rate of 1,800 pcphpl and 50% green time)

⁴Rounded to nearest 1,000

The key feature of these relationships is that they embody the occurrence of "*peak spreading*", the shifting away of traffic from a single peak period into adjacent time periods as highway users change their traveling times in response to congestion. Peak spreading is evident in Figure B.1 in that the highest AADT/C range has a less pronounced afternoon peak and more traffic distributed in the morning hours than the lower AADT/C ranges. However, direct application of these distributions would lead to problems for AADT/C ratios on the boundary values. For example, the high AADT/C range's hourly distribution is flatter than the middle range; this could possibly lead to predicting congestion in an hour for the middle range while not predicting congestion in the same hour for the high range. Therefore, a smoothing procedure was used as described in Appendix B. This procedure accounts for problems at the boundary values and further spreads out traffic throughout the day as AADT/C ratios increase above 13. This additional peak spreading feature was deemed necessary since the data for developing the distributions (the 713 ATRs previously discussed) did not have a large number of sites where AADT/C was greater than 13.

2B. Hourly Traffic Variability. In addition to the peak spreading feature, another traffic-related component was also considered in model development: traffic variability. On a given highway segment for a certain hour, traffic does not remain constant from day-to-day as implied from the temporal distributions. Although traditional analysis assumes constant traffic, it was felt that allowing traffic to vary stochastically would provide a better representation of real-world conditions. For example, consider a freeway that, based on its "average" temporal distribution, experiences a peak hour volume just under its capacity. However, on some days actual traffic will exceed capacity. This effect is lost if average volumes are used. To account for traffic variation, coefficients of variation (CV, the standard deviation divided by the mean) were computed for hourly volumes for day of the week (weekday versus weekend/holiday) and

functional class using the ATR data (Figure 2.2). CVs were calculated for each ATR location where data were reported by individual direction for each day of the week and hour. These values were then averaged by functional class to produce the values in Figure 2.2. In general, weekday CVs are smaller than weekend CVs, higher functional class CVs are smaller than the lower classes, and hours with higher volumes have smaller CVs. This information is used to vary hourly volumes stochastically, as described in Step 3.

3. Randomly Select Demand Volume. For a given AADT/C level being studied, "target" hourly traffic volumes are developed as:

$$\text{Hourly Volume} = (\text{AADT/C}) * (\text{Capacity of the Test Segment}) * \\ (\text{Hourly Pct}) * (\text{Weekday/Weekend Factor}). \quad (1)$$

Here the weekday/weekend factor is used to convert AADT to average weekday daily traffic (AWDT) or average weekend daily traffic (AWEDT). These factors were also developed from the 713 urban ATRs and are 1.0757 for AWDT and 0.8393 for AWEDT. For this target volume, a test volume for the given day is determined by randomly sampling from a normal distribution where the mean is the target volume and the standard deviation has been developed from the data in Figure 2.2. For each AADT/C level, a total of 72 hours are studied for a given day: 24 for the AM peak direction, 24 for the PM peak direction, and 24 for weekends/holidays.

4. Analyze Traffic Conditions on the Test Segment. A key assumption in the model is the setting of the length of the test segment over which speed measurements are to be taken. If the segment is short, then even a small queue will dominate the speeds on the segment. If it is long, then the effect of queues will be diluted. For freeways, the segment length was set to 1.5 miles to represent a reasonable interchange spacing in urban areas. For arterials, the segment length was set to the signal spacing being studied. (This was done as a simplified way to account for signal density.) The model then starts its procedures by determining if there is

HOUR	FUNCTIONAL CLASS													
	URBAN INTERSTATE		URBAN FREEWAY		URBAN PRINC. ARTERIAL		URBAN MINOR ARTERIAL		URBAN COLLECTOR		URBAN LOCAL		TOTAL	
	DAY OF WEEK		DAY OF WEEK		DAY OF WEEK		DAY OF WEEK		DAY OF WEEK		DAY OF WEEK		DAY OF WEEK	
	WEEKEND	WEEKDAY	WEEKEND	WEEKDAY	WEEKEND	WEEKDAY	WEEKEND	WEEKDAY	WEEKEND	WEEKDAY	WEEKEND	WEEKDAY	WEEKEND	WEEKDAY
	COEFF	COEFF	COEFF	COEFF	COEFF	COEFF	COEFF	COEFF	COEFF	COEFF	COEFF	COEFF	COEFF	COEFF
	VAR	VAR	VAR	VAR	VAR	VAR	VAR	VAR	VAR	VAR	VAR	VAR	VAR	VAR
1	26.83	26.78	27.93	32.68	28.59	33.37	31.14	41.35	34.23	44.64	44.31	42.09	28.62	32.47
2	27.32	27.34	31.75	37.96	31.79	39.77	36.31	54.02	42.98	58.60	55.91	57.32	31.47	37.79
3	26.82	25.63	33.57	39.46	33.95	42.66	41.45	60.29	49.32	69.27	59.72	59.29	33.18	39.52
4	28.59	23.29	36.12	37.59	37.59	41.05	49.38	60.63	56.22	76.76	65.85	61.68	36.76	38.33
5	34.54	22.01	39.88	32.32	42.47	34.57	55.14	48.94	62.72	64.03	53.70	38.82	41.93	32.83
6	44.64	19.12	47.09	22.82	47.37	25.77	55.21	32.96	59.83	37.26	49.28	27.29	48.02	24.36
7	51.23	14.59	52.74	16.43	50.03	17.42	55.22	20.70	55.02	21.68	40.53	20.27	51.78	16.88
8	54.66	11.85	55.98	13.72	53.36	14.42	57.31	16.62	57.79	18.12	52.71	14.88	55.02	13.81
9	41.18	11.37	41.54	13.27	41.54	13.12	42.01	15.52	43.89	16.90	38.30	14.07	41.54	12.99
10	29.77	11.71	29.97	12.87	31.63	13.08	32.06	15.30	31.76	16.74	30.17	14.21	30.72	13.02
11	25.05	12.69	25.93	13.70	28.80	13.86	28.44	15.34	29.92	16.63	27.23	14.16	26.90	13.73
12	22.18	13.14	23.11	13.76	26.52	13.74	27.05	14.54	28.85	15.52	26.16	13.75	24.52	13.71
13	18.56	13.07	18.78	13.27	21.27	13.40	21.58	13.73	22.33	15.22	20.24	13.12	19.94	13.38
14	17.47	13.05	17.69	13.15	20.23	13.62	21.30	13.94	21.20	15.41	19.60	13.22	18.99	13.45
15	17.68	12.69	18.10	13.12	20.01	13.34	21.05	13.45	20.98	14.85	19.41	12.97	19.02	13.13
16	18.89	11.75	19.26	12.59	21.01	12.62	22.16	13.13	22.23	14.63	21.17	11.72	20.16	12.43
17	20.40	11.44	20.67	12.41	21.89	12.28	23.38	13.15	22.38	13.33	23.81	11.60	21.40	12.13
18	21.20	12.48	21.29	13.33	22.62	13.35	23.82	14.09	22.59	13.71	24.91	12.67	22.08	13.12
19	21.01	16.15	21.60	16.78	23.74	16.79	24.58	16.87	23.57	16.15	23.38	15.61	22.48	16.50
20	22.29	19.66	23.75	20.57	25.78	20.32	26.59	20.72	25.65	19.87	25.45	18.67	24.23	20.11
21	23.96	20.05	25.15	21.98	28.19	22.55	29.63	23.74	28.22	23.20	27.56	21.00	26.31	21.67
22	25.38	19.94	27.36	22.02	31.49	24.18	33.26	25.68	30.60	24.32	31.05	21.83	28.73	22.41
23	29.58	23.96	32.43	26.26	36.04	29.40	39.20	32.47	36.03	30.32	31.36	22.68	33.41	27.25
24	36.33	29.32	39.64	33.18	43.51	36.35	46.68	40.46	42.81	39.38	39.15	27.98	40.54	33.80

Figure 2.2. Average Coefficients of Variation from Urban ATR Sites

Source: Reference (24)

a queue leftover from the previous hour. If not, it then determines if the test volume exceeds the segment capacity.

5. Use Uncongested Speed Functions. If there is no standing queue and if the test volume is less than capacity, then uncongested speed functions developed specifically for this research are applied. These were developed through use of the microscopic traffic simulation models: FRESIM (freeways) and NETSIM (arterials). A series of experiments were devised to study a range of factors for each highway type. For freeways, V/C ratio was used as the main determinant of freeway speeds in urban areas and was computed from the volume per lane and truck percentage. (Since FRESIM doesn't account for lane width and lateral clearance, these items were assumed to be at their "ideal" levels.) For signalized arterials, a variation of the V/C ratio was used: V_m/C_m , the volume of all lane groups on the main approach divided by the capacity of all lane groups on the main approach. A full factorial design was run with the following factors and their levels:

- V_m/C_m (0.2, 0.4, 0.6, 0.75, and 0.85);
- free-flow speed (40 and 50 mph);
- left-turn bay and phase (present/absent);
- signals per mile (0.33, 0.5, 1, 3, 6, and 10); and
- signal progression (fixed time versus progressive).

Where more than one signal was included in the test network, all signals on the section were assumed to have the same V_m/C_m ratio. Also signals were spaced at even intervals. The results indicate that both V_m/C_m and signal density are strong determinants of arterial speed. It should be pointed out that for the fixed time case, the experiment used zero offsets between the signal cycles in the test network. Thus, all cycles changed at the same time. Because the signals were closely spaced, a degree of progression existed for the fixed time case. Curiously, little

difference was noted between the fixed time and progression cases. This was originally assumed to be due the "progression" in the fixed time case as noted above. However, further testing, as explained in Chapter 4, found this not to be the case. Applying the simulation models resulted in a data set to which a series of equations were fit to the significant factors (The equations are shown in Figure 2.3.) The dependent variable in these equations was a delay-based measure expressed in excess hours per vehicle-mile, in other words, the extra travel time incurred by vehicles compared to the travel time incurred at the free flow speed. As shown in Step 10, this measure of delay can be combined with the free flow speed to calculate the actual speed.

6. Determine Percent of Link Under Queuing. If test volume exceeds capacity, a queue is assumed to form. For simplicity, the program assumes that the bottleneck point from which the queue builds is at the downstream end of the segment. The program accumulates total travel time on the segment. If the length of the queue exceeds the length of the segment, total delay due to the bottleneck will naturally exceed total delay on the segment itself. (This additional delay can be estimated by increasing segment length.) For freeways, once volumes exceed capacity, vehicles are assumed to move through the bottleneck point at a flow rate less than capacity. Therefore, two basic freeway capacity values are used: 2,300 pcphpl (the new *HCM* capacity for six or more lanes) for unsaturated conditions and 2,000 pcphpl for oversaturated conditions (7).

Queues are estimated for the beginning and ending of each hour. If the demand volume plus any leftover queue is greater than the capacity of the section, the queue at the end of the hour is calculated by:

$$Q_2 = Q_1 + V - C \quad (2)$$

Where: Q_1 = queue at the beginning of the hour (vehicles)

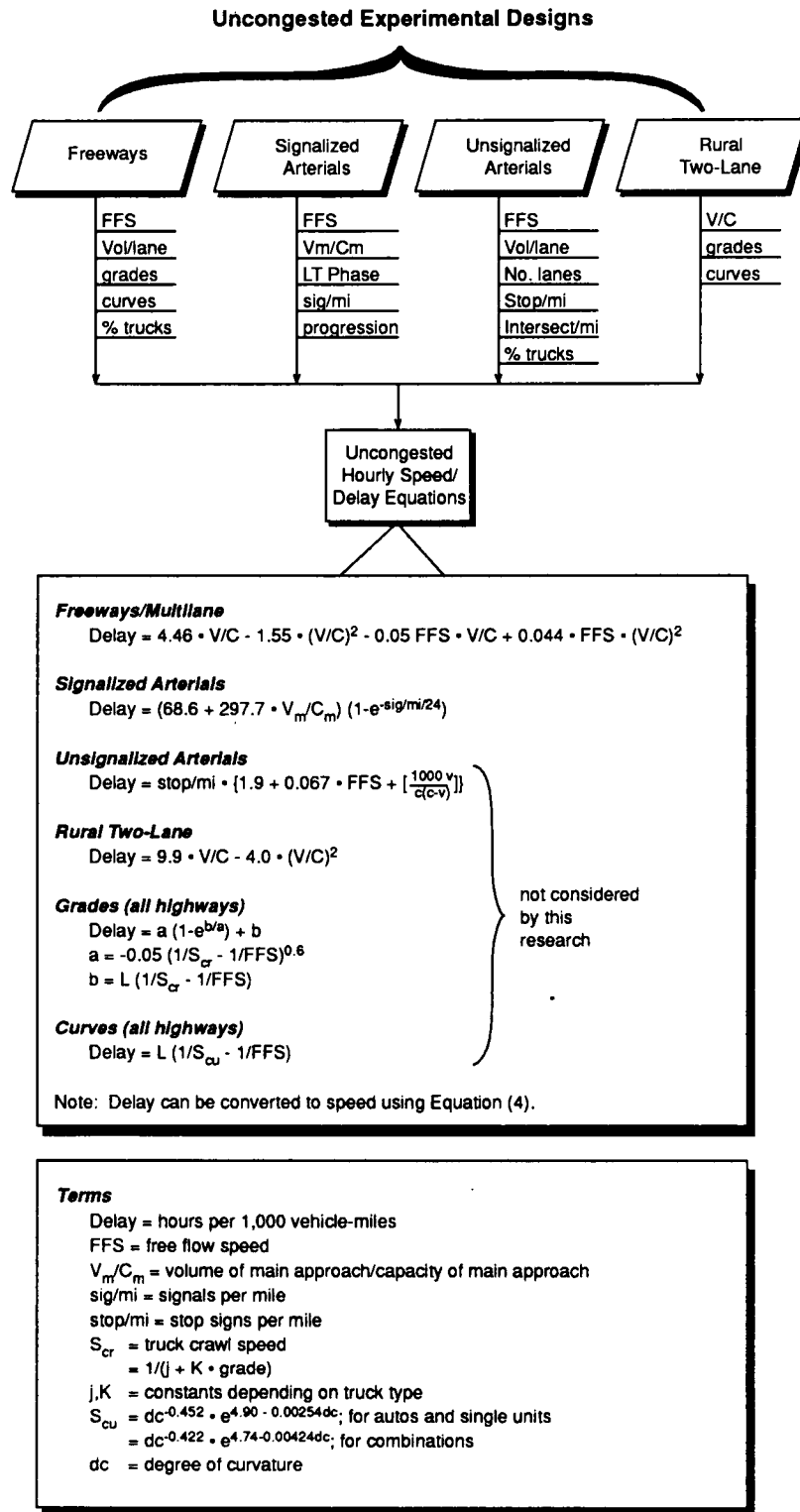


Figure 2.3 Original Uncongested Delay Functions from Reference (22)

Q2 = queue at the end of the hour (vehicles)

V = demand (test) volume for the hour (vehicles)

C = bottleneck capacity of the section (vehicles).

Queue length is found by multiplying the number of queued vehicles by an assumed queue spacing which was set at 43 feet per vehicle; this value includes assumed values of 18 feet for the average vehicle length and 25 feet for front bumper-to-rear bumper spacing.

7. Calculate Queue Speed. The speed on the segment is based on estimating total vehicle-hours of travel (VHT) and vehicle-miles of travel (VMT) first, then computing speeds as VMT/VHT. VMT and VHT are tracked separately for queued and unqueued portions of the test segment:

$$\text{VMT} = \{(\text{UQL} * \text{DVOL}) + (\text{AQL} * \text{CAP})\} / 5280 \quad (3)$$

Where: UQL = length of the segment that is not queued, in feet

DVOL = demand volume for this hour (determined stochastically from the temporal distributions), in vehicles

AQL = average queue length during the hour, in feet

CAP = the bottleneck capacity, in vehicles

The first term counts the number of vehicles that are entering the segment at the back of the queue. When the entire segment is consumed by a queue, this term becomes zero. The second term counts the number of vehicles in the queue that are processed through the bottleneck.

$$\text{VHT} = (\text{UQL} * \text{DVOL} * \text{UQDEL}) + (\text{AQL} / \text{QSPACE}) \quad (4)$$

Where: UQDEL = unqueued delay, in hours per vehicle-foot, calculated using the uncongested delay function

QSPACE = spacing of vehicles in the queue, in feet per vehicle

$$= \text{Queue Speed/CAP}$$

The first term is the number of vehicle-hours experienced by vehicles on the unqueued portion of the segment. The second term calculates the number of vehicles that (on average) are in the queue during the hour. Note that QSPACE depends on the assumed queue speed, which for freeways was determined empirically to be 15.5 mph. The second term is equivalent to estimating queued VHT (QVHT) as a function of queued VMT (QVMT) and queue speed:

$$\text{QVHT} = \text{QVMT/Queue Speed} \quad (5)$$

Letting:

$$\text{QVMT} = \text{AQL} * \text{CAP (the second term in Equation (3))}, \text{ and}$$

$$\text{Queue Speed} = \text{CAP} * \text{QSPACE},$$

produces:

$$\text{QVMT} = (\text{AQL} * \text{CAP})/(\text{CAP} * \text{QSPACE})$$

$$= \text{AQL/QSPACE}.$$

Nonqueue Speed is determined from the uncongested speed functions. Queue speed for freeways was developed from empirical data from freeway management systems in Orlando and Denver and was found to be 15.5 mph (24). For arterials, queue speed was determined analytically as capacity (vehicles per hour) times vehicle spacing (feet per vehicle) and is roughly 8-9 mph.

8. Compute Average Speeds for Each Hour and the Entire Day. Once one of the 72 hours is completed, the program goes onto the next hour, noting any queues that may have formed in the first hour. Once speeds for all 72 hours are computed for a given AADT/C level, the process is started over for that AADT/C level by randomly determining hourly volumes again. This procedure is done 1,000 times and is meant to represent the natural variation in daily volumes. At the end of the 1,000 cycles, a table is produced for each AADT/C that shows

the average values for volume, speed, delay, and queue length. (Speed is the volume-weighted average speed.)

9. Curve Fitting. For ease of application, the data in the tables is fit with a series of equations, although the tables may also be used directly. Sets of equations for three time periods are developed: (1) the peak hour of the facility, (2) peak period (defined as the six hours from 7-10 a.m. and 4-7 p.m.), and (3) the entire day. Because the temporal distributions distinguished weekdays and weekends, separate equations were developed for these as well as both combined. These equations are extremely useful for planning applications where only limited data are available. Delay (rather than speed) was used as the dependent variable in the equations for two reasons. First, it is computationally more efficient because it avoids the calculation of average speeds weighted by volumes. Second, it allows the inclusion of multiple sources of delay (such as delay attributable to grades and curves) in the final speed estimation.

10. Combine Estimated Delay with Free Flow Speed. Since delay is defined as the time that is experienced by vehicles in excess of what it would have been at the free flow speed, the final speed on the segment can be computed as:

$$\text{Speed} = \frac{1}{1/\text{FFS} + \text{Delay}/1000} \quad (6)$$

Where: FFS is the free flow speed (mph), and

Delay is the predicted value from the equations in hours per 1,000 vehicle-miles.

3. DISSERTATION METHODOLOGY

3.1 Introduction

Chapter 2 outlined the background of the author's speed modeling procedure. The main purpose of the current research is to develop a procedure, based on the QSIM formulation discussed in Chapter 2, that can be used as a post-processor to output from travel forecasting models to improve link and areawide estimates of speeds. Prior to developing and applying the post-processor, the methodology will be validated against field data for both freeways and arterials. Once the QSIM post-processor is developed, it is applied to a case study and comparisons are made to the speeds predicted by "best standard practice". If the field data comparison uncovers problems with the methodology, revisions will be made in the base procedures, QSIM will be re-run, and new speed prediction equations will be developed from the QSIM output.

The author's speed estimation methodology is based on using the HPMS data base, a statistical sample of highway segment, that can be expanded to represent state and national highway conditions. The speed models are applied to each segment individually. By comparison, transportation-related air quality analysis is typically based on network (travel forecasting) models where many hundreds, sometimes thousands, of individual links exist. Speeds on these individual links are estimated during the traffic assignment process, usually with some variant of the BPR function. It is believed by many analysts that the speeds resulting from the final assignment are too crude for use in air quality analysis; speeds are used to achieve realistic traffic assignments (link volumes) rather than to match any observed or theoretical norms. Therefore, many urban areas use a "post-processing" approach where the final assignments and basic link data are used to estimate speeds external to the travel

forecasting process. Most areas base their post-processors on standard and well-known procedures, such as the *HCM*, and estimate speeds link-by-link.

3.2 Procedures for Validation Against Field Data

The author had already collected detailed freeway data from Orlando and Denver as part of the *Roadway Usage Patterns: Urban Case Studies* project (23). These data were collected by the cities' freeway management systems. The highway segments covered in both cities are six-lane sections. Table 3.1 shows the basic geometric characteristics of the sections.

- The Orlando data are for an 11.0 mile section of I-4 including both north and south sides of the central business district (CBD). These data cover a 29 day period and provide speeds and volumes at five minute intervals for 25 stations spaced approximately every 1/2 mile. AADTs range from 110,000 to 175,000 vpd.
- The Denver data are for a 9.5 mile section of I-25 on the south side of the Denver CBD. These data cover an 88 day time period and provide speeds and volumes at five minute intervals for 12 stations spaced a little less than one mile apart. However, the Denver data cover only the periods from 5:00 am to 10:00 am and 2:00 pm to 7:00 pm.

Table 3.1. 1993 HPMS Data for I-25 (Denver) and I-4 (Orlando)

Highway	Lane Width (ft)	Right Shoulder Width (ft.)	Left Shoulder Width (ft.)	Peak Hour Trucks (%)	Average Grade (%)
I-25, Denver	12	10	4	8-10	1.5
I-4, Orlando	12	10	10	6	1.5

Arterial data were also available for a section of New Jersey State Route 10 (SR-10) near Livingston (which lies within the New York City metropolitan area). These data had been collected by Garmen Associates as part of another study. The data include detailed geometrics, signal timing specifications, turning movements, and travel time runs made by the floating car method. The study section of SR-10 is a four-lane arterial running through a heavily commercialized area. During peak hours, preference is given to through movements at intersections the expense of movements on the side streets.

3.3 Adaptation of the Methodology to a Post-Processor for Travel Forecasting Models

It is a simple matter to apply the equations by individual link to a typical output from the travel forecasting procedure: simply note the free flow speed, AADT/C ratio, and signal density of the link and perform the calculations. In the case of arterials, signal density may be computed for either a single link or a group of successive links if the links have similar AADT/C ratios. However, the spatial effects of congestion on freeways -- the spillback of queues from one link onto another -- are not considered directly by the freeway equations. For consistency, the QSIM model tabulates speeds over a constant freeway link length (1.5 miles⁷), although it does keep track of the actual queue length even if it extends beyond the link over which speeds are tabulated. If a longer link length is used, the average speed on the link will be higher (even with the same input volume) because queues will be present over a smaller portion of the total link length. If queues are allowed to extend back beyond the length of a congested link onto an uncongested link, predicted speeds will be lower on the (previously) uncongested link. In contrast, the lengths over which arterial speeds are computed by the

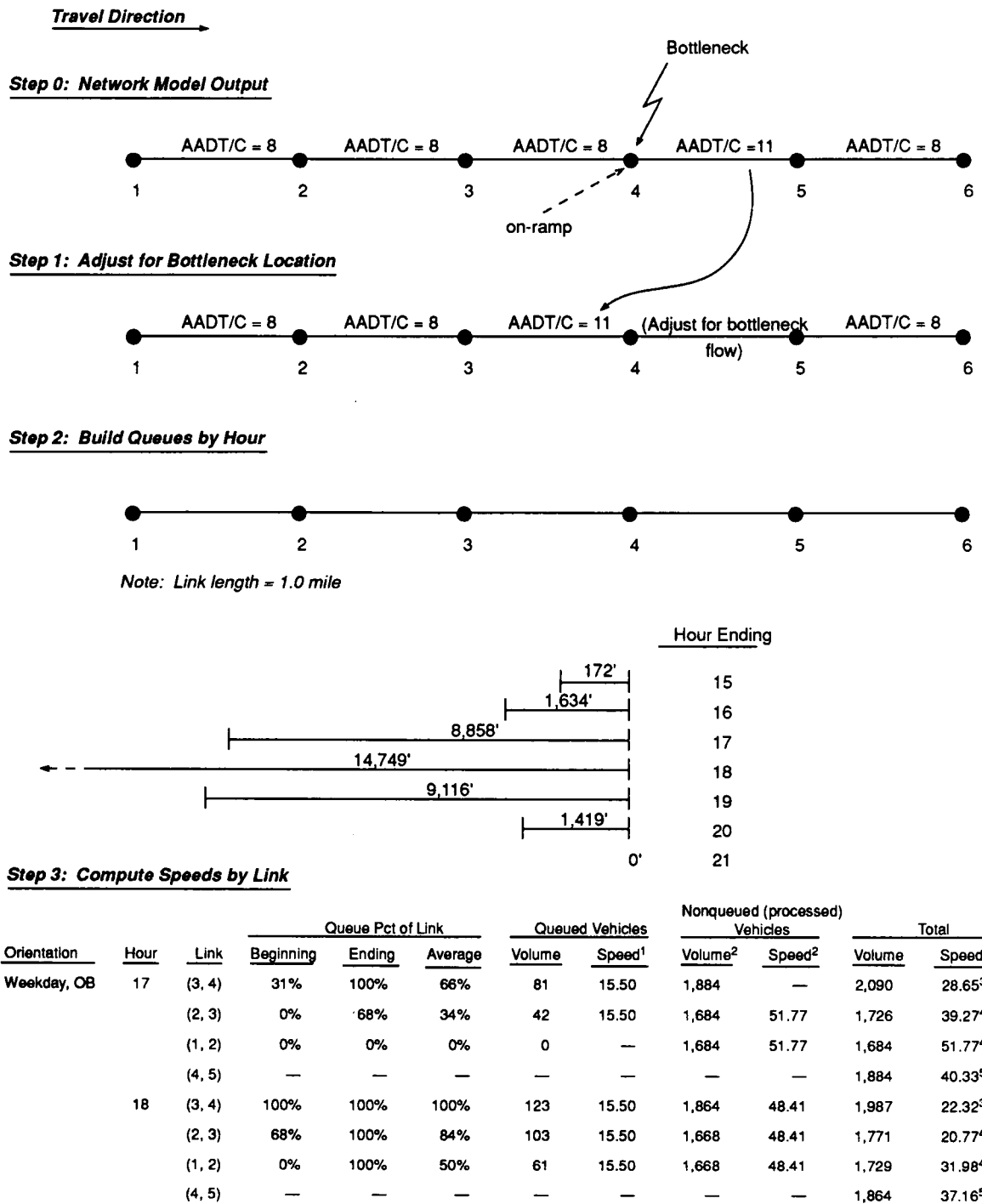
⁷The 1.5 mile link length was thought to be representative of average interchange spacing on typical urban freeways.

author's speed methodology vary with signal density. For example, if a signal density of two signals per mile is studied, then the speeds are computed over a half mile segment upstream from the assumed signal (bottleneck). A signal density of five per mile would lead to a segment study length of 0.2 miles. (This method was chosen as a compromise because the simple queuing methodology does not allow the study of a string of intersections.⁸) Therefore, the effect of spillbacks are considered from signal to signal **within** the section being studied -- the effect of the queue spilling back behind the first signal in the segment is not considered.

To address the issue of spillbacks, a methodology was developed for applying the equations on a freeway segment (multiple links) rather than on an individual link-by-link basis. Figure 3.1 displays the procedure that first starts by addressing the "queue mislocation" in travel forecasting networks. Due to the way in which traffic is loaded onto networks, volumes well in excess of capacity can be assigned to links. In reality, these "congested" links never experience the assigned volume because a bottleneck will exist at the upstream node, and queues will form upstream from this point. Consider the network in Figure 3.1. Link (4,5) has an AADT/C value high enough that peak hour volumes exceed capacity. The reason that occurs is that extra volume is entering at node 4, thus, this is the bottleneck point. From here, the following steps are taken:

- Step 1: Adjust the Network for the Bottleneck Location. The simplest way of handling the misplaced queue is to move the volume from the link downstream of the bottleneck to the link immediately upstream, then modify the conditions on the downstream link, and conduct the analysis from there. For hours when queuing is present, the downstream link is then treated as being influenced directly by the upstream queue: the

⁸For uncongested conditions, the speed function developed with NETSIM does include the effect of signal density.



AH 0296-012 SA

- ¹ As determined from the Orlando and Denver field data, the average speed in queues is 15.5 mph.
 - ² Taken from QSIM output using the original AADT/C of the link.
 - ³ Computed using AADT/C = 11.
 - ⁴ Computed using Equations (3) and (4).
 - ⁵ Average of speed at V/C = 1.0 and upstream speed.
- NOTE: ALL VOLUMES ARE ON A PER LANE BASIS.**

Figure 3.1 Application of the Speed Methodology to Consider Queue Spillbacks

link volumes is the discharge volume from the queue ("Actual Volume" from Appendix C), the speed at the start of the link is the queue speed from the upstream link, the speed at the end of the link is the speed predicted by the uncongested speed function using $V/C = 1.0$ (52.0 mph), and the overall link speed is the average of these two speeds.

- Step 2: Build Queues by Hour. For this step, the data on queue lengths (measured in total vehicles) in Appendix C can be used along with an assumed queue spacing.⁹ With this information, it is then possible to build and dissipate queue distances by hour.
- Step 3: Compute Speeds by Link. The queue length information is then used as shown in Figure 3.1 to compute link speeds. For the link immediately upstream of the bottleneck, the overall speed is taken directly from the QSIM output. For the remaining links, Equations (3) and (4) are used after the proportion of the link with a queue is determined.

The result of applying this process is to lower speeds on links that otherwise would have had higher (uncongested) speeds. In Figure 3.1, link (2,3) would have had a speed of 51.77 mph (based on its AADT/C value of 8) if it were considered in isolation. However, since the queue has spread to include part of it, the modified procedure predicts a speed of 39.27 mph. Higher congestion levels would lead to queues influencing even more links; the maximum queue length for $AADT/C = 13$ is 840 vehicles per lane (almost seven miles).

3.4 Case Study Comparisons

Case study comparisons will proceed at two levels. First, hypothetical freeway and

⁹For this research we used a queue spacing of 43 feet, comprised of an average vehicle length of 18 feet and a from-bumper-to-rear-bumper gap of 25 feet.

signalized arterial corridors will be used to demonstrate the procedure. Multiple bottlenecks will exist on these test corridors and two general levels of congestion will be studied (Tables 3.2 and 3.3).

Knox County, Tennessee will serve as the *in vivo* case study for applying the methodology and comparing its speed estimation procedures to "best standard practice", as defined below. Knox County is a typical "medium-sized" urban area with a 1990 population of nearly 340,000. The local Metropolitan Planning Organization (MPO) maintains on-going travel forecasting process using the MINUTP software. The MINUTP network used in the modeling process has 239 zones, 1,407 nodes, and 3,108 links. Selected corridors and subareas from this network will be used to perform comparisons between the new speed procedures and "best standard practice" which is defined as using historic methodologies applied to MINUTP output link-by-link. Since Knox County performs 24-hour traffic assignments, AADT will be the starting point for the comparisons. The post-processor will use the temporal distributions developed by the author to determine hour-by-hour demand volumes on the network. Knox County's K- and D-factors will be used to derive peak hour volume for the "best standard practice " case; offpeak hourly volumes will be based on Knox County's current procedure for their determination. The methodologies for "best standard practice shall be:

- Freeways. The original BPR curve will be used for uncongested conditions ($V/C < 1.0$) because it replicates the relationship in the revised (1994) *HCM* the closest of all its variants. For congested conditions the modified BPR4 equation will be used because they seem to do a reasonable job of predicting speeds under queuing.
- Signalized Arterials. A similar comparison will be conducted for signalized arterials. Because the author's research verified that signal density is an extremely important factor in determining arterial speeds, the *HCM (Chapter 11)* planning methodology is

Table 3.2. Test Network for Freeways

		Congestion Level			
		Moderate		High	
A-Node	B-Node	AADT	AADT/C	AADT	AADT/C
1	2	60,000	7.5	75,000	9.4
2	3	62,000	7.7	77,500	9.7
3	4	65,000	8.1	81,250	10.1
4	5	70,000	8.7	87,500	10.9
5	6	70,000	8.7	87,500	10.9
6	7	70,000	8.7	87,500	10.9
7	8	70,000	8.7	87,500	10.9
8	9	75,000	9.4	93,750	11.7
9	10	80,000	10.0	100,000	12.5
10	11	85,000	10.6	106,250	13.3
11	12	95,000	11.9	118,750	14.8
12	13	85,000	10.6	106,250	13.3
13	14	60,000	7.5	75,000	9.4
14	15	70,000	8.7	87,500	10.9
15	16	70,000	8.7	87,500	10.9
16	17	90,000	11.2	112,500	14.0
17	18	65,000	8.1	81,250	10.1
18	19	65,000	8.1	81,250	10.1
19	20	65,000	8.1	81,250	10.1
20	21	65,000	8.1	81,250	10.1

Notes: (1) 10% trucks
(2) capacity = 2,002 vphpl
(3) link length = 1 mile

Table 3.3. Test Network for Signalized Arterials

		Congestion Level			
		Moderate		High	
A-NODE	B-NODE	AADT	AADT/C	AADT	AADT/C
1	2	29,000	8.1	36,250	10.1
2	3	30,000	8.3	37,500	10.4
3	4	31,000	8.6	38,750	10.8
4	5	31,000	8.6	38,750	10.8
5	6	32,000	8.9	40,000	11.1
6	7	33,000	9.2	41,250	11.5
7	8	36,000	10.0	45,000	12.5
8	9	39,000	10.8	48,750	13.5
9	10	29,000	8.1	36,250	10.1
10	11	44,000	12.2	55,000	15.3
11	12	39,000	10.8	48,750	13.5
12	13	38,000	10.6	47,500	13.2
13	14	46,000	12.8	57,500	16.0
14	15	33,000	9.2	41,250	11.5
15	16	33,000	9.2	41,250	11.5
16	17	41,500	11.5	51,875	14.4
17	18	31,000	8.6	38,750	10.8
18	19	31,000	8.6	38,750	10.8
19	20	31,000	8.6	38,750	10.8
20	21	31,000	8.6	38,750	10.8

- Notes: (1) 0% trucks
 (2) capacity = 900 vphpl (assuming 1,800 vphpl saturation flow rate and 50% green time)
 (3) link length = 0.5 miles

considered to be the most desirable "standard practice" for post-processing speeds from network model output. However, the level of data detail required to apply the *HCM* method is generally not available from network models. For example, the estimation of intersection delay requires information on the nature of signal progression, arterial classification, lane group V/C, cycle length, and lane group green time. Of these, cycle length, progression, and green time are not used by MINUTP. Therefore, it will be necessary to make some simplifying assumptions about these data elements. In addition to the *HCM*, the BPR4 equation will also be applied since it depends solely on V/C ratio and is easier to apply on a network basis.

4. SPEED MODEL (QSIM) DEVELOPMENT AND VALIDATION

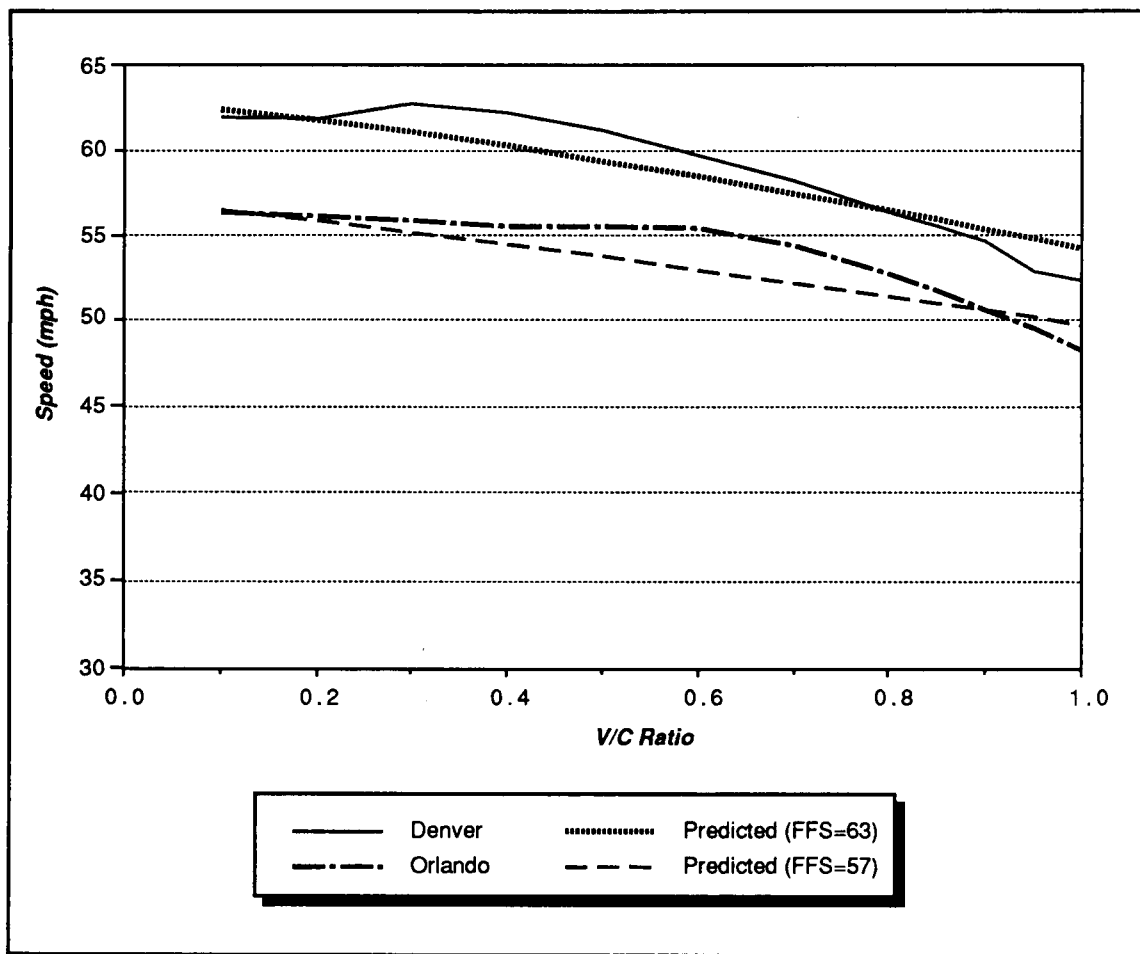
4.1 Verification of the QSIM Model With Field Data

4.1.1 Introduction

The author's modeling procedure (QSIM) was applied as described in Chapter 2 and a series of predictive equations were developed. As explained in the following sections, the procedure was subjected to validation against available field data.

4.1.2 Comparison of The QSIM Model With Freeway Data

For uncongested conditions on freeways, comparisons of QSIM's speed function were made against data from the Denver and Orlando freeway surveillance systems. Because both uncongested and congested (saturated) conditions are present in the data, the first step in this validation test is to cull out saturated conditions from the field data on the basis of density and speed. Based on guidance provided in the *HCM*, data were excluded from the uncongested analysis if one of two conditions were met: (1) speeds were less than 30 mph or (2) speeds were less than 40 mph and density was greater than 47 vehicles per lane-mile. The next step was to compute V/C ratios for all hours studied and compare them to QSIM's estimates. Figure 4.1 shows that QSIM's uncongested freeway speed function follows the field data closely. For V/C ratios below 0.80-0.85, QSIM has a slight tendency to underpredict speeds while at higher V/C levels it slightly overpredicts speed. Based on these close results, I do not see any need to adjust QSIM's speed function for uncongested freeways. Figure 4.1 also exhibits the problem of free flow speed estimation. Note that for Orlando the free flow speed appears to be around 57 mph but for Denver it is around 63 mph. (I assume that the systems are properly calibrated.) A cursory review of the prevailing conditions shows that lane width, lateral clearance, percent trucks, and terrain are all similar (Table 4.1). Both systems cover highway segments that have



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Figure 4.1 Comparison of QSIM's Uncongested Speed Function and Freeway Surveillance Data

Table 4.1. 1993 HPMS Data for I-25 (Denver) and I-4 (Orlando)

Highway	Lane Width (ft)	Right Shoulder Width (ft.)	Left Shoulder Width (ft.)	Peak Hour Trucks (%)	Average Grade (%)
I-25, Denver	12	10	4	8-10	1.5
I-4, Orlando	12	10	10	6	1.5

approximately one interchange per mile but Orlando's system has many more complicated interchange designs. Orlando's system also includes areas on both sides of the CBD; Denver's system covers an area that is entirely south of the CBD. Finally, because Orlando is a popular tourist destination, I postulate that it has a higher proportion of drivers who are unfamiliar with the system. The difference in these conditions probably leads to the lower free flow speed in Orlando. Note also, the very slight increase in speeds for Denver for V/C of 0.3 and 0.4. Closer examination of the data revealed that the majority of hours where V/C was 0.1 and 0.2 were night time hours, but I chose to leave all hours of the day in the comparison since the difference was small.

Although the new *HCM* relationships have not been plotted on Figure 4.1, it should be pointed out that the *HCM* speed curves are flatter over the 0.0 to about 0.8 V/C range than those suggested by either QSIM or the field data. However, the speeds where volume equals capacity ($V/C = 1.0$) are very close. For Denver, the *HCM* predicts a speed of roughly 51.8 mph while the field data indicate a speed of 52.4 mph. For Orlando, the *HCM* predicts a speed of roughly 48.8 mph while the field data indicate a speed of 49.7 mph. QSIM and field data show a slight but constant decrease of speeds over the full range of uncongested V/C ratios whereas the *HCM* shows no effect of V/C ratio on speed over a wide range of V/C ratios. However, regardless of the shape of the curve, the methods converge on the same speed at the

point where volume equals capacity.

For congested conditions, the first step was to check the estimation of speeds in queues, because this is an important factor used directly by QSIM. The Orlando and Denver data were screened to identify queuing conditions defined by at least one continuous hour (of five-minute measurements) where speeds were less than 30 mph and density was greater than 42 vehicles per lane. From these candidate hours, only those five-minute measurements where density was between 67-100 vehicles per lane were analyzed; higher densities were assumed to be indicative of incident conditions. Results showed that for Orlando, the average queue speed was 16.1 mph (standard deviation = 4.9) and 15.0 for Denver (standard deviation = 5.0; Table 4.2). Based on these results, QSIM's average queue speed was changed from its current value of 17.9 mph to 15.5 mph. This speed applies to all vehicles whenever a queue has been determined to exist by the model. Thus, 15.5 mph is assumed to be the lowest speed experienced by vehicles under the conditions modeled, that is, recurring congestion caused by freeway on-ramps. Other types of bottlenecks -- such as lane drops (e.g., three lanes merging into two) and incidents -- are likely to have lower queue speeds than 15.5 mph due to lower flows through the bottleneck in relation to demand volume. (This would cause vehicle spacing to increase. The resulting increase in density leads to lower speeds.) These types of bottlenecks are beyond the scope of the current work but are fertile ground for future research.

Overall validation under congested conditions is more difficult using freeway surveillance data alone. The problem is that QSIM (or any other analytical method) must use the **demand** volume as input, even if the volume is over capacity. Such conditions are not possible to observe directly in the field since under forced flow, observed volumes will be less than the ideal capacity. The scope of the current work precludes original data collection,

Table 4.2. Queue Speeds from Denver and Orlando Freeway Data

Urban Area	No. Hours	Avg. Speed	Std. Dev.	5th %ile	95th %ile
Orlando	2,407	16.1 mph	4.9	8 mph	25 mph
Denver	1,263	15.0 mph	5.0	7 mph	24 mph

therefore, freeway surveillance data appear to be the only viable way of checking QSIM's performance under congested (queuing) conditions. The approach undertaken is shown in Figure 4.2 and is based on estimating the demand volume at a bottleneck point by "borrowing" the temporal distribution from a nearby upstream location that does not experience queuing. This approach assumes that the traffic patterns of the two locations are identical.

The first step in the approach was to identify recurring bottleneck locations for both Orlando and Denver; this was accomplished by producing the speed contour plots alluded to in Figure 4.2 for each day of data. Each of these daily plots were then reviewed to identify locations where high vehicle densities occurred routinely during peak hours. (Figure 4.3 shows an example of one of these daily speed contour plots.) There are several problems with trying to locate bottlenecks in this manner. First, incidents are imbedded in the data and are not uniquely identified. This problem was avoided by excluding the few days with massive amounts of congestion. Second, queues from secondary bottlenecks may spill back to affect the primary location, however, the data are not detailed enough to allow this determination. In the end, Station 204 in the Denver system and Station 14 in the Orlando system were identified as recurring bottleneck locations.

A much larger problem with using the freeway surveillance data in this manner is the

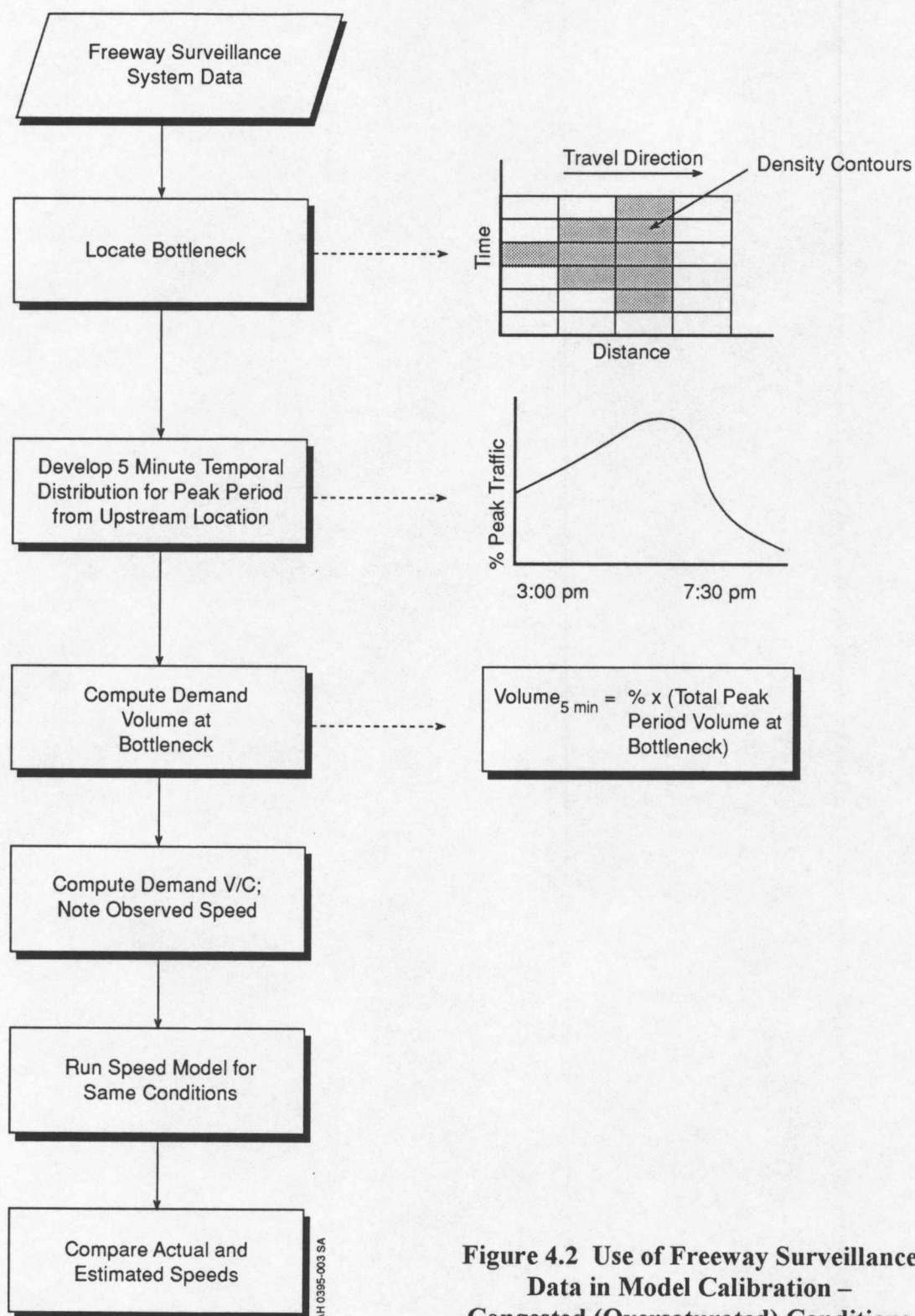


Figure 4.2 Use of Freeway Surveillance Data in Model Calibration – Congested (Oversaturated) Conditions

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large amount of variation that exists in both speeds and the physical capacity of the section under study. Procedures in the *HCM* would indicate that capacity is fixed. However, several important factors are either not considered in the calculation of capacity or can not be distinguished from our data. In the latter category, the field data in hand do not break out the number of trucks in the traffic stream; only total vehicles are included. Use of a fixed percent trucks in the capacity calculation does not allow for the fact that the observed number of trucks in a given hour can vary.¹⁰ Therefore, even accepting that *HCM* procedures account for every factor influencing capacity, the data will naturally show that physical capacity varies from day-to-day because of the fluctuation in the truck mix. Beyond this, other factors not considered by the *HCM* also may affect capacity. Traffic engineers have observed that when traffic flow approaches the theoretical capacity, it becomes highly sensitive to external influences. Under extremely dense conditions, a single aberrant driver may be all that is needed to shift the traffic stream into forced flow. Other factors that may affect capacity include weather, light conditions, and pavement condition.

The determination of capacity is extremely important for the QSIM model because it uses capacity to determine whether traffic is operating in either the free flow or forced flow regimes. However, given the problems with capacity noted above, comparisons between the field data (which in effect have a variable capacity) and QSIM results (based on a fixed capacity) are probably inappropriate. To get a more "fair" comparison, QSIM's capacity was allowed to vary stochastically. That is, for each hour of comparison, QSIM was run several times where the capacity value for a particular run was sampled from a normal distribution with

¹⁰The percent trucks for the Orlando (six percent) and Denver (10 percent) data were determined from the 1992 HPMS data. HPMS sections for both I-4 and I-25 were identified in these data.

a mean of 2,350 passenger cars per hour per lane (pcphpl) with a standard deviation of 50 for Denver and 90 for Orlando. The mean value of 2,350 pcphpl was selected using the following procedure. First, daily capacity was assumed to vary both above and below the theoretical capacity. To capture those cases higher than the theoretical capacity, any hours where volume was greater than or equal to the theoretical capacity were identified. For those below, the V/C ratio had to be between 0.9 and 1.0 plus the density of vehicles had to be between 40 and 42 vehicles per lane-mile in order for the data to qualify. (This is the density at capacity suggested by the *HCM*.) To illustrate this procedure, refer to the plots of speed versus V/C ratio in Figures 4.4 and 4.5. All those hourly observations at or above $V/C = 1.0$ were included in the capacity variability calculations. In addition, those hourly observations between V/C values of 0.9-1.0 and a density between 40-42 were also included. Figures 4.4 and 4.5 show clearly that many hourly volumes exceeded the theoretical capacity. At other times, capacity densities are achieved at volumes less than the theoretical capacity. Using this information, the average capacity for Orlando was 2,283 vehicles per hour per lane (vphpl; this includes trucks) and for Denver it was 2,179 vphpl. Because trucks are imbedded in the total hourly volumes, they were "backed out" of these values producing capacities of 2,374 pcphpl for Orlando and 2,311 pcphpl for Denver. A middle value of 2,350 pcphpl was then selected based on this information.

Speeds for each QSIM run were then averaged; these were used as the basis for the comparisons shown in Appendix D. On average, the hour-by-hour comparisons showed that QSIM overpredicted speeds by about seven percent. For entire peak periods, QSIM's performance improves: about four percent high on average. Overall, QSIM's predictions are in line with the field data.

4.1.3 Comparison of The QSIM Model With Arterial Data

Validation of QSIM for signalized arterials is more difficult than for freeways because

Legend: A = 1 obs, B = 2 obs, etc.

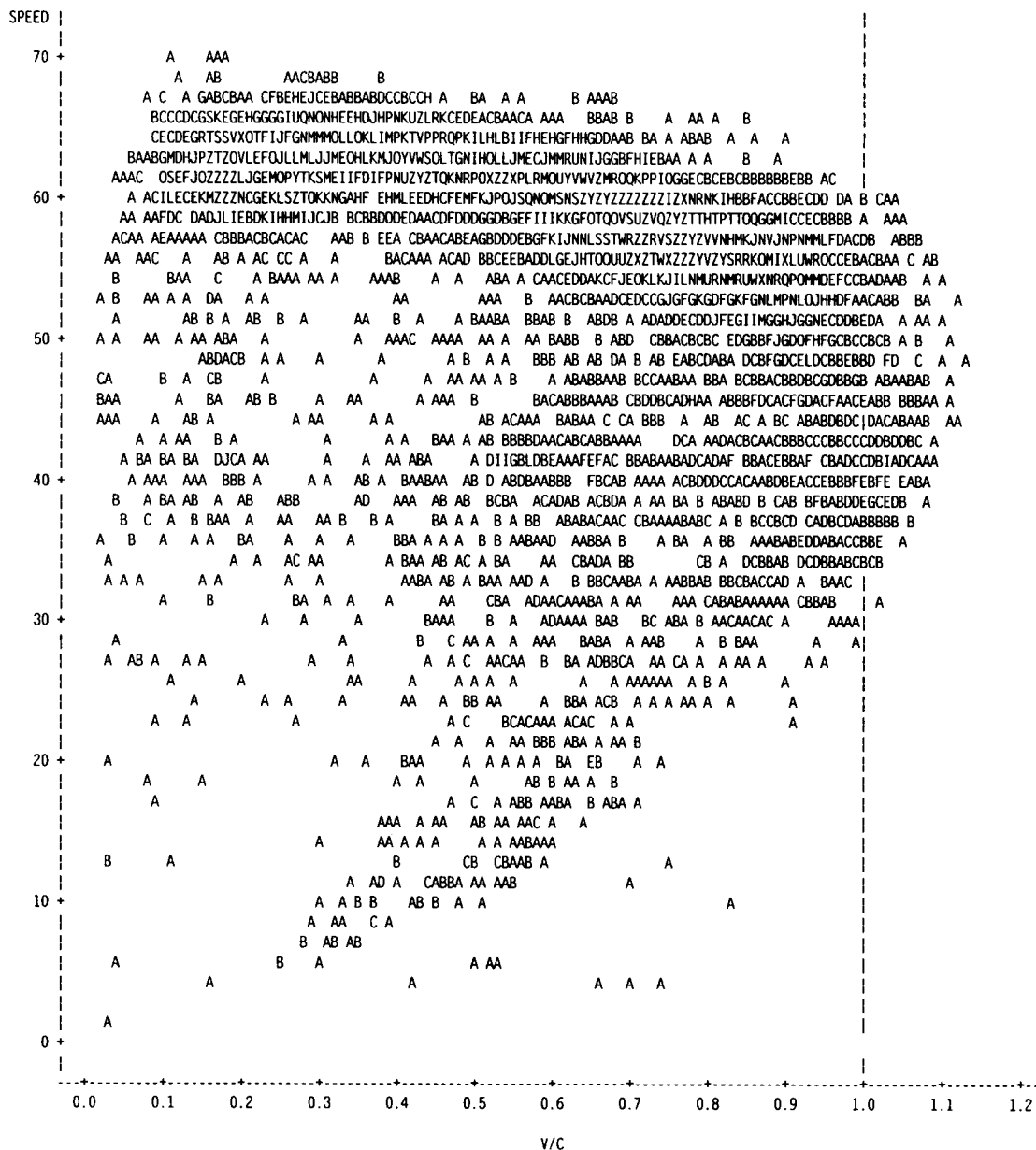


Figure 4.4. Denver (I-25) Speed Data

Legend: A = 1 obs. B = 2 obs. etc.

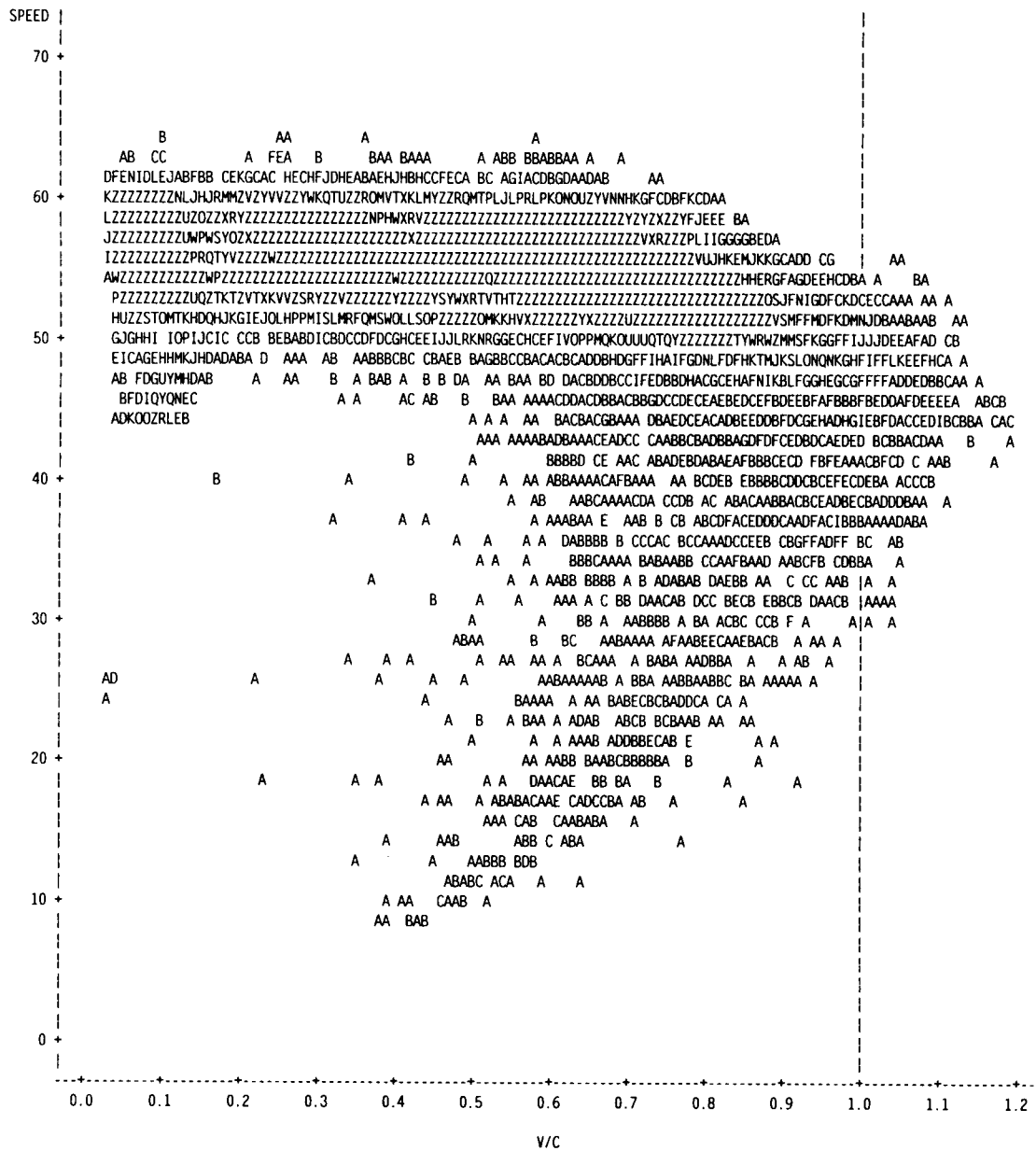


Figure 4.5. Orlando (I-4) Speed Data

of the methods used to estimate arterial speeds. For example, travel time measurements using the "floating car" method are the standard way of measuring speeds along an arterial route. However, these data are limited for two reasons. First, the small sample size (usually one per time period) does not adequately account for the daily variation in the traffic stream; measured travel times are highly dependent on the particular day and start time the runs were made. Second, volumes and saturation levels that correspond to the actual conditions encountered by the vehicle are almost never captured -- average values are typically used. Nonetheless, given the significance of estimating arterial speeds for air quality and other planning applications, the author decided to pursue validation against the arterial dataset described in Chapter 3.

The results of the comparison are summarized in Figure 4.6 and show that the original QSIM formulation consistently underpredicts speeds for this section of highway. Because QSIM's arterial speed function is based on NETSIM results, it was decided to apply NETSIM to the N.J. Route 10 data. The results of this comparison appear in Table 4.3. The NETSIM-predicted speeds and the actual measured speeds are in very close agreement. This fact lead to questions about the original NETSIM runs that were used to develop the QSIM equation in the *HPMS Speed Determination Models* study. The original data files were located and run through NETSIM again to determine if a mistake had been made in compiling the outputs. Surprisingly, the results showed that the new NETSIM runs produced consistently higher speeds than the original runs (Figure 4.7). The difference is particularly striking in the high V/C cases. The only difference in the two runs was that NETSIM Version 3 was used in the original runs while Version 5 (the most recent release) was used for the new runs. Further investigation revealed that some default values such as queue discharge headway have been revised in Version 5. It is also likely that other internal relationships have been changed. Based on these findings, it was decided to completely revise QSIM's signalized arterial function by replicating

EASTBOUND - NJ Route 10									
No.	Control Point	Mile		Volume	Cycle	Direction	Lane Grp	Capacity	V/C
		Marker							
4	Whippany Rd.	0	1613	PM_1	EB	TR		3014	0.592
				PM_2	EB	TR		2230	0.800
5	Troy Hills Rd.	0.256	1639	PM_1	EB	T		2801	0.647
				PM_2	EB	T		2257	0.802
6	Algonquin Pkwy.	0.673	1579	PM_1	EB	T		3135	0.557
				PM_2	EB	T		2675	0.652
7	Ridgedale Ave.	1.184	1716	PM_1	EB	TR		2448	0.775
				PM_2	EB	TR		1565	1.212
11	River Road	0	1357	PM_1	EB	TR		2524	0.594
				PM_2	EB	TR		1696	0.884
12	Okner Pkwy.	0.449	1733	PM_1	EB	TR		2968	0.645
				PM_2	EB	TR		2215	0.864
13	Walnut Ave.	0.899	1535	PM_1	EB	T		3072	0.552
				PM_2	EB	T		2487	0.682
Eastbound									
FFS = 50									
----- Speeds-----									
Cycle	Signals	Avg Vol	Avg V/C	Sig/Mi	Actual	Predicted	Delay	%Error	
PM_1	4.5	1626.00	0.620	3.906	28.00	17.41	37.441	-37.82%	
PM_2	4.5	1626.00	0.801	3.906	28.00	15.28	45.425	-45.41%	
PM_1	5.6	1609.00	0.603	2.398	39.00	23.14	23.221	-40.67%	
PM_2	5.6	1609.00	0.728	2.398	39.00	21.40	26.720	-45.12%	
PM_1	6.7	1647.50	0.671	1.957	29.00	24.59	20.672	-15.22%	
PM_2	6.7	1647.50	0.944	1.957	29.00	21.30	26.938	-26.54%	
PM_1	4.5.6	1610.33	0.599	2.972	32.50	20.69	28.322	-36.32%	
PM_2	4.5.6	1610.33	0.752	2.972	32.50	18.67	33.548	-42.54%	
PM_1	5.6.7	1644.67	0.663	2.155	32.37	23.54	22.478	-27.27%	
PM_2	5.6.7	1644.67	0.897	2.155	32.37	20.68	28.364	-36.12%	
PM_1	4.5.6.7	1636.75	0.645	2.534	30.14	21.88	25.714	-27.42%	
PM_2	4.5.6.7	1636.75	0.873	2.534	30.14	19.09	32.394	-36.68%	
PM_1	11.12	1545.00	0.623	2.227	31.00	23.72	22.153	-23.47%	
PM_2	11.12	1545.00	0.873	2.227	31.00	20.55	28.651	-33.69%	
PM_1	12.13	1634.00	0.601	2.222	39.00	24.06	21.555	-38.30%	
PM_2	12.13	1634.00	0.779	2.222	39.00	21.67	26.147	-44.44%	
PM_1	11.12.13	1541.67	0.599	2.225	34.55	24.08	21.522	-30.29%	
PM_2	11.12.13	1541.67	0.809	2.225	34.55	21.29	26.977	-38.39%	

Figure 4.6. Comparison of QSIM Arterial Speed Function With Field Data

Table 4.3. Application of NETSIM to N.J. Route 10 Dataset

Link	NETSIM Speed	Actual Speed	Percent Difference
(7,6)	39.17	41.00	-4.5%
(6,5)	33.63	37.00	-9.1%
(5,4)	32.76	28.00	17.0%
(7,6,5)	36.47	38.83	-6.1%
(6,5,4)	33.29	32.00	4.0%
(7,6,5,4)	35.60	34.70	2.6%
(4,5)	31.52	28.00	12.6%
(5,6)	37.78	39.01	-3.2%
(6,7)	33.90	29.02	16.8%
(4,5,6)	35.13	32.50	8.1%
(5,6,7)	35.54	32.37	9.8%
(4,5,6)	34.59	30.14	14.8%

FFS	LT BAY	V/C		Signals Per Mile					
				0.33	0.5	1	3	6	10
50	Yes	V/C = 0.2	Original	41.10	39.57	36.76	25.91	19.86	19.56
			Revised	44.17	43.19	38.47	26.44	22.21	20.00
		V/C = 0.4	Original	38.44	37.57	34.50	22.14	17.25	14.60
			Revised	42.18	41.24	36.11	21.56	20.17	18.41
		V/C = 0.6	Original	36.88	35.04	32.24	19.40	14.52	12.85
			Revised	40.25	39.05	34.37	19.32	18.59	16.95
		V/C = 0.75	Original	36.00	33.92	30.86	17.12	10.27	9.60
			Revised	39.33	37.52	33.27	18.50	17.44	15.87
		V/C = 0.85	Original	24.08	23.32	14.65	9.29	6.73	3.84
			Revised	38.89	36.41	32.22	17.68	16.48	14.64

Figure 4.7. Comparison of Original and Revised NETSIM Runs

Note: The original runs were made with NETSIM Version 3. The revised runs were made with NETSIM Version 5. Input data in both cases were the same.

the original experiment with the new version (Version 5) of NETSIM. The results are displayed in Figures 4.8 and 4.9. These data were used to re-fit the equation used for QSIM's signalized arterial function which has become:

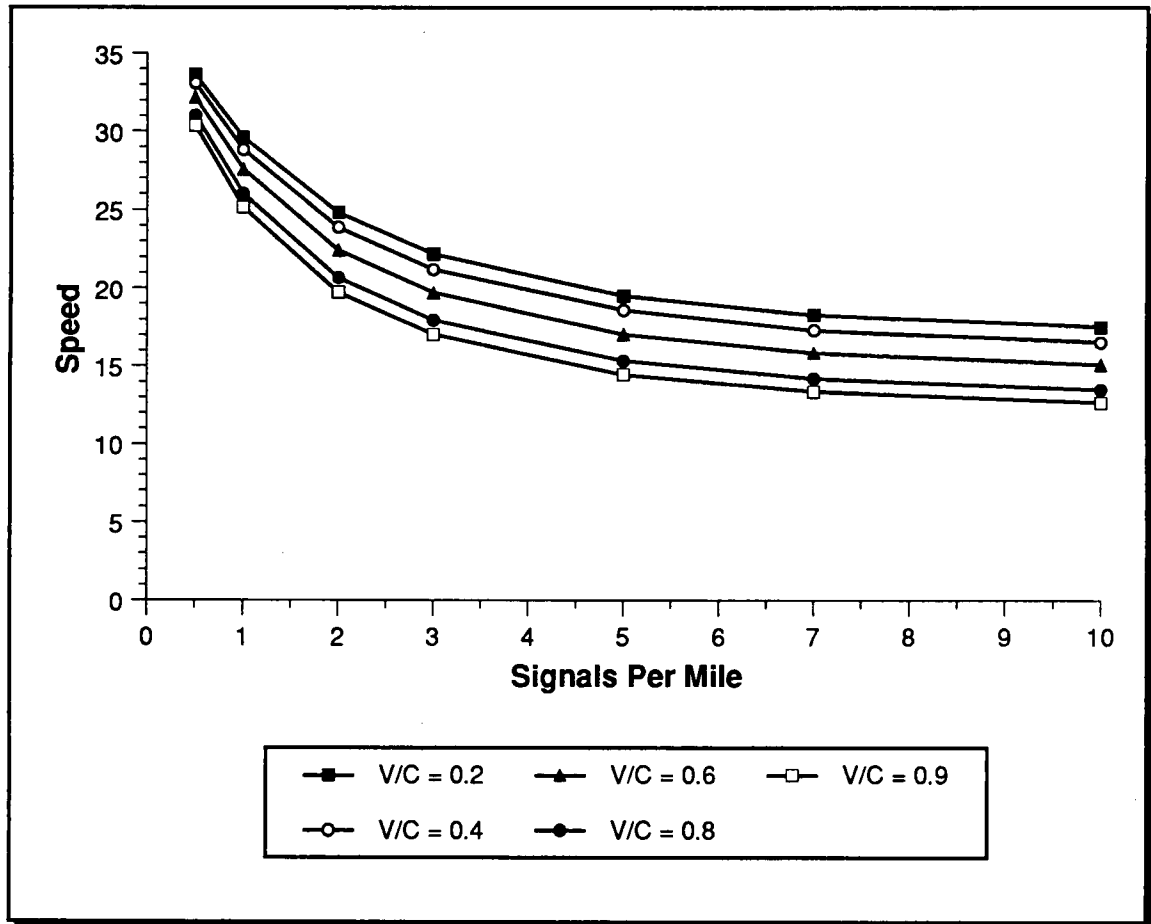
$$d_{sig} = (32.6 + 30.0 (V/C)^2) (1 - e^{-3n}). \quad (7)$$

Where:

- d_{sig} is delay in vehicle-hours per 1,000 vehicle-miles.
- V/C is volume-to-capacity ratio.
- n is the number of signals per mile.

The original NETSIM experiment from the *HPMS Speed Determination Models* study also tested for the effect of progression in the test networks. The first set of runs in the test networks assumed zero offsets for all the signals, that is, their cycles turned at exactly the same time. (This is the condition used in the tests described above and is reflected in Figure 4.7.) The second set of runs used time-space diagrams to achieve signal progression in the test direction. The results of the original study showed only a marginal improvement in speeds due to progression. At that time, the reason for the small difference was attributed to the fact that a large degree of progression exists in networks with closely spaced signals and zero offsets. The end result was that progression was not included as a separate factor in the original models and it was assumed that the models applied to an "average" situation. However, since the tests described above cast some doubt on the validity of the original approach, it was decided to re-test for the effect of progression. As shown in Table 4.4, the results of this test showed that progression does in fact have a significant effect on vehicle speeds. It is not clear as to what caused the original results showing only a marginal effect of progression. (It could have been the difference in the NETSIM versions, a mistake in the offset plans, or both.) In any event, the results in Table 4.4 are considered to be more reliable.

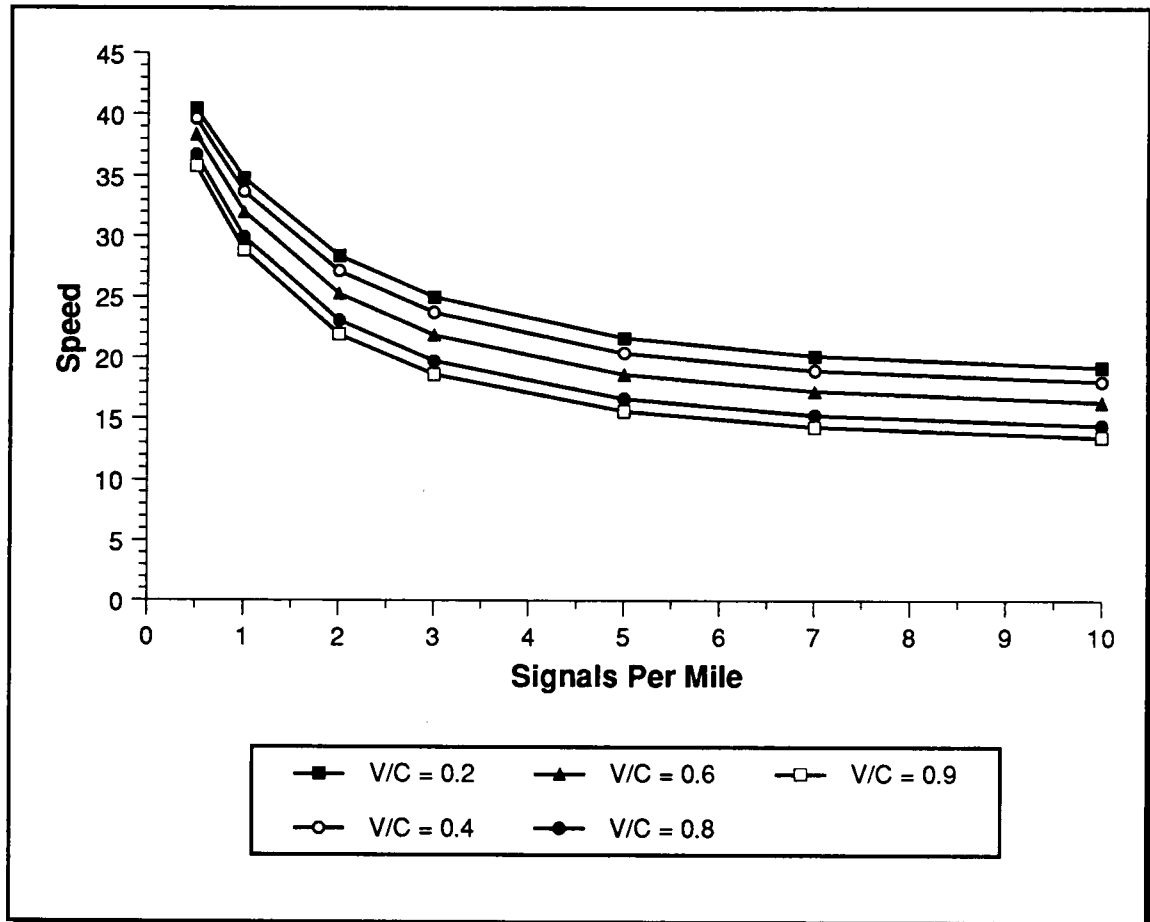
Uncongested Signalized Arterials
FFS=40 LT Bay=Yes Fixed Time



AH 0696-001 SA

Figure 4.8 Arterial Speed Results, FFS=40

Uncongested Signalized Arterials
FFS=50 LT Bay=Yes Fixed Time



AH 0696-001 SA

Figure 4.9 Arterial Speed Results, FFS=50

Table 4.4. Effect of Progression on Vehicle Speeds

Signals/Mi	Signalization	V/C					
		0.2	0.4	0.6	0.75	0.85	0.95
6	Progression	28.8	29.7	28.8	28.5	27.3	24.2
	No Progression ¹	22.2	20.2	18.6	17.4	16.5	14.8
10	Progression	24.5	25.2	24.1	23.2	22.6	17.4
	No Progression ¹	20.0	18.4	17.0	15.9	14.6	12.5

¹Zero offsets in signal timing.

4.2 Final QSIM Results

4.2.1 Introduction

Based on the above refinements QSIM was applied to produce new hourly speed tables by AADT/C level for freeways and signalized arterials (Appendix C). The free flow speeds used in these runs were 60 mph for freeways and 40 mph for arterials. Three signal densities were tested for arterials: 0.2, 2, and 20 signals per mile. QSIM produces separate results for weekday travel in the morning peak direction, weekday travel in the afternoon peak direction, and weekend/holiday travel in both directions combined. (Appendix C shows these distinctions.) The results are summarized over all days and directions in Figures 4.10 and 4.11; these values are for the volume-weighted average speeds for the two weekday and one weekend

HOUR	AAOT/C																																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																
	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph															
1	59.9	59.8	59.8	59.7	59.6	59.5	59.4	59.4	59.3	59.2	59.1	59.0	58.7	58.4	58.0	57.5	56.9	55.7																
2	60.0	59.9	59.9	59.8	59.7	59.7	59.7	59.6	59.5	59.5	59.4	59.4	59.1	58.8	58.4	57.9	57.3	56.0																
3	60.0	59.9	59.9	59.9	59.8	59.8	59.7	59.7	59.7	59.6	59.6	59.6	59.3	59.0	58.6	58.1	57.6	56.7																
4	60.0	59.9	59.9	59.9	59.9	59.8	59.8	59.8	59.8	59.7	59.7	59.7	59.4	59.1	58.8	58.3	57.7	57.1																
5	60.0	59.9	59.9	59.9	59.8	59.8	59.7	59.7	59.7	59.7	59.6	59.6	59.4	59.1	58.7	58.2	57.5	56.6																
6	59.9	59.8	59.7	59.6	59.5	59.4	59.2	59.2	59.1	59.0	58.8	58.7	58.5	58.1	57.7	57.1	56.2	54.1																
7	59.7	59.4	59.1	58.8	58.4	58.0	57.6	57.2	56.7	56.2	55.8	54.7	53.1	51.3	49.7	45.8	43.3	39.7																
8	59.6	59.1	58.6	58.0	57.4	56.7	55.3	53.4	47.5	42.6	39.4	36.2	32.7	29.6	27.8	25.7	24.9	23.5																
9	59.7	59.3	59.0	58.6	58.1	57.7	56.8	54.6	46.9	40.0	35.3	31.2	27.7	24.8	23.3	21.7	21.0	20.0																
10	59.8	59.5	59.2	58.9	58.6	58.2	57.9	57.4	55.0	46.7	37.9	31.7	28.2	25.0	23.2	21.5	20.7	19.7																
11	59.7	59.5	59.2	58.9	58.5	58.2	57.8	57.4	57.0	55.6	49.3	37.7	32.1	27.4	24.9	22.5	21.0	19.5																
12	59.7	59.4	59.1	58.8	58.4	58.0	57.6	57.1	56.7	56.1	54.3	45.7	37.1	29.9	26.3	22.8	20.7	18.9																
13	59.7	59.4	59.0	58.7	58.3	57.9	57.4	57.0	56.5	55.8	54.7	49.2	40.6	31.4	26.4	22.2	19.9	18.2																
14	59.7	59.4	59.0	58.6	58.2	57.8	57.4	56.9	56.4	55.8	54.6	50.7	42.8	32.0	26.1	21.4	19.1	17.5																
15	59.7	59.3	58.9	58.5	58.1	57.6	57.2	56.6	56.1	55.4	54.0	49.5	42.0	31.6	24.8	20.2	18.2	16.8																
16	59.6	59.2	58.7	58.2	57.7	57.1	56.6	56.0	54.8	53.1	49.9	43.3	35.7	26.8	21.8	18.6	17.1	16.2																
17	59.6	59.1	58.5	58.0	57.3	56.7	55.7	54.3	50.9	46.0	39.8	33.4	27.4	22.3	19.3	17.3	16.4	15.8																
18	59.6	59.1	58.5	57.9	57.3	56.7	55.2	52.7	47.5	40.5	34.0	28.6	24.1	20.5	18.3	16.9	16.1	15.7																
19	59.7	59.3	59.0	58.6	58.2	57.7	56.9	54.9	49.4	41.2	33.5	27.7	23.6	20.3	18.3	17.0	16.1	15.7																
20	59.8	59.5	59.3	59.0	58.7	58.4	58.1	57.7	56.5	51.5	41.7	31.5	26.0	21.8	19.0	17.4	16.4	15.8																
21	59.8	59.6	59.4	59.2	59.0	58.7	58.5	58.3	58.0	57.5	54.4	43.1	33.3	26.0	21.3	18.4	17.0	16.2																
22	59.8	59.7	59.5	59.3	59.1	58.9	58.7	58.4	58.1	57.9	57.6	55.1	48.0	36.5	26.6	20.8	18.1	16.7																
23	59.9	59.7	59.6	59.4	59.2	59.1	58.9	58.7	58.5	58.2	58.0	57.7	55.4	48.5	35.4	25.2	19.9	17.5																
24	59.9	59.8	59.7	59.5	59.4	59.3	59.2	59.0	58.9	58.7	58.5	58.4	57.8	56.0	48.0	33.7	23.3	18.9																

Figure 4.10. QSIM Results for Freeways (Combined All Days and Both Directions)

SIGNALS/MILE: 0.2

		AADT/C																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
HOUR	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED
	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph
1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.0	36.9	36.8	36.6	36.4
2	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.0	37.0	36.9	36.7	36.5
3	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.0	36.9	36.8	36.6
4	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.0	36.9	36.8	36.7
5	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.0	36.9	36.8	36.6
6	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.0	36.9	36.8	36.6
7	37.1	37.1	37.1	37.1	37.1	37.1	37.0	37.0	36.9	36.8	36.7	36.6	36.4	36.3	36.1	36.0	35.6	35.3	34.4
8	37.1	37.1	37.0	36.9	36.8	36.7	36.5	36.4	36.2	35.9	35.4	34.7	34.3	33.6	32.7	31.7	31.3	30.0	26.8
9	37.1	37.1	37.1	37.0	36.9	36.8	36.7	36.5	36.4	36.1	35.8	35.2	34.8	33.5	31.4	29.7	28.9	26.8	26.8
10	37.1	37.1	37.1	37.0	37.0	37.0	36.9	36.8	36.7	36.6	36.5	36.3	36.2	35.9	35.5	34.0	32.4	30.9	28.2
11	37.1	37.1	37.1	37.0	37.0	37.0	36.9	36.8	36.7	36.5	36.4	36.2	36.0	35.6	35.6	35.0	33.9	32.4	29.9
12	37.1	37.1	37.1	37.0	36.9	36.8	36.7	36.5	36.3	36.2	35.9	35.7	35.0	34.6	34.2	33.0	31.8	28.9	28.9
13	37.1	37.1	37.0	37.0	36.8	36.7	36.5	36.4	36.2	36.0	35.6	35.0	34.2	33.6	31.9	30.7	29.4	26.5	26.5
14	37.1	37.1	37.0	37.0	36.9	36.7	36.6	36.4	36.2	36.1	35.7	34.8	33.8	32.8	30.4	28.8	26.5	24.0	24.0
15	37.1	37.1	37.0	37.0	36.8	36.7	36.6	36.4	36.2	35.9	35.7	34.6	33.2	31.6	29.7	27.4	24.5	22.1	22.1
16	37.1	37.1	37.0	36.9	36.8	36.6	36.4	36.2	36.0	35.6	34.9	33.0	31.1	28.7	26.6	24.0	21.8	19.5	19.5
17	37.1	37.1	37.0	36.9	36.7	36.5	36.3	36.0	35.6	34.4	33.7	30.1	28.0	24.9	22.4	20.0	18.4	16.5	16.5
18	37.1	37.1	37.0	36.9	36.7	36.5	36.3	35.9	35.2	33.7	32.5	28.2	25.4	22.1	19.3	17.2	15.9	14.4	14.4
19	37.1	37.1	37.1	37.0	36.9	36.8	36.7	36.5	36.2	35.3	33.7	30.5	25.8	22.1	18.8	16.6	15.2	13.8	13.8
20	37.1	37.1	37.1	37.0	37.0	36.9	36.8	36.7	36.6	36.5	36.0	35.2	31.0	27.0	22.3	18.9	16.9	15.2	15.2
21	37.1	37.1	37.1	37.1	37.0	37.0	37.0	36.9	36.8	36.7	36.5	36.5	35.1	33.6	28.9	23.6	21.6	18.4	18.4
22	37.1	37.1	37.1	37.1	37.1	37.1	37.0	36.9	36.9	36.8	36.8	36.7	36.4	36.2	34.9	30.6	28.5	23.3	23.3
23	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.0	37.0	37.0	36.9	36.8	36.8	36.6	36.5	35.3	33.6	29.3	29.3
24	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.0	37.0	37.0	36.9	36.8	36.7	36.5	35.8	33.3	33.3

Figure 4.11. QSIM Results for Signalized Arterials (Combined All Days and Both Directions)

SIGNALS/MILE: 2

HOUR	AADT/C																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph	SPEED mph
1	25.1	25.1	25.1	25.0	25.0	25.0	25.0	24.9	24.9	24.9	24.8	24.8	24.7	24.4	24.2	23.8	23.3	22.7
2	25.1	25.1	25.1	25.1	25.0	25.0	25.0	25.0	25.0	25.0	25.0	24.9	24.8	24.7	24.4	24.1	23.7	23.0
3	25.1	25.1	25.1	25.1	25.1	25.1	25.0	25.0	25.0	25.0	25.0	25.0	24.9	24.8	24.6	24.3	23.9	23.3
4	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.0	25.0	25.0	24.9	24.7	24.4	23.9	23.4
5	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.0	25.0	25.0	25.0	24.9	24.8	24.6	24.3	23.8	23.2
6	25.1	25.1	25.1	25.0	25.0	25.0	25.0	25.0	24.9	24.9	24.8	24.6	24.5	24.3	24.0	23.6	23.0	22.2
7	25.1	25.0	25.0	24.9	24.7	24.6	24.4	24.2	23.9	23.5	23.1	22.6	22.3	21.9	21.5	20.7	20.0	18.9
8	25.0	24.9	24.7	24.3	24.0	23.5	23.0	22.6	22.1	21.3	20.4	19.0	17.8	16.7	15.8	14.9	14.2	13.5
9	25.0	24.9	24.8	24.5	24.3	23.9	23.5	23.1	22.7	22.1	21.4	20.1	18.5	16.7	15.4	14.1	13.1	12.2
10	25.0	25.0	24.9	24.7	24.5	24.3	24.0	23.7	23.3	22.9	22.4	22.0	21.3	19.9	18.5	16.5	15.0	13.5
11	25.0	25.0	24.8	24.6	24.4	24.1	23.8	23.5	23.1	22.6	22.2	21.4	21.0	20.4	19.4	17.9	16.1	14.5
12	25.0	24.9	24.8	24.5	24.2	23.9	23.5	23.0	22.6	22.0	21.5	20.6	19.8	18.7	17.7	16.2	14.7	13.2
13	25.0	24.9	24.7	24.4	24.0	23.6	23.1	22.6	22.1	21.5	20.6	19.5	18.2	16.7	15.4	13.8	12.8	11.5
14	25.0	24.9	24.7	24.4	24.1	23.7	23.2	22.7	22.2	21.6	20.7	19.3	17.8	15.9	14.2	12.5	11.5	10.4
15	25.0	24.9	24.7	24.4	24.0	23.6	23.1	22.6	22.1	21.4	20.4	18.6	17.0	15.0	13.1	11.5	10.4	9.6
16	25.0	24.9	24.6	24.2	23.8	23.3	22.7	22.2	21.4	20.4	19.0	16.1	14.4	12.4	11.1	10.0	9.1	8.7
17	25.0	24.8	24.5	24.1	23.6	23.0	22.3	21.5	20.3	18.8	16.9	14.0	12.1	10.8	9.8	9.0	8.3	8.0
18	25.0	24.8	24.5	24.1	23.6	23.0	22.2	21.2	19.6	17.6	15.6	13.3	11.4	10.3	9.4	8.7	8.1	7.8
19	25.0	24.9	24.8	24.5	24.2	23.9	23.5	22.9	21.9	20.2	18.1	15.3	12.9	11.2	10.2	9.3	8.6	8.1
20	25.0	25.0	24.9	24.7	24.5	24.3	24.1	23.7	23.3	22.8	22.0	19.8	17.1	14.4	12.3	11.0	9.7	9.0
21	25.1	25.0	24.9	24.8	24.7	24.6	24.4	24.2	23.9	23.6	23.3	22.7	21.3	19.0	16.0	14.0	12.1	10.7
22	25.1	25.0	25.0	24.9	24.8	24.7	24.5	24.4	24.2	24.0	23.7	23.4	23.1	22.2	20.5	18.2	15.8	13.3
23	25.1	25.0	25.0	25.0	24.9	24.8	24.8	24.6	24.6	24.4	24.2	24.1	23.8	23.4	22.9	22.0	19.6	16.8
24	25.1	25.1	25.0	25.0	25.0	24.9	24.9	24.8	24.8	24.7	24.6	24.5	24.2	24.0	23.6	23.1	21.5	19.5

Figure 4.11. (Continued)

SIGNALS/MILE: 20

HOUR	AADT/C																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED	SPEED
mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph
1	17.3	17.3	17.3	17.2	17.2	17.2	17.2	17.1	17.1	17.1	17.0	17.0	16.8	16.6	16.3	15.9	15.4	14.9
2	17.3	17.3	17.3	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.1	17.0	16.9	16.6	16.3	15.8	15.3
3	17.3	17.3	17.3	17.3	17.3	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.1	17.0	16.7	16.5	16.0	15.6
4	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.2	17.2	17.2	17.2	17.0	16.8	16.5	16.2	15.6
5	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.2	17.2	17.2	17.2	17.2	17.1	17.0	16.7	16.4	16.0	15.4
6	17.3	17.3	17.2	17.2	17.2	17.2	17.2	17.1	17.1	17.0	16.9	16.8	16.6	16.4	16.1	15.7	15.3	14.6
7	17.2	17.2	17.1	17.0	16.9	16.8	16.6	16.3	16.1	15.7	15.3	14.8	14.6	14.2	13.8	13.2	12.9	12.3
8	17.2	17.1	16.8	16.5	16.2	15.7	15.2	14.8	14.3	13.7	12.8	11.9	11.5	11.0	10.5	10.1	9.8	9.5
9	17.2	17.1	17.0	16.7	16.4	16.1	15.7	15.3	14.9	14.3	13.8	12.9	12.6	11.5	10.8	10.2	9.7	9.2
10	17.2	17.2	17.1	16.9	16.7	16.4	16.2	15.8	15.5	15.0	14.7	14.2	13.8	13.2	12.3	11.5	10.7	10.0
11	17.2	17.2	17.0	16.8	16.6	16.3	15.9	15.6	15.2	14.7	14.3	13.9	13.4	13.1	12.5	11.7	11.0	10.2
12	17.2	17.1	16.9	16.7	16.4	16.0	15.6	15.2	14.7	14.3	13.8	13.3	12.6	11.9	11.6	10.8	10.4	9.5
13	17.2	17.1	16.9	16.6	16.2	15.8	15.3	14.9	14.3	13.8	13.2	12.4	11.7	11.1	10.3	9.6	9.3	8.6
14	17.2	17.1	16.9	16.6	16.2	15.8	15.4	14.9	14.4	13.9	13.2	12.2	11.4	10.7	9.7	9.1	8.7	8.2
15	17.2	17.1	16.9	16.6	16.2	15.8	15.3	14.8	14.3	13.6	13.1	11.8	10.8	10.1	9.3	8.7	8.2	8.0
16	17.2	17.0	16.8	16.4	16.0	15.4	14.9	14.3	13.8	13.0	12.0	10.3	9.8	9.0	8.4	8.0	7.7	7.6
17	17.2	17.0	16.7	16.3	15.7	15.1	14.5	13.9	13.0	11.8	11.2	9.6	9.0	8.3	8.1	7.7	7.6	7.3
18	17.2	17.0	16.7	16.3	15.7	15.1	14.5	13.7	12.7	11.6	10.9	9.5	9.0	8.4	8.1	7.7	7.5	7.3
19	17.2	17.1	17.0	16.7	16.4	16.1	15.6	15.1	14.4	13.5	12.5	11.1	10.1	9.2	8.5	8.2	7.8	7.6
20	17.2	17.2	17.1	16.9	16.7	16.5	16.2	15.9	15.5	15.2	14.5	13.7	12.1	10.8	9.7	9.1	8.6	8.2
21	17.3	17.2	17.1	17.0	16.9	16.7	16.6	16.3	16.0	15.8	15.4	15.2	14.3	13.3	11.7	10.6	9.9	9.2
22	17.3	17.2	17.2	17.1	17.0	16.9	16.7	16.5	16.4	16.1	15.9	15.7	15.2	14.9	14.0	12.5	11.7	10.4
23	17.3	17.2	17.2	17.2	17.1	17.0	16.9	16.8	16.7	16.6	16.4	16.2	16.0	15.6	15.3	14.4	13.5	11.9
24	17.3	17.2	17.2	17.2	17.2	17.1	17.1	17.0	16.9	16.9	16.7	16.7	16.4	16.1	15.7	15.3	14.3	13.3

Figure 4.11. (Continued)

condition.¹¹

4.2.2 Curve Fitting Procedure and Final Equations

The data in the tables may be used directly by analysts if desired. However, equations were developed from the data in the tables to facilitate application of the procedure. The curve fitting process was as follows. First, three separate time periods were defined: peak hour, peak period, and daily. Second, three analysis periods were defined: weekday, weekend/holiday, and combined. All hours of a day were used in the daily analyses. The peak period for both freeways and arterials included three hours in the morning (7-10 AM) and three hours in the afternoon (4-7 PM). This choice is something of a compromise since for high AADT/C levels all six hours will be congested while for low AADT/C levels fewer hours will be congested. Consideration was given to varying the length of the peak period as a function of AADT/C but was dismissed in favor of consistency. Determination of the peak hour was made by inspecting Figures 4.10 and 4.11 for the lowest hourly speeds. The peak hour for freeways was between 4 PM and 5 PM for AADT/C ≤ 10 and between 5 PM and 6 PM for AADT/C > 10 . For arterials the peak hour was between 4 PM and 5 PM. *The equations are valid for AADT/C levels up to 18; beyond that the QSIM output tables should be used.*

Curve fitting for freeways was straightforward. Plots of the data indicated that polynomial forms of AADT/C could be easily fit to the data. The results appear in Table 4.5. The dependent variable in these equations is weighted average hourly delay measured in hours per 1,000 vehicle-miles. For example, consider the Peak Period. The equation for predicting weekday delay (in hours per 1,000 vehicle-miles) is:

¹¹Computationally, vehicle-hours and vehicle-miles are summed for the three conditions and speed is calculated by dividing vehicle-miles by vehicle-hours. This is the same as taking the weighted average of the individual speed values.

Table 4.5. Coefficients for Freeway Delay Equations

Peak Period	Weekday	Weekend	Combined
AADT/C			
AADT/C ²			
AADT/C ³			0.0347966374
AADT/C ⁴			-.0122499794
AADT/C ⁵	0.0001732632	0.0000253342	0.0016577982
AADT/C ⁶	-.0000116968		-.0000862934
AADT/C ⁷	0.0000001974	-.0000000318	0.0000015096

Peak Hour	Weekday	Weekend	Combined
AADT/C			
AADT/C ²			
AADT/C ³	0.1055828979		0.0824450974
AADT/C ⁴	-.0417711090		-.0316382045
AADT/C ⁵	0.0059009773	0.0000256501	0.0043851790
AADT/C ⁶	-.0003319769		-.0002436727
AADT/C ⁷	0.0000064684		0.0000047234

Table 4.5. (Continued)

Daily	Weekday	Weekend	Combined
AADT/C			
AADT/C ²			
AADT/C ³	0.0551483782	0.0096559689	0.0461854203
AADT/C ⁴	-.0189486676	-.0023347525	-.0154380323
AADT/C ⁵	0.0023287974	0.0001925990	0.0018559670
AADT/C ⁶	-.0001133801	-.0000044347	-.0000887095
AADT/C ⁷	0.0000018954		0.0000014614

$$\text{Delay} = 0.0001732632 * (\text{AADT}/C)^5 - 0.0000116968 * (\text{AADT}/C)^6 + 0.0000001974 * (\text{AADT}/C)^7.$$

Speed is calculated by using Equation (6):

$$\text{Speed} = \frac{1}{1/\text{FFS} + \text{Delay}/1000} \quad (6)$$

Where: FFS is the free flow speed.

As a complete example, assume a 6-lane freeway with a calculated one-way (*HCM*) capacity (based on 3-lanes in one direction) of 6,600 vphpl and a free flow speed of 60 mph. Its AADT is 158,400 vpd, therefore its AADT/C is: $158,400/(2 * 6,600) = 12.0$. Delay for Weekday Peak Period is calculated using the above formula and is 15.2602 hours per 1,000 vehicle miles. Weekday Peak Period Speeds (i.e., the weighted average speed for the 6-hour period defined as the Peak Period) is:

$$\begin{aligned} \text{Speed} &= \frac{1}{1/60 + 15.2602/1000} \\ &= 31.32 \text{ mph.} \end{aligned}$$

Curve fitting for arterials was far more complex due to the extra influence of signal density (in addition to AADT/C). The same basic functional form was assumed as for the uncongested delay function as described in Chapter 2. Two separate models were fit from the data with the cutoff point being an AADT/C value of seven (Table 4.6).

AADT/C ≤ 7

$$\text{Delay} = (1 - e^{-.3n}) * (\text{NOQ} + Q) \quad (8)$$

where: n = signals per mile

NOQ = predicted value from the "no queue equations"

Q = predicted value from the "queue equations".

For example, consider the Peak Period. The equation for predicting weekday delay for an

Table 4.6. Coefficients for Arterial Delay Equations

No Queue, Peak Period	Weekday	Weekend	Combined
INTERCEPT	32.6326	32.8082	32.6270
AADT/C			
AADT/C ²	0.27187282	0.10420309	0.23911219
AADT/C ³	-0.01054104		-0.00898736
AADT/C ⁴		-0.00012311	
AADT/C ⁵			
AADT/C ⁶			
AADT/C ⁷			

Queue Equations, Peak Period	Weekday	Weekend	Combined
AADT/C			
AADT/C ²			
AADT/C ³			
AADT/C ⁴			
AADT/C ⁵			
AADT/C ⁶	0.0000288004	0.0000025067	0.0000225491
AADT/C ⁷	-0.0000013948		-0.0000010684

AADT/C > 7 Equations, Peak Period	Weekday	Weekend	Combined
(AADT/C - 7)	2.789265513		
(AADT/C - 7) ²			0.265213232
(AADT/C - 7) ³		0.0142379985	
(AADT/C - 7)(1 - e ⁻³ⁿ)			1.445427904
(AADT/C - 7) ² (1 - e ⁻³ⁿ)	0.259827162	0.1060087507	
(AADT/C - 7) ³ (1 - e ⁻³ⁿ)			

Table 4.6. (Continued)

No Queue Equations, Peak Hour	Weekday	Weekend	Combined
INTERCEPT	32.9859	32.6524	32.8591
AADT/C			
AADT/C ²	0.36235337	0.13826170	0.31492585
AADT/C ³	-0.01545356		-0.01297063
AADT/C ⁴		-0.00019683	
AADT/C ⁵			
AADT/C ⁶			
AADT/C ⁷			

Queue Equations, Peak Hour	Weekday	Weekend	Combined
AADT/C			
AADT/C ²			
AADT/C ³			
AADT/C ⁴			
AADT/C ⁵	0.0004278173	0.0000639922	0.0003209231
AADT/C ⁶	-0.0000010179		
AADT/C ⁷			-0.0000007210

AADT/C > 7 Equations, Peak Hour	Weekday	Weekend	Combined
(AADT/C - 7)	4.935624291		
(AADT/C - 7) ²			0.430066318
(AADT/C - 7) ³		0.0213118297	
(AADT/C - 7)(1 - e ⁻³ⁿ)			1.916741055
(AADT/C - 7) ² (1 - e ⁻³ⁿ)	0.191184548	0.1612475797	
(AADT/C - 7) ³ (1 - e ⁻³ⁿ)			

Table 4.6. (Continued)

No Queue Equations, Daily	Weekday	Weekend	Combined
INTERCEPT	32.9015	32.8089	32.5177
AADT/C			
AADT/C ²	0.15119788	0.10661207	0.19583856
AADT/C ³			-0.00728030
AADT/C ⁴		-0.00015241	
AADT/C ⁵			
AADT/C ⁶	-0.00000333		
AADT/C ⁷	0.00000014		

Queue Equations, Daily	Weekday	Weekend	Combined
AADT/C			
AADT/C ²			
AADT/C ³			
AADT/C ⁴			0.0007935231
AADT/C ⁵		0.0000325589	
AADT/C ⁶	0.0000144058		
AADT/C ⁷	-0.0000006601		

AADT/C > 7 Equations, Daily	Weekday	Weekend	Combined
(AADT/C - 7)			
(AADT/C - 7) ²	0.1852764500		0.1586415772
(AADT/C - 7) ³		0.0102536589	
(AADT/C - 7)(1 - e ⁻³ⁿ)			
(AADT/C - 7) ² (1 - e ⁻³ⁿ)	0.1346060360		0.1211710141
(AADT/C - 7) ³ (1 - e ⁻³ⁿ)		0.0097281924	

AADT/C value of 5, free flow speed of 40 mph, and 3 signals per mile is:

$$\begin{aligned}
 \text{Delay} &= (1 - e^{-3*3}) * \{32.6326 + (0.27187282 * 5^2) - \\
 &\quad (0.01054104 * 5^3) + (0.0000288004 * 5^6) - \\
 &\quad (0.0000013948 * 5^7)\} \\
 &= (0.59343) * (38.4530) \\
 &= 22.819 \text{ hours per 1000 vehicle-miles.}
 \end{aligned}$$

Speed is calculated by using the same formula as for freeways above, except that a different free flow speed is used:

$$\begin{aligned}
 \text{Speed} &= \frac{1}{1/40 + 22.819/1000} \\
 &= 20.9 \text{ mph.}
 \end{aligned}$$

AADT/C > 7

$$\text{Delay} = (EQ_{>7}) + \{(1 - e^{-3n}) * (NOQ)\} \quad (9)$$

Where: $EQ_{>7}$ is the predicted value from the "AADT/C > 7" Equations.

For example, consider a segment where AADT/C = 12, free flow speed = 40 mph, and signals per mile = 4. Delay for the peak period on weekdays is calculated as:

$$\begin{aligned}
 EQ_7 &= \{2.789265513 * (12 - 7)\} + \{0.259827 * (12 - 7)^2 * (1 - e^{-3*4})\} \\
 &= 13.9463 + 4.5392 \\
 &= 18.4855 \\
 NOQ &= 32.6326 + (0.27187282 * 12^2) - (0.01054104 * 12^3) \\
 &= 53.5667
 \end{aligned}$$

Therefore:

$$\begin{aligned}
 \text{Delay} &= 18.4855 + \{(1 - e^{-3*4}) * 53.5667\} \\
 &= 55.9182.
 \end{aligned}$$

Speed is then calculated as:

$$\begin{aligned}\text{Speed} &= \frac{1}{1/40 + 55.9182/1000} \\ &= 12.4 \text{ mph.}\end{aligned}$$

At first glance, the distinction in final predicted speeds for the peak period and the peak hour is very small: for facilities with high AADT/C ratios the final speeds are practically the same. What then is gained by predicting peak period versus peak hour speeds? It must be remembered that much more VMT travels during the six-hour peak period than in the single peak hour. Therefore, more vehicles are exposed to the low speeds in the peak period. To aid the analyst in determining the percent of traffic that moves in the peak period and peak hour, Tables 4.7 and 4.8 were developed. These data were developed from the QSIM output (Appendix C), which in turn are based on the temporal distributions presented in Chapter 2.

Table 4.7. VMT Proportions for Freeways

<u>AADT/C</u>	<u>PERCENT OF TRAFFIC IN PEAK HOUR</u>	<u>PERCENT OF TRAFFIC IN PEAK PERIOD</u>
1	0.0787	0.3844
2	0.0786	0.3844
3	0.0788	0.3847
4	0.0789	0.3852
5	0.0789	0.3845
6	0.0784	0.3842
7	0.0787	0.3844
8	0.0768	0.3830
9	0.0745	0.3814
10	0.0718	0.3777
11	0.0619	0.3720
12	0.0620	0.3644
13	0.0602	0.3497
14	0.0570	0.3339
15	0.0557	0.3188
16	0.0533	0.3045
17	0.0509	0.2925
18	0.0489	0.2823
19	0.0472	0.2742
20	0.0457	0.2675
21	0.0442	0.2606
22	0.0431	0.2554
23	0.0423	0.2519
24	0.0419	0.2506

Table 4.8. VMT Proportions for Arterials

<u>AADT/C</u>	<u>PERCENT OF TRAFFIC IN PEAK HOUR</u>	<u>PERCENT OF TRAFFIC IN PEAK PERIOD</u>
1	0.0782	0.3702
2	0.0769	0.3690
3	0.0777	0.3690
4	0.0777	0.3702
5	0.0784	0.3709
6	0.0779	0.3697
7	0.0779	0.3704
8	0.0766	0.3684
9	0.0765	0.3668
10	0.0747	0.3655
11	0.0729	0.3613
12	0.0711	0.3608
13	0.0681	0.3498
14	0.0649	0.3391
15	0.0616	0.3295
16	0.0589	0.3185
17	0.0564	0.3089
18	0.0540	0.3000

5. APPLICATION OF THE SPEED MODELING PROCEDURE

5.1 Introduction

This Chapter demonstrates the application of the new speed modeling procedure in two ways. First, the delay and speed equations developed in Chapter 4 are applied to the output from a typical travel forecasting model. Application of the equations is straightforward and allows for assessing the impacts areawide without extensive computer programming. However, the full effects of queuing are not addressed by applying the equations since the impact of spillbacks onto upstream links are not fully incorporated. As discussed in Chapter 3, the equations fully account for the temporal aspects of congestion. However, the spatial aspects (spillbacks of queues onto links upstream of the bottleneck) are only partially addressed because the length over which speeds are measured is fixed. Therefore, a more detailed, but less extensive, comparison is made to hypothetical freeway and signalized arterial corridors. This second comparison incorporates the spatial effects of queues as they spread upstream onto other links. In both cases, the results are compared to speed estimates using methods in standard practice, and the implications for air quality planning and congestion management are assessed. Both of the comparisons are based on using the output from travel forecasting (network) models.

5.2 Application of the Equations to the Knoxville Planning Network

5.2.1 Background

The Knoxville Metropolitan Planning Commission (MPC) administers transportation planning for the Knoxville Urban Area which includes all of Knox County and the urbanized portion of Blount County. To perform long-range travel forecasts, MPC uses the commercially-

available MINUTP software. MINUTP is based on the so-called "traditional four-step modeling process" that has been in use for at least 30 years in the transportation profession. (The four steps are trip generation, trip distribution, modal split, and traffic assignment.) For the purpose of comparison, MPC's travel forecasts for the year 2020 are used. The basis for the forecasts is a schematic network of the Knoxville highway system. Basic characteristics of the network are provided in Figure 5.1. Exclusive of centroid connectors, a total of 1,841 one-way links are used to represent the Knoxville network, including 252 freeway ("Interstate" plus "expressway") links. Based on the network model's predicted V/C ratios, 20 percent of the links are expected to experience congestion (oversaturation; Figure 5.2).

After the final traffic assignment is made, MINUTP prints out the link speeds that were used in the final assignment. These speeds are often used by planners to identify congestion and as input to the MOBILE model in air quality planning. Because these speeds are an artifact of the assignment process -- and do not necessarily reflect actual operating conditions -- many urban areas post-process the network information; this is done here as well. Based on the discussion in Chapter 2, the BPR function was the basis for the post-processing. For freeways, the standard BPR equation (see Table A.3)) was used for V/C ratios less than 1.0 and the modified BPR4 equation (see Table A.3) was used for V/C ratios greater than or equal to 1.0. For signalized arterials, the modified BPR4 equation was used. *These formulations are considered to provide the best measure of "standard practice". All comparisons are made for the peak hour only.* In highly congested networks characterized by extensive queuing, estimating speeds for the peak hour only does not take full advantage of the new procedure. However, peak hour comparisons are useful since they provide a conservative estimate of the new procedure and it is easier to implement. Also, Knoxville's traffic conditions are not considered by the author to be "highly congested", even for the 2020 forecast year.

FUNCTIONAL CLASSIFICATION	TYPE OF AREA										TOTAL		
	CBD		CBD FRINGE		RESIDENTIAL		SUBURBAN COMMERCIAL		RURAL			(CENTROID)	
	NO. LINKS		NO. LINKS		NO. LINKS		NO. LINKS		NO. LINKS			NO. LINKS	
INTERSTATE	25		42		83				24			174	
EXPRESSWAY	22				34		16		6			78	
CENTROID											1.042	1.042	
COLLECTOR	130		147		245				34			556	
PRIMARY ARTERIAL	66		165		423		47		172			873	
5-LANE ARTERIAL			30		38		88		4			160	
TOTAL	257		384		823		151		240		1.028	2.883	

Figure 5.1. Basic Characteristics of the Knoxville Network, Year 2020

Note: Links are one-way.

<u>Functional Class</u>	<u>V/C Ratio</u>				
Frequency Row Pct	0.00 - 0.80	0.81 - 0.90	0.91 - 0.99	G.E. 1.00	Total
INTERSTATE	116 66.67	39 22.41	4 2.30	15 8.62	174
EXPRESSWAY	51 65.38	16 20.51	3 3.85	8 10.26	78
PRIMARY ARTERIAL	481 55.10	144 16.49	59 6.76	189 21.65	873
5-LANE ARTERIAL	60 37.50	41 25.63	19 11.88	40 25.00	160
COLLECTOR	334 60.07	77 13.85	28 5.04	117 21.04	556
Total	1042	317	113	369	1841

Figure 5.2. Volume-to-Capacity Ratios for the Knoxville Network, Year 2020

Note: Links are one-way.

Specifically, the following equation for freeways based on QSIM results was used:

$$\begin{aligned} \text{Freeway Peak Hr Delay} = & (0.1055828979 * \text{AADT/C}^3) - (0.0417711090 * \text{AADT/C}^4) + \\ & (0.0059009773 * \text{AADT/C}^5) - (0.0003319769 * \text{AADT/C}^6) + \\ & (0.0000064684 * \text{AADT/C}^7). \end{aligned}$$

This equation is taken directly from Table 4.5 for predicting weekday, peak hour delays. Similarly, the equations in Table 4.6 are used for signalized arterial delay estimation. Note that the arterial equations are more complicated to apply because they were fit with stepwise regression techniques. For example, for AADT/C values greater than 7.0, Equation (9) from Chapter 4 is used:

$$\text{Arterial Peak Hr Delay} = (\text{EQ}_{>7}) + \{(1 - e^{-3n}) * (\text{NOQ})\} \quad (9)$$

Where:

$$\begin{aligned} \text{EQ}_{>7} = & (4.935624291 * (\text{AADT/C} - 7)) + \{0.191184548 * \\ & (\text{AADT/C} - 7)^2 * (1 - e^{-3n})\} \end{aligned}$$

$$n = \text{signals per mile}$$

$$\text{NOQ} = 32.9859 + (0.36235337 * \text{AADT/C}^2) - (0.01545356 * \text{AADT/C}^3).$$

The equations for EQ_7 and NOQ are taken directly from Table 4.10. For the comparison, signals per mile was set to 1.0. Ideally, this value should be set to $1/(\text{link length})$ if there is a signal present on the link. However, no network data were available on the location of signals. Therefore, the value of 1.0 was chosen as an average value since not all arterial links have signals. Examples of how these equations are applied were given in Chapter 4.

5.2.2 Results and Implications for Congestion Management

The full link-by-link comparisons for speed and emissions prediction are provided in Appendix E and a sample is provided in Figure 5.3. A network-wide summary for freeways

FACILITY TYPE=FREEWAY										NOx EMIS FAC (LDGV)		NOx EMIS FAC (HDDV)	
MODEL	MODEL2	AAOT/C	PEAK HR VMT	V/C	BPR SPEED	MINUTP SPEED	OSIM SPEED	% DIFF. BPR VS OSIM	% DIFF. MINUTP VS OSIM	CO EMIS FAC	VOC EMIS FAC	NOx EMIS FAC (LDGV)	NOx EMIS FAC (HDDV)
726	1280	8.24	3,830	0.82	52.56	44.08	46.26	0.136	0.047	5.51	0.77	1.15	4.64
727	644	6.81	248	0.68	53.83	48.86	51.56	0.044	0.052	5.03	0.72	1.26	5.19
727	726	6.42	643	0.64	54.07	45.17	52.14	0.037	0.134	4.99	0.71	1.27	5.27
734	644	7.26	1,092	0.73	53.50	44.68	50.45	0.060	0.114	5.13	0.73	1.23	5.05
734	735	8.62	1,453	0.86	52.11	43.48	44.04	0.183	0.013	5.74	0.80	1.12	4.47
735	736	15.62	285	1.56	14.74	22.72	14.98	0.016	0.516	14.14	1.76	0.97	5.34
735	1035	10.24	451	1.02	37.02	46.73	33.03	0.121	0.415	7.30	0.99	1.00	4.15
736	737	1.03	34	0.10	55.00	46.00	54.78	0.004	0.160	4.79	0.69	1.34	5.67
736	1040	14.60	266	1.46	25.31	33.75	15.94	0.588	1.117	13.42	1.68	0.97	5.21
855	716	4.57	208	0.46	54.76	48.97	52.50	0.043	0.067	4.96	0.71	1.28	5.32
857	861	5.17	896	0.52	54.60	48.59	52.56	0.039	0.076	4.95	0.71	1.28	5.33
861	857	5.18	897	0.52	54.60	48.59	52.56	0.039	0.076	4.95	0.71	1.28	5.33
861	1101	5.45	547	0.55	54.51	36.82	52.58	0.037	0.300	4.95	0.71	1.28	5.33
1001	240	7.22	1,254	0.72	53.53	53.98	50.55	0.059	0.068	5.12	0.73	1.23	5.07
1001	570	6.59	9,151	0.66	53.97	53.98	51.92	0.039	0.040	5.00	0.71	1.27	5.24
1001	1002	5.12	14,322	0.51	54.62	47.51	52.56	0.039	0.096	4.95	0.71	1.28	5.33
1004	1213	7.08	1,549	0.71	53.63	50.51	50.94	0.053	0.008	5.08	0.72	1.24	5.12
1005	625	4.29	847	0.43	54.81	50.18	52.50	0.044	0.044	4.96	0.71	1.28	5.33
1005	1004	5.85	2,764	0.59	54.35	57.38	52.52	0.035	0.093	4.96	0.71	1.28	5.33
1006	1107	7.76	6,955	0.78	53.06	52.90	48.60	0.092	0.089	5.29	0.75	1.19	4.85
1007	1005	7.73	6,818	0.77	53.09	58.96	48.74	0.089	0.210	5.28	0.75	1.20	4.87
1008	1098	7.64	1,538	0.76	53.17	40.08	49.13	0.082	0.184	5.24	0.74	1.20	4.91
1009	1008	10.71	8,590	1.07	35.41	48.76	29.97	0.181	0.627	7.92	1.06	0.99	4.20
1010	1009	8.71	15,782	0.87	52.00	57.50	43.49	0.196	0.322	5.80	0.81	1.11	4.44
1010	1110	5.99	187	0.60	54.29	51.91	52.47	0.035	0.011	4.96	0.71	1.28	5.32
1011	1010	10.51	15,980	1.05	36.09	51.64	31.25	0.155	0.652	7.65	1.03	0.99	4.17
1011	1012	13.03	5,359	1.30	28.75	42.14	19.30	0.490	1.184	11.44	1.46	0.96	4.82
1011	1059	5.30	3,895	0.53	54.56	49.85	52.57	0.038	0.052	4.95	0.71	1.28	5.33
1011	1114	0.00	0	0.00	55.00	46.00	55.00	0.000	0.164	4.77	0.68	1.35	5.71
1012	1011	11.79	4,852	1.18	32.03	45.09	24.03	0.333	0.876	9.52	1.25	0.97	4.44
1012	1036	14.38	3,819	1.44	25.74	42.46	16.26	0.584	1.612	13.20	1.66	0.97	5.17
1013	1014	8.30	3,674	0.83	52.50	52.29	45.93	0.143	0.138	5.54	0.78	1.14	4.61
1013	1051	8.50	974	0.85	52.26	54.66	44.77	0.167	0.221	5.66	0.79	1.13	4.52

Figure 5.3. Example of Knoxville Link-by-Link Comparisons

and arterials is shown in Figure 5.4. On average, QSIM speeds for freeways are 16 percent lower than the MINUTP speeds and 11 percent lower than the BPR post-processed speeds. Given that less than 10 percent of freeways are congested (based on V/C ratio; Figure 5.2), it is not surprising that the difference is relatively small; in unsaturated traffic conditions for freeways, there is little difference in the speed estimation procedures. It is only under saturated (queuing) conditions that QSIM is expected to show notably lower speeds. For arterials, however, the situation is quite different. QSIM predicts 44 percent lower speeds than MINUTP and 35 percent lower speeds than the BPR function. Two reasons are offered for these differences. First, a larger percentage of arterials function over capacity (25 percent) than freeways. Second, and more importantly, both the BPR and MINUTP methods do not consider signal density. As shown in Chapter 2, the NETSIM tests showed that signal density is a highly significant factor in determining arterial speeds. The implications of these results for congestion are directly derived; even in an area of moderate congestion like Knoxville, failure to account for queuing in saturated conditions can lead to underestimation of network delay and consequent overestimation of speed. Although no independently-derived speed/delay data are available for Knoxville, QSIM is believed to produce more reliable estimates because of its theoretical derivation and its calibration to field data.

5.2.3 Results and Implications for Air Quality Planning

The implications for air quality planning are assessed by inputting the link speeds to a series of equations previously developed by the author (25). The equations were developed by running the MOBILE5a model in a series of experiments and fitting curves to the resulting data. The equations use speed, analysis year, temperature, Inspection/Maintenance (I/M) programs, and operating mode fractions as independent variables (Figure 5.5). Four operating mode

Carbon Monoxide

$$\text{CO (all vehs)} = (2.474580\text{E}+35) * (\text{Speed}^{-0.835570}) * e^{[(\text{Year} * -0.037526) + (\text{Temp} * -0.010446) + \text{I/M} + \text{OpMode}]}$$

Where: I/M = -0.079580 for BASE
= -0.387433 for ENHANCED
= 0.0 for NONE

OpMode = 0.168820 for URBAN ARTERIALS
= 0.0 for URBAN FREEWAYS

Volatile Organic Compounds

$$\text{VOC (all vehs)} = (3.905683\text{E}+30) * (\text{Speed}^{-0.727746}) * e^{[(\text{Year} * -0.033509) + (\text{Temp} * -0.002888) + \text{I/M} + \text{OpMode}]}$$

Where: I/M = -0.053098 for BASE
= -0.319623 for ENHANCED
= 0.0 for NONE

OpMode = 0.193333 for URBAN ARTERIALS
= 0.0 for URBAN FREEWAYS

Nitrous Oxides, LDGV

$$G(x) = (5.832495\text{E}+17) * e^{[(\text{Year} * -0.02000495) + (\text{Temp} * -0.0055747) + \text{I/M} + \text{OpMode}]}$$

Where: I/M = -0.0083550 for BASE
= -0.2339572 for ENHANCED
= 0.0 for NONE

OpMode = 0.0893598 for URBAN ARTERIALS
= 0.0 for URBAN FREEWAYS

$$F(x) = 0.9346129 + (1/\text{Speed} * 1.3578598470); \text{ for speeds } \leq 20 \text{ mph} \\ = 0.9642574 + (\text{Speed}^4 * 0.0000000433); \text{ for speeds } > 20 \text{ mph}$$

$$\text{NO}_x \text{ (LDGV)} = F(x) * G(x)$$

Nitrous Oxides, HDDV

$$\text{NO}_x \text{ (HDDV)} = e^{[92.5710376 + (\text{Speed} * -0.0480016) + (\text{Speed_Sq} * 0.0007100) + (\text{Year} * -0.0447208)]}$$

Where: Speed_Sq = Speed²

Nitrous Oxides, All Vehicles

$$\text{NO}_x \text{ (All Vehs)} = 0.9 * [\text{NO}_x \text{ (LDGV)}] + 0.1 * [\text{NO}_x \text{ (HDDV)}]; \text{ assuming 10 percent trucks}$$

Figure 5.5. Emission Factor Equations Used for the Emissions Comparisons
Emission factors (dependent variables in the above equations) are in grams per mile.

fractions were developed to represent average travel on arterials and freeways. Other MOBILE5a inputs were set to default values. Temperature was set at 75 degrees and no I/M program was assumed for the comparison. The analysis year was set to 2020 for the Knoxville network comparisons and 1996 for the hypothetical corridor comparisons. For air quality comparisons, the equations in Figure 5.1 were applied at the link level and summed over the network. Individual link speeds were used to estimate emission rates, which were then multiplied by link VMT, and converted to pounds. The results are summarized as follows:

<u>Pollutant</u>	<u>QSIM vs. MINUTP</u>	<u>QSIM vs. BPR</u>
CO	+33%	+24%
VOC	+28%	+20%
NO _x	-5%	-5%

Using traditional methods of speed estimation leads to a 20 to 33 percent underestimation of carbon monoxide and volatile organic compounds for the peak hour. The so-called NO_x dilemma is also apparent; the lower speeds predicted by QSIM lead to slightly decreased NO_x emissions.

5.3 Application of the Queuing Procedure to Test Corridors (QNET)

5.3.1 Background

To get a more complete picture of the impact of queuing on speed, the basic queuing procedure in QSIM was extracted and applied to the hypothetical test corridors given in Chapter 3 and Tables 5.1 and 5.2. The test corridor approach was taken so as to apply the procedure under highly congested traffic conditions. This procedure has been named "QNET" to indicate

Table 5.1. Test Network for Freeways

		Congestion Level			
		Moderate		High	
A-Node	B-Node	AADT	AADT/C	AADT	AADT/C
1	2	60,000	7.5	75,000	9.4
2	3	62,000	7.7	77,500	9.7
3	4	65,000	8.1	81,250	10.1
4	5	70,000	8.7	87,500	10.9
5	6	70,000	8.7	87,500	10.9
6	7	70,000	8.7	87,500	10.9
7	8	70,000	8.7	87,500	10.9
8	9	75,000	9.4	93,750	11.7
9	10	80,000	10.0	100,000	12.5
10	11	85,000	10.6	106,250	13.3
11	12	95,000	11.9	118,750	14.8
12	13	85,000	10.6	106,250	13.3
13	14	60,000	7.5	75,000	9.4
14	15	70,000	8.7	87,500	10.9
15	16	70,000	8.7	87,500	10.9
16	17	90,000	11.2	112,500	14.0
17	18	65,000	8.1	81,250	10.1
18	19	65,000	8.1	81,250	10.1
19	20	65,000	8.1	81,250	10.1
20	21	65,000	8.1	81,250	10.1

Notes: (1) 10% trucks
(2) capacity = 2,002 vphpl
(3) link length = 1 mile

Table 5.2. Test Network for Signalized Arterials

		Congestion Level			
		Moderate		High	
A-NODE	B-NODE	AADT	AADT/C	AADT	AADT/C
1	2	29,000	8.1	36,250	10.1
2	3	30,000	8.3	37,500	10.4
3	4	31,000	8.6	38,750	10.8
4	5	31,000	8.6	38,750	10.8
5	6	32,000	8.9	40,000	11.1
6	7	33,000	9.2	41,250	11.5
7	8	36,000	10.0	45,000	12.5
8	9	39,000	10.8	48,750	13.5
9	10	29,000	8.1	36,250	10.1
10	11	44,000	12.2	55,000	15.3
11	12	39,000	10.8	48,750	13.5
12	13	38,000	10.6	47,500	13.2
13	14	46,000	12.8	57,500	16.0
14	15	33,000	9.2	41,250	11.5
15	16	33,000	9.2	41,250	11.5
16	17	41,500	11.5	51,875	14.4
17	18	31,000	8.6	38,750	10.8
18	19	31,000	8.6	38,750	10.8
19	20	31,000	8.6	38,750	10.8
20	21	31,000	8.6	38,750	10.8

- Notes: (1) 0% trucks
(2) capacity = 900 vphpl (assuming 1,800 vphpl saturation flow rate and 50% green time)
(3) link length = 0.5 miles

that it deals with queuing in networks. QNET uses a more detailed (enhanced) approach the application of the QSIM equations as was done for the Knoxville network. The results of applying the QNET procedure are considered to be more representative of real-world conditions because of the full incorporation of spatial aspects of queuing in addition to the temporal aspects. Details of the procedure are provided below.

- The peak period was used as opposed to the peak hour. The peak period is defined as six hours: 7:00 a.m. to 10:00 a.m. and 4:00 p.m. to 7:00 p.m. In the larger urban areas, the concept of a single peak hour is no longer relevant: traffic operates in oversaturated conditions for several hours in the morning and afternoon. The temporal distributions in Appendix B were used to determine the hourly volumes for each segment by using Equation (1). The freeway and arterial capacities given in Tables 5.1 and 5.3 were used for the comparisons.
- For freeways, the same BPR functions were used as for Knoxville. For arterials, the *HCM* method for Urban and Suburban Arterials (Chapter 11) was used because it considers signal density in estimating speeds. Using the *HCM* methodology provides a more rigorous comparison to the new method.
- The information on queue length was obtained from Appendix C. Linear interpolation was used for fractional AADT/C values. The procedure used in the queuing analysis is exemplified in Figure 5.6. For each link, the queue implied by the link's AADT/C ratio is plotted on the network diagram. The extent of queuing on an individual link is determined by inspection of all the queues that may influence it.

5.3.2 Results and Implications for Congestion Management and Air Quality

As anticipated, the QNET procedure estimates dramatically lower speeds when queuing

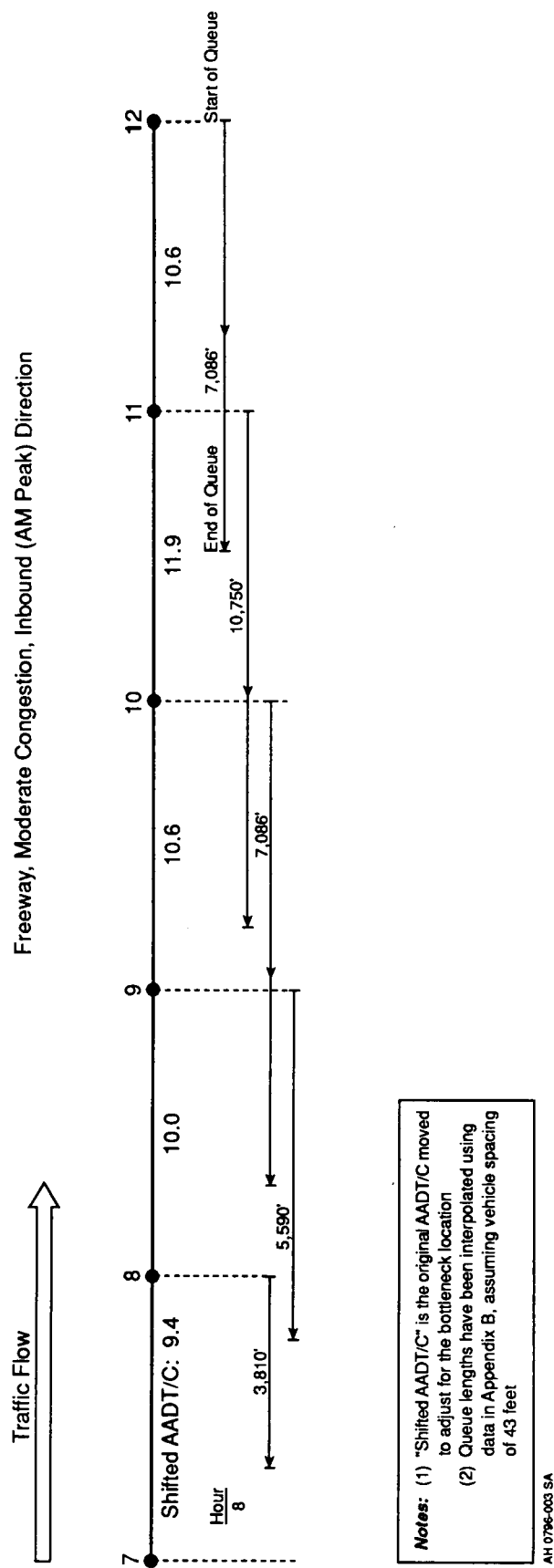


Figure 5.6 Application of QNET Procedure to Test Network

CONGESTION CASE	PEAK ORIENTATION	HOUR	VMT	QNET SPEED	BPR SPEED	QNET VEH-	BPR VEH-
				(mph)	(mph)	HOURS	HOURS
HIGH	INBOUND	8	75,633	34.8	40.5	2,175	1,866
		9	68,083	15.8	44.9	4,317	1,518
		10	53,248	18.5	57.6	2,880	924
		17	61,048	39.4	56.2	1,548	1,085
		18	60,812	20.8	56.3	2,917	1,081
		19	51,279	20.0	57.9	2,570	885
		TOTAL	370,104	22.6	50.3	16,408	7,359
	OUTBOUND	8	58,562	48.8	56.5	1,201	1,036
		9	54,082	39.2	57.4	1,378	943
		10	45,326	42.9	58.6	1,056	773
		17	73,691	32.1	42.9	2,294	1,717
		18	72,866	16.6	43.5	4,386	1,675
		19	58,959	16.5	56.6	3,580	1,042
		TOTAL	363,486	26.2	50.6	13,896	7,185
MODERATE	INBOUND	8	67,498	42.3	54.8	1,595	1,231
		9	55,422	26.9	57.1	2,058	970
		10	41,108	32.9	59.0	1,251	697
		17	50,703	54.5	58.1	931	873
		18	50,084	52.8	58.1	948	861
		19	40,399	53.5	59.1	755	683
		TOTAL	305,215	40.5	57.4	7,538	5,316
	OUTBOUND	8	45,473	55.1	58.5	825	778
		9	41,192	55.2	58.9	746	699
		10	34,733	56.2	59.5	618	584
		17	65,452	42.2	55.4	1,549	1,182
		18	65,163	25.2	55.5	2,588	1,175
		19	47,794	24.7	58.4	1,937	819
		TOTAL	299,807	36.3	57.2	8,263	5,237

Figure 5.7. Application of QNET Procedure to Freeway Test Corridor

CONGESTION CASE	PEAK ORIENTATION	HOUR	CO EMIS. QNET	CO EMIS. BPR	VOC EMIS. QNET	VOC EMIS. BPR	NOx EMIS. QNET	NOx EMIS. BPR
			(LBS.)	(LBS.)	(LBS.)	(LBS.)	(LBS.)	(LBS.)
HIGH	INBOUND	8	2.873	2.507	356	314	456	542
		9	5.009	2.078	569	264	442	515
		10	3.411	1.327	393	173	337	458
		17	2.083	1.552	261	202	404	507
		18	3.491	1.546	406	202	414	505
		19	3.057	1.272	354	166	353	445
		TOTAL	19,923	10,283	2,339	1,322	2,405	2,972
	OUTBOUND	8	1.675	1.483	215	193	432	490
		9	1.831	1.353	228	177	397	463
		10	1.429	1.113	180	146	340	401
		17	2.983	2.331	366	294	444	541
		18	5.125	2.280	585	288	468	537
		19	4.176	1.492	477	195	380	494
		TOTAL	17,219	10,051	2,051	1,293	2,460	2,926
MODERATE	INBOUND	8	2.172	1.754	274	228	453	540
		9	2.557	1.391	305	182	381	471
		10	1.609	1.005	196	132	291	368
		17	1.325	1.255	172	164	404	442
		18	1.340	1.239	173	162	395	437
		19	1.069	985	139	129	326	363
		TOTAL	10,073	7,629	1,260	997	2,249	2,621
	OUTBOUND	8	1.176	1.119	153	147	368	401
		9	1.064	1.008	138	132	336	368
		10	883	843	115	111	289	315
		17	2.110	1.687	266	220	437	531
		18	3.196	1.677	380	218	426	529
		19	2.375	1.178	281	154	321	420
		TOTAL	10,804	7,512	1,334	981	2,177	2,564

Figure 5.7 (Continued)

is extensive. As shown in Figure 5.7 for the highly congested freeway corridor case, the QNET peak period speeds are remarkably lower (by a factor of two) than the BPR speeds. For the moderate congestion case, the differences are less striking; the QNET speeds for the peak period are about 30 percent lower than those predicted by the BPR equation. Figure 5.8 provides more detail on the situation. In the hour ending at 8:00 a.m., demand volumes are over capacity for a substantial portion of the network; this is indicated by the low (below 30 mph) speeds predicted by the BPR function. The QNET procedure also "sees" this condition, but since it is in the process of building a queue during this hour, speeds are still relatively high (over 30 mph). It is the hours ending at 9:00 and 10:00 a.m. that the QNET procedure really comes into play. The queue built during the 7:00 to 8:00 hour, in conjunction with high demand volumes for the next two hours, is seen to have a strong impact on speeds. Almost the whole network is affected by queuing during these hours. For the high congestion case, if the peak period was extended beyond 10:00 a.m., the queue's effects would still be felt. Also, if time slices less than one hour were used, the queue would almost certainly build quicker (analytically speaking) resulting in lower speeds during the beginning of the morning peak. Thus, for heavily congested networks, it can be seen that failing to account for queuing results in a highly serious overestimation of speeds. The difference in estimated speeds by the two methods translate directly to a wide gap in emission estimates. The CO and VOC estimates for the corridor are nearly twice as high using the QNET speeds while NO_x emissions are lower.

For arterials, the corridor-wide differences are less pronounced between QNET and the *HCM* (Chapter 11) methodology, although QNET speeds are consistently lower by 30-40 percent (Figure 5.9). Since both QNET and the *HCM* consider signal density in computing speeds, and signal density was found to be a key determinant of arterial speeds earlier in this work, it is not surprising that the two methods produce closer results than QNET vs. BPR for

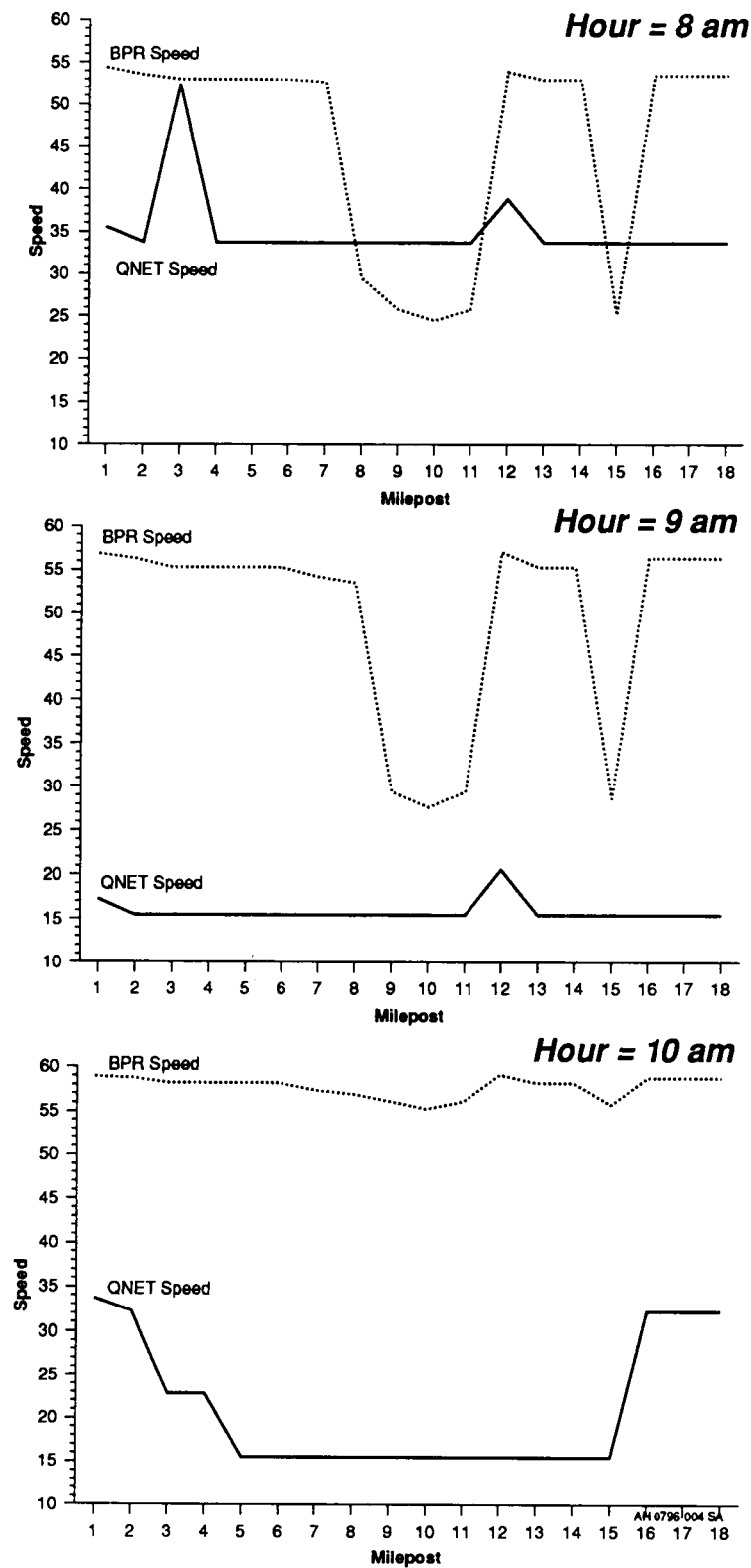


Figure 5.8 QNET vs. BPR Speeds for a Highly Congested Freeway Corridor (Peak Direction)

CONGESTION CASE	PEAK ORIENTATION	HOUR	VMT	QNET SPEED	HCM SPEED	QNET VEH-	HCM VEH-
				(mph)	(mph)	HOURS	HOURS
HIGH	INBOUND	8	13,672	17.3	22.0	789	622
		9	11,981	16.2	25.1	741	478
		10	10,010	19.1	25.3	523	396
		17	13,148	16.4	23.0	800	573
		18	12,886	12.6	23.6	1,022	546
		19	10,758	14.6	25.4	734	424
		TOTAL	72,455	15.7	23.8	4,610	3,039
	OUTBOUND	8	10,326	20.3	25.2	509	410
		9	10,298	20.3	25.2	507	409
		10	9,364	20.7	24.9	453	375
		17	15,078	13.9	17.5	1,088	862
		18	14,953	8.3	18.2	1,794	823
		19	11,943	8.7	25.0	1,379	478
		TOTAL	71,962	12.6	21.4	5,729	3,357
MODERATE	INBOUND	8	11,787	19.5	25.1	604	470
		9	10,328	20.0	25.5	518	406
		10	8,272	21.1	24.2	391	342
		17	10,863	20.1	25.1	540	432
		18	10,663	20.2	25.2	528	423
		19	8,647	21.0	24.5	412	353
		TOTAL	60,561	20.2	25.0	2,993	2,425
	OUTBOUND	8	7,989	21.2	23.8	377	335
		9	7,999	21.2	23.9	378	335
		10	7,487	21.4	23.4	349	320
		17	13,596	16.6	22.7	821	600
		18	13,635	12.3	22.9	1,110	595
		19	10,181	14.7	25.4	691	402
		TOTAL	60,886	16.3	23.5	3,726	2,587

Figure 5.9. Application of QNET Procedure to Arterial Test Corridor

CONGESTION CASE	PEAK ORIENTATION	HOUR	CO EMIS. QNET	CO EMIS. HCM	VOC EMIS. QNET	VOC EMIS. HCM	NOx EMIS. QNET	NOx EMIS. HCM
			(LBS.)	(LBS.)	(LBS.)	(LBS.)	(LBS.)	(LBS.)
HIGH	INBOUND	8	1.099	901	129	109	91	87
		9	1.016	708	118	87	80	75
		10	741	587	88	72	65	62
		17	1.104	836	129	101	88	83
		18	1.336	801	151	97	90	81
		19	987	630	114	77	73	67
		TOTAL	6.283	4.464	729	544	488	456
	OUTBOUND	8	728	608	87	75	66	64
		9	726	607	87	74	66	64
		10	650	556	78	68	60	59
		17	1.462	1.198	168	141	105	100
		18	2.211	1.153	240	136	116	98
		19	1.707	709	186	87	92	75
		TOTAL	7.485	4.831	846	581	506	460
MODERATE	INBOUND	8	859	697	102	85	76	74
		9	739	603	88	74	67	64
		10	564	504	68	61	53	52
		17	772	641	92	79	70	68
		18	755	627	90	77	69	67
		19	594	522	71	64	55	54
		TOTAL	4.283	3.593	513	440	390	378
	OUTBOUND	8	544	493	65	60	51	50
		9	545	493	66	60	51	50
		10	505	469	61	57	48	47
		17	1.135	873	133	106	91	86
		18	1.449	869	163	105	96	86
		19	933	597	108	73	70	63
		TOTAL	5.110	3.793	596	461	407	383

Figure 5.9. (Continued)

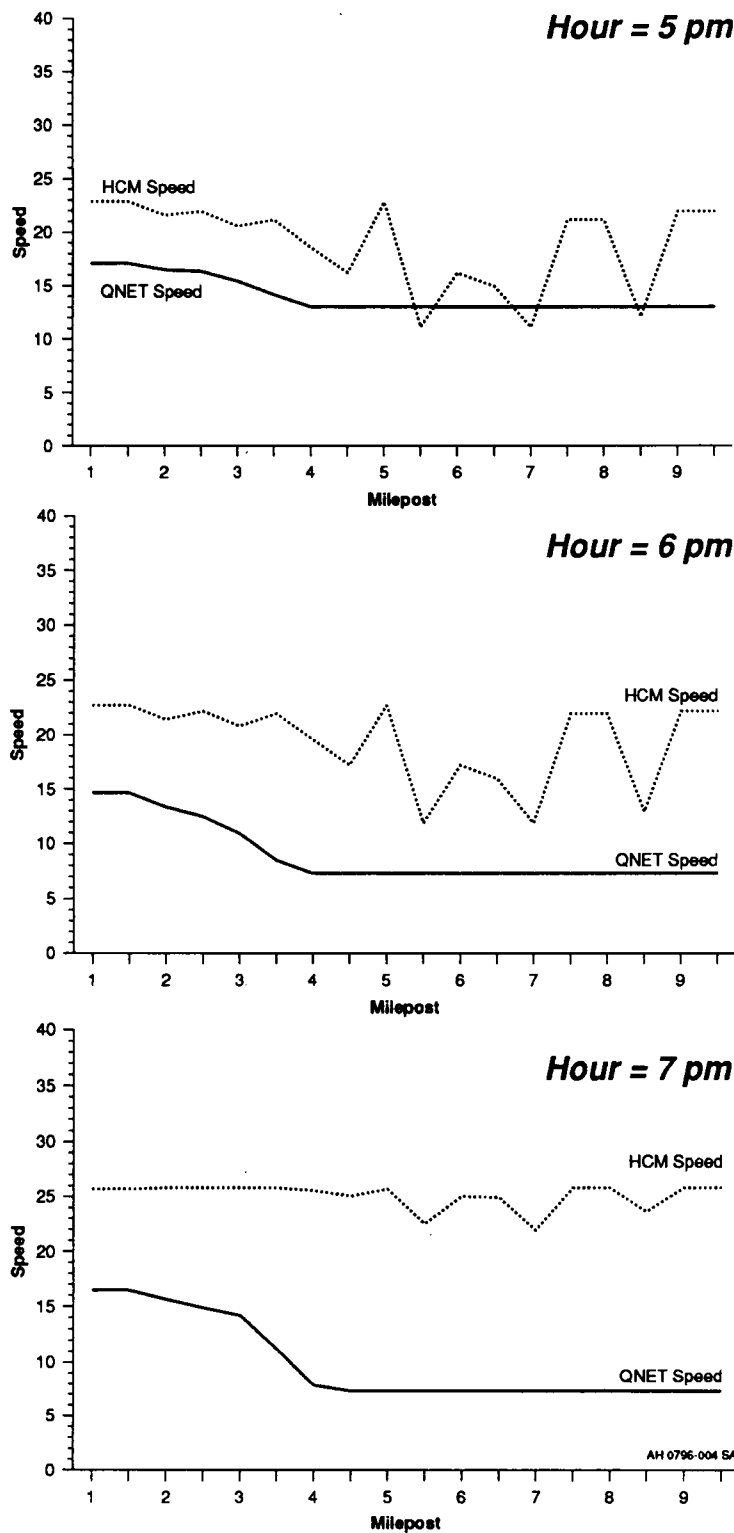


Figure 5.10 QNET vs. HCM Speeds for a Highly Congested Arterial Corridor (Peak Direction)

freeways. (If the BPR function were to be used for arterials, I would expect a much larger difference in speeds based on the Knox County results reported earlier in this Chapter.) Figure 5.10 depicts the link-by-link speeds and shows that when AADT/C levels are very high (over 14), substantial speed differences can be expected. An important reason why queuing is not as influential on arterial speeds across a wide range of AADT/C values is that the QNET procedure does not assume that a capacity drop occurs once traffic flow has "broken down" as on freeways. As with freeways, the air quality effects are roughly proportional to the difference in speeds estimated by the two procedures.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This research has focused on the development, calibration, and application of a new methodology for estimating vehicle speeds for air quality and other transportation planning applications. The methodology uses data that are readily available to transportation planners and embodies several theoretical and practical concepts missing from traditional speed estimation methodologies. The new methodology has been developed in two forms: (1) a set of simple equations that can be applied to individual highway segments or network links and (2) a detailed method for tracking the speed characteristics of highway segments over time and space. (The equations were developed using the detailed methodology but do not fully account for the growth and dissipation of queues over space because speeds had to be measured over a fixed distance.) Several conclusions have been reached as a result of this research.

1. Traditional speed estimation methodologies produce a wide range of results and do not explicitly consider the effects of queuing. These methods include the *Highway Capacity Manual* methods and various link speed functions such as the BPR equation and its variants. They are all based on relating speed to volume and capacity for individual hours. Most provide reasonable results for uncongested conditions. However, in urban settings, traffic flow under congested conditions are of greater interest to planners and engineers. Here the traditional methods show considerable variability and inaccuracy, both of which are related to the methods' inability to handle queuing over time (successive hours) and space (highway distance).
2. For predicting speed and delay in congested conditions, traditional highway capacity analysis is the starting point, rather than the final step. The notion that traffic flow

exists in two regimes (congested and uncongested) has been around for years. This has not, however, stopped researchers and practitioners from developing and applying unified models of traffic flow. This dissertation starts with the premise that conditions are so substantially different in the two regimes that they must be treated separately. Highway capacity is extremely useful in defining the break between these regimes and for relating speed to volume for uncongested conditions. However, treatment of congested conditions requires a distinct type of analysis; queuing analysis was chosen for this dissertation and was found to produce reliable results.

3. Congestion is more appropriately related to AADT/C rather than to V/C. Because the V/C ratio is an hourly concept (i.e., hourly volume divided by hourly capacity), it can not measure the interactive effects of successive hours of congestion. In most large urban areas, congested conditions occur for multiple hours in both the morning and afternoon, rendering the concept of a single peak hour of traffic meaningless. Therefore, congestion metrics that can account for the peak period or 24-hour delays are more appropriate. This dissertation uses the concept of AADT/C to reflect these delays. Although this is not the first application of the AADT/C concept, this dissertation has refined and extended it. Specifically, detailed temporal distributions and a peak spreading procedure were developed to allow accurate prediction of hourly volumes throughout the day, which is the key underpinning of the AADT/C concept.
4. In addition to the two distinct flow regimes, speeds must be estimated separately for uninterrupted flow (freeway) and interrupted flow (signalized arterial) facilities. This fact is acknowledged by the *HCM* but most post-processing methodologies do not make this distinction. The research presented here has demonstrated techniques for estimating speeds for these four categories (congested vs. uncongested and interrupted vs.

uninterrupted flow facilities).

5. On freeways, uncongested speeds can be closely approximated with several methods.

This dissertation found that either the original BPR function, the new *HCM*, or the speed function developed by this dissertation with FRESIM can be used as reliable estimators of speed. Both the BPR and the FRESIM-based functions show that speeds decrease slightly but constantly as V/C ratio increases up to a value of 1.0. (Refer to Figure 4.1 and Table A.3.) The *HCM* speed vs. V/C curve remains flat over V/C ratios less than about 0.8 and shows a slight decrease from there to a V/C of 1.0. Examination of data from Orlando and Denver indicates that speeds do indeed decrease slightly as a function of V/C. However, the magnitude of the differences in speeds resulting from the three methods is sufficiently small so that any of them can be realistically applied.

6. On congested freeways, no existing method is adequate for predicting speeds over more than one hour since they do not account for queuing. When volumes exceed capacity in a single hour, one of the modified BPR equations can be used to approximate speeds in that hour. (See Table A.3 for a description of these functions.) However, because queues form when volumes exceed capacity and they are present at the start of the next hour, the full effect of the first hour's traffic is missed if a standard speed function is used.

7. On signalized arterials, signal density and progression were found to be strong determinants of speeds. For uncongested conditions, signal density and progression are at least as important as V/C ratio in determining speeds. Therefore, arterial speed methodologies must account for these factors. Because it includes factors for signal density and progression, the Chapter 11 methodology of the *HCM* can be used as a

reliable predictor of uncongested arterial speeds, although for planning applications much of the required detail must be assumed. In contrast, the methodology developed in this dissertation requires a limited amount of data: AADT/C level, signal density, and nature of progression. The *HCM* methodology does not directly account for queuing effects, although for V/C ratios below 1.2 its delay equations produce large delays that approximate the effects of queuing. (Above 1.2, the delay equations produce unrealistically large delay estimates.) However, even with this approximation, as with all of the traditional methods examined in this dissertation, the cumulative effect of queues over successive hours is not considered.

8. Based on the above points, the main finding of the dissertation is that under congested conditions (queuing), traditional methods of speed estimation overestimate speeds (i.e., produce higher speed estimates than should be obtained) by a substantial margin. This overestimation is directly related to the level of congestion. For extremely congested networks, such as those encountered when performing 20-year traffic forecasts, the speed overestimation by traditional methods can be inordinately large. Conversely, for uncongested facilities, speed estimation is much simpler and a variety of methods can be used, subject to the observations in Point 7 above. Finally, the overestimation of speeds in congested conditions has ramifications for air quality planning, congestion management, and other transportation planning applications. If speeds are predicted to be higher than observed in the field, CO and VOC estimates will be lower than they should be and NO_x emissions will (usually) be higher. Other implications of using higher-than-expected speed estimates include underestimating the extent of congestion in an urban area and underestimating the benefits of highway improvements and transportation control strategies.

9. This dissertation developed a new speed estimation methodology that is based on queuing theory. The methodology was incorporated into a model (QSIM) and applied to develop a set of easily applied equations for predicting delays and speed. The methodology was used to develop the QSIM model which was run to produce a dataset from which predictive equations were developed. The equations require only very limited data so that they can be used for planning applications where detailed data inputs are generally unavailable. The equations relate delay to AADT/C ratio and for signalized arterials, to signal density and progression as well. The equations can be applied to either links in a travel forecasting network or to individual highway segments.
10. The QSIM model includes several features that are improvements over traditional methods. These include:
- The use of temporal distributions as a basis for developing hourly traffic estimates. The temporal distributions include a feature for estimating peak spreading.
 - Accounting for daily variation in traffic by allowing hourly traffic estimates to vary stochastically. This is thought to be a more realistic representation of how traffic behaves in the field and is an improvement over using the static K- and D-factors to develop peak hour volumes only.
 - On freeways, the inclusion of a capacity drop after flow has broken down (i.e., after the onset of queuing) more correctly models the growth and dissipation of queues.
 - Separate functions are used to estimate speeds in queuing and free flow conditions. The uncongested speed functions were developed with microscopic traffic simulation models and validated with field data. Speeds for queuing conditions

were taken from field data for freeways and from traffic flow theory for signalized arterials. The two are combined in a weighted fashion depending on the size of the queue on the test link.

- The concept of highway capacity, a basic tenet of the transportation profession, is used to determine when traffic operates under free flow and queuing conditions as well as a basis for estimating free flow speeds and the extent of queuing on the test link.
- The methodology is based on estimating delay rather than speed at its most basic level. Delay is measured in excess hours per vehicle-mile traveled, i.e., the delay beyond that experienced at the free flow speed. Speeds are estimated by combining delay estimates with knowledge of a facility's free flow speed. This approach has the advantages of being more compatible with emerging congestion monitoring techniques and allowing the estimation of speeds on facilities with different free flow speeds.

11. The QNET procedure was developed as an extension of QSIM to account for queue spillbacks onto upstream links. The QSIM model is sensitive to the length of the highway segment over which speed/delay measurements are taken. If the segment is long, then a queue of certain length has less effect on overall speeds/delays than if the segment was short. However, in order for a set of standard equations to be developed, QSIM segment lengths had to be fixed. This means that under highly congested conditions, a good portion of the delay occurs off the test segment and is not included in the delay estimates. For freeways, the test segment length was set to 1.5 miles, which approximates the length of most urban freeway links. (Minimum interchange spacing in urban areas is roughly one mile.) For the signalized arterial analysis, test

segment length was set equal to signal density to approximate its effect. (For example, a high signal density indicates a short segment length. This means that a queue of a fixed length has greater influence over the segment's speeds/delays than a lower signal density which has a longer segment length.) The QNET procedure takes information on the predicted queue lengths from QSIM and assigns them to a network link-by-link (rather than to a single, fixed test segment), allowing for queues to spillback onto upstream links in the network. Speeds/delays can then be estimated based on the portion of the link consumed with queuing and the same basic procedures as used by QSIM. Results show that in moderate to highly congested networks, the spillback phenomenon has a substantial effect on network speeds.

6.2 Recommendations

The author makes two recommendations for further work based on the results of the dissertation. First, a more complete validation of the QSIM and QNET procedures are in order. The Orlando and Denver freeway data used for the validation in Chapter 4 were useful but limited. Specifically, the identification of bottlenecks and queue lengths was synthetic and not based on actual observation, and the occurrence of incidents was not noted. For arterials, the New Jersey data was extremely valuable in identifying and correcting a problem with the original QSIM results. However, the data was mainly for unsaturated conditions (i.e., V/C ratios less than 1.0). Arterial data where queuing is experienced at signals would be very helpful in validating the model.

The second recommendation is to further refine the QNET procedure. The technique used in this dissertation involved manual calculations to a relatively simple corridor. Large scale application of QNET to travel forecasting models will require that the procedure be

automated. The results of automating QNET will be useful in two ways. First, it will improve the reliability of speed estimates at the end of the travel forecasting process and eliminate the need for *ad hoc* post-processing of network information. Second, the revised speeds can be used as a basis for improving the travel forecasting process in general. The revised speeds resulting from a pass through the travel forecasting process can be used as a basis for a second iteration of the models. By estimating the effects of queuing and using this as the basis for a revised pass through the travel forecasting process, the research will provide a more realistic method of dealing with congested networks. (This procedure is often referred to as "feedback".) Feedback can be used to both the trip distribution and traffic assignment steps of the travel forecasting procedure to produce more reliable traffic forecasts. The reason for this is that both distribution and assignment use uncongested speeds as a starting point; if reliable estimates of congested speeds are used instead, their results are improved.

REFERENCES

1. Ruiter, Earl R., "Highway Vehicle Speed Estimation Procedures For Use In Emission Inventories", prepared for U.S. Environmental Protection Agency, Contract 68D90073, September, 1991.
2. Dowling, Richard and Alexander Skabardonis, "Improving the Average Travel Speeds Estimated By Planning Models", presented at 71st Annual Meeting of the Transportation Research Board, January, 1992.
3. Cambridge Systematics, *Short-Term Travel Model Improvements*, prepared for the Travel Model Improvement Program, FHWA, October 1994.
4. "Highway Capacity Manual: Third Edition", *Special Report 209*, Transportation Research Board, 1994.
5. *Congestion Management Systems: State-of-the-Practice Review*, Texas Transportation Institute, November, 1993.
6. Hickling Corporation, *Research Strategies for Improving Highway User Cost Estimating Methodologies*, NCHRP Project 2-18(1), unpublished Interim Report.
7. Hall, F.L. and K. Agyemang-Duah, "Freeway Capacity Drop and the Definition of Capacity", paper presented at the Transportation Research Board Annual Meeting, 1991.
8. MacDonald, O.J., Y. Dehgani, and O. Altan, *An Empirical Queuing Analysis for The Central Artery Freeway Complex in the Central Boston Area*, paper presented at the 71st Transportation Research Board Annual Meeting, 1992.
9. Dowling, Richard and Alexander Skabardonis, *Improving the Average Travel Speeds Estimated By Planning Models*, presented at 71st Annual Meeting of the Transportation Research Board, January, 1992.
10. May, Adolf D., *Traffic Flow Fundamentals*, Prentice Hall, Englewood Cliffs, New Jersey, 1990.
11. Hall, F.L., Anna Pushkar, and Yong Shi, *Some Observations on Speed-Flow and Flow-Occupancy Relationships Under Congested Conditions*, paper presented at the 72nd Transportation Research Board Annual Meeting, 1993.
12. Jack Faucett Associates, *The Highway Economic Requirements System Technical Report*; prepared for Highway Needs and Investment Branch; Office of Policy; FHWA; July, 1991.
13. Elkins, G.E., B.C. Butler, R. High, and R. Harrison, *Estimating Vehicle Performance Measures, Volume I, Technical Report*; prepared by TRDF for FHWA; July, 1987.

14. Ewing, Reid and Antoine Khoury, "Predicted vs. Actual Levels of Service: Evaluation of Three Arterial Analysis Procedures", *ITE 1991 Compendium of Technical Papers*, Institute of Transportation Engineers.
15. Courage, Kenneth G., Randall H. Showers, and Douglas S. McLeod, *Reconciling Estimated and Measured Travel Times on Urban Arterials*, paper presented at the 74th Transportation Research Board Annual Meeting, 1995.
16. Ewing, Reid, "Roadway Levels of Service in an Era of Growth Management", *Transportation Research Record 1364*, Transportation Research Board, 1992.
17. Creighton-Hamburg, Inc., *Freeway-Surface Arterial VMT Splitter*, FHWA, U.S. Department of Transportation, 1971.
18. Federal Highway Administration, *Traffic Assignment*, August, 1973.
19. Branston, David, "Link Capacity Functions: A Review", *Transportation Research*, V10, N4, pp. 223-236, 1977.
20. Singh, Rupinder, "Beyond the BPR Curve: Updating Speed-Flow and Speed-Capacity Relationships in Traffic Assignment", presented at the Fifth Transportation Planning Methods Applications Conference, April 1995.
21. Federal Highway Administration, *TRAF Technical Manual*.
22. Margiotta, Richard, et al., *Speed Determination Models for the Highway Performance Monitoring System: Final Report*, prepared by SAIC for FHWA, October 31, 1993.
23. Margiotta, Richard, Harry Cohen, and Robert Morris, *Roadway Usage Patterns: Urban Case Studies: Final Report*, prepared by SAIC for Volpe National Transportation System Center and FHWA, July 22, 1994.
24. Margiotta, Richard A. et al., *Development of Diurnal Traffic Distribution and Daily, Peak, and Offpeak Speed Estimation Procedures for Air Quality Planning*, prepared for FHWA, February 1996.

APPENDICES

APPENDIX A

DETAILED LITERATURE REVIEW

A.1 Introduction

The literature reviewed for this research focuses on the effects of urban congestion, therefore, a substantial number of studies related to speed estimation have been excluded (e.g., those for rural two-lane highways). Urban freeways and arterials with signals are the focus of the research; unsignalized arterials are not covered because they are not usually considered to experience a substantial amount of congestion. *The term "arterials" is used throughout this dissertation to mean highways with traffic signals present to distinguish them from freeways which have no such restrictions on traffic flow. The term "congested" is meant to indicate traffic flow that is in the so-called unstable (forced flow) operating regime, Level of Service "F" in HCM terms.*

A.2 Urban Freeways

The Highway Capacity Manual (*HCM*) serves as a focal point for research on highway capacity and the relationships between highway congestion and speed (4). It is the basic reference document used by traffic engineers in planning, designing, and analyzing highways. Researchers frequently compare their data on traffic volumes and speeds with the tables and curves in the *HCM*. Also, much past and ongoing research by NCHRP and FHWA has as an explicitly stated objective the development of findings and procedures for inclusion in the next edition of the *HCM*.

HCM procedures for determining the capacity of multilane uninterrupted flow facilities, including freeways and multilane highways without access control, take into account the following highway characteristics:

- number of lanes;
- lane widths and lateral clearances;

- vehicle mix and the effects of grades on truck operating characteristics; and
- driver population.

For highways with design speeds greater than 60 mph, the newly revised *HCM* has recommends two capacity values: 2,200 vehicles per lane per hour as the capacity of four-lane freeways and rural multilane highways and 2,300 for freeways with six or more lanes. The following ideal conditions are assumed for these values:

- 12-foot lane widths;
- level terrain;
- 6-foot lateral clearances between the edge of the travel lanes and the nearest obstacle or object on the roadside or in the median;
- all passenger cars in the stream; and
- driver characteristics typical of weekday commuter traffic streams in urban areas or regular users in other areas.

The effects of deviations from these ideal conditions are taken into account through a series of adjustment factors that reduce capacity downward from the ideal values of 2,200 and 2,300. The new procedure distinguishes between "ideal speed" and "actual speed". Ideal speed is based on assuming there are no trucks in the traffic stream and the newly-defined speed-flow curves. These new curves are very different from the 1985 *HCM* curves. The previous speed-flow relationships showed a somewhat parabolic decrease in speeds as volumes move toward capacity, culminating in a speed of around 30 mph at capacity. The new curves show a flat relationship between speed and flow over most of the volume range less than capacity. The new relationships keep ideal speeds constant until 55 to 80 percent of capacity (depending on free flow speed and number of lanes), and drop only 5 to 12 miles per hour when capacity is reached. The adjustments are applied to estimate a maximum service flow rate under the

prevailing conditions. Once the capacity of a section is established, the *HCM* method also estimates the maximum service flow for prevailing conditions and the speed-flow curves are used to derive level of service, ideal speed, and ideal density. Actual speed can then be computed by accounting for trucks' influence in the traffic stream in a three step process:

- actual density is computed by converting trucks to passenger car equivalents;
- volume per lane in the 15 minute peak period is calculated using the peak hour factor; and
- speed is calculated assuming the linear relationship that flow rate equals speed times density.

A review of the recent literature on traffic flow theory indicates several important areas where the speed-flow relationships for freeways and multilane highways presented in the 1985 *HCM* have been challenged:

- There is evidence for a "two-capacity" hypothesis under which the occurrence of bottlenecks on a section creates a metered flow that is less than the free-flow capacity of the section. For example, Hall and Agyemang-Duah found that the queue discharge rate on a section of the Queen Elizabeth Highway in Ontario was 6 percent less than the free-flow capacity of the section (7). The lowering of capacity under breakdown conditions is acknowledged in the new Chapter 6 of the *HCM*. Chapter 6 now notes that the reduction is highly dependent on local conditions and can range from no appreciable drop in capacity to as much as a 25 percent decrease. Chapter 6 also presents a simple method for examining queues.
- Perhaps the most important issue to be addressed in developing improved speed estimation procedures for planning applications is how to estimate the

consequences of queuing which result when the number of vehicles attempting to use a section exceeds its capacity. The new *HCM* procedures provide an excellent basis for determining capacities and speeds when flows are under capacity. However, little guidance is provided on what speeds are like under saturated traffic conditions. For planning applications, the speeds in saturated conditions are extremely important because models will typically produce volume estimates in well in excess of capacity. For example, travel forecasting models routinely predict link volume-to-capacity (V/C) ratios of 1.3 and higher.

I believe that the failure to address queuing is the major shortcoming of existing procedures and any methods proposed for speed estimation must consider it.

The need to account for queuing and complex geometric conditions lead rise to a procedure developed to analyze Boston's Central Artery/Tunnel (CA/T) freeway project (8). The procedure is based on the queuing methodology in the *FREQ8PE* macroscopic simulation model. (This is one of many variations of the original *FREQ* model.) Because the CA/T project has extensive weaving and merge areas, capacity reductions for these areas were developed (Table A.1). Similar to the Dowling and Skabardonis procedure (9), queues form when volumes exceed capacity. The procedure then uses assumes values for jam density (180 vehicles per hour per lane or vphpl) and capacity density (60 vphpl). Storage capacity is estimated as jam density minus capacity density. Queue length is then computed as:

$$\text{Queue Length} = (QU/C_s) * 0.5 * 5280$$

Where:

QU = excess demand attempting to use the section

C_s = storage capacity

Table A.1. Capacity Reductions from the CA/T Project Analysis

LOS	Vehicles Per Hour Per Lane Capacity Decrease	
	Weaving Sections	Isolated Merge Sections
C	< 80	80 - 100
D	180 - 220	80 - 100
E	220 - 270	100
F	> 270	100

0.5 = delay adjustment term, based on the assumption that delay per queued vehicle varies linearly from zero for the first vehicle to a maximum value for the last vehicle

5280 = feet per mile.

The speed of vehicles in a queue is then related to queue length and a combination of the delays (in seconds) for conditions at the capacity threshold and in the queue.

$$\text{Queue Speed} = [\text{Queue Length}/(T_u + T_d)] * (3600/5280)$$

$$T_u = (\text{Queue Length}/S_c) * (3600/5280)$$

$$T_d = (V_d/C_d) * 3600$$

Where:

T_u	=	delay (unconstrained) at capacity
S_c	=	assumed speed at capacity
3600	=	seconds per hour.
T_d	=	average delay in the queue
V_d	=	(first vehicle's delay + last vehicle's delay)/2
	=	$QU * 0.5$
C_d	=	total downstream capacity.

Traffic stream models represent another opportunity for speed estimation. These models provide the fundamental relationships of macroscopic traffic stream characteristics (e.g., speed, flow, and density) for uninterrupted flow facilities. Various formulations have been advanced over the years -- including those by Greenshields, Greenberg, Underwood and Edie -- and represent both single regime (combined free flow and congested) and multiregime (separate free flow and congested) conditions. A full treatment of these models can be found in May (10). The main drawback of these models for speed prediction is that because they have density and flow as the independent variables in the equation, these must first be predicted. A recent extension of these models relates congested speed directly to flow alone (11):

$$\text{Congested Speed} = 0.003 * \text{flow} + 0.0000166 * \text{flow}^2.$$

Still, since this equation is meant to be applied over a full range of congested conditions, the prediction of flow (vph) for each congestion increment is required for this to be a useful model for the current research.

A.3 Arterials With Signalized Intersections

The *HCM* provides procedures for estimating the capacities of signalized intersections, delays at intersections, and average speeds on arterials with signalized intersections. Two

procedures are provided in Chapter 9 of the *HCM* for determining the capacities of signalized intersections: an operational analysis procedure and a planning analysis procedure. The operational analysis procedure is very detailed and requires extensive inputs. Even the planning analysis procedure, which provides much more approximate estimates of intersection capacity, requires input information that may not be widely available for planning applications:

- demand volumes for all turning and through movements; and
- number of lanes on each intersection approach and an identification of exclusive left-turn lanes.

The newly revised Chapter 11 of the *HCM* provides a procedure that can be used to calculate average travel speed on arterials with signalized intersections. The operational procedure works as follows:

- Using equations from the *HCM*, calculate total intersection delay as function of stopped delay. Stopped delay is the sum of uniform delay (adjusted for progression or type of control) and incremental delay. Uniform delay is a function of volume, capacity, green time, cycle length, and green time. Incremental delay is a function of volume, capacity, arrival type, and platooning.
- Add intersection delay to travel time at free-flow speed on the section to get total travel time for the section.
- Divide total travel time into section length to get average travel speed.

The planning methodology follows the same basic steps but uses an assumed adjusted saturation flow rate and a weighted effective green ratio to estimate parameters in the intersection delay equations.

When intersection demand volumes exceed capacity, it is difficult to estimate delays

accurately since spillbacks may extend to adjacent intersections. The *HCM* states that the procedure for estimating intersection delays can be used with caution for ratios of demand volume to capacity of 1.2 or less.

In addition to the *HCM*, other planning techniques have been developed for estimating speeds on signalized arterials. For comparison purposes, the older version of the HERS model contains a more approximate procedure to calculate intersection delays (12). The HERS procedure first analyzes the effect of stop signs and then the effect of traffic signals. The effect of stop signs is analyzed by assuming that they are evenly spaced, and that each stop sign results in deceleration from some maximum speed to a full stop, followed by immediate acceleration back to the maximum speed. The maximum speed is assumed to be the unconstrained speed produced by the aggregate limiting velocity model (LVM) or, if the stop signs are spaced too closely for this speed to be attainable, the maximum speed is the highest speed attainable. Average speed over the cycle is derived from the maximum speed and the acceleration and deceleration rates. These assumptions appear to be more realistic than the assumption that average speed is the speed produced by the aggregate LVM and the maximum speed is some higher speed, as indicated by the Texas Research and Development Foundation (TRDF) report (13). Acceleration and deceleration rates are obtained from the TRDF acceleration and deceleration equations. Use of more modest acceleration and deceleration rates would produce lower average speeds and, in many cases, lower maximum speeds.

The effect of traffic signals is analyzed by presuming that all signals are synchronized but not staggered. For sections on which signals are staggered, the procedure thus tends to overestimate the effects on travel time and costs. Hence, the development of a separate procedure for estimating the effects of staggered signals appears to be warranted.

The HERS procedure for estimating the effect of traffic signals distinguishes between

sections with "closely spaced" signals (on which all vehicles stop once every signal cycle) and sections with "widely spaced" signals (on which there is some probability that a vehicle will not be stopped during a signal cycle). The two types of sections are distinguished on the basis of the average distance between signals, the length of the red cycle, and the average speed on the section after adjustment for stop signs. This information, along with the TRDF acceleration and deceleration equations, is then used to estimate the expected number of stops for traffic signals and the effect on average travel speed (called "average effective speed" by HERS). The procedure can be easily extended to estimate idling time and average running speed.

Another class of models to consider as an alternative to the *HCM* procedure is arterial signal timing models such as PASSER II and TRANSYT-7F. Both models generally achieve improved accuracy over the *HCM* arterial methodology through a much more detailed treatment of the propagation of traffic along an arterial route. The *HCM* relies on a simple categorization of arrival type from 1 to 6, i.e, the progression design is not realistically considered. The other class of models is traffic simulation models, such as TRAF-NETSIM. (Simulation models are discussed below.)

However, the results of recent field studies casts suspicion on the validity of all analytical models, including the *HCM* and its competitors. For example, two studies within the past four years suggest that the *HCM* arterial methodology substantially underestimates speeds (14, 15). In particular, Courage, Showers, and McLeod developed adjustment factors to be applied to the incremental and uniform delay components of the *HCM* arterial methodology to achieve a better match predicted and observed speeds, as measured with the floating car method (15). They found that the floating car has a distinct advantage in systems that have a degree of progression as compared to the "average vehicle". That is, once the floating car is in the system, it receives all of the advantage of progression that does not accrue to all vehicles.

Ewing developed a simple linear model for predicting arterial travel speed based on two independent variables: peak hour traffic volume and signal density (16):

$$\text{Avg. Travel Speed} = 44.7 - (0.0087 * \text{Peak Hour Volume}) - (7.74 * \text{Signals/Mile}).$$

The model was based on 17 two-lane streets in Seminole County, Florida. It is unclear from Ewing's research if the constant of 44.7 can be thought of as the free flow speed in this model. The R^2 value of 0.55 for this model is relatively low and the inclusion of signal characteristics is probably needed to increase the model's usefulness. In the early 1970s, Creighton and Hamburg developed a speed function that also included signal density as a key variable as well as volume and speed limit (17). A comparison of the *HCM* (Chapter 11) method, and the Ewing and Creighton-Hamburg functions appears in Figure A.1.

A.4 Generic Techniques

Dowling and Skabardonis developed a procedure for predicting the effects of queues on travel speeds (9). Their procedure was developed as part of a traffic assignment output "post-processor" to provide improved speeds for air quality impact analysis. A highly modified version of the procedure was adopted by the Research Team in developing the base model we propose we to use for this project. The procedure recommended by Dowling and Skabardonis is as follows.

- Divide the peak period into time slices. Dowling and Skabardonis used 1- hour slices because of computational limitations of the assignment package they were using; however, it is possible to use smaller or larger time slices depending on data availability.
- Apply temporal distribution percentages to average daily traffic to determine

Volume	V/C	HCM Speed	Ewing Speed	Creighton Hamburg Speed
1,325	0.70	27.9	23.5	27.8
1,515	0.80	26.8	22.6	27.2
1,715	0.90	24.7	21.8	23.9
1,800	0.95	23.1	21.4	22.5
1,900	1.00	20.1	21.0	20.8
2,090	1.10	13.5	20.1	17.6
2,285	1.20	8.6	19.3	14.3

No. Lanes = 4
 m = 16
 C = 90
 g/C = 0.5
 FFS = 40
 Signals/Mile = 2.0
 Capacity = 1,900

Creighton-Hamburg Arterial Function

$$\begin{aligned}
 S(w,n) &= 3600 / \{ (3600/w) + 12.5n \} \\
 f(n) &= -0.336n^3 + 3.905n^2 - 16.116n && \text{if } n < 5.5 \\
 f(n) &= 0.69n - 39.14 && \text{if } n \geq 5.5
 \end{aligned}$$

For $d \leq 0.8c$

$$a = S(w,n) + df(n)$$

For $0.8c < d < 1.4c$

$$\begin{aligned}
 m &= (S(w,n) + 0.8cf(n) - S_m) / -0.6 \\
 b &= 2.333S(w,n) + 1.867cf(n) - 1.333S_m \\
 a &= (md/c) + b
 \end{aligned}$$

For $d \geq 1.4c$

$$a = S_m$$

Where:

- a = average arterial speed (mph)
- d = arterial volume per lane (vehicle/sec)
- n = signals per mile
- w = arterial speed limit
- c = arterial capacity per lane (vehicle/sec)
- $S(w,n)$ = free flow speed for a given speed limit and signal density
- $f(n)$ = rate of speed change with volume
- S_m = minimum speed.

Figure A.1. Comparison of Selected Arterial Speed Functions

"demand" volumes in each time slice.

- When the demand volume for a slice exceeds capacity, queuing occurs. The length of the queue is determined by the excess of demand volume over capacity.
- Calculate average link speed for each time slice based on queue length and average speed in the queue. Specifically, average link speed can be calculated as follows:

$$\text{Ave. Link Speed} = \text{Ave. Queue Speed} * (\text{Ave. Queue Length} / \text{Link Length}) + \\ \text{Non-Queue Speed} * (1 - \text{Ave. Queue Length} / \text{Link Length})$$

Where:

$$\text{Ave. Queue Speed} = \text{Capacity/Lane} * \text{Vehicle Spacing in Queue.}$$

$$\text{Ave. Queue Length} = \text{Ave. Queue} * \text{Vehicle Spacing in Queue.}$$

$$\text{Ave. Queue} = (Q_1 + Q_2) / 2.$$

$$Q_1 = \text{Queue at start of time slice.}$$

$$Q_2 = \text{Queue at end of time slice.}$$

Dowling and Skabardonis note that, while their procedure assumes that the queue will occur on the same segment where volume is predicted to exceed capacity, in reality the queue would form upstream of the bottleneck section. However, since the purpose of the analysis is to predict the effect of queuing on speed, this mislocation of the queue may not be a problem. Further, it should be noted that this procedure does not account for the consequences of a queue extending upstream and causing additional queues due, for example, to the blocking of intersections and ramps. The effects of this shortcoming are at least partially offset by the fact that the procedure does not account for the improved speeds on links downstream from the bottleneck.

Simpler procedures have also been used to represent speeds under queuing. The traffic assignment component of urban travel forecasting models uses a link speed function to develop minimum time paths through a network. Several link speed functions have been developed over the years, most of which are based on the original formulation from the Bureau of Public Roads (BPR; 18). These functions relate speed to link volume and capacity as shown in Figure A.2. Other functions have also been proposed and applied to the traffic assignment problem. These take on different model forms -- such as exponential, logarithmic, and hyperbolic -- but still fundamentally relate speed to link volume and capacity (19). A recent study by Ruiter recommended the use of *HCM* procedures as the basic speed estimation method (1). The study also provided procedures for developing approximate representations of speed when assigned volumes to individual links exceed capacity during the peak period. Another recent study by Singh for the Metropolitan Transportation Commission (MTC) in Oakland, CA compared a multitude of the BPR variants that have been used by urban areas (20). He concluded that an exponent of 10 and a constant of 0.2 provided the best results. The Creighton-Hamburg freeway function also developed a function for speed prediction; like Ruiter it too relies an estimated speed at capacity (17).

As shown in Figure A.2, the functions show a high degree of variability in their speed predictions for the same V/C level. It must be remembered, however, that these functions were not necessarily developed to match field measurements of speed. Rather, they were developed (for the most part) as a means of deriving realistic traffic assignments. Some of the functions, such as the modified BPR equations and the CSI/JHK function, were developed as an alternative to the original BPR to get a more realistic estimation of congested speeds. (Note that both BPR variants in Figure A.2 estimate a speed of 30 mph at a V/C of 1.0, as would be predicted by the older freeway versions of the *HCM*.) Interestingly, the original BPR curve,

FFS = 60 mph

V/C	BPR ($S_c=25\text{mph}$)	Ruiter ($S_c=50\text{mph}$)	Ruiter ($S_c=50\text{mph}$)	CSI/JHK	Mod BPR4	Mod BPR10	Davidson ($J=0.5$)	MTC
0.10	60.00			60.00	59.99	60.00	56.84	60.00
0.50	59.44			59.97	56.47	59.94	40.00	59.99
0.75	57.28			59.27	45.58	56.80	24.00	59.33
0.90	54.62			56.99	36.23	44.49	10.91	56.09
0.95	53.47			55.49	33.07	37.53	5.71	53.58
1.00	52.17	24.98	49.70	53.45	30.00	30.00	N/a	50.00
1.05	50.75	23.46	46.68	50.80	27.08	22.82		45.26
1.10	49.20	22.21	44.18	47.52	24.35	16.70		39.51
1.15	47.53	21.17	42.10	43.64	21.83	11.89		33.17
1.20	45.77	20.30	40.35	39.30	19.52	8.34		26.81
1.30	42.00	18.93	37.60	30.01	15.56	4.06		15.97
1.40	38.07	17.92	35.59	21.37	12.39	2.00		8.84
1.50	34.10	17.16	34.08	14.49	9.90	1.02		4.79
1.60	30.26	16.58	32.92	9.58	7.94	0.54		2.61
1.70	26.63	16.13	32.02	6.29	6.42	0.30		1.45
1.80	23.30	15.78	31.31	4.14	5.22	0.17		0.83

Notes: (1) FFS = free flow speed
(2) S_c = speed at capacity
(3) Functions

BPR: $\text{FFS}/(1 + (0.15 * (V/C)^4))$
 Ruiter: $S_c * (0.555 + (0.444 * (V/C)^3))$
 CSI/JHK: $\text{FFS}/(1 + (0.1225 * (V/C)^8))$
 Mod BPR4: $\text{FFS}/(1 + (V/C)^4)$
 MOD BPR10: $\text{FFS}/(1 + (V/C)^{10})$
 Davidson: $\text{FFS}/(1 - (0.5 * V/C)/(1 - V/C))$
 MTC: $\text{FFS}/(1 + (0.20 * (V/C)^{10}))$

Figure A.2. Speeds Produced By The BPR Function and Its Variants

which was previously criticized for not following the old *HCM* freeway curve, now follows the new curve very closely, although it predicts lower speeds at and near capacity than does the new *HCM*. Also, the BPR formulations are typically applied uniformly to both freeways and signalized arterials, even though the nature of traffic flow on these two types of facilities are fundamentally different. (The *HCM* characterizes the difference as uninterrupted flow {freeways} versus interrupted flow {arterials} because of the presence of traffic control devices on arterials.)

The fundamental problem with any variant of the BPR curve is that they do not account directly for the effects of queuing. The curves have not been calibrated on any data where volumes exceed capacity and any match to predicted speeds in oversaturated conditions is purely coincidental. Further, the temporal and spatial aspects of congestion (queues) are not accounted for in any fashion; in the field, queues built up in one hour will affect traffic in successive hours **and** queues from one link will "spill back" onto upstream links. It is these characteristics that the research presented here addresses.

Traffic simulation models are another method for determining speeds as a function of highway and traffic conditions. FHWA has been developing a family of microscopic traffic simulation models collectively known as TRAF since the 1970s. Separate microscopic models were developed to handle different facility types: ROADSIM (rural two-lane roads), NETSIM (urban arterials), and FRESIM (freeways).¹ These models are dubbed "microscopic" because they track the movements of individual vehicles, including the influences of driver behavior, second-by-second as they proceed through a network. (The so-called "macroscopic" models do not model vehicles in this way but rely on deterministic traffic flow relationships instead.) One

¹FHWA is now developing the CORSIM model which integrates NETSIM and FRESIM into a single framework.

of the key underpinnings of the microscopic models is their stochastic (random) handling of certain features including the assignment of vehicle types, driver types, and turning movements. The simulation proceeds second-by-second on a highly detailed network given by the user. In the case of NETSIM, intersection geometry and signal characteristics are coded. In the case of FRESIM, lane configuration and ramp junctures are designated. Vehicles then enter into the network via random generation at "source" nodes so as to match user-specified volumes for the simulation period (typically one hour). As they are generated the characteristics discussed above are assigned. The movement of vehicles through the network is governed by "car-following logic", that is, the driver responds to the movement of the vehicle directly ahead. If the driver wants to change lanes, the vehicles in the adjacent lane are examined to ensure that the lane change maneuver can occur safely. In NETSIM, the driver responds to traffic signals and stop signs by controlling the speed of the vehicle and stopping it when necessary. In FRESIM, drivers respond to warning signs regarding the loss of lanes. As with all simulation models, a "warm-up period" is used to initialize the network, that is, the network is filled with vehicles before measurements are taken. Nineteen consecutive time periods can be simulated, each with its own traffic characteristics. A large variety of performance measurements are output from the models including delay, speed, density, and actual traffic flow. These measurements are available for individual links as well as various aggregations of the network.

Since the models monitor the movement of vehicles every second, both NETSIM and FRESIM explicitly account for the growth and decline of queues over time, including the effect of "spillbacks" onto upstream links. Additionally, because traffic can be varied by time period, the cumulative effect of congestion over the course of a day can be simulated. This feature -- the ability to handle traffic in oversaturated conditions -- distinguishes the microscopic models from many other analytic techniques (21).

APPENDIX B

TEMPORAL TRAFFIC DISTRIBUTIONS AND PEAK SPREADING PROCEDURE USED IN THE RESEARCH

Table B.1. Weekday Temporal Distributions

TYPE OF FACILITY: FREEWAY

	AADT/C					
	LE 7.0		7.1 -- 11.0		GT 11.0	
	PEAK DIRECTION		PEAK DIRECTION		PEAK DIRECTION	
	AM	PM	AM	PM	AM	PM
	PCT. OF	PCT. OF	PCT. OF	PCT. OF	PCT. OF	PCT. OF
	DAILY VOL.	DAILY VOL.	DAILY VOL.	DAILY VOL.	DAILY VOL.	DAILY VOL.
HOUR						
1	0.42	0.58	0.44	0.57	0.47	0.54
2	0.27	0.33	0.27	0.34	0.27	0.32
3	0.23	0.25	0.22	0.26	0.20	0.24
4	0.23	0.22	0.21	0.21	0.18	0.18
5	0.38	0.29	0.36	0.28	0.31	0.25
6	1.17	0.68	1.12	0.69	1.06	0.72
7	3.26	1.75	3.16	1.90	2.86	2.18
8	4.83	2.90	4.59	3.05	3.90	3.27
9	3.56	2.57	3.80	2.76	3.66	3.04
10	2.58	2.24	2.75	2.30	2.94	2.53
11	2.46	2.33	2.50	2.34	2.68	2.49
12	2.56	2.56	2.61	2.61	2.73	2.69
13	2.65	2.71	2.68	2.75	2.75	2.78
14	2.70	2.77	2.75	2.81	2.82	2.86
15	2.93	3.12	2.93	3.15	2.97	3.15
16	3.26	4.01	3.21	3.87	3.21	3.60
17	3.47	4.81	3.38	4.43	3.28	3.82
18	3.42	4.85	3.32	4.39	3.29	3.77
19	2.66	3.23	2.66	3.20	2.82	3.22
20	1.95	2.23	1.97	2.25	2.12	2.36
21	1.54	1.78	1.54	1.79	1.62	1.86
22	1.40	1.63	1.44	1.69	1.54	1.74
23	1.14	1.30	1.19	1.39	1.27	1.46
24	0.79	0.98	0.83	1.05	0.89	1.07
TOTAL	49.87	50.13	49.92	50.08	49.84	50.16

Source: Reference (23)

Table B.1. (Continued)

TYPE OF FACILITY: NONFREEWAY

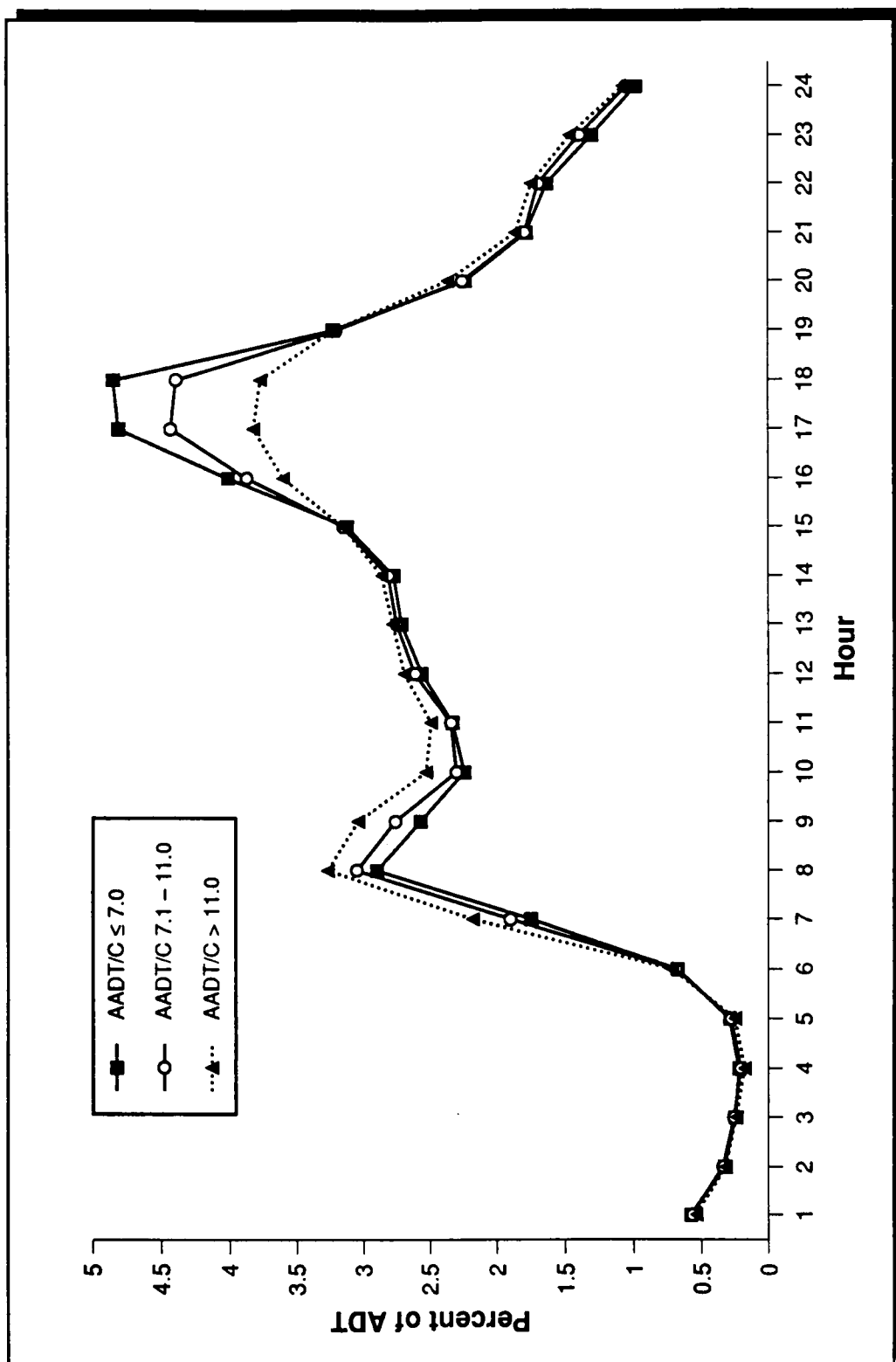
	AADT/C					
	LE 7.0		7.1 -- 11.0		GT 11.0	
	PEAK DIRECTION		PEAK DIRECTION		PEAK DIRECTION	
	AM	PM	AM	PM	AM	PM
	PCT. OF	PCT. OF	PCT. OF	PCT. OF	PCT. OF	PCT. OF
	DAILY VOL.	DAILY VOL.	DAILY VOL.	DAILY VOL.	DAILY VOL.	DAILY VOL.
HOUR						
1	0.34	0.47	0.37	0.47	0.41	0.49
2	0.21	0.28	0.23	0.27	0.24	0.28
3	0.15	0.18	0.17	0.18	0.18	0.20
4	0.14	0.14	0.16	0.15	0.17	0.18
5	0.24	0.18	0.28	0.20	0.33	0.27
6	0.74	0.42	0.81	0.48	1.03	0.67
7	2.23	1.19	2.35	1.27	2.55	1.72
8	4.11	2.28	3.85	2.39	3.57	2.79
9	3.45	2.33	3.42	2.39	3.09	2.78
10	2.64	2.29	2.69	2.31	2.58	2.47
11	2.64	2.56	2.65	2.54	2.62	2.57
12	2.90	3.02	2.90	2.98	2.83	2.89
13	3.20	3.35	3.17	3.30	3.04	3.13
14	3.14	3.24	3.14	3.22	3.06	3.13
15	3.18	3.44	3.16	3.37	3.21	3.34
16	3.40	4.13	3.35	3.93	3.41	3.78
17	3.46	4.78	3.49	4.49	3.47	3.92
18	3.31	4.83	3.45	4.55	3.39	3.86
19	2.68	3.23	2.75	3.31	2.82	3.12
20	2.14	2.41	2.18	2.53	2.28	2.53
21	1.73	1.97	1.75	2.07	1.83	2.09
22	1.49	1.71	1.50	1.77	1.55	1.80
23	1.10	1.26	1.11	1.25	1.22	1.29
24	0.74	0.94	0.75	0.90	0.83	0.97
TOTAL	49.36	50.64	49.67	50.33	49.71	50.29

Source: Reference (23)

Table B.2. Final Weekend/Holiday Temporal Distributions

	TYPE OF FACILITY:	
	FREEWAY	NONFREEWAY
	PCT. OF	PCT. OF
	DAILY VOL.	DAILY VOL.
HOUR		
1	2.16	2.01
2	1.45	1.36
3	1.06	0.90
4	0.69	0.57
5	0.63	0.50
6	1.02	0.79
7	1.98	1.55
8	2.87	2.43
9	3.70	3.42
10	4.69	4.72
11	5.66	5.92
12	6.45	6.85
13	7.06	7.64
14	7.06	7.63
15	7.09	7.62
16	7.19	7.60
17	7.19	7.40
18	6.90	6.87
19	6.22	6.04
20	5.15	5.09
21	4.24	4.22
22	3.77	3.66
23	3.27	2.96
24	2.50	2.26
TOTAL	100.00	100.00

Source: Reference (23)



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Figure B.1 Example Temporal Distribution Used in the Study

Peak Spreading Procedure

The peak spreading procedure is shown in Table B.3. The formula for smoothing the distributions of AADT/C ratios greater than or equal to 13 is basically a weighted average computation between the actual hourly percentage derived from Tables B.1 or B.2 and a perfectly flat daily temporal distribution. The first term in the equation represents the weight applied to the actual percentage. The second term is the weight applied to a perfectly flat distribution, which has an hourly percentage equal to $(1/48)$, since there are two directions being considered.

Table B.3. Modification Procedures for Temporal Distributions

AADT/C Range	Modifications
1-7	None; low range used
8	$(1/3 \text{ of low range}) + (2/3 \text{ of middle range})$
9	None; middle range used
10	$(2/3 \text{ of middle range}) + (1/3 \text{ of high range})$
11	$(1/3 \text{ of middle range}) + (2/3 \text{ of high range})$
12	None; high range used
13+	$\left[\{ \text{pct} * (24 - \text{AADT/C}) \} + \{ (1/48) * (\text{AADT/C} - 12) \} \right] / 12$ where: pct = hourly distribution of traffic from (5)

Source: Reference (24)

An example will clarify the process. For an AADT/C of 14, the "weight" on the actual percentage is 10 and the weight on the "flat" percentage $(1/48)$ is 2. For an AADT/C of 16,

these weights are 8 and 4, respectively. The percentages resulting from applying the formula to selected AADT/C ratios for the morning direction are shown in Table B.4. Note the procedure adds volumes to offpeak hours as it subtracts from peak hours. It should be pointed out that this procedure is not based on observed data but has been instituted as a purely mechanical procedure to account for two conditions: (1) counterintuitive results at the AADT/C boundaries of the original temporal distributions and (2) excessive queuing that would result at very high AADT/C ratios if the temporal distributions were unaltered. This second condition is really the phenomenon of peak spreading.

Table B.4. Application of Smoothing Procedure to Selected AADT/C Ratios,
Morning Peak Direction

Hour	Original Distribution ¹	Hourly Distributions ²			
		AADT/C = 13	AADT/C = 14	AADT/C = 15	AADT/C = 16
1	0.47%	0.60%	0.74%	0.87%	1.01%
2	0.27%	0.42%	0.57%	0.72%	0.87%
3	0.20%	0.36%	0.51%	0.67%	0.83%
4	0.18%	0.34%	0.50%	0.66%	0.81%
5	0.31%	0.46%	0.61%	0.75%	0.90%
6	1.06%	1.15%	1.23%	1.32%	1.40%
7	2.86%	2.80%	2.73%	2.67%	2.60%
8	3.90%	3.75%	3.60%	3.45%	3.29%
9	3.66%	3.53%	3.40%	3.27%	3.13%
10	2.94%	2.87%	2.80%	2.73%	2.65%
11	2.68%	2.63%	2.58%	2.53%	2.48%
12	2.73%	2.68%	2.62%	2.57%	2.51%
13	2.75%	2.69%	2.64%	2.58%	2.53%
14	2.82%	2.76%	2.70%	2.64%	2.57%
15	2.97%	2.90%	2.82%	2.75%	2.67%
16	3.21%	3.12%	3.02%	2.93%	2.83%
17	3.28%	3.18%	3.08%	2.98%	2.88%
18	3.29%	3.19%	3.09%	2.99%	2.89%
19	2.82%	2.76%	2.70%	2.64%	2.57%
20	2.12%	2.12%	2.11%	2.11%	2.11%
21	1.62%	1.66%	1.70%	1.74%	1.77%
22	1.54%	1.59%	1.63%	1.68%	1.72%
23	1.27%	1.34%	1.41%	1.47%	1.54%
24	0.89%	0.99%	1.09%	1.19%	1.29%

¹From Table B.1

²Developed by applying the formula in Table B.3

Source: Reference (24)

APPENDIX C

QSIM RESULTS FOR FREEWAYS AND ARTERIALS

NOTES

1. Volumes reported are the **average** volumes that result from applying the stochastic variation procedure.
2. IB = Inbound Direction. This is the direction in which the morning peak occurs. Typically, this is the "Inbound" direction on radial facilities connecting to the Central Business District. The reverse is true for the OB ("Outbound") direction. The "Weekend" time period is for both directions combined.

FREEWAYS, AADT/C = 1

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	19	19	0	59.95
WEEKDAY, IB	2	13	13	0	59.97
WEEKDAY, IB	3	10	10	0	59.98
WEEKDAY, IB	4	10	10	0	59.97
WEEKDAY, IB	5	18	18	0	59.96
WEEKDAY, IB	6	54	54	0	59.87
WEEKDAY, IB	7	148	148	0	59.64
WEEKDAY, IB	8	221	221	0	59.45
WEEKDAY, IB	9	163	163	0	59.61
WEEKDAY, IB	10	118	118	0	59.72
WEEKDAY, IB	11	113	113	0	59.73
WEEKDAY, IB	12	116	116	0	59.72
WEEKDAY, IB	13	121	121	0	59.71
WEEKDAY, IB	14	123	123	0	59.71
WEEKDAY, IB	15	134	134	0	59.68
WEEKDAY, IB	16	149	149	0	59.64
WEEKDAY, IB	17	158	158	0	59.62
WEEKDAY, IB	18	156	156	0	59.62
WEEKDAY, IB	19	121	121	0	59.71
WEEKDAY, IB	20	89	89	0	59.78
WEEKDAY, IB	21	71	71	0	59.83
WEEKDAY, IB	22	64	64	0	59.85
WEEKDAY, IB	23	52	52	0	59.87
WEEKDAY, IB	24	36	36	0	59.91
WEEKDAY, OB	1	26	26	0	59.94
WEEKDAY, OB	2	15	15	0	59.96
WEEKDAY, OB	3	12	12	0	59.97
WEEKDAY, OB	4	10	10	0	59.98
WEEKDAY, OB	5	13	13	0	59.97
WEEKDAY, OB	6	31	31	0	59.93
WEEKDAY, OB	7	80	80	0	59.81
WEEKDAY, OB	8	134	134	0	59.68
WEEKDAY, OB	9	118	118	0	59.72
WEEKDAY, OB	10	103	103	0	59.76
WEEKDAY, OB	11	107	107	0	59.74
WEEKDAY, OB	12	117	117	0	59.72
WEEKDAY, OB	13	124	124	0	59.70
WEEKDAY, OB	14	127	127	0	59.69
WEEKDAY, OB	15	143	143	0	59.66
WEEKDAY, OB	16	184	184	0	59.55
WEEKDAY, OB	17	220	220	0	59.46
WEEKDAY, OB	18	222	222	0	59.45
WEEKDAY, OB	19	148	148	0	59.64
WEEKDAY, OB	20	102	102	0	59.75
WEEKDAY, OB	21	81	81	0	59.80
WEEKDAY, OB	22	75	75	0	59.82
WEEKDAY, OB	23	60	60	0	59.86
WEEKDAY, OB	24	45	45	0	59.89
WEEKEND	1	38	38	0	59.91
WEEKEND	2	26	26	0	59.94
WEEKEND	3	19	19	0	59.95
WEEKEND	4	12	12	0	59.97
WEEKEND	5	11	11	0	59.97
WEEKEND	6	18	18	0	59.95
WEEKEND	7	36	36	0	59.90
WEEKEND	8	51	51	0	59.85
WEEKEND	9	67	67	0	59.82
WEEKEND	10	83	83	0	59.79
WEEKEND	11	101	101	0	59.75
WEEKEND	12	116	116	0	59.71
WEEKEND	13	126	126	0	59.69
WEEKEND	14	127	127	0	59.69
WEEKEND	15	127	127	0	59.69
WEEKEND	16	128	128	0	59.69
WEEKEND	17	127	127	0	59.69
WEEKEND	18	123	123	0	59.70
WEEKEND	19	111	111	0	59.73
WEEKEND	20	92	92	0	59.77
WEEKEND	21	76	76	0	59.81
WEEKEND	22	67	67	0	59.83
WEEKEND	23	58	58	0	59.85
WEEKEND	24	45	45	0	59.88

FREEWAYS, AADT/C = 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	39	39	0	59.90
WEEKDAY, IB	2	26	26	0	59.94
WEEKDAY, IB	3	21	21	0	59.95
WEEKDAY, IB	4	21	21	0	59.95
WEEKDAY, IB	5	35	35	0	59.92
WEEKDAY, IB	6	107	107	0	59.74
WEEKDAY, IB	7	298	298	0	59.24
WEEKDAY, IB	8	442	442	0	58.83
WEEKDAY, IB	9	327	327	0	59.17
WEEKDAY, IB	10	236	236	0	59.41
WEEKDAY, IB	11	225	225	0	59.44
WEEKDAY, IB	12	234	234	0	59.42
WEEKDAY, IB	13	245	245	0	59.39
WEEKDAY, IB	14	248	248	0	59.38
WEEKDAY, IB	15	268	268	0	59.33
WEEKDAY, IB	16	303	303	0	59.23
WEEKDAY, IB	17	316	316	0	59.20
WEEKDAY, IB	18	315	315	0	59.20
WEEKDAY, IB	19	244	244	0	59.38
WEEKDAY, IB	20	179	179	0	59.55
WEEKDAY, IB	21	140	140	0	59.65
WEEKDAY, IB	22	129	129	0	59.68
WEEKDAY, IB	23	104	104	0	59.74
WEEKDAY, IB	24	72	72	0	59.82
WEEKDAY, OB	1	53	53	0	59.87
WEEKDAY, OB	2	30	30	0	59.93
WEEKDAY, OB	3	23	23	0	59.94
WEEKDAY, OB	4	20	20	0	59.95
WEEKDAY, OB	5	26	26	0	59.94
WEEKDAY, OB	6	62	62	0	59.85
WEEKDAY, OB	7	160	160	0	59.61
WEEKDAY, OB	8	266	266	0	59.33
WEEKDAY, OB	9	234	234	0	59.42
WEEKDAY, OB	10	206	206	0	59.49
WEEKDAY, OB	11	214	214	0	59.47
WEEKDAY, OB	12	236	236	0	59.41
WEEKDAY, OB	13	249	249	0	59.38
WEEKDAY, OB	14	253	253	0	59.37
WEEKDAY, OB	15	284	284	0	59.28
WEEKDAY, OB	16	366	366	0	59.06
WEEKDAY, OB	17	442	442	0	58.83
WEEKDAY, OB	18	440	440	0	58.84
WEEKDAY, OB	19	295	295	0	59.25
WEEKDAY, OB	20	205	205	0	59.48
WEEKDAY, OB	21	165	165	0	59.59
WEEKDAY, OB	22	149	149	0	59.63
WEEKDAY, OB	23	119	119	0	59.70
WEEKDAY, OB	24	89	89	0	59.77
WEEKEND	1	76	76	0	59.81
WEEKEND	2	51	51	0	59.87
WEEKEND	3	38	38	0	59.91
WEEKEND	4	25	25	0	59.94
WEEKEND	5	22	22	0	59.94
WEEKEND	6	37	37	0	59.90
WEEKEND	7	69	69	0	59.79
WEEKEND	8	104	104	0	59.67
WEEKEND	9	130	130	0	59.64
WEEKEND	10	167	167	0	59.56
WEEKEND	11	204	204	0	59.47
WEEKEND	12	229	229	0	59.41
WEEKEND	13	248	248	0	59.37
WEEKEND	14	249	249	0	59.37
WEEKEND	15	253	253	0	59.36
WEEKEND	16	256	256	0	59.34
WEEKEND	17	256	256	0	59.34
WEEKEND	18	244	244	0	59.37
WEEKEND	19	222	222	0	59.43
WEEKEND	20	183	183	0	59.54
WEEKEND	21	151	151	0	59.62
WEEKEND	22	133	133	0	59.66
WEEKEND	23	116	116	0	59.70
WEEKEND	24	91	91	0	59.75

FREEWAYS, AADT/C = 3

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	58	58	0	59.86
WEEKDAY, IB	2	38	38	0	59.91
WEEKDAY, IB	3	31	31	0	59.92
WEEKDAY, IB	4	31	31	0	59.92
WEEKDAY, IB	5	52	52	0	59.87
WEEKDAY, IB	6	160	160	0	59.60
WEEKDAY, IB	7	445	445	0	58.81
WEEKDAY, IB	8	666	666	0	58.13
WEEKDAY, IB	9	487	487	0	58.70
WEEKDAY, IB	10	356	356	0	59.09
WEEKDAY, IB	11	338	338	0	59.13
WEEKDAY, IB	12	350	350	0	59.10
WEEKDAY, IB	13	363	363	0	59.06
WEEKDAY, IB	14	373	373	0	59.03
WEEKDAY, IB	15	405	405	0	58.94
WEEKDAY, IB	16	448	448	0	58.81
WEEKDAY, IB	17	478	478	0	58.73
WEEKDAY, IB	18	469	469	0	58.75
WEEKDAY, IB	19	364	364	0	59.05
WEEKDAY, IB	20	268	268	0	59.31
WEEKDAY, IB	21	210	210	0	59.47
WEEKDAY, IB	22	192	192	0	59.52
WEEKDAY, IB	23	157	157	0	59.60
WEEKDAY, IB	24	109	109	0	59.72
WEEKDAY, OB	1	80	80	0	59.80
WEEKDAY, OB	2	45	45	0	59.89
WEEKDAY, OB	3	35	35	0	59.91
WEEKDAY, OB	4	30	30	0	59.93
WEEKDAY, OB	5	39	39	0	59.91
WEEKDAY, OB	6	93	93	0	59.77
WEEKDAY, OB	7	239	239	0	59.40
WEEKDAY, OB	8	399	399	0	58.96
WEEKDAY, OB	9	352	352	0	59.10
WEEKDAY, OB	10	307	307	0	59.22
WEEKDAY, OB	11	320	320	0	59.18
WEEKDAY, OB	12	353	353	0	59.09
WEEKDAY, OB	13	371	371	0	59.04
WEEKDAY, OB	14	384	384	0	59.00
WEEKDAY, OB	15	428	428	0	58.87
WEEKDAY, OB	16	551	551	0	58.50
WEEKDAY, OB	17	662	662	0	58.15
WEEKDAY, OB	18	663	663	0	58.14
WEEKDAY, OB	19	440	440	0	58.83
WEEKDAY, OB	20	310	310	0	59.19
WEEKDAY, OB	21	243	243	0	59.38
WEEKDAY, OB	22	223	223	0	59.43
WEEKDAY, OB	23	180	180	0	59.54
WEEKDAY, OB	24	134	134	0	59.65
WEEKEND	1	117	117	0	59.70
WEEKEND	2	78	78	0	59.81
WEEKEND	3	57	57	0	59.86
WEEKEND	4	37	37	0	59.91
WEEKEND	5	34	34	0	59.91
WEEKEND	6	54	54	0	59.85
WEEKEND	7	106	106	0	59.67
WEEKEND	8	158	158	0	59.48
WEEKEND	9	198	198	0	59.43
WEEKEND	10	255	255	0	59.31
WEEKEND	11	299	299	0	59.20
WEEKEND	12	345	345	0	59.08
WEEKEND	13	376	376	0	59.00
WEEKEND	14	379	379	0	59.00
WEEKEND	15	377	377	0	59.01
WEEKEND	16	386	386	0	58.97
WEEKEND	17	387	387	0	58.96
WEEKEND	18	371	371	0	59.00
WEEKEND	19	329	329	0	59.13
WEEKEND	20	274	274	0	59.28
WEEKEND	21	226	226	0	59.41
WEEKEND	22	202	202	0	59.48
WEEKEND	23	174	174	0	59.54
WEEKEND	24	133	133	0	59.64

FREEWAYS, AADT/C - 4

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	78	78	0	59.81
WEEKDAY, IB	2	50	50	0	59.87
WEEKDAY, IB	3	42	42	0	59.90
WEEKDAY, IB	4	42	42	0	59.90
WEEKDAY, IB	5	70	70	0	59.83
WEEKDAY, IB	6	214	214	0	59.46
WEEKDAY, IB	7	595	595	0	58.35
WEEKDAY, IB	8	888	888	0	57.37
WEEKDAY, IB	9	656	656	0	58.17
WEEKDAY, IB	10	471	471	0	58.75
WEEKDAY, IB	11	448	448	0	58.81
WEEKDAY, IB	12	465	465	0	58.76
WEEKDAY, IB	13	484	484	0	58.70
WEEKDAY, IB	14	497	497	0	58.66
WEEKDAY, IB	15	534	534	0	58.55
WEEKDAY, IB	16	599	599	0	58.35
WEEKDAY, IB	17	638	638	0	58.23
WEEKDAY, IB	18	626	626	0	58.26
WEEKDAY, IB	19	483	483	0	58.69
WEEKDAY, IB	20	360	360	0	59.04
WEEKDAY, IB	21	280	280	0	59.27
WEEKDAY, IB	22	256	256	0	59.34
WEEKDAY, IB	23	212	212	0	59.45
WEEKDAY, IB	24	146	146	0	59.62
WEEKDAY, OB	1	106	106	0	59.73
WEEKDAY, OB	2	62	62	0	59.85
WEEKDAY, OB	3	45	45	0	59.89
WEEKDAY, OB	4	40	40	0	59.90
WEEKDAY, OB	5	53	53	0	59.87
WEEKDAY, OB	6	125	125	0	59.69
WEEKDAY, OB	7	320	320	0	59.18
WEEKDAY, OB	8	533	533	0	58.56
WEEKDAY, OB	9	471	471	0	58.75
WEEKDAY, OB	10	410	410	0	58.93
WEEKDAY, OB	11	425	425	0	58.88
WEEKDAY, OB	12	470	470	0	58.75
WEEKDAY, OB	13	493	493	0	58.67
WEEKDAY, OB	14	510	510	0	58.62
WEEKDAY, OB	15	572	572	0	58.43
WEEKDAY, OB	16	737	737	0	57.90
WEEKDAY, OB	17	883	883	0	57.40
WEEKDAY, OB	18	889	889	0	57.36
WEEKDAY, OB	19	590	590	0	58.35
WEEKDAY, OB	20	407	407	0	58.90
WEEKDAY, OB	21	326	326	0	59.14
WEEKDAY, OB	22	301	301	0	59.22
WEEKDAY, OB	23	237	237	0	59.38
WEEKDAY, OB	24	181	181	0	59.52
WEEKEND	1	155	155	0	59.60
WEEKEND	2	102	102	0	59.74
WEEKEND	3	75	75	0	59.81
WEEKEND	4	49	49	0	59.88
WEEKEND	5	45	45	0	59.88
WEEKEND	6	73	73	0	59.79
WEEKEND	7	141	141	0	59.55
WEEKEND	8	210	210	0	59.30
WEEKEND	9	266	266	0	59.20
WEEKEND	10	339	339	0	59.06
WEEKEND	11	397	397	0	58.90
WEEKEND	12	455	455	0	58.74
WEEKEND	13	508	508	0	58.59
WEEKEND	14	501	501	0	58.63
WEEKEND	15	501	501	0	58.63
WEEKEND	16	509	509	0	58.59
WEEKEND	17	509	509	0	58.58
WEEKEND	18	490	490	0	58.64
WEEKEND	19	445	445	0	58.78
WEEKEND	20	365	365	0	59.02
WEEKEND	21	300	300	0	59.20
WEEKEND	22	266	266	0	59.29
WEEKEND	23	232	232	0	59.38
WEEKEND	24	179	179	0	59.51

FREEWAYS, AADT/C = 5

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	96	96	0	59.76
WEEKDAY, IB	2	64	64	0	59.84
WEEKDAY, IB	3	52	52	0	59.87
WEEKDAY, IB	4	52	52	0	59.87
WEEKDAY, IB	5	88	88	0	59.78
WEEKDAY, IB	6	266	266	0	59.32
WEEKDAY, IB	7	741	741	0	57.86
WEEKDAY, IB	8	1,110	1,110	0	56.55
WEEKDAY, IB	9	816	816	0	57.63
WEEKDAY, IB	10	586	586	0	58.39
WEEKDAY, IB	11	563	563	0	58.46
WEEKDAY, IB	12	581	581	0	58.40
WEEKDAY, IB	13	604	604	0	58.33
WEEKDAY, IB	14	618	618	0	58.28
WEEKDAY, IB	15	670	670	0	58.12
WEEKDAY, IB	16	748	748	0	57.86
WEEKDAY, IB	17	796	796	0	57.70
WEEKDAY, IB	18	781	781	0	57.75
WEEKDAY, IB	19	608	608	0	58.30
WEEKDAY, IB	20	448	448	0	58.78
WEEKDAY, IB	21	354	354	0	59.06
WEEKDAY, IB	22	323	323	0	59.15
WEEKDAY, IB	23	259	259	0	59.32
WEEKDAY, IB	24	181	181	0	59.52
WEEKDAY, OB	1	132	132	0	59.67
WEEKDAY, OB	2	76	76	0	59.81
WEEKDAY, OB	3	58	58	0	59.86
WEEKDAY, OB	4	50	50	0	59.88
WEEKDAY, OB	5	66	66	0	59.84
WEEKDAY, OB	6	156	156	0	59.61
WEEKDAY, OB	7	400	400	0	58.95
WEEKDAY, OB	8	668	668	0	58.13
WEEKDAY, OB	9	589	589	0	58.39
WEEKDAY, OB	10	513	513	0	58.62
WEEKDAY, OB	11	530	530	0	58.56
WEEKDAY, OB	12	588	588	0	58.38
WEEKDAY, OB	13	618	618	0	58.28
WEEKDAY, OB	14	633	633	0	58.24
WEEKDAY, OB	15	710	710	0	57.98
WEEKDAY, OB	16	920	920	0	57.26
WEEKDAY, OB	17	1,102	1,102	0	56.60
WEEKDAY, OB	18	1,111	1,111	0	56.55
WEEKDAY, OB	19	743	743	0	57.83
WEEKDAY, OB	20	517	517	0	58.57
WEEKDAY, OB	21	409	409	0	58.89
WEEKDAY, OB	22	374	374	0	59.01
WEEKDAY, OB	23	300	300	0	59.20
WEEKDAY, OB	24	224	224	0	59.40
WEEKEND	1	191	191	0	59.50
WEEKEND	2	130	130	0	59.67
WEEKEND	3	95	95	0	59.76
WEEKEND	4	61	61	0	59.85
WEEKEND	5	56	56	0	59.85
WEEKEND	6	90	90	0	59.74
WEEKEND	7	177	177	0	59.45
WEEKEND	8	249	249	0	59.17
WEEKEND	9	329	329	0	58.99
WEEKEND	10	418	418	0	58.80
WEEKEND	11	501	501	0	58.58
WEEKEND	12	576	576	0	58.34
WEEKEND	13	635	635	0	58.19
WEEKEND	14	630	630	0	58.22
WEEKEND	15	631	631	0	58.20
WEEKEND	16	638	638	0	58.17
WEEKEND	17	637	637	0	58.16
WEEKEND	18	616	616	0	58.23
WEEKEND	19	552	552	0	58.44
WEEKEND	20	460	460	0	58.73
WEEKEND	21	377	377	0	58.97
WEEKEND	22	334	334	0	59.10
WEEKEND	23	292	292	0	59.20
WEEKEND	24	222	222	0	59.38

FREEWAYS, AADT/C - 6

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	116	116	0	59.71
WEEKDAY, IB	2	76	76	0	59.81
WEEKDAY, IB	3	62	62	0	59.85
WEEKDAY, IB	4	62	62	0	59.85
WEEKDAY, IB	5	104	104	0	59.74
WEEKDAY, IB	6	322	322	0	59.16
WEEKDAY, IB	7	890	890	0	57.34
WEEKDAY, IB	8	1,328	1,328	0	55.71
WEEKDAY, IB	9	981	981	0	57.04
WEEKDAY, IB	10	710	710	0	57.99
WEEKDAY, IB	11	678	678	0	58.09
WEEKDAY, IB	12	704	704	0	58.00
WEEKDAY, IB	13	726	726	0	57.93
WEEKDAY, IB	14	738	738	0	57.89
WEEKDAY, IB	15	807	807	0	57.65
WEEKDAY, IB	16	901	901	0	57.33
WEEKDAY, IB	17	953	953	0	57.15
WEEKDAY, IB	18	933	933	0	57.21
WEEKDAY, IB	19	740	740	0	57.85
WEEKDAY, IB	20	536	536	0	58.50
WEEKDAY, IB	21	426	426	0	58.84
WEEKDAY, IB	22	385	385	0	58.97
WEEKDAY, IB	23	311	311	0	59.17
WEEKDAY, IB	24	218	218	0	59.42
WEEKDAY, OB	1	158	158	0	59.59
WEEKDAY, OB	2	91	91	0	59.77
WEEKDAY, OB	3	69	69	0	59.83
WEEKDAY, OB	4	60	60	0	59.85
WEEKDAY, OB	5	80	80	0	59.81
WEEKDAY, OB	6	188	188	0	59.53
WEEKDAY, OB	7	481	481	0	58.70
WEEKDAY, OB	8	801	801	0	57.68
WEEKDAY, OB	9	702	702	0	58.02
WEEKDAY, OB	10	615	615	0	58.30
WEEKDAY, OB	11	636	636	0	58.23
WEEKDAY, OB	12	706	706	0	58.00
WEEKDAY, OB	13	740	740	0	57.88
WEEKDAY, OB	14	760	760	0	57.81
WEEKDAY, OB	15	852	852	0	57.50
WEEKDAY, OB	16	1,109	1,109	0	56.56
WEEKDAY, OB	17	1,318	1,318	0	55.75
WEEKDAY, OB	18	1,327	1,327	0	55.70
WEEKDAY, OB	19	898	898	0	57.28
WEEKDAY, OB	20	611	611	0	58.26
WEEKDAY, OB	21	486	486	0	58.66
WEEKDAY, OB	22	448	448	0	58.78
WEEKDAY, OB	23	354	354	0	59.04
WEEKDAY, OB	24	267	267	0	59.27
WEEKEND	1	231	231	0	59.39
WEEKEND	2	154	154	0	59.60
WEEKEND	3	114	114	0	59.71
WEEKEND	4	72	72	0	59.82
WEEKEND	5	67	67	0	59.83
WEEKEND	6	110	110	0	59.69
WEEKEND	7	224	224	0	59.26
WEEKEND	8	305	305	0	58.94
WEEKEND	9	391	391	0	58.80
WEEKEND	10	497	497	0	58.54
WEEKEND	11	614	614	0	58.20
WEEKEND	12	686	686	0	57.98
WEEKEND	13	748	748	0	57.80
WEEKEND	14	752	752	0	57.80
WEEKEND	15	755	755	0	57.79
WEEKEND	16	768	768	0	57.73
WEEKEND	17	758	758	0	57.75
WEEKEND	18	729	729	0	57.84
WEEKEND	19	661	661	0	58.08
WEEKEND	20	547	547	0	58.45
WEEKEND	21	457	457	0	58.72
WEEKEND	22	402	402	0	58.88
WEEKEND	23	352	352	0	59.02
WEEKEND	24	265	265	0	59.25

FREEWAYS, AADT/C - 7

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	138	138	0	59.65
WEEKDAY, IB	2	88	88	0	59.78
WEEKDAY, IB	3	73	73	0	59.82
WEEKDAY, IB	4	74	74	0	59.82
WEEKDAY, IB	5	122	122	0	59.70
WEEKDAY, IB	6	375	375	0	59.00
WEEKDAY, IB	7	1,055	1,055	0	56.73
WEEKDAY, IB	8	1,547	1,543	4	53.57
WEEKDAY, IB	9	1,144	1,148	0	55.54
WEEKDAY, IB	10	832	832	0	57.58
WEEKDAY, IB	11	783	783	0	57.74
WEEKDAY, IB	12	818	818	0	57.61
WEEKDAY, IB	13	851	851	0	57.49
WEEKDAY, IB	14	865	865	0	57.44
WEEKDAY, IB	15	941	941	0	57.18
WEEKDAY, IB	16	1,043	1,043	0	56.81
WEEKDAY, IB	17	1,111	1,111	0	56.56
WEEKDAY, IB	18	1,090	1,090	0	56.63
WEEKDAY, IB	19	857	857	0	57.44
WEEKDAY, IB	20	629	629	0	58.20
WEEKDAY, IB	21	496	496	0	58.63
WEEKDAY, IB	22	451	451	0	58.77
WEEKDAY, IB	23	361	361	0	59.02
WEEKDAY, IB	24	252	252	0	59.32
WEEKDAY, OB	1	183	183	0	59.52
WEEKDAY, OB	2	106	106	0	59.73
WEEKDAY, OB	3	81	81	0	59.80
WEEKDAY, OB	4	70	70	0	59.83
WEEKDAY, OB	5	94	94	0	59.77
WEEKDAY, OB	6	218	218	0	59.45
WEEKDAY, OB	7	561	561	0	58.45
WEEKDAY, OB	8	930	930	0	57.22
WEEKDAY, OB	9	820	820	0	57.62
WEEKDAY, OB	10	717	717	0	57.97
WEEKDAY, OB	11	751	751	0	57.84
WEEKDAY, OB	12	820	820	0	57.61
WEEKDAY, OB	13	875	875	0	57.41
WEEKDAY, OB	14	886	886	0	57.38
WEEKDAY, OB	15	996	996	0	56.98
WEEKDAY, OB	16	1,278	1,278	0	55.90
WEEKDAY, OB	17	1,539	1,538	2	54.23
WEEKDAY, OB	18	1,560	1,558	4	53.13
WEEKDAY, OB	19	1,035	1,039	0	55.87
WEEKDAY, OB	20	719	719	0	57.90
WEEKDAY, OB	21	564	564	0	58.40
WEEKDAY, OB	22	524	524	0	58.55
WEEKDAY, OB	23	417	417	0	58.86
WEEKDAY, OB	24	317	317	0	59.13
WEEKEND	1	269	269	0	59.28
WEEKEND	2	178	178	0	59.54
WEEKEND	3	132	132	0	59.66
WEEKEND	4	85	85	0	59.78
WEEKEND	5	78	78	0	59.79
WEEKEND	6	127	127	0	59.63
WEEKEND	7	243	243	0	59.21
WEEKEND	8	353	353	0	58.75
WEEKEND	9	457	457	0	58.52
WEEKEND	10	581	581	0	58.25
WEEKEND	11	699	699	0	57.89
WEEKEND	12	793	793	0	57.60
WEEKEND	13	875	875	0	57.35
WEEKEND	14	888	888	0	57.31
WEEKEND	15	871	871	0	57.38
WEEKEND	16	903	903	0	57.23
WEEKEND	17	892	892	0	57.27
WEEKEND	18	855	855	0	57.38
WEEKEND	19	780	780	0	57.67
WEEKEND	20	654	654	0	58.08
WEEKEND	21	532	532	0	58.46
WEEKEND	22	468	468	0	58.68
WEEKEND	23	403	403	0	58.86
WEEKEND	24	311	311	0	59.11

FREEWAYS, AADT/C - 8

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	156	156	0	59.60
WEEKDAY, IB	2	102	102	0	59.74
WEEKDAY, IB	3	80	80	0	59.80
WEEKDAY, IB	4	82	82	0	59.80
WEEKDAY, IB	5	136	136	0	59.66
WEEKDAY, IB	6	418	418	0	58.88
WEEKDAY, IB	7	1,169	1,169	0	56.29
WEEKDAY, IB	8	1,724	1,711	13	50.51
WEEKDAY, IB	9	1,341	1,354	1	51.95
WEEKDAY, IB	10	979	979	0	56.96
WEEKDAY, IB	11	911	911	0	57.29
WEEKDAY, IB	12	949	949	0	57.14
WEEKDAY, IB	13	978	978	0	57.04
WEEKDAY, IB	14	994	994	0	56.98
WEEKDAY, IB	15	1,075	1,075	0	56.68
WEEKDAY, IB	16	1,177	1,177	0	56.30
WEEKDAY, IB	17	1,250	1,250	0	56.03
WEEKDAY, IB	18	1,230	1,230	0	56.09
WEEKDAY, IB	19	965	965	0	57.05
WEEKDAY, IB	20	714	714	0	57.91
WEEKDAY, IB	21	560	560	0	58.42
WEEKDAY, IB	22	520	520	0	58.55
WEEKDAY, IB	23	428	428	0	58.81
WEEKDAY, IB	24	298	298	0	59.19
WEEKDAY, OB	1	209	209	0	59.45
WEEKDAY, OB	2	123	123	0	59.68
WEEKDAY, OB	3	94	94	0	59.76
WEEKDAY, OB	4	80	80	0	59.80
WEEKDAY, OB	5	103	103	0	59.75
WEEKDAY, OB	6	247	247	0	59.37
WEEKDAY, OB	7	667	667	0	58.11
WEEKDAY, OB	8	1,087	1,087	0	56.65
WEEKDAY, OB	9	975	975	0	57.07
WEEKDAY, OB	10	834	834	0	57.57
WEEKDAY, OB	11	852	852	0	57.50
WEEKDAY, OB	12	952	952	0	57.13
WEEKDAY, OB	13	1,003	1,003	0	56.95
WEEKDAY, OB	14	1,016	1,016	0	56.90
WEEKDAY, OB	15	1,144	1,144	0	56.41
WEEKDAY, OB	16	1,442	1,442	0	55.24
WEEKDAY, OB	17	1,693	1,684	9	51.77
WEEKDAY, OB	18	1,698	1,688	19	48.41
WEEKDAY, OB	19	1,174	1,192	1	51.63
WEEKDAY, OB	20	812	812	0	57.37
WEEKDAY, OB	21	655	655	0	58.11
WEEKDAY, OB	22	609	609	0	58.25
WEEKDAY, OB	23	502	502	0	58.59
WEEKDAY, OB	24	370	370	0	58.96
WEEKEND	1	305	305	0	59.17
WEEKEND	2	205	205	0	59.46
WEEKEND	3	150	150	0	59.61
WEEKEND	4	98	98	0	59.75
WEEKEND	5	87	87	0	59.77
WEEKEND	6	150	150	0	59.56
WEEKEND	7	280	280	0	59.07
WEEKEND	8	419	419	0	58.38
WEEKEND	9	530	530	0	57.80
WEEKEND	10	669	669	0	57.82
WEEKEND	11	810	810	0	57.50
WEEKEND	12	914	914	0	57.14
WEEKEND	13	1,003	1,003	0	56.87
WEEKEND	14	1,006	1,006	0	56.87
WEEKEND	15	1,002	1,002	0	56.89
WEEKEND	16	1,021	1,021	0	56.80
WEEKEND	17	1,028	1,028	0	56.73
WEEKEND	18	987	987	0	56.87
WEEKEND	19	891	891	0	57.24
WEEKEND	20	743	743	0	57.77
WEEKEND	21	601	601	0	58.25
WEEKEND	22	543	543	0	58.43
WEEKEND	23	466	466	0	58.64
WEEKEND	24	359	359	0	58.93

FREEWAYS, AADT/C - 9

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	179	179	0	59.53
WEEKDAY, IB	2	113	113	0	59.71
WEEKDAY, IB	3	89	89	0	59.78
WEEKDAY, IB	4	87	87	0	59.79
WEEKDAY, IB	5	147	147	0	59.63
WEEKDAY, IB	6	456	456	0	58.76
WEEKDAY, IB	7	1,306	1,306	0	55.59
WEEKDAY, IB	8	1,898	1,837	61	41.39
WEEKDAY, IB	9	1,565	1,604	22	39.34
WEEKDAY, IB	10	1,135	1,157	0	51.77
WEEKDAY, IB	11	1,040	1,040	0	56.81
WEEKDAY, IB	12	1,067	1,067	0	56.70
WEEKDAY, IB	13	1,103	1,103	0	56.57
WEEKDAY, IB	14	1,132	1,132	0	56.46
WEEKDAY, IB	15	1,206	1,206	0	56.18
WEEKDAY, IB	16	1,328	1,328	0	55.70
WEEKDAY, IB	17	1,402	1,402	0	55.42
WEEKDAY, IB	18	1,371	1,371	0	55.52
WEEKDAY, IB	19	1,099	1,099	0	56.55
WEEKDAY, IB	20	816	816	0	57.54
WEEKDAY, IB	21	632	632	0	58.18
WEEKDAY, IB	22	599	599	0	58.29
WEEKDAY, IB	23	489	489	0	58.61
WEEKDAY, IB	24	338	338	0	59.06
WEEKDAY, OB	1	234	234	0	59.38
WEEKDAY, OB	2	139	139	0	59.65
WEEKDAY, OB	3	105	105	0	59.74
WEEKDAY, OB	4	87	87	0	59.79
WEEKDAY, OB	5	114	114	0	59.72
WEEKDAY, OB	6	285	285	0	59.27
WEEKDAY, OB	7	778	778	0	57.73
WEEKDAY, OB	8	1,258	1,258	0	55.98
WEEKDAY, OB	9	1,138	1,138	0	56.46
WEEKDAY, OB	10	947	947	0	57.17
WEEKDAY, OB	11	963	963	0	57.10
WEEKDAY, OB	12	1,074	1,074	0	56.67
WEEKDAY, OB	13	1,125	1,125	0	56.49
WEEKDAY, OB	14	1,157	1,157	0	56.36
WEEKDAY, OB	15	1,297	1,297	0	55.82
WEEKDAY, OB	16	1,591	1,586	5	53.12
WEEKDAY, OB	17	1,828	1,798	36	45.45
WEEKDAY, OB	18	1,812	1,785	63	39.24
WEEKDAY, OB	19	1,323	1,375	11	41.29
WEEKDAY, OB	20	928	938	0	54.88
WEEKDAY, OB	21	743	743	0	57.80
WEEKDAY, OB	22	701	701	0	57.95
WEEKDAY, OB	23	578	578	0	58.33
WEEKDAY, OB	24	428	428	0	58.78
WEEKEND	1	339	339	0	59.07
WEEKEND	2	235	235	0	59.38
WEEKEND	3	170	170	0	59.56
WEEKEND	4	110	110	0	59.72
WEEKEND	5	100	100	0	59.74
WEEKEND	6	162	162	0	59.54
WEEKEND	7	313	313	0	58.98
WEEKEND	8	451	450	1	57.31
WEEKEND	9	599	600	0	57.70
WEEKEND	10	744	744	0	57.64
WEEKEND	11	894	894	0	57.17
WEEKEND	12	1,037	1,037	0	56.68
WEEKEND	13	1,135	1,135	0	56.36
WEEKEND	14	1,131	1,131	0	56.38
WEEKEND	15	1,136	1,136	0	56.37
WEEKEND	16	1,151	1,150	0	56.12
WEEKEND	17	1,158	1,158	0	56.00
WEEKEND	18	1,105	1,106	0	56.33
WEEKEND	19	995	995	0	56.86
WEEKEND	20	829	829	0	57.45
WEEKEND	21	678	678	0	58.00
WEEKEND	22	602	602	0	58.22
WEEKEND	23	517	517	0	58.47
WEEKEND	24	396	396	0	58.81

FREEWAYS, AADT/C - 10

TIME PERIOD	hour	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	203	203	0	59.47
WEEKDAY, IB	2	123	123	0	59.69
WEEKDAY, IB	3	96	96	0	59.76
WEEKDAY, IB	4	92	92	0	59.77
WEEKDAY, IB	5	156	156	0	59.61
WEEKDAY, IB	6	496	496	0	58.64
WEEKDAY, IB	7	1,409	1,408	1	54.92
WEEKDAY, IB	8	2,008	1,879	130	34.26
WEEKDAY, IB	9	1,727	1,756	101	30.26
WEEKDAY, IB	10	1,292	1,383	11	37.58
WEEKDAY, IB	11	1,173	1,183	1	53.87
WEEKDAY, IB	12	1,218	1,219	0	55.96
WEEKDAY, IB	13	1,233	1,233	0	56.07
WEEKDAY, IB	14	1,274	1,274	0	55.91
WEEKDAY, IB	15	1,346	1,346	0	55.62
WEEKDAY, IB	16	1,475	1,474	0	54.96
WEEKDAY, IB	17	1,529	1,528	1	54.47
WEEKDAY, IB	18	1,508	1,508	1	54.35
WEEKDAY, IB	19	1,248	1,249	0	55.51
WEEKDAY, IB	20	930	931	0	57.03
WEEKDAY, IB	21	719	719	0	57.89
WEEKDAY, IB	22	673	673	0	58.05
WEEKDAY, IB	23	559	559	0	58.39
WEEKDAY, IB	24	389	389	0	58.90
WEEKDAY, OB	1	256	256	0	59.32
WEEKDAY, OB	2	153	153	0	59.60
WEEKDAY, OB	3	116	116	0	59.71
WEEKDAY, OB	4	91	91	0	59.78
WEEKDAY, OB	5	122	122	0	59.70
WEEKDAY, OB	6	321	321	0	59.16
WEEKDAY, OB	7	914	914	0	57.25
WEEKDAY, OB	8	1,434	1,434	0	55.27
WEEKDAY, OB	9	1,314	1,314	0	55.77
WEEKDAY, OB	10	1,091	1,091	0	56.63
WEEKDAY, OB	11	1,095	1,095	0	56.61
WEEKDAY, OB	12	1,208	1,208	0	56.15
WEEKDAY, OB	13	1,270	1,270	0	55.91
WEEKDAY, OB	14	1,296	1,296	0	55.82
WEEKDAY, OB	15	1,434	1,433	1	54.97
WEEKDAY, OB	16	1,718	1,706	13	50.48
WEEKDAY, OB	17	1,942	1,861	94	37.30
WEEKDAY, OB	18	1,914	1,836	172	29.26
WEEKDAY, OB	19	1,457	1,565	65	29.56
WEEKDAY, OB	20	1,043	1,105	2	44.37
WEEKDAY, OB	21	824	827	0	56.90
WEEKDAY, OB	22	777	777	0	57.67
WEEKDAY, OB	23	653	653	0	58.07
WEEKDAY, OB	24	479	479	0	58.61
WEEKEND	1	384	384	0	58.93
WEEKEND	2	261	261	0	59.30
WEEKEND	3	190	190	0	59.50
WEEKEND	4	121	121	0	59.69
WEEKEND	5	112	112	0	59.70
WEEKEND	6	182	182	0	59.45
WEEKEND	7	359	359	0	58.77
WEEKEND	8	509	508	1	57.62
WEEKEND	9	663	663	1	56.54
WEEKEND	10	833	833	1	56.71
WEEKEND	11	1,003	1,004	0	56.62
WEEKEND	12	1,152	1,152	0	56.20
WEEKEND	13	1,246	1,245	1	55.48
WEEKEND	14	1,250	1,251	0	55.62
WEEKEND	15	1,263	1,262	0	55.70
WEEKEND	16	1,271	1,270	2	54.94
WEEKEND	17	1,264	1,264	3	54.34
WEEKEND	18	1,219	1,221	1	55.12
WEEKEND	19	1,117	1,117	0	56.02
WEEKEND	20	917	917	0	57.07
WEEKEND	21	760	760	0	57.69
WEEKEND	22	675	675	0	57.96
WEEKEND	23	579	579	0	58.25
WEEKEND	24	440	440	0	58.68

FREEWAYS, AADT/C - 11

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	232	232	0	59.39
WEEKDAY, IB	2	135	135	0	59.65
WEEKDAY, IB	3	104	104	0	59.74
WEEKDAY, IB	4	95	95	0	59.76
WEEKDAY, IB	5	163	163	0	59.59
WEEKDAY, IB	6	540	540	0	58.50
WEEKDAY, IB	7	1,503	1,502	1	54.44
WEEKDAY, IB	8	2,080	1,893	188	29.77
WEEKDAY, IB	9	1,870	1,835	224	24.58
WEEKDAY, IB	10	1,449	1,594	79	26.42
WEEKDAY, IB	11	1,311	1,379	10	40.96
WEEKDAY, IB	12	1,351	1,359	2	52.60
WEEKDAY, IB	13	1,372	1,373	0	55.05
WEEKDAY, IB	14	1,414	1,414	0	55.34
WEEKDAY, IB	15	1,491	1,489	2	54.36
WEEKDAY, IB	16	1,616	1,615	4	53.10
WEEKDAY, IB	17	1,672	1,669	6	51.59
WEEKDAY, IB	18	1,677	1,670	13	49.28
WEEKDAY, IB	19	1,384	1,393	4	51.25
WEEKDAY, IB	20	1,056	1,060	0	55.90
WEEKDAY, IB	21	792	792	0	57.63
WEEKDAY, IB	22	762	762	0	57.71
WEEKDAY, IB	23	635	635	0	58.13
WEEKDAY, IB	24	433	433	0	58.76
WEEKDAY, OB	1	280	280	0	59.24
WEEKDAY, OB	2	165	165	0	59.57
WEEKDAY, OB	3	125	125	0	59.69
WEEKDAY, OB	4	94	94	0	59.77
WEEKDAY, OB	5	129	129	0	59.68
WEEKDAY, OB	6	362	362	0	59.04
WEEKDAY, OB	7	1,042	1,042	0	56.78
WEEKDAY, OB	8	1,607	1,606	1	54.20
WEEKDAY, OB	9	1,489	1,490	1	54.44
WEEKDAY, OB	10	1,241	1,242	0	55.93
WEEKDAY, OB	11	1,231	1,231	0	56.07
WEEKDAY, OB	12	1,343	1,343	0	55.62
WEEKDAY, OB	13	1,408	1,408	0	55.23
WEEKDAY, OB	14	1,425	1,425	0	55.17
WEEKDAY, OB	15	1,594	1,591	4	53.50
WEEKDAY, OB	16	1,827	1,793	38	44.78
WEEKDAY, OB	17	2,052	1,884	206	28.65
WEEKDAY, OB	18	2,001	1,864	343	22.32
WEEKDAY, OB	19	1,592	1,722	212	21.74
WEEKDAY, OB	20	1,170	1,350	33	30.00
WEEKDAY, OB	21	933	965	1	49.90
WEEKDAY, OB	22	866	867	0	57.26
WEEKDAY, OB	23	728	728	0	57.80
WEEKDAY, OB	24	528	528	0	58.45
WEEKEND	1	421	421	0	58.81
WEEKEND	2	283	283	0	59.24
WEEKEND	3	207	207	0	59.46
WEEKEND	4	135	135	0	59.65
WEEKEND	5	124	124	0	59.67
WEEKEND	6	202	202	0	59.40
WEEKEND	7	389	389	0	58.65
WEEKEND	8	553	552	1	57.07
WEEKEND	9	723	723	0	56.89
WEEKEND	10	902	901	2	55.93
WEEKEND	11	1,111	1,112	0	55.93
WEEKEND	12	1,263	1,260	3	54.80
WEEKEND	13	1,389	1,387	4	53.70
WEEKEND	14	1,373	1,374	3	53.42
WEEKEND	15	1,367	1,369	1	54.13
WEEKEND	16	1,395	1,394	2	54.14
WEEKEND	17	1,412	1,409	6	52.87
WEEKEND	18	1,350	1,349	7	51.48
WEEKEND	19	1,206	1,210	3	53.44
WEEKEND	20	1,017	1,020	0	56.02
WEEKEND	21	832	832	0	57.43
WEEKEND	22	741	741	0	57.74
WEEKEND	23	647	647	0	58.02
WEEKEND	24	494	494	0	58.47

FREEWAYS, AADT/C = 12

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	260	260	0	59.31
WEEKDAY, IB	2	149	149	0	59.62
WEEKDAY, IB	3	112	112	0	59.72
WEEKDAY, IB	4	99	99	0	59.76
WEEKDAY, IB	5	168	168	0	59.58
WEEKDAY, IB	6	577	577	0	58.37
WEEKDAY, IB	7	1,582	1,576	6	52.81
WEEKDAY, IB	8	2,139	1,896	250	26.97
WEEKDAY, IB	9	2,009	1,872	387	21.32
WEEKDAY, IB	10	1,622	1,756	253	20.65
WEEKDAY, IB	11	1,472	1,625	100	25.46
WEEKDAY, IB	12	1,493	1,554	39	36.57
WEEKDAY, IB	13	1,516	1,539	15	45.35
WEEKDAY, IB	14	1,557	1,563	8	49.85
WEEKDAY, IB	15	1,630	1,630	8	50.47
WEEKDAY, IB	16	1,749	1,738	20	47.93
WEEKDAY, IB	17	1,798	1,776	42	42.96
WEEKDAY, IB	18	1,813	1,783	72	37.54
WEEKDAY, IB	19	1,545	1,575	41	37.43
WEEKDAY, IB	20	1,148	1,187	2	47.50
WEEKDAY, IB	21	892	894	0	56.82
WEEKDAY, IB	22	858	858	0	57.39
WEEKDAY, IB	23	703	703	0	57.90
WEEKDAY, IB	24	489	489	0	58.57
WEEKDAY, OB	1	299	299	0	59.19
WEEKDAY, OB	2	179	179	0	59.53
WEEKDAY, OB	3	134	134	0	59.66
WEEKDAY, OB	4	97	97	0	59.76
WEEKDAY, OB	5	137	137	0	59.66
WEEKDAY, OB	6	395	395	0	58.94
WEEKDAY, OB	7	1,210	1,210	0	56.13
WEEKDAY, OB	8	1,801	1,776	25	47.72
WEEKDAY, OB	9	1,671	1,674	22	45.14
WEEKDAY, OB	10	1,387	1,406	3	49.40
WEEKDAY, OB	11	1,371	1,373	1	54.68
WEEKDAY, OB	12	1,478	1,478	1	54.51
WEEKDAY, OB	13	1,512	1,512	1	54.19
WEEKDAY, OB	14	1,558	1,558	2	53.87
WEEKDAY, OB	15	1,743	1,727	18	49.38
WEEKDAY, OB	16	1,934	1,859	93	37.52
WEEKDAY, OB	17	2,148	1,891	350	23.42
WEEKDAY, OB	18	2,068	1,864	554	18.85
WEEKDAY, OB	19	1,772	1,817	510	18.03
WEEKDAY, OB	20	1,295	1,609	196	20.48
WEEKDAY, OB	21	1,026	1,199	24	31.48
WEEKDAY, OB	22	967	990	0	51.55
WEEKDAY, OB	23	806	807	0	57.46
WEEKDAY, OB	24	593	593	0	58.20
WEEKEND	1	458	458	0	58.70
WEEKEND	2	306	306	0	59.17
WEEKEND	3	224	224	0	59.41
WEEKEND	4	149	149	0	59.61
WEEKEND	5	132	132	0	59.65
WEEKEND	6	219	219	0	59.35
WEEKEND	7	427	427	0	58.53
WEEKEND	8	614	613	1	56.84
WEEKEND	9	779	780	0	56.91
WEEKEND	10	982	981	0	56.52
WEEKEND	11	1,221	1,214	7	53.29
WEEKEND	12	1,385	1,382	10	51.03
WEEKEND	13	1,501	1,493	18	48.79
WEEKEND	14	1,506	1,511	13	48.55
WEEKEND	15	1,519	1,515	18	48.53
WEEKEND	16	1,520	1,518	20	47.11
WEEKEND	17	1,531	1,523	28	45.44
WEEKEND	18	1,477	1,480	26	45.03
WEEKEND	19	1,319	1,336	9	47.93
WEEKEND	20	1,108	1,117	0	54.25
WEEKEND	21	910	910	0	57.13
WEEKEND	22	806	806	0	57.48
WEEKEND	23	691	691	0	57.84
WEEKEND	24	531	531	0	58.33

FREEWAYS, AADT/C = 13

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	353	353	0	59.03
WEEKDAY, IB	2	247	247	0	59.34
WEEKDAY, IB	3	210	210	0	59.45
WEEKDAY, IB	4	197	197	0	59.49
WEEKDAY, IB	5	264	264	0	59.31
WEEKDAY, IB	6	673	673	0	58.05
WEEKDAY, IB	7	1,656	1,640	16	49.91
WEEKDAY, IB	8	2,215	1,889	343	23.70
WEEKDAY, IB	9	2,079	1,869	553	18.54
WEEKDAY, IB	10	1,697	1,815	436	17.94
WEEKDAY, IB	11	1,562	1,739	259	19.97
WEEKDAY, IB	12	1,578	1,689	148	25.12
WEEKDAY, IB	13	1,606	1,666	88	31.26
WEEKDAY, IB	14	1,631	1,662	57	37.27
WEEKDAY, IB	15	1,712	1,714	56	39.44
WEEKDAY, IB	16	1,842	1,805	93	36.25
WEEKDAY, IB	17	1,890	1,838	145	31.59
WEEKDAY, IB	18	1,899	1,838	206	27.72
WEEKDAY, IB	19	1,623	1,685	144	26.96
WEEKDAY, IB	20	1,268	1,381	31	34.48
WEEKDAY, IB	21	977	1,005	2	49.73
WEEKDAY, IB	22	931	933	0	56.72
WEEKDAY, IB	23	787	787	0	57.58
WEEKDAY, IB	24	566	566	0	58.32
WEEKDAY, OB	1	390	390	0	58.92
WEEKDAY, OB	2	275	275	0	59.26
WEEKDAY, OB	3	229	229	0	59.40
WEEKDAY, OB	4	193	193	0	59.51
WEEKDAY, OB	5	232	232	0	59.40
WEEKDAY, OB	6	488	488	0	58.66
WEEKDAY, OB	7	1,289	1,289	0	55.82
WEEKDAY, OB	8	1,879	1,827	53	42.72
WEEKDAY, OB	9	1,764	1,768	49	38.59
WEEKDAY, OB	10	1,479	1,516	12	42.64
WEEKDAY, OB	11	1,450	1,460	2	51.79
WEEKDAY, OB	12	1,565	1,563	4	53.09
WEEKDAY, OB	13	1,624	1,621	7	51.63
WEEKDAY, OB	14	1,648	1,644	11	49.86
WEEKDAY, OB	15	1,824	1,793	42	43.55
WEEKDAY, OB	16	1,999	1,878	163	30.90
WEEKDAY, OB	17	2,236	1,880	519	19.88
WEEKDAY, OB	18	2,169	1,863	825	16.82
WEEKDAY, OB	19	1,857	1,842	840	16.23
WEEKDAY, OB	20	1,369	1,751	457	17.08
WEEKDAY, OB	21	1,115	1,458	115	22.21
WEEKDAY, OB	22	1,056	1,151	20	38.59
WEEKDAY, OB	23	892	910	2	52.16
WEEKDAY, OB	24	684	686	0	57.29
WEEKEND	1	546	546	0	58.40
WEEKEND	2	400	400	0	58.88
WEEKEND	3	323	323	0	59.12
WEEKEND	4	242	242	0	59.35
WEEKEND	5	230	230	0	59.36
WEEKEND	6	308	308	0	59.05
WEEKEND	7	511	511	0	58.21
WEEKEND	8	695	691	4	55.86
WEEKEND	9	877	876	5	53.95
WEEKEND	10	1,102	1,103	4	53.74
WEEKEND	11	1,315	1,308	11	51.61
WEEKEND	12	1,463	1,454	20	48.44
WEEKEND	13	1,584	1,574	30	44.90
WEEKEND	14	1,579	1,578	31	43.07
WEEKEND	15	1,578	1,580	29	43.38
WEEKEND	16	1,625	1,612	41	42.48
WEEKEND	17	1,625	1,600	67	38.95
WEEKEND	18	1,558	1,560	65	37.91
WEEKEND	19	1,412	1,447	30	41.37
WEEKEND	20	1,179	1,204	5	49.17
WEEKEND	21	1,008	1,011	2	54.62
WEEKEND	22	901	904	0	56.60
WEEKEND	23	796	796	0	57.47
WEEKEND	24	629	629	0	57.94

FREEWAYS, AADT/C - 14

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	447	447	0	58.74
WEEKDAY, IB	2	349	349	0	59.04
WEEKDAY, IB	3	312	312	0	59.16
WEEKDAY, IB	4	304	304	0	59.20
WEEKDAY, IB	5	372	372	0	59.00
WEEKDAY, IB	6	763	763	0	57.74
WEEKDAY, IB	7	1,737	1,706	32	46.65
WEEKDAY, IB	8	2,287	1,886	433	21.48
WEEKDAY, IB	9	2,170	1,868	735	17.10
WEEKDAY, IB	10	1,795	1,843	687	16.47
WEEKDAY, IB	11	1,642	1,813	516	17.00
WEEKDAY, IB	12	1,671	1,789	398	18.91
WEEKDAY, IB	13	1,677	1,769	306	21.26
WEEKDAY, IB	14	1,714	1,771	249	23.68
WEEKDAY, IB	15	1,795	1,799	245	25.39
WEEKDAY, IB	16	1,912	1,849	308	24.27
WEEKDAY, IB	17	1,961	1,860	409	21.90
WEEKDAY, IB	18	1,969	1,860	519	20.06
WEEKDAY, IB	19	1,694	1,782	431	19.79
WEEKDAY, IB	20	1,345	1,580	197	22.46
WEEKDAY, IB	21	1,079	1,239	37	31.86
WEEKDAY, IB	22	1,027	1,060	4	49.40
WEEKDAY, IB	23	895	899	0	56.04
WEEKDAY, IB	24	678	678	0	57.90
WEEKDAY, OB	1	494	494	0	58.58
WEEKDAY, OB	2	373	373	0	58.96
WEEKDAY, OB	3	337	337	0	59.08
WEEKDAY, OB	4	299	299	0	59.21
WEEKDAY, OB	5	336	336	0	59.11
WEEKDAY, OB	6	593	593	0	58.32
WEEKDAY, OB	7	1,373	1,373	0	55.34
WEEKDAY, OB	8	1,955	1,858	97	37.05
WEEKDAY, OB	9	1,841	1,810	128	30.74
WEEKDAY, OB	10	1,556	1,627	57	31.98
WEEKDAY, OB	11	1,524	1,560	21	41.52
WEEKDAY, OB	12	1,653	1,651	22	45.81
WEEKDAY, OB	13	1,697	1,693	26	45.11
WEEKDAY, OB	14	1,732	1,720	37	42.44
WEEKDAY, OB	15	1,889	1,830	96	35.86
WEEKDAY, OB	16	2,100	1,880	316	24.19
WEEKDAY, OB	17	2,295	1,867	744	17.39
WEEKDAY, OB	18	2,214	1,857	1,101	15.72
WEEKDAY, OB	19	1,923	1,849	1,175	15.48
WEEKDAY, OB	20	1,476	1,819	832	15.84
WEEKDAY, OB	21	1,200	1,672	360	17.78
WEEKDAY, OB	22	1,137	1,389	108	25.25
WEEKDAY, OB	23	981	1,073	16	39.39
WEEKDAY, OB	24	774	790	1	53.34
WEEKEND	1	661	661	0	58.01
WEEKEND	2	502	502	0	58.55
WEEKEND	3	429	429	0	58.78
WEEKEND	4	348	348	0	59.03
WEEKEND	5	333	333	0	59.05
WEEKEND	6	421	421	0	58.62
WEEKEND	7	607	607	0	57.71
WEEKEND	8	800	785	15	52.91
WEEKEND	9	965	961	19	50.25
WEEKEND	10	1,181	1,190	11	50.50
WEEKEND	11	1,383	1,371	23	47.52
WEEKEND	12	1,554	1,532	45	42.67
WEEKEND	13	1,678	1,655	68	39.05
WEEKEND	14	1,665	1,661	72	36.49
WEEKEND	15	1,687	1,687	73	36.25
WEEKEND	16	1,709	1,687	95	34.99
WEEKEND	17	1,700	1,686	109	33.19
WEEKEND	18	1,636	1,628	117	32.57
WEEKEND	19	1,490	1,532	75	34.44
WEEKEND	20	1,284	1,335	25	41.12
WEEKEND	21	1,101	1,121	5	50.31
WEEKEND	22	993	998	0	55.56
WEEKEND	23	895	895	1	56.70
WEEKEND	24	728	729	0	57.40

FREEWAYS, AADT/C = 15

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	578	578	0	58.29
WEEKDAY, IB	2	467	467	0	58.66
WEEKDAY, IB	3	429	429	0	58.80
WEEKDAY, IB	4	428	428	0	58.82
WEEKDAY, IB	5	492	492	0	58.63
WEEKDAY, IB	6	881	881	0	57.31
WEEKDAY, IB	7	1,806	1,761	44	44.56
WEEKDAY, IB	8	2,346	1,884	506	20.25
WEEKDAY, IB	9	2,215	1,862	859	16.30
WEEKDAY, IB	10	1,846	1,847	858	15.83
WEEKDAY, IB	11	1,712	1,836	734	16.10
WEEKDAY, IB	12	1,730	1,827	636	16.94
WEEKDAY, IB	13	1,754	1,818	572	17.89
WEEKDAY, IB	14	1,794	1,818	547	18.77
WEEKDAY, IB	15	1,871	1,836	582	19.10
WEEKDAY, IB	16	1,990	1,857	715	18.35
WEEKDAY, IB	17	2,017	1,860	872	17.52
WEEKDAY, IB	18	2,033	1,858	1,048	16.73
WEEKDAY, IB	19	1,775	1,833	990	16.49
WEEKDAY, IB	20	1,424	1,754	659	17.25
WEEKDAY, IB	21	1,176	1,553	282	20.44
WEEKDAY, IB	22	1,127	1,321	88	28.44
WEEKDAY, IB	23	980	1,053	15	41.75
WEEKDAY, IB	24	803	817	1	53.77
WEEKDAY, OB	1	613	613	0	58.18
WEEKDAY, OB	2	496	496	0	58.56
WEEKDAY, OB	3	456	456	0	58.72
WEEKDAY, OB	4	421	421	0	58.84
WEEKDAY, OB	5	461	461	0	58.72
WEEKDAY, OB	6	708	708	0	57.93
WEEKDAY, OB	7	1,463	1,461	2	54.42
WEEKDAY, OB	8	2,016	1,877	140	33.30
WEEKDAY, OB	9	1,905	1,846	200	27.01
WEEKDAY, OB	10	1,627	1,705	122	26.76
WEEKDAY, OB	11	1,606	1,661	68	32.05
WEEKDAY, OB	12	1,709	1,717	60	36.73
WEEKDAY, OB	13	1,776	1,767	69	36.64
WEEKDAY, OB	14	1,802	1,781	89	34.98
WEEKDAY, OB	15	1,955	1,858	186	28.95
WEEKDAY, OB	16	2,131	1,883	435	21.55
WEEKDAY, OB	17	2,353	1,862	926	16.67
WEEKDAY, OB	18	2,275	1,854	1,347	15.44
WEEKDAY, OB	19	1,991	1,851	1,487	15.28
WEEKDAY, OB	20	1,552	1,835	1,204	15.42
WEEKDAY, OB	21	1,299	1,774	728	16.35
WEEKDAY, OB	22	1,225	1,607	347	19.21
WEEKDAY, OB	23	1,089	1,340	97	25.58
WEEKDAY, OB	24	873	960	9	40.00
WEEKEND	1	757	757	0	57.64
WEEKEND	2	622	622	0	58.13
WEEKEND	3	552	552	0	58.38
WEEKEND	4	464	464	0	58.65
WEEKEND	5	455	455	0	58.64
WEEKEND	6	530	530	0	58.22
WEEKEND	7	721	718	4	55.33
WEEKEND	8	883	872	15	50.78
WEEKEND	9	1,072	1,061	26	47.65
WEEKEND	10	1,249	1,249	26	46.77
WEEKEND	11	1,439	1,432	32	44.64
WEEKEND	12	1,619	1,581	70	39.34
WEEKEND	13	1,745	1,699	116	33.60
WEEKEND	14	1,746	1,724	139	30.73
WEEKEND	15	1,741	1,724	156	29.50
WEEKEND	16	1,766	1,736	186	27.85
WEEKEND	17	1,768	1,739	215	26.89
WEEKEND	18	1,709	1,704	220	26.54
WEEKEND	19	1,574	1,630	164	28.02
WEEKEND	20	1,380	1,462	82	32.48
WEEKEND	21	1,176	1,237	22	41.49
WEEKEND	22	1,076	1,093	4	51.54
WEEKEND	23	1,011	1,012	3	54.44
WEEKEND	24	828	830	2	55.05

FREEWAYS, AADT/C - 16

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	710	710	0	57.82
WEEKDAY, IB	2	605	605	0	58.20
WEEKDAY, IB	3	574	574	0	58.32
WEEKDAY, IB	4	563	563	0	58.40
WEEKDAY, IB	5	622	622	0	58.20
WEEKDAY, IB	6	983	983	0	56.94
WEEKDAY, IB	7	1,879	1,793	86	38.62
WEEKDAY, IB	8	2,387	1,876	598	19.09
WEEKDAY, IB	9	2,266	1,858	1,006	15.84
WEEKDAY, IB	10	1,909	1,851	1,063	15.44
WEEKDAY, IB	11	1,774	1,845	992	15.51
WEEKDAY, IB	12	1,819	1,845	966	15.74
WEEKDAY, IB	13	1,825	1,842	949	15.93
WEEKDAY, IB	14	1,858	1,842	965	16.05
WEEKDAY, IB	15	1,911	1,848	1,028	16.13
WEEKDAY, IB	16	2,038	1,855	1,210	15.92
WEEKDAY, IB	17	2,059	1,854	1,415	15.63
WEEKDAY, IB	18	2,078	1,854	1,639	15.38
WEEKDAY, IB	19	1,862	1,849	1,652	15.28
WEEKDAY, IB	20	1,503	1,831	1,324	15.45
WEEKDAY, IB	21	1,269	1,760	833	16.36
WEEKDAY, IB	22	1,227	1,624	437	19.05
WEEKDAY, IB	23	1,105	1,381	161	24.70
WEEKDAY, IB	24	909	1,043	27	34.99
WEEKDAY, OB	1	740	740	0	57.71
WEEKDAY, OB	2	628	628	0	58.11
WEEKDAY, OB	3	597	597	0	58.25
WEEKDAY, OB	4	555	555	0	58.41
WEEKDAY, OB	5	596	596	0	58.29
WEEKDAY, OB	6	832	832	0	57.50
WEEKDAY, OB	7	1,544	1,541	3	53.85
WEEKDAY, OB	8	2,075	1,882	196	29.27
WEEKDAY, OB	9	1,975	1,864	307	22.83
WEEKDAY, OB	10	1,710	1,776	240	22.20
WEEKDAY, OB	11	1,689	1,746	183	24.84
WEEKDAY, OB	12	1,787	1,783	187	26.80
WEEKDAY, OB	13	1,830	1,804	212	26.34
WEEKDAY, OB	14	1,861	1,820	254	24.83
WEEKDAY, OB	15	2,012	1,860	405	21.91
WEEKDAY, OB	16	2,187	1,868	724	18.15
WEEKDAY, OB	17	2,397	1,855	1,265	15.67
WEEKDAY, OB	18	2,315	1,853	1,728	15.15
WEEKDAY, OB	19	2,035	1,852	1,911	15.06
WEEKDAY, OB	20	1,619	1,851	1,679	15.08
WEEKDAY, OB	21	1,404	1,833	1,250	15.38
WEEKDAY, OB	22	1,319	1,779	790	16.40
WEEKDAY, OB	23	1,186	1,605	371	19.11
WEEKDAY, OB	24	990	1,256	105	25.58
WEEKEND	1	899	899	0	57.10
WEEKEND	2	748	748	0	57.38
WEEKEND	3	681	681	0	57.85
WEEKEND	4	596	596	0	58.21
WEEKEND	5	599	599	0	58.13
WEEKEND	6	671	670	1	56.95
WEEKEND	7	838	828	11	52.18
WEEKEND	8	1,006	979	39	44.48
WEEKEND	9	1,207	1,196	50	42.43
WEEKEND	10	1,361	1,363	48	41.96
WEEKEND	11	1,533	1,518	63	40.07
WEEKEND	12	1,713	1,655	120	34.44
WEEKEND	13	1,824	1,762	182	29.66
WEEKEND	14	1,815	1,770	227	26.71
WEEKEND	15	1,813	1,771	269	24.89
WEEKEND	16	1,837	1,773	333	23.47
WEEKEND	17	1,819	1,770	383	22.36
WEEKEND	18	1,765	1,748	399	21.94
WEEKEND	19	1,653	1,723	329	22.93
WEEKEND	20	1,453	1,584	198	25.65
WEEKEND	21	1,275	1,390	84	31.82
WEEKEND	22	1,198	1,253	29	41.10
WEEKEND	23	1,087	1,107	9	49.37
WEEKEND	24	960	965	4	53.82

FREEWAYS, AADT/C - 17

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	844	844	0	57.31
WEEKDAY, IB	2	746	746	0	57.68
WEEKDAY, IB	3	716	716	0	57.83
WEEKDAY, IB	4	717	717	0	57.86
WEEKDAY, IB	5	766	766	0	57.68
WEEKDAY, IB	6	1,104	1,104	0	56.46
WEEKDAY, IB	7	1,927	1,820	107	36.39
WEEKDAY, IB	8	2,402	1,870	639	18.43
WEEKDAY, IB	9	2,286	1,859	1,066	15.71
WEEKDAY, IB	10	1,975	1,854	1,186	15.41
WEEKDAY, IB	11	1,843	1,849	1,181	15.35
WEEKDAY, IB	12	1,855	1,850	1,185	15.42
WEEKDAY, IB	13	1,867	1,850	1,202	15.51
WEEKDAY, IB	14	1,911	1,849	1,264	15.55
WEEKDAY, IB	15	1,967	1,851	1,380	15.55
WEEKDAY, IB	16	2,092	1,854	1,618	15.37
WEEKDAY, IB	17	2,129	1,853	1,893	15.24
WEEKDAY, IB	18	2,143	1,853	2,184	15.12
WEEKDAY, IB	19	1,922	1,851	2,255	15.09
WEEKDAY, IB	20	1,602	1,847	2,010	15.15
WEEKDAY, IB	21	1,371	1,831	1,550	15.39
WEEKDAY, IB	22	1,335	1,784	1,101	16.13
WEEKDAY, IB	23	1,210	1,663	648	17.73
WEEKDAY, IB	24	1,047	1,415	280	21.18
WEEKDAY, OB	1	869	869	0	57.23
WEEKDAY, OB	2	786	786	0	57.53
WEEKDAY, OB	3	747	747	0	57.71
WEEKDAY, OB	4	710	710	0	57.88
WEEKDAY, OB	5	739	739	0	57.79
WEEKDAY, OB	6	959	959	0	57.02
WEEKDAY, OB	7	1,631	1,621	10	51.46
WEEKDAY, OB	8	2,112	1,903	219	28.49
WEEKDAY, OB	9	2,012	1,870	360	21.92
WEEKDAY, OB	10	1,780	1,814	326	20.73
WEEKDAY, OB	11	1,762	1,801	287	21.82
WEEKDAY, OB	12	1,850	1,821	315	22.36
WEEKDAY, OB	13	1,881	1,825	371	21.33
WEEKDAY, OB	14	1,925	1,841	455	20.31
WEEKDAY, OB	15	2,067	1,865	657	18.55
WEEKDAY, OB	16	2,223	1,861	1,019	16.41
WEEKDAY, OB	17	2,408	1,853	1,574	15.25
WEEKDAY, OB	18	2,349	1,852	2,071	15.03
WEEKDAY, OB	19	2,087	1,852	2,306	15.02
WEEKDAY, OB	20	1,685	1,852	2,139	15.01
WEEKDAY, OB	21	1,462	1,848	1,752	15.07
WEEKDAY, OB	22	1,427	1,831	1,348	15.37
WEEKDAY, OB	23	1,299	1,768	879	16.38
WEEKDAY, OB	24	1,126	1,563	442	18.95
WEEKEND	1	1,003	1,002	1	56.28
WEEKEND	2	884	885	0	56.66
WEEKEND	3	814	815	0	57.32
WEEKEND	4	762	762	0	57.30
WEEKEND	5	759	759	1	57.13
WEEKEND	6	818	813	5	54.95
WEEKEND	7	982	955	32	47.91
WEEKEND	8	1,169	1,108	94	39.46
WEEKEND	9	1,269	1,261	102	37.20
WEEKEND	10	1,467	1,464	105	36.21
WEEKEND	11	1,638	1,606	138	33.76
WEEKEND	12	1,769	1,705	202	29.40
WEEKEND	13	1,864	1,782	284	25.61
WEEKEND	14	1,885	1,806	363	23.20
WEEKEND	15	1,895	1,815	442	21.67
WEEKEND	16	1,896	1,806	532	20.35
WEEKEND	17	1,913	1,815	630	19.32
WEEKEND	18	1,836	1,801	664	18.55
WEEKEND	19	1,747	1,784	627	18.78
WEEKEND	20	1,553	1,707	473	20.03
WEEKEND	21	1,371	1,570	274	23.45
WEEKEND	22	1,279	1,419	134	29.03
WEEKEND	23	1,208	1,281	61	36.28
WEEKEND	24	1,054	1,093	22	42.91

FREEWAYS, AADT/C - 18

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	990	989	1	56.32
WEEKDAY, IB	2	909	908	2	55.97
WEEKDAY, IB	3	889	891	0	56.58
WEEKDAY, IB	4	867	867	0	57.29
WEEKDAY, IB	5	916	916	0	57.15
WEEKDAY, IB	6	1,230	1,229	0	55.81
WEEKDAY, IB	7	1,987	1,845	143	33.48
WEEKDAY, IB	8	2,411	1,871	683	18.19
WEEKDAY, IB	9	2,300	1,856	1,126	15.60
WEEKDAY, IB	10	2,011	1,853	1,285	15.30
WEEKDAY, IB	11	1,903	1,850	1,337	15.26
WEEKDAY, IB	12	1,936	1,853	1,421	15.28
WEEKDAY, IB	13	1,924	1,851	1,494	15.32
WEEKDAY, IB	14	1,960	1,851	1,603	15.29
WEEKDAY, IB	15	2,013	1,853	1,763	15.21
WEEKDAY, IB	16	2,113	1,852	2,024	15.10
WEEKDAY, IB	17	2,146	1,852	2,318	15.06
WEEKDAY, IB	18	2,164	1,852	2,630	15.04
WEEKDAY, IB	19	1,967	1,852	2,745	15.03
WEEKDAY, IB	20	1,674	1,852	2,567	15.03
WEEKDAY, IB	21	1,477	1,848	2,197	15.09
WEEKDAY, IB	22	1,453	1,839	1,811	15.31
WEEKDAY, IB	23	1,326	1,801	1,336	15.84
WEEKDAY, IB	24	1,167	1,686	816	17.14
WEEKDAY, OB	1	1,026	1,025	1	56.21
WEEKDAY, OB	2	941	942	0	56.83
WEEKDAY, OB	3	888	888	0	57.19
WEEKDAY, OB	4	876	876	0	57.02
WEEKDAY, OB	5	896	896	0	57.13
WEEKDAY, OB	6	1,101	1,100	0	56.28
WEEKDAY, OB	7	1,696	1,674	22	48.67
WEEKDAY, OB	8	2,159	1,888	293	25.21
WEEKDAY, OB	9	2,054	1,869	477	19.51
WEEKDAY, OB	10	1,840	1,832	485	18.51
WEEKDAY, OB	11	1,817	1,826	476	18.67
WEEKDAY, OB	12	1,917	1,847	547	18.57
WEEKDAY, OB	13	1,938	1,846	638	18.02
WEEKDAY, OB	14	1,985	1,851	771	17.36
WEEKDAY, OB	15	2,088	1,858	1,002	16.52
WEEKDAY, OB	16	2,251	1,857	1,396	15.63
WEEKDAY, OB	17	2,411	1,852	1,954	15.15
WEEKDAY, OB	18	2,348	1,852	2,450	15.04
WEEKDAY, OB	19	2,144	1,852	2,742	15.03
WEEKDAY, OB	20	1,767	1,852	2,657	15.02
WEEKDAY, OB	21	1,574	1,852	2,380	15.04
WEEKDAY, OB	22	1,502	1,846	2,036	15.14
WEEKDAY, OB	23	1,397	1,826	1,607	15.39
WEEKDAY, OB	24	1,252	1,758	1,101	16.11
WEEKEND	1	1,146	1,143	3	54.83
WEEKEND	2	1,024	1,025	2	55.16
WEEKEND	3	961	962	0	56.29
WEEKEND	4	895	895	0	57.05
WEEKEND	5	895	892	3	55.48
WEEKEND	6	980	964	19	49.82
WEEKEND	7	1,145	1,106	58	41.15
WEEKEND	8	1,228	1,177	108	36.02
WEEKEND	9	1,381	1,363	127	34.70
WEEKEND	10	1,546	1,527	146	33.90
WEEKEND	11	1,691	1,640	197	30.67
WEEKEND	12	1,841	1,741	297	26.04
WEEKEND	13	1,932	1,809	420	23.01
WEEKEND	14	1,946	1,818	548	20.63
WEEKEND	15	1,949	1,833	664	19.15
WEEKEND	16	1,940	1,826	778	18.34
WEEKEND	17	1,973	1,833	919	17.53
WEEKEND	18	1,923	1,826	1,016	17.10
WEEKEND	19	1,812	1,812	1,016	17.12
WEEKEND	20	1,620	1,781	855	17.72
WEEKEND	21	1,468	1,696	627	19.17
WEEKEND	22	1,394	1,598	424	21.75
WEEKEND	23	1,310	1,471	262	25.10
WEEKEND	24	1,193	1,304	152	29.99

FREEWAYS, AADT/C = 19

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	1.159	1.155	4	54.32
WEEKDAY, IB	2	1.072	1.074	2	54.18
WEEKDAY, IB	3	1.052	1.052	1	55.35
WEEKDAY, IB	4	1.050	1.051	1	56.00
WEEKDAY, IB	5	1.100	1.101	0	56.25
WEEKDAY, IB	6	1.372	1.367	5	54.01
WEEKDAY, IB	7	2.011	1.851	165	31.94
WEEKDAY, IB	8	2.403	1.867	701	17.93
WEEKDAY, IB	9	2.328	1.856	1,173	15.54
WEEKDAY, IB	10	2.051	1.854	1,370	15.24
WEEKDAY, IB	11	1.949	1.851	1,468	15.18
WEEKDAY, IB	12	1.978	1.852	1,593	15.19
WEEKDAY, IB	13	1.984	1.852	1,725	15.17
WEEKDAY, IB	14	2.019	1.852	1,891	15.12
WEEKDAY, IB	15	2.060	1.852	2,099	15.05
WEEKDAY, IB	16	2.144	1.852	2,392	15.03
WEEKDAY, IB	17	2.180	1.852	2,719	15.02
WEEKDAY, IB	18	2.164	1.852	3,031	15.01
WEEKDAY, IB	19	1.989	1.852	3,169	15.01
WEEKDAY, IB	20	1.748	1.852	3,064	15.01
WEEKDAY, IB	21	1.576	1.852	2,788	15.01
WEEKDAY, IB	22	1.552	1.851	2,489	15.04
WEEKDAY, IB	23	1.468	1.845	2,112	15.18
WEEKDAY, IB	24	1.303	1.807	1,609	15.55
WEEKDAY, OB	1	1.190	1.187	3	54.70
WEEKDAY, OB	2	1.106	1.105	5	53.91
WEEKDAY, OB	3	1.061	1.065	1	54.88
WEEKDAY, OB	4	1.059	1.059	0	56.43
WEEKDAY, OB	5	1.078	1.078	0	56.51
WEEKDAY, OB	6	1.239	1.238	1	55.59
WEEKDAY, OB	7	1.782	1.741	42	44.85
WEEKDAY, OB	8	2.157	1.890	309	24.67
WEEKDAY, OB	9	2.076	1.873	512	19.35
WEEKDAY, OB	10	1.907	1.851	569	18.12
WEEKDAY, OB	11	1.878	1.843	604	17.74
WEEKDAY, OB	12	1.955	1.848	711	17.37
WEEKDAY, OB	13	1.986	1.852	845	16.81
WEEKDAY, OB	14	2.020	1.850	1,015	16.30
WEEKDAY, OB	15	2.124	1.855	1,284	15.72
WEEKDAY, OB	16	2.270	1.854	1,700	15.25
WEEKDAY, OB	17	2.400	1.853	2,247	15.08
WEEKDAY, OB	18	2.354	1.852	2,750	15.03
WEEKDAY, OB	19	2.147	1.852	3,044	15.02
WEEKDAY, OB	20	1.833	1.852	3,025	15.02
WEEKDAY, OB	21	1.663	1.851	2,838	15.02
WEEKDAY, OB	22	1.609	1.850	2,597	15.05
WEEKDAY, OB	23	1.522	1.844	2,276	15.18
WEEKDAY, OB	24	1.400	1.828	1,847	15.42
WEEKEND	1	1.275	1.268	7	53.25
WEEKEND	2	1.194	1.192	10	51.34
WEEKEND	3	1.135	1.140	4	52.33
WEEKEND	4	1.094	1.094	4	53.15
WEEKEND	5	1.083	1.075	12	51.71
WEEKEND	6	1.141	1.110	42	45.88
WEEKEND	7	1.249	1.206	85	38.63
WEEKEND	8	1.411	1.311	185	31.95
WEEKEND	9	1.536	1.466	255	29.22
WEEKEND	10	1.630	1.592	292	27.93
WEEKEND	11	1.800	1.713	379	25.48
WEEKEND	12	1.915	1.791	503	22.74
WEEKEND	13	1.969	1.820	652	20.13
WEEKEND	14	1.992	1.846	798	18.40
WEEKEND	15	1.983	1.841	940	17.37
WEEKEND	16	1.993	1.839	1,093	16.73
WEEKEND	17	1.990	1.843	1,240	16.41
WEEKEND	18	1.953	1.842	1,351	16.25
WEEKEND	19	1.853	1.834	1,370	16.20
WEEKEND	20	1.708	1.817	1,261	16.48
WEEKEND	21	1.586	1.784	1,062	17.01
WEEKEND	22	1.487	1.720	830	18.28
WEEKEND	23	1.477	1.660	646	20.07
WEEKEND	24	1.349	1.539	456	22.11

FREEWAYS, AADT/C = 20

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	1.322	1.307	15	51.13
WEEKDAY, IB	2	1.254	1.254	14	48.74
WEEKDAY, IB	3	1.241	1.245	10	49.61
WEEKDAY, IB	4	1.220	1.227	3	52.68
WEEKDAY, IB	5	1.285	1.283	4	53.81
WEEKDAY, IB	6	1.501	1.489	16	49.85
WEEKDAY, IB	7	2.046	1.862	200	30.50
WEEKDAY, IB	8	2.392	1.868	725	17.93
WEEKDAY, IB	9	2.305	1.856	1,174	15.60
WEEKDAY, IB	10	2.094	1.853	1,415	15.23
WEEKDAY, IB	11	2.017	1.853	1,580	15.15
WEEKDAY, IB	12	2.014	1.852	1,741	15.12
WEEKDAY, IB	13	2.014	1.851	1,904	15.09
WEEKDAY, IB	14	2.067	1.852	2,119	15.08
WEEKDAY, IB	15	2.093	1.852	2,359	15.08
WEEKDAY, IB	16	2.165	1.852	2,672	15.05
WEEKDAY, IB	17	2.192	1.852	3,013	15.03
WEEKDAY, IB	18	2.206	1.852	3,366	15.03
WEEKDAY, IB	19	2.063	1.852	3,577	15.03
WEEKDAY, IB	20	1.828	1.851	3,554	15.03
WEEKDAY, IB	21	1.667	1.851	3,369	15.03
WEEKDAY, IB	22	1.660	1.850	3,179	15.04
WEEKDAY, IB	23	1.589	1.850	2,919	15.07
WEEKDAY, IB	24	1.475	1.844	2,550	15.13
WEEKDAY, OB	1	1.334	1.323	11	51.76
WEEKDAY, OB	2	1.287	1.285	14	49.05
WEEKDAY, OB	3	1.247	1.255	6	50.71
WEEKDAY, OB	4	1.246	1.245	6	52.12
WEEKDAY, OB	5	1.258	1.260	4	52.72
WEEKDAY, OB	6	1.381	1.379	6	52.64
WEEKDAY, OB	7	1.841	1.781	66	41.32
WEEKDAY, OB	8	2.177	1.889	353	23.38
WEEKDAY, OB	9	2.101	1.873	581	18.72
WEEKDAY, OB	10	1.959	1.854	686	17.57
WEEKDAY, OB	11	1.938	1.848	776	17.10
WEEKDAY, OB	12	1.998	1.855	920	16.69
WEEKDAY, OB	13	2.027	1.853	1,094	16.16
WEEKDAY, OB	14	2.074	1.854	1,314	15.77
WEEKDAY, OB	15	2.150	1.855	1,609	15.51
WEEKDAY, OB	16	2.253	1.853	2,008	15.22
WEEKDAY, OB	17	2.365	1.852	2,522	15.05
WEEKDAY, OB	18	2.336	1.852	3,006	15.02
WEEKDAY, OB	19	2.168	1.852	3,322	15.02
WEEKDAY, OB	20	1.900	1.851	3,370	15.02
WEEKDAY, OB	21	1.730	1.851	3,249	15.02
WEEKDAY, OB	22	1.724	1.851	3,122	15.04
WEEKDAY, OB	23	1.609	1.849	2,881	15.06
WEEKDAY, OB	24	1.499	1.845	2,536	15.14
WEEKEND	1	1.426	1.400	26	49.24
WEEKEND	2	1.349	1.346	29	45.20
WEEKEND	3	1.297	1.312	14	46.14
WEEKEND	4	1.267	1.266	15	47.73
WEEKEND	5	1.240	1.233	22	47.89
WEEKEND	6	1.291	1.242	71	41.37
WEEKEND	7	1.438	1.321	188	32.01
WEEKEND	8	1.575	1.422	341	26.85
WEEKEND	9	1.612	1.539	415	25.10
WEEKEND	10	1.746	1.682	479	23.86
WEEKEND	11	1.893	1.774	598	21.95
WEEKEND	12	1.933	1.808	723	20.14
WEEKEND	13	2.027	1.840	911	18.31
WEEKEND	14	2.035	1.842	1,104	17.08
WEEKEND	15	2.041	1.846	1,298	16.42
WEEKEND	16	2.047	1.847	1,498	15.94
WEEKEND	17	2.034	1.847	1,685	15.74
WEEKEND	18	1.998	1.846	1,838	15.61
WEEKEND	19	1.918	1.847	1,909	15.52
WEEKEND	20	1.813	1.841	1,881	15.54
WEEKEND	21	1.693	1.827	1,747	15.82
WEEKEND	22	1.657	1.808	1,596	16.28
WEEKEND	23	1.583	1.764	1,415	16.77
WEEKEND	24	1.470	1.712	1,172	17.56

FREEWAYS, AADT/C - 21

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	1,513	1,475	38	46.87
WEEKDAY, IB	2	1,432	1,425	46	41.99
WEEKDAY, IB	3	1,449	1,451	44	41.01
WEEKDAY, IB	4	1,420	1,433	31	43.05
WEEKDAY, IB	5	1,488	1,494	25	44.29
WEEKDAY, IB	6	1,656	1,633	48	42.07
WEEKDAY, IB	7	2,078	1,865	260	26.98
WEEKDAY, IB	8	2,335	1,865	730	17.62
WEEKDAY, IB	9	2,266	1,857	1,140	15.61
WEEKDAY, IB	10	2,112	1,854	1,398	15.27
WEEKDAY, IB	11	2,035	1,851	1,581	15.17
WEEKDAY, IB	12	2,043	1,852	1,773	15.10
WEEKDAY, IB	13	2,046	1,852	1,967	15.08
WEEKDAY, IB	14	2,077	1,852	2,192	15.06
WEEKDAY, IB	15	2,111	1,852	2,451	15.02
WEEKDAY, IB	16	2,166	1,852	2,765	15.02
WEEKDAY, IB	17	2,175	1,852	3,089	15.01
WEEKDAY, IB	18	2,198	1,852	3,434	15.01
WEEKDAY, IB	19	2,052	1,852	3,635	15.01
WEEKDAY, IB	20	1,897	1,852	3,680	15.01
WEEKDAY, IB	21	1,806	1,852	3,634	15.01
WEEKDAY, IB	22	1,775	1,852	3,557	15.01
WEEKDAY, IB	23	1,700	1,852	3,405	15.03
WEEKDAY, IB	24	1,590	1,850	3,146	15.05
WEEKDAY, OB	1	1,509	1,463	46	44.71
WEEKDAY, OB	2	1,497	1,479	64	38.74
WEEKDAY, OB	3	1,457	1,464	57	38.43
WEEKDAY, OB	4	1,448	1,466	40	40.20
WEEKDAY, OB	5	1,462	1,470	32	42.63
WEEKDAY, OB	6	1,547	1,549	29	44.40
WEEKDAY, OB	7	1,929	1,820	139	33.67
WEEKDAY, OB	8	2,190	1,885	444	21.20
WEEKDAY, OB	9	2,137	1,866	714	17.46
WEEKDAY, OB	10	2,004	1,855	863	16.49
WEEKDAY, OB	11	2,002	1,852	1,013	16.11
WEEKDAY, OB	12	2,038	1,850	1,200	15.73
WEEKDAY, OB	13	2,073	1,854	1,420	15.46
WEEKDAY, OB	14	2,079	1,852	1,646	15.32
WEEKDAY, OB	15	2,159	1,853	1,952	15.21
WEEKDAY, OB	16	2,252	1,852	2,352	15.08
WEEKDAY, OB	17	2,347	1,852	2,847	15.03
WEEKDAY, OB	18	2,302	1,852	3,297	15.01
WEEKDAY, OB	19	2,181	1,852	3,626	15.01
WEEKDAY, OB	20	1,958	1,852	3,732	15.01
WEEKDAY, OB	21	1,837	1,852	3,717	15.01
WEEKDAY, OB	22	1,837	1,852	3,702	15.01
WEEKDAY, OB	23	1,762	1,852	3,612	15.01
WEEKDAY, OB	24	1,666	1,851	3,427	15.03
WEEKEND	1	1,616	1,552	64	43.14
WEEKEND	2	1,533	1,506	91	36.73
WEEKEND	3	1,510	1,516	84	35.68
WEEKEND	4	1,478	1,478	84	35.70
WEEKEND	5	1,485	1,458	111	33.90
WEEKEND	6	1,480	1,420	171	30.82
WEEKEND	7	1,614	1,476	309	27.31
WEEKEND	8	1,663	1,508	464	24.09
WEEKEND	9	1,721	1,628	557	23.01
WEEKEND	10	1,839	1,722	674	21.59
WEEKEND	11	1,909	1,789	794	19.98
WEEKEND	12	2,007	1,816	984	18.37
WEEKEND	13	2,049	1,847	1,186	17.26
WEEKEND	14	2,048	1,846	1,389	16.45
WEEKEND	15	2,055	1,847	1,596	15.93
WEEKEND	16	2,062	1,850	1,808	15.65
WEEKEND	17	2,078	1,852	2,035	15.46
WEEKEND	18	2,036	1,848	2,222	15.36
WEEKEND	19	2,008	1,849	2,381	15.37
WEEKEND	20	1,875	1,848	2,408	15.38
WEEKEND	21	1,797	1,844	2,362	15.40
WEEKEND	22	1,757	1,833	2,286	15.55
WEEKEND	23	1,714	1,825	2,175	15.78
WEEKEND	24	1,654	1,809	2,020	15.97

FREEWAYS. AADT/C = 22

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	1.718	1.606	113	37.61
WEEKDAY, IB	2	1.693	1.628	178	29.75
WEEKDAY, IB	3	1.668	1.651	194	28.54
WEEKDAY, IB	4	1.662	1.655	202	28.61
WEEKDAY, IB	5	1.678	1.675	205	28.86
WEEKDAY, IB	6	1.803	1.753	255	26.94
WEEKDAY, IB	7	2.106	1.869	492	21.48
WEEKDAY, IB	8	2.279	1.865	906	17.06
WEEKDAY, IB	9	2.233	1.856	1,282	15.63
WEEKDAY, IB	10	2.122	1.854	1,551	15.25
WEEKDAY, IB	11	2.082	1.853	1,780	15.11
WEEKDAY, IB	12	2.090	1.851	2,019	15.05
WEEKDAY, IB	13	2.084	1.852	2,250	15.04
WEEKDAY, IB	14	2.093	1.852	2,492	15.03
WEEKDAY, IB	15	2.124	1.852	2,764	15.02
WEEKDAY, IB	16	2.165	1.852	3,077	15.01
WEEKDAY, IB	17	2.175	1.852	3,400	15.01
WEEKDAY, IB	18	2.206	1.852	3,755	15.01
WEEKDAY, IB	19	2.077	1.852	3,979	15.01
WEEKDAY, IB	20	1.993	1.852	4,121	15.01
WEEKDAY, IB	21	1.899	1.852	4,168	15.01
WEEKDAY, IB	22	1.881	1.852	4,196	15.01
WEEKDAY, IB	23	1.849	1.852	4,193	15.01
WEEKDAY, IB	24	1.767	1.852	4,109	15.01
WEEKDAY, OB	1	1.734	1.618	116	37.69
WEEKDAY, OB	2	1.677	1.622	170	30.52
WEEKDAY, OB	3	1.665	1.635	200	28.15
WEEKDAY, OB	4	1.670	1.671	198	28.00
WEEKDAY, OB	5	1.654	1.664	188	28.60
WEEKDAY, OB	6	1.765	1.738	215	28.55
WEEKDAY, OB	7	1.992	1.848	359	24.55
WEEKDAY, OB	8	2.177	1.873	663	19.08
WEEKDAY, OB	9	2.138	1.862	939	16.67
WEEKDAY, OB	10	2.052	1.855	1,136	16.01
WEEKDAY, OB	11	2.038	1.854	1,320	15.71
WEEKDAY, OB	12	2.079	1.853	1,546	15.43
WEEKDAY, OB	13	2.091	1.853	1,783	15.31
WEEKDAY, OB	14	2.123	1.853	2,053	15.23
WEEKDAY, OB	15	2.143	1.853	2,343	15.16
WEEKDAY, OB	16	2.220	1.852	2,711	15.08
WEEKDAY, OB	17	2.280	1.852	3,139	15.05
WEEKDAY, OB	18	2.272	1.852	3,558	15.03
WEEKDAY, OB	19	2.158	1.852	3,865	15.02
WEEKDAY, OB	20	2.045	1.852	4,058	15.02
WEEKDAY, OB	21	1.918	1.852	4,124	15.01
WEEKDAY, OB	22	1.924	1.852	4,195	15.01
WEEKDAY, OB	23	1.876	1.852	4,220	15.01
WEEKDAY, OB	24	1.780	1.851	4,148	15.02
WEEKEND	1	1.775	1.646	129	36.22
WEEKEND	2	1.731	1.659	201	29.11
WEEKEND	3	1.692	1.658	235	27.14
WEEKEND	4	1.654	1.635	255	26.53
WEEKEND	5	1.698	1.618	335	24.86
WEEKEND	6	1.709	1.585	459	22.94
WEEKEND	7	1.765	1.603	621	21.70
WEEKEND	8	1.824	1.624	822	20.54
WEEKEND	9	1.845	1.721	945	19.90
WEEKEND	10	1.960	1.777	1,129	18.83
WEEKEND	11	1.993	1.817	1,305	17.83
WEEKEND	12	2.045	1.841	1,509	17.12
WEEKEND	13	2.093	1.847	1,755	16.38
WEEKEND	14	2.073	1.850	1,978	15.99
WEEKEND	15	2.089	1.851	2,216	15.59
WEEKEND	16	2.087	1.850	2,454	15.34
WEEKEND	17	2.123	1.850	2,727	15.23
WEEKEND	18	2.074	1.851	2,950	15.15
WEEKEND	19	2.025	1.852	3,123	15.15
WEEKEND	20	1.957	1.848	3,233	15.19
WEEKEND	21	1.932	1.850	3,315	15.19
WEEKEND	22	1.873	1.845	3,344	15.23
WEEKEND	23	1.841	1.843	3,342	15.28
WEEKEND	24	1.821	1.834	3,329	15.33

FREEWAYS, AADT/C = 23

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	1.904	1.717	187	32.77
WEEKDAY, IB	2	1.923	1.739	371	24.07
WEEKDAY, IB	3	1.886	1.764	492	21.59
WEEKDAY, IB	4	1.871	1.783	580	20.46
WEEKDAY, IB	5	1.900	1.799	680	19.55
WEEKDAY, IB	6	1.962	1.832	810	18.85
WEEKDAY, IB	7	2.129	1.855	1,085	17.22
WEEKDAY, IB	8	2.217	1.856	1,446	15.85
WEEKDAY, IB	9	2.183	1.854	1,774	15.33
WEEKDAY, IB	10	2.131	1.853	2,053	15.13
WEEKDAY, IB	11	2.107	1.852	2,308	15.06
WEEKDAY, IB	12	2.116	1.852	2,571	15.05
WEEKDAY, IB	13	2.119	1.852	2,838	15.02
WEEKDAY, IB	14	2.115	1.852	3,101	15.01
WEEKDAY, IB	15	2.148	1.852	3,397	15.01
WEEKDAY, IB	16	2.166	1.852	3,711	15.01
WEEKDAY, IB	17	2.165	1.852	4,024	15.01
WEEKDAY, IB	18	2.164	1.852	4,335	15.01
WEEKDAY, IB	19	2.120	1.852	4,603	15.01
WEEKDAY, IB	20	2.046	1.852	4,797	15.01
WEEKDAY, IB	21	2.003	1.852	4,948	15.01
WEEKDAY, IB	22	2.021	1.852	5,118	15.01
WEEKDAY, IB	23	1.984	1.852	5,250	15.01
WEEKDAY, IB	24	1.953	1.852	5,351	15.01
WEEKDAY, OB	1	1.931	1.711	220	31.77
WEEKDAY, OB	2	1.937	1.757	400	23.85
WEEKDAY, OB	3	1.883	1.757	526	21.15
WEEKDAY, OB	4	1.883	1.782	627	19.75
WEEKDAY, OB	5	1.925	1.805	747	18.91
WEEKDAY, OB	6	1.935	1.826	856	18.27
WEEKDAY, OB	7	2.081	1.851	1,087	17.21
WEEKDAY, OB	8	2.156	1.860	1,382	16.15
WEEKDAY, OB	9	2.153	1.855	1,681	15.52
WEEKDAY, OB	10	2.090	1.853	1,918	15.26
WEEKDAY, OB	11	2.097	1.853	2,162	15.12
WEEKDAY, OB	12	2.127	1.853	2,437	15.07
WEEKDAY, OB	13	2.124	1.852	2,708	15.06
WEEKDAY, OB	14	2.128	1.852	2,985	15.05
WEEKDAY, OB	15	2.152	1.852	3,285	15.04
WEEKDAY, OB	16	2.178	1.852	3,611	15.02
WEEKDAY, OB	17	2.214	1.852	3,973	15.01
WEEKDAY, OB	18	2.208	1.852	4,330	15.01
WEEKDAY, OB	19	2.157	1.852	4,635	15.01
WEEKDAY, OB	20	2.092	1.852	4,875	15.01
WEEKDAY, OB	21	2.028	1.852	5,051	15.01
WEEKDAY, OB	22	2.034	1.852	5,232	15.01
WEEKDAY, OB	23	1.990	1.852	5,370	15.01
WEEKDAY, OB	24	1.964	1.852	5,482	15.01
WEEKEND	1	1.931	1.719	213	31.41
WEEKEND	2	1.933	1.758	388	23.70
WEEKEND	3	1.922	1.769	541	21.01
WEEKEND	4	1.923	1.780	684	19.56
WEEKEND	5	1.920	1.763	841	18.71
WEEKEND	6	1.937	1.735	1,043	18.10
WEEKEND	7	1.949	1.739	1,254	17.91
WEEKEND	8	1.921	1.726	1,449	17.62
WEEKEND	9	1.977	1.764	1,662	17.58
WEEKEND	10	2.007	1.815	1,854	17.17
WEEKEND	11	2.063	1.831	2,087	16.51
WEEKEND	12	2.091	1.844	2,335	15.96
WEEKEND	13	2.113	1.851	2,597	15.59
WEEKEND	14	2.110	1.851	2,856	15.40
WEEKEND	15	2.113	1.852	3,117	15.24
WEEKEND	16	2.107	1.851	3,373	15.17
WEEKEND	17	2.107	1.851	3,629	15.11
WEEKEND	18	2.102	1.852	3,879	15.11
WEEKEND	19	2.093	1.852	4,121	15.07
WEEKEND	20	2.021	1.852	4,290	15.05
WEEKEND	21	2.019	1.851	4,458	15.06
WEEKEND	22	1.987	1.851	4,594	15.07
WEEKEND	23	1.983	1.849	4,729	15.07
WEEKEND	24	1.961	1.849	4,841	15.06

FREEWAYS, AADT/C - 24

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	2.162	1.796	366	26.44
WEEKDAY, IB	2	2.085	1.802	650	20.23
WEEKDAY, IB	3	2.131	1.830	951	17.96
WEEKDAY, IB	4	2.099	1.838	1,212	16.80
WEEKDAY, IB	5	2.159	1.845	1,525	16.04
WEEKDAY, IB	6	2.136	1.851	1,811	15.54
WEEKDAY, IB	7	2.129	1.852	2,087	15.29
WEEKDAY, IB	8	2.131	1.853	2,366	15.15
WEEKDAY, IB	9	2.126	1.852	2,640	15.06
WEEKDAY, IB	10	2.119	1.852	2,907	15.02
WEEKDAY, IB	11	2.121	1.852	3,176	15.02
WEEKDAY, IB	12	2.141	1.852	3,465	15.01
WEEKDAY, IB	13	2.144	1.852	3,758	15.01
WEEKDAY, IB	14	2.122	1.852	4,028	15.01
WEEKDAY, IB	15	2.142	1.852	4,318	15.01
WEEKDAY, IB	16	2.138	1.852	4,604	15.01
WEEKDAY, IB	17	2.126	1.852	4,878	15.01
WEEKDAY, IB	18	2.135	1.852	5,161	15.01
WEEKDAY, IB	19	2.122	1.852	5,430	15.01
WEEKDAY, IB	20	2.130	1.852	5,708	15.01
WEEKDAY, IB	21	2.132	1.852	5,988	15.01
WEEKDAY, IB	22	2.115	1.852	6,251	15.01
WEEKDAY, IB	23	2.136	1.852	6,535	15.01
WEEKDAY, IB	24	2.145	1.852	6,829	15.01
WEEKDAY, OB	1	2.152	1.788	364	26.45
WEEKDAY, OB	2	2.119	1.816	666	20.03
WEEKDAY, OB	3	2.143	1.831	978	17.90
WEEKDAY, OB	4	2.118	1.845	1,252	16.78
WEEKDAY, OB	5	2.136	1.848	1,541	16.10
WEEKDAY, OB	6	2.127	1.851	1,817	15.72
WEEKDAY, OB	7	2.119	1.854	2,082	15.47
WEEKDAY, OB	8	2.122	1.853	2,351	15.23
WEEKDAY, OB	9	2.134	1.852	2,633	15.09
WEEKDAY, OB	10	2.129	1.852	2,909	15.05
WEEKDAY, OB	11	2.129	1.852	3,187	15.03
WEEKDAY, OB	12	2.135	1.852	3,470	15.03
WEEKDAY, OB	13	2.144	1.852	3,762	15.02
WEEKDAY, OB	14	2.114	1.852	4,024	15.02
WEEKDAY, OB	15	2.113	1.852	4,285	15.01
WEEKDAY, OB	16	2.124	1.852	4,557	15.01
WEEKDAY, OB	17	2.137	1.852	4,842	15.01
WEEKDAY, OB	18	2.115	1.852	5,105	15.01
WEEKDAY, OB	19	2.133	1.852	5,386	15.01
WEEKDAY, OB	20	2.125	1.852	5,660	15.01
WEEKDAY, OB	21	2.112	1.852	5,920	15.01
WEEKDAY, OB	22	2.112	1.852	6,180	15.01
WEEKDAY, OB	23	2.138	1.852	6,466	15.01
WEEKDAY, OB	24	2.104	1.852	6,719	15.01
WEEKEND	1	2.120	1.781	339	27.52
WEEKEND	2	2.117	1.799	657	20.25
WEEKEND	3	2.147	1.818	986	17.82
WEEKEND	4	2.125	1.828	1,283	16.71
WEEKEND	5	2.097	1.824	1,555	16.15
WEEKEND	6	2.156	1.816	1,896	16.10
WEEKEND	7	2.191	1.804	2,283	16.10
WEEKEND	8	2.162	1.808	2,638	16.03
WEEKEND	9	2.089	1.819	2,908	15.91
WEEKEND	10	2.151	1.838	3,221	15.79
WEEKEND	11	2.144	1.845	3,520	15.54
WEEKEND	12	2.129	1.851	3,798	15.31
WEEKEND	13	2.124	1.852	4,070	15.22
WEEKEND	14	2.151	1.852	4,370	15.12
WEEKEND	15	2.132	1.852	4,650	15.06
WEEKEND	16	2.131	1.851	4,930	15.04
WEEKEND	17	2.129	1.852	5,207	15.02
WEEKEND	18	2.133	1.852	5,488	15.01
WEEKEND	19	2.118	1.852	5,754	15.01
WEEKEND	20	2.125	1.852	6,027	15.02
WEEKEND	21	2.123	1.852	6,298	15.02
WEEKEND	22	2.138	1.852	6,584	15.02
WEEKEND	23	2.145	1.852	6,878	15.01
WEEKEND	24	2.088	1.851	7,114	15.02

SIGNALIZED ARTERIALS, AADT/C = 1

SIGNALS/MILE = 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	6	6	0	25.07
WEEKDAY, IB	2	4	4	0	25.07
WEEKDAY, IB	3	3	3	0	25.07
WEEKDAY, IB	4	2	2	0	25.07
WEEKDAY, IB	5	4	4	0	25.07
WEEKDAY, IB	6	13	13	0	25.07
WEEKDAY, IB	7	40	40	0	25.05
WEEKDAY, IB	8	73	73	0	25.00
WEEKDAY, IB	9	62	62	0	25.02
WEEKDAY, IB	10	47	47	0	25.04
WEEKDAY, IB	11	47	47	0	25.04
WEEKDAY, IB	12	51	51	0	25.04
WEEKDAY, IB	13	57	57	0	25.03
WEEKDAY, IB	14	56	56	0	25.03
WEEKDAY, IB	15	57	57	0	25.03
WEEKDAY, IB	16	61	61	0	25.02
WEEKDAY, IB	17	62	62	0	25.02
WEEKDAY, IB	18	59	59	0	25.03
WEEKDAY, IB	19	48	48	0	25.04
WEEKDAY, IB	20	38	38	0	25.05
WEEKDAY, IB	21	31	31	0	25.06
WEEKDAY, IB	22	27	27	0	25.06
WEEKDAY, IB	23	19	19	0	25.06
WEEKDAY, IB	24	13	13	0	25.07
WEEKDAY, OB	1	8	8	0	25.07
WEEKDAY, OB	2	5	5	0	25.07
WEEKDAY, OB	3	3	3	0	25.07
WEEKDAY, OB	4	3	3	0	25.07
WEEKDAY, OB	5	3	3	0	25.07
WEEKDAY, OB	6	8	8	0	25.07
WEEKDAY, OB	7	21	21	0	25.06
WEEKDAY, OB	8	41	41	0	25.05
WEEKDAY, OB	9	42	42	0	25.05
WEEKDAY, OB	10	41	41	0	25.05
WEEKDAY, OB	11	46	46	0	25.04
WEEKDAY, OB	12	54	54	0	25.03
WEEKDAY, OB	13	60	60	0	25.02
WEEKDAY, OB	14	58	58	0	25.03
WEEKDAY, OB	15	62	62	0	25.02
WEEKDAY, OB	16	74	74	0	25.00
WEEKDAY, OB	17	85	85	0	24.98
WEEKDAY, OB	18	87	87	0	24.97
WEEKDAY, OB	19	58	58	0	25.03
WEEKDAY, OB	20	43	43	0	25.04
WEEKDAY, OB	21	35	35	0	25.05
WEEKDAY, OB	22	31	31	0	25.06
WEEKDAY, OB	23	23	23	0	25.06
WEEKDAY, OB	24	17	17	0	25.07
WEEKEND	1	14	14	0	25.07
WEEKEND	2	9	9	0	25.07
WEEKEND	3	6	6	0	25.07
WEEKEND	4	4	4	0	25.07
WEEKEND	5	4	4	0	25.07
WEEKEND	6	6	6	0	25.07
WEEKEND	7	11	11	0	25.07
WEEKEND	8	17	17	0	25.06
WEEKEND	9	24	24	0	25.06
WEEKEND	10	33	33	0	25.05
WEEKEND	11	42	42	0	25.04
WEEKEND	12	48	48	0	25.04
WEEKEND	13	54	54	0	25.03
WEEKEND	14	54	54	0	25.03
WEEKEND	15	54	54	0	25.03
WEEKEND	16	53	53	0	25.03
WEEKEND	17	52	52	0	25.03
WEEKEND	18	48	48	0	25.04
WEEKEND	19	42	42	0	25.04
WEEKEND	20	36	36	0	25.05
WEEKEND	21	30	30	0	25.06
WEEKEND	22	26	26	0	25.06
WEEKEND	23	21	21	0	25.06
WEEKEND	24	16	16	0	25.06

SIGNALIZED ARTERIALS, AADT/C - 2

SIGNALS/MILE - 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	12	12	0	25.07
WEEKDAY, IB	2	8	8	0	25.07
WEEKDAY, IB	3	5	5	0	25.07
WEEKDAY, IB	4	5	5	0	25.07
WEEKDAY, IB	5	8	8	0	25.07
WEEKDAY, IB	6	27	27	0	25.06
WEEKDAY, IB	7	79	79	0	24.99
WEEKDAY, IB	8	147	147	0	24.80
WEEKDAY, IB	9	124	124	0	24.88
WEEKDAY, IB	10	94	94	0	24.96
WEEKDAY, IB	11	94	94	0	24.96
WEEKDAY, IB	12	104	104	0	24.93
WEEKDAY, IB	13	115	115	0	24.90
WEEKDAY, IB	14	112	112	0	24.91
WEEKDAY, IB	15	114	114	0	24.90
WEEKDAY, IB	16	123	123	0	24.88
WEEKDAY, IB	17	123	123	0	24.88
WEEKDAY, IB	18	119	119	0	24.89
WEEKDAY, IB	19	96	96	0	24.95
WEEKDAY, IB	20	77	77	0	24.99
WEEKDAY, IB	21	61	61	0	25.02
WEEKDAY, IB	22	54	54	0	25.03
WEEKDAY, IB	23	39	39	0	25.05
WEEKDAY, IB	24	26	26	0	25.06
WEEKDAY, OB	1	17	17	0	25.07
WEEKDAY, OB	2	10	10	0	25.07
WEEKDAY, OB	3	7	7	0	25.07
WEEKDAY, OB	4	5	5	0	25.07
WEEKDAY, OB	5	6	6	0	25.07
WEEKDAY, OB	6	15	15	0	25.07
WEEKDAY, OB	7	43	43	0	25.05
WEEKDAY, OB	8	82	82	0	24.98
WEEKDAY, OB	9	83	83	0	24.98
WEEKDAY, OB	10	82	82	0	24.98
WEEKDAY, OB	11	92	92	0	24.96
WEEKDAY, OB	12	109	109	0	24.92
WEEKDAY, OB	13	120	120	0	24.88
WEEKDAY, OB	14	116	116	0	24.90
WEEKDAY, OB	15	122	122	0	24.88
WEEKDAY, OB	16	147	147	0	24.80
WEEKDAY, OB	17	171	171	0	24.70
WEEKDAY, OB	18	171	171	0	24.70
WEEKDAY, OB	19	115	115	0	24.90
WEEKDAY, OB	20	86	86	0	24.97
WEEKDAY, OB	21	71	71	0	25.00
WEEKDAY, OB	22	61	61	0	25.02
WEEKDAY, OB	23	45	45	0	25.04
WEEKDAY, OB	24	33	33	0	25.05
WEEKEND	1	28	28	0	25.06
WEEKEND	2	19	19	0	25.06
WEEKEND	3	13	13	0	25.07
WEEKEND	4	8	8	0	25.07
WEEKEND	5	7	7	0	25.07
WEEKEND	6	11	11	0	25.07
WEEKEND	7	22	22	0	25.06
WEEKEND	8	35	35	0	25.04
WEEKEND	9	48	48	0	25.03
WEEKEND	10	66	66	0	25.00
WEEKEND	11	84	84	0	24.96
WEEKEND	12	96	96	0	24.94
WEEKEND	13	106	106	0	24.92
WEEKEND	14	106	106	0	24.92
WEEKEND	15	107	107	0	24.92
WEEKEND	16	107	107	0	24.91
WEEKEND	17	104	104	0	24.92
WEEKEND	18	96	96	0	24.94
WEEKEND	19	85	85	0	24.97
WEEKEND	20	71	71	0	25.00
WEEKEND	21	59	59	0	25.02
WEEKEND	22	51	51	0	25.03
WEEKEND	23	41	41	0	25.04
WEEKEND	24	32	32	0	25.05

SIGNALIZED ARTERIALS, AADT/C = 3

SIGNALS/MILE = 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	18	18	0	25.06
WEEKDAY, IB	2	11	11	0	25.07
WEEKDAY, IB	3	8	8	0	25.07
WEEKDAY, IB	4	7	7	0	25.07
WEEKDAY, IB	5	13	13	0	25.07
WEEKDAY, IB	6	40	40	0	25.05
WEEKDAY, IB	7	119	119	0	24.89
WEEKDAY, IB	8	221	221	0	24.46
WEEKDAY, IB	9	184	184	0	24.64
WEEKDAY, IB	10	142	142	0	24.82
WEEKDAY, IB	11	142	142	0	24.81
WEEKDAY, IB	12	155	155	0	24.77
WEEKDAY, IB	13	171	171	0	24.70
WEEKDAY, IB	14	169	169	0	24.71
WEEKDAY, IB	15	172	172	0	24.70
WEEKDAY, IB	16	183	183	0	24.65
WEEKDAY, IB	17	186	186	0	24.64
WEEKDAY, IB	18	177	177	0	24.67
WEEKDAY, IB	19	143	143	0	24.80
WEEKDAY, IB	20	115	115	0	24.89
WEEKDAY, IB	21	92	92	0	24.95
WEEKDAY, IB	22	80	80	0	24.98
WEEKDAY, IB	23	59	59	0	25.02
WEEKDAY, IB	24	40	40	0	25.04
WEEKDAY, OB	1	25	25	0	25.06
WEEKDAY, OB	2	15	15	0	25.07
WEEKDAY, OB	3	10	10	0	25.07
WEEKDAY, OB	4	8	8	0	25.07
WEEKDAY, OB	5	9	9	0	25.07
WEEKDAY, OB	6	22	22	0	25.06
WEEKDAY, OB	7	64	64	0	25.02
WEEKDAY, OB	8	122	122	0	24.88
WEEKDAY, OB	9	125	125	0	24.87
WEEKDAY, OB	10	123	123	0	24.88
WEEKDAY, OB	11	137	137	0	24.83
WEEKDAY, OB	12	163	163	0	24.73
WEEKDAY, OB	13	179	179	0	24.66
WEEKDAY, OB	14	175	175	0	24.68
WEEKDAY, OB	15	184	184	0	24.64
WEEKDAY, OB	16	222	222	0	24.46
WEEKDAY, OB	17	257	257	0	24.26
WEEKDAY, OB	18	258	258	0	24.24
WEEKDAY, OB	19	172	172	0	24.69
WEEKDAY, OB	20	131	131	0	24.84
WEEKDAY, OB	21	105	105	0	24.92
WEEKDAY, OB	22	91	91	0	24.96
WEEKDAY, OB	23	68	68	0	25.00
WEEKDAY, OB	24	50	50	0	25.03
WEEKEND	1	43	43	0	25.04
WEEKEND	2	29	29	0	25.06
WEEKEND	3	19	19	0	25.06
WEEKEND	4	12	12	0	25.07
WEEKEND	5	11	11	0	25.07
WEEKEND	6	17	17	0	25.06
WEEKEND	7	33	33	0	25.04
WEEKEND	8	53	53	0	24.99
WEEKEND	9	72	72	0	24.97
WEEKEND	10	101	101	0	24.91
WEEKEND	11	123	123	0	24.85
WEEKEND	12	145	145	0	24.78
WEEKEND	13	160	160	0	24.73
WEEKEND	14	161	161	0	24.73
WEEKEND	15	160	160	0	24.73
WEEKEND	16	161	161	0	24.72
WEEKEND	17	157	157	0	24.73
WEEKEND	18	146	146	0	24.77
WEEKEND	19	126	126	0	24.85
WEEKEND	20	107	107	0	24.91
WEEKEND	21	89	89	0	24.96
WEEKEND	22	77	77	0	24.98
WEEKEND	23	62	62	0	25.01
WEEKEND	24	47	47	0	25.03

SIGNALIZED ARTERIALS, AADT/C - 4

SIGNALS/MILE - 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	24	24	0	25.06
WEEKDAY, IB	2	15	15	0	25.07
WEEKDAY, IB	3	11	11	0	25.07
WEEKDAY, IB	4	10	10	0	25.07
WEEKDAY, IB	5	17	17	0	25.07
WEEKDAY, IB	6	53	53	0	25.03
WEEKDAY, IB	7	159	159	0	24.74
WEEKDAY, IB	8	294	294	0	24.01
WEEKDAY, IB	9	248	248	0	24.31
WEEKDAY, IB	10	187	187	0	24.63
WEEKDAY, IB	11	188	188	0	24.62
WEEKDAY, IB	12	206	206	0	24.54
WEEKDAY, IB	13	229	229	0	24.41
WEEKDAY, IB	14	225	225	0	24.43
WEEKDAY, IB	15	226	226	0	24.43
WEEKDAY, IB	16	244	244	0	24.33
WEEKDAY, IB	17	248	248	0	24.31
WEEKDAY, IB	18	237	237	0	24.37
WEEKDAY, IB	19	190	190	0	24.60
WEEKDAY, IB	20	154	154	0	24.75
WEEKDAY, IB	21	123	123	0	24.86
WEEKDAY, IB	22	107	107	0	24.91
WEEKDAY, IB	23	80	80	0	24.98
WEEKDAY, IB	24	53	53	0	25.03
WEEKDAY, OB	1	34	34	0	25.05
WEEKDAY, OB	2	20	20	0	25.06
WEEKDAY, OB	3	13	13	0	25.07
WEEKDAY, OB	4	10	10	0	25.07
WEEKDAY, OB	5	13	13	0	25.07
WEEKDAY, OB	6	30	30	0	25.06
WEEKDAY, OB	7	85	85	0	24.98
WEEKDAY, OB	8	163	163	0	24.73
WEEKDAY, OB	9	167	167	0	24.72
WEEKDAY, OB	10	164	164	0	24.73
WEEKDAY, OB	11	182	182	0	24.65
WEEKDAY, OB	12	216	216	0	24.48
WEEKDAY, OB	13	238	238	0	24.36
WEEKDAY, OB	14	233	233	0	24.39
WEEKDAY, OB	15	246	246	0	24.31
WEEKDAY, OB	16	296	296	0	24.00
WEEKDAY, OB	17	342	342	0	23.66
WEEKDAY, OB	18	346	346	0	23.62
WEEKDAY, OB	19	231	231	0	24.38
WEEKDAY, OB	20	171	171	0	24.67
WEEKDAY, OB	21	140	140	0	24.80
WEEKDAY, OB	22	123	123	0	24.86
WEEKDAY, OB	23	90	90	0	24.95
WEEKDAY, OB	24	67	67	0	25.00
WEEKEND	1	57	57	0	25.02
WEEKEND	2	38	38	0	25.05
WEEKEND	3	25	25	0	25.06
WEEKEND	4	16	16	0	25.07
WEEKEND	5	14	14	0	25.07
WEEKEND	6	22	22	0	25.06
WEEKEND	7	44	44	0	25.02
WEEKEND	8	70	70	0	24.93
WEEKEND	9	97	97	0	24.88
WEEKEND	10	134	134	0	24.79
WEEKEND	11	164	164	0	24.68
WEEKEND	12	191	191	0	24.57
WEEKEND	13	217	217	0	24.44
WEEKEND	14	214	214	0	24.48
WEEKEND	15	213	213	0	24.48
WEEKEND	16	212	212	0	24.47
WEEKEND	17	207	207	0	24.49
WEEKEND	18	192	192	0	24.56
WEEKEND	19	171	171	0	24.67
WEEKEND	20	142	142	0	24.79
WEEKEND	21	118	118	0	24.87
WEEKEND	22	102	102	0	24.92
WEEKEND	23	83	83	0	24.96
WEEKEND	24	64	64	0	25.00

SIGNALIZED ARTERIALS, AADT/C = 5

SIGNALS/MILE = 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	30	30	0	25.06
WEEKDAY, IB	2	19	19	0	25.06
WEEKDAY, IB	3	13	13	0	25.07
WEEKDAY, IB	4	12	12	0	25.07
WEEKDAY, IB	5	21	21	0	25.06
WEEKDAY, IB	6	66	66	0	25.01
WEEKDAY, IB	7	198	198	0	24.57
WEEKDAY, IB	8	368	368	0	23.45
WEEKDAY, IB	9	309	309	0	23.91
WEEKDAY, IB	10	233	233	0	24.40
WEEKDAY, IB	11	237	237	0	24.37
WEEKDAY, IB	12	257	257	0	24.25
WEEKDAY, IB	13	285	285	0	24.06
WEEKDAY, IB	14	280	280	0	24.10
WEEKDAY, IB	15	284	284	0	24.07
WEEKDAY, IB	16	305	305	0	23.94
WEEKDAY, IB	17	309	309	0	23.91
WEEKDAY, IB	18	295	295	0	24.00
WEEKDAY, IB	19	240	240	0	24.34
WEEKDAY, IB	20	192	192	0	24.57
WEEKDAY, IB	21	155	155	0	24.74
WEEKDAY, IB	22	135	135	0	24.82
WEEKDAY, IB	23	98	98	0	24.93
WEEKDAY, IB	24	66	66	0	25.00
WEEKDAY, OB	1	42	42	0	25.04
WEEKDAY, OB	2	25	25	0	25.06
WEEKDAY, OB	3	17	17	0	25.07
WEEKDAY, OB	4	13	13	0	25.07
WEEKDAY, OB	5	16	16	0	25.07
WEEKDAY, OB	6	37	37	0	25.05
WEEKDAY, OB	7	106	106	0	24.92
WEEKDAY, OB	8	205	205	0	24.55
WEEKDAY, OB	9	209	209	0	24.53
WEEKDAY, OB	10	205	205	0	24.55
WEEKDAY, OB	11	228	228	0	24.42
WEEKDAY, OB	12	271	271	0	24.16
WEEKDAY, OB	13	298	298	0	23.97
WEEKDAY, OB	14	289	289	0	24.04
WEEKDAY, OB	15	306	306	0	23.92
WEEKDAY, OB	16	370	370	0	23.44
WEEKDAY, OB	17	427	427	0	22.95
WEEKDAY, OB	18	432	432	0	22.89
WEEKDAY, OB	19	290	290	0	23.99
WEEKDAY, OB	20	217	217	0	24.44
WEEKDAY, OB	21	176	176	0	24.65
WEEKDAY, OB	22	153	153	0	24.76
WEEKDAY, OB	23	114	114	0	24.88
WEEKDAY, OB	24	84	84	0	24.96
WEEKEND	1	70	70	0	25.00
WEEKEND	2	48	48	0	25.03
WEEKEND	3	32	32	0	25.05
WEEKEND	4	20	20	0	25.06
WEEKEND	5	18	18	0	25.06
WEEKEND	6	28	28	0	25.05
WEEKEND	7	55	55	0	25.00
WEEKEND	8	83	83	0	24.89
WEEKEND	9	120	120	0	24.79
WEEKEND	10	166	166	0	24.64
WEEKEND	11	207	207	0	24.46
WEEKEND	12	241	241	0	24.26
WEEKEND	13	271	271	0	24.11
WEEKEND	14	269	269	0	24.14
WEEKEND	15	268	268	0	24.13
WEEKEND	16	266	266	0	24.14
WEEKEND	17	259	259	0	24.18
WEEKEND	18	242	242	0	24.28
WEEKEND	19	211	211	0	24.46
WEEKEND	20	179	179	0	24.63
WEEKEND	21	148	148	0	24.76
WEEKEND	22	128	128	0	24.83
WEEKEND	23	104	104	0	24.90
WEEKEND	24	79	79	0	24.96

SIGNALIZED ARTERIALS, AADT/C = 6

SIGNALS/MILE = 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	37	37	0	25.05
WEEKDAY, IB	2	22	22	0	25.06
WEEKDAY, IB	3	16	16	0	25.07
WEEKDAY, IB	4	15	15	0	25.07
WEEKDAY, IB	5	25	25	0	25.06
WEEKDAY, IB	6	80	80	0	24.98
WEEKDAY, IB	7	238	238	0	24.35
WEEKDAY, IB	8	440	440	0	22.82
WEEKDAY, IB	9	371	371	0	23.43
WEEKDAY, IB	10	282	282	0	24.09
WEEKDAY, IB	11	284	284	0	24.07
WEEKDAY, IB	12	312	312	0	23.88
WEEKDAY, IB	13	343	343	0	23.64
WEEKDAY, IB	14	335	335	0	23.71
WEEKDAY, IB	15	342	342	0	23.65
WEEKDAY, IB	16	367	367	0	23.47
WEEKDAY, IB	17	370	370	0	23.44
WEEKDAY, IB	18	353	353	0	23.57
WEEKDAY, IB	19	292	292	0	23.99
WEEKDAY, IB	20	230	230	0	24.36
WEEKDAY, IB	21	187	187	0	24.60
WEEKDAY, IB	22	161	161	0	24.72
WEEKDAY, IB	23	117	117	0	24.87
WEEKDAY, IB	24	79	79	0	24.97
WEEKDAY, OB	1	50	50	0	25.03
WEEKDAY, OB	2	30	30	0	25.06
WEEKDAY, OB	3	20	20	0	25.06
WEEKDAY, OB	4	15	15	0	25.07
WEEKDAY, OB	5	19	19	0	25.06
WEEKDAY, OB	6	45	45	0	25.04
WEEKDAY, OB	7	128	128	0	24.86
WEEKDAY, OB	8	246	246	0	24.32
WEEKDAY, OB	9	249	249	0	24.30
WEEKDAY, OB	10	246	246	0	24.32
WEEKDAY, OB	11	273	273	0	24.15
WEEKDAY, OB	12	325	325	0	23.78
WEEKDAY, OB	13	357	357	0	23.53
WEEKDAY, OB	14	347	347	0	23.61
WEEKDAY, OB	15	367	367	0	23.45
WEEKDAY, OB	16	446	446	0	22.76
WEEKDAY, OB	17	511	511	0	22.14
WEEKDAY, OB	18	516	516	0	22.06
WEEKDAY, OB	19	351	351	0	23.53
WEEKDAY, OB	20	257	257	0	24.20
WEEKDAY, OB	21	209	209	0	24.48
WEEKDAY, OB	22	183	183	0	24.62
WEEKDAY, OB	23	134	134	0	24.81
WEEKDAY, OB	24	100	100	0	24.91
WEEKEND	1	85	85	0	24.96
WEEKEND	2	57	57	0	25.02
WEEKEND	3	38	38	0	25.05
WEEKEND	4	24	24	0	25.06
WEEKEND	5	21	21	0	25.06
WEEKEND	6	34	34	0	25.05
WEEKEND	7	69	69	0	24.95
WEEKEND	8	102	102	0	24.79
WEEKEND	9	143	143	0	24.69
WEEKEND	10	197	197	0	24.47
WEEKEND	11	253	253	0	24.18
WEEKEND	12	287	287	0	23.97
WEEKEND	13	319	319	0	23.76
WEEKEND	14	321	321	0	23.76
WEEKEND	15	320	320	0	23.76
WEEKEND	16	320	320	0	23.76
WEEKEND	17	308	308	0	23.84
WEEKEND	18	286	286	0	23.98
WEEKEND	19	253	253	0	24.21
WEEKEND	20	213	213	0	24.45
WEEKEND	21	179	179	0	24.61
WEEKEND	22	154	154	0	24.72
WEEKEND	23	126	126	0	24.82
WEEKEND	24	94	94	0	24.91

SIGNALIZED ARTERIALS. AADT/C = 7

SIGNALS/MILE = 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	43	43	0	25.04
WEEKDAY, IB	2	26	26	0	25.06
WEEKDAY, IB	3	19	19	0	25.06
WEEKDAY, IB	4	17	17	0	25.07
WEEKDAY, IB	5	29	29	0	25.06
WEEKDAY, IB	6	93	93	0	24.95
WEEKDAY, IB	7	282	282	0	24.07
WEEKDAY, IB	8	513	513	0	22.09
WEEKDAY, IB	9	433	433	0	22.88
WEEKDAY, IB	10	331	331	0	23.75
WEEKDAY, IB	11	329	329	0	23.75
WEEKDAY, IB	12	362	362	0	23.49
WEEKDAY, IB	13	402	402	0	23.15
WEEKDAY, IB	14	392	392	0	23.23
WEEKDAY, IB	15	399	399	0	23.18
WEEKDAY, IB	16	425	425	0	22.96
WEEKDAY, IB	17	432	432	0	22.90
WEEKDAY, IB	18	412	412	0	23.06
WEEKDAY, IB	19	338	338	0	23.64
WEEKDAY, IB	20	269	269	0	24.11
WEEKDAY, IB	21	217	217	0	24.44
WEEKDAY, IB	22	188	188	0	24.59
WEEKDAY, IB	23	136	136	0	24.80
WEEKDAY, IB	24	92	92	0	24.94
WEEKDAY, OB	1	58	58	0	25.02
WEEKDAY, OB	2	35	35	0	25.05
WEEKDAY, OB	3	23	23	0	25.06
WEEKDAY, OB	4	18	18	0	25.07
WEEKDAY, OB	5	22	22	0	25.06
WEEKDAY, OB	6	52	52	0	25.03
WEEKDAY, OB	7	149	149	0	24.78
WEEKDAY, OB	8	285	285	0	24.07
WEEKDAY, OB	9	291	291	0	24.04
WEEKDAY, OB	10	286	286	0	24.07
WEEKDAY, OB	11	322	322	0	23.80
WEEKDAY, OB	12	377	377	0	23.36
WEEKDAY, OB	13	423	423	0	22.96
WEEKDAY, OB	14	405	405	0	23.13
WEEKDAY, OB	15	429	429	0	22.91
WEEKDAY, OB	16	514	514	0	22.09
WEEKDAY, OB	17	596	596	0	21.20
WEEKDAY, OB	18	607	607	0	20.98
WEEKDAY, OB	19	404	405	0	23.04
WEEKDAY, OB	20	302	302	0	23.89
WEEKDAY, OB	21	243	243	0	24.27
WEEKDAY, OB	22	214	214	0	24.46
WEEKDAY, OB	23	158	158	0	24.72
WEEKDAY, OB	24	118	118	0	24.85
WEEKEND	1	99	99	0	24.92
WEEKEND	2	66	66	0	25.00
WEEKEND	3	44	44	0	25.04
WEEKEND	4	28	28	0	25.06
WEEKEND	5	25	25	0	25.06
WEEKEND	6	39	39	0	25.04
WEEKEND	7	75	75	0	24.93
WEEKEND	8	118	118	0	24.70
WEEKEND	9	167	167	0	24.52
WEEKEND	10	230	230	0	24.26
WEEKEND	11	288	288	0	23.91
WEEKEND	12	332	332	0	23.61
WEEKEND	13	373	373	0	23.32
WEEKEND	14	379	379	0	23.28
WEEKEND	15	370	370	0	23.37
WEEKEND	16	376	376	0	23.27
WEEKEND	17	362	362	0	23.39
WEEKEND	18	336	336	0	23.59
WEEKEND	19	299	299	0	23.89
WEEKEND	20	255	255	0	24.18
WEEKEND	21	209	209	0	24.43
WEEKEND	22	179	179	0	24.61
WEEKEND	23	144	144	0	24.75
WEEKEND	24	111	111	0	24.86

SIGNALIZED ARTERIALS. AADT/C = 8

SIGNALS/MILE = 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHs)	SPEED
WEEKDAY, IB	1	51	51	0	25.03
WEEKDAY, IB	2	32	32	0	25.05
WEEKDAY, IB	3	23	23	0	25.06
WEEKDAY, IB	4	22	22	0	25.06
WEEKDAY, IB	5	37	37	0	25.05
WEEKDAY, IB	6	111	111	0	24.90
WEEKDAY, IB	7	325	325	0	23.76
WEEKDAY, IB	8	568	568	0	21.52
WEEKDAY, IB	9	488	488	0	22.36
WEEKDAY, IB	10	382	382	0	23.34
WEEKDAY, IB	11	380	380	0	23.35
WEEKDAY, IB	12	416	416	0	23.02
WEEKDAY, IB	13	456	456	0	22.64
WEEKDAY, IB	14	446	446	0	22.74
WEEKDAY, IB	15	454	454	0	22.68
WEEKDAY, IB	16	479	479	0	22.45
WEEKDAY, IB	17	494	494	0	22.31
WEEKDAY, IB	18	482	482	0	22.41
WEEKDAY, IB	19	385	385	0	23.25
WEEKDAY, IB	20	307	307	0	23.84
WEEKDAY, IB	21	247	247	0	24.26
WEEKDAY, IB	22	214	214	0	24.46
WEEKDAY, IB	23	158	158	0	24.71
WEEKDAY, IB	24	107	107	0	24.90
WEEKDAY, OB	1	67	67	0	25.00
WEEKDAY, OB	2	39	39	0	25.05
WEEKDAY, OB	3	26	26	0	25.06
WEEKDAY, OB	4	21	21	0	25.06
WEEKDAY, OB	5	26	26	0	25.06
WEEKDAY, OB	6	63	63	0	25.02
WEEKDAY, OB	7	176	176	0	24.67
WEEKDAY, OB	8	333	333	0	23.73
WEEKDAY, OB	9	338	338	0	23.70
WEEKDAY, OB	10	330	330	0	23.76
WEEKDAY, OB	11	364	364	0	23.48
WEEKDAY, OB	12	431	431	0	22.88
WEEKDAY, OB	13	477	477	0	22.45
WEEKDAY, OB	14	459	459	0	22.61
WEEKDAY, OB	15	486	486	0	22.36
WEEKDAY, OB	16	576	576	0	21.44
WEEKDAY, OB	17	663	661	1	20.14
WEEKDAY, OB	18	673	672	2	19.52
WEEKDAY, OB	19	467	469	0	22.11
WEEKDAY, OB	20	349	349	0	23.51
WEEKDAY, OB	21	288	288	0	23.98
WEEKDAY, OB	22	249	249	0	24.24
WEEKDAY, OB	23	182	182	0	24.60
WEEKDAY, OB	24	131	131	0	24.80
WEEKEND	1	112	112	0	24.88
WEEKEND	2	76	76	0	24.98
WEEKEND	3	50	50	0	25.03
WEEKEND	4	32	32	0	25.05
WEEKEND	5	27	27	0	25.06
WEEKEND	6	46	46	0	25.03
WEEKEND	7	87	87	0	24.88
WEEKEND	8	140	140	0	24.49
WEEKEND	9	194	194	0	24.32
WEEKEND	10	265	265	0	23.99
WEEKEND	11	334	334	0	23.55
WEEKEND	12	382	382	0	23.15
WEEKEND	13	428	428	0	22.82
WEEKEND	14	429	429	0	22.82
WEEKEND	15	425	425	0	22.86
WEEKEND	16	425	425	0	22.84
WEEKEND	17	417	417	0	22.86
WEEKEND	18	388	388	0	23.12
WEEKEND	19	341	341	0	23.54
WEEKEND	20	289	289	0	23.93
WEEKEND	21	236	236	0	24.29
WEEKEND	22	208	208	0	24.45
WEEKEND	23	166	166	0	24.64
WEEKEND	24	128	128	0	24.78

SIGNALIZED ARTERIALS, AADT/C = 9

SIGNALS/MILE = 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	59	59	0	25.02
WEEKDAY, IB	2	37	37	0	25.05
WEEKDAY, IB	3	28	28	0	25.06
WEEKDAY, IB	4	26	26	0	25.06
WEEKDAY, IB	5	44	44	0	25.04
WEEKDAY, IB	6	129	129	0	24.84
WEEKDAY, IB	7	379	379	0	23.33
WEEKDAY, IB	8	621	621	0	20.92
WEEKDAY, IB	9	549	549	0	21.74
WEEKDAY, IB	10	434	434	0	22.87
WEEKDAY, IB	11	430	430	0	22.90
WEEKDAY, IB	12	463	463	0	22.58
WEEKDAY, IB	13	509	509	0	22.11
WEEKDAY, IB	14	504	504	0	22.18
WEEKDAY, IB	15	508	508	0	22.14
WEEKDAY, IB	16	541	541	0	21.81
WEEKDAY, IB	17	565	565	0	21.58
WEEKDAY, IB	18	556	556	0	21.65
WEEKDAY, IB	19	444	444	0	22.72
WEEKDAY, IB	20	352	352	0	23.46
WEEKDAY, IB	21	280	280	0	24.03
WEEKDAY, IB	22	243	243	0	24.29
WEEKDAY, IB	23	178	178	0	24.62
WEEKDAY, IB	24	119	119	0	24.85
WEEKDAY, OB	1	76	76	0	24.98
WEEKDAY, OB	2	44	44	0	25.04
WEEKDAY, OB	3	29	29	0	25.06
WEEKDAY, OB	4	24	24	0	25.06
WEEKDAY, OB	5	32	32	0	25.06
WEEKDAY, OB	6	77	77	0	24.99
WEEKDAY, OB	7	204	204	0	24.54
WEEKDAY, OB	8	385	385	0	23.31
WEEKDAY, OB	9	385	385	0	23.32
WEEKDAY, OB	10	371	371	0	23.43
WEEKDAY, OB	11	409	409	0	23.09
WEEKDAY, OB	12	477	477	0	22.44
WEEKDAY, OB	13	526	526	0	21.95
WEEKDAY, OB	14	518	518	0	22.03
WEEKDAY, OB	15	542	542	0	21.77
WEEKDAY, OB	16	632	631	1	20.52
WEEKDAY, OB	17	724	720	5	18.35
WEEKDAY, OB	18	734	731	8	17.08
WEEKDAY, OB	19	534	542	0	20.49
WEEKDAY, OB	20	407	407	0	22.96
WEEKDAY, OB	21	334	334	0	23.62
WEEKDAY, OB	22	286	286	0	23.99
WEEKDAY, OB	23	201	201	0	24.50
WEEKDAY, OB	24	144	144	0	24.75
WEEKEND	1	125	125	0	24.84
WEEKEND	2	87	87	0	24.96
WEEKEND	3	56	56	0	25.02
WEEKEND	4	36	36	0	25.05
WEEKEND	5	31	31	0	25.05
WEEKEND	6	49	49	0	25.02
WEEKEND	7	97	97	0	24.85
WEEKEND	8	151	151	0	24.42
WEEKEND	9	219	219	0	24.18
WEEKEND	10	295	295	0	23.75
WEEKEND	11	369	369	0	23.23
WEEKEND	12	434	434	0	22.68
WEEKEND	13	484	484	0	22.23
WEEKEND	14	482	482	0	22.29
WEEKEND	15	482	482	0	22.30
WEEKEND	16	480	479	0	22.25
WEEKEND	17	470	470	0	22.31
WEEKEND	18	434	434	0	22.67
WEEKEND	19	381	381	0	23.20
WEEKEND	20	323	323	0	23.67
WEEKEND	21	266	266	0	24.10
WEEKEND	22	230	230	0	24.31
WEEKEND	23	184	184	0	24.54
WEEKEND	24	141	141	0	24.72

SIGNALIZED ARTERIALS, AADT/C = 10

SIGNALS/MILE = 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	68	68	0	25.00
WEEKDAY, IB	2	41	41	0	25.04
WEEKDAY, IB	3	31	31	0	25.06
WEEKDAY, IB	4	30	30	0	25.06
WEEKDAY, IB	5	53	53	0	25.03
WEEKDAY, IB	6	156	156	0	24.74
WEEKDAY, IB	7	434	434	0	22.83
WEEKDAY, IB	8	675	674	1	19.90
WEEKDAY, IB	9	594	596	0	21.03
WEEKDAY, IB	10	476	476	0	22.46
WEEKDAY, IB	11	472	472	0	22.50
WEEKDAY, IB	12	516	516	0	22.05
WEEKDAY, IB	13	556	556	0	21.65
WEEKDAY, IB	14	558	558	0	21.62
WEEKDAY, IB	15	567	567	0	21.52
WEEKDAY, IB	16	604	604	0	21.07
WEEKDAY, IB	17	621	621	0	20.86
WEEKDAY, IB	18	610	610	0	20.94
WEEKDAY, IB	19	499	499	0	22.10
WEEKDAY, IB	20	398	398	0	23.07
WEEKDAY, IB	21	318	318	0	23.76
WEEKDAY, IB	22	269	269	0	24.11
WEEKDAY, IB	23	205	205	0	24.48
WEEKDAY, IB	24	139	139	0	24.77
WEEKDAY, OB	1	85	85	0	24.96
WEEKDAY, OB	2	49	49	0	25.03
WEEKDAY, OB	3	34	34	0	25.05
WEEKDAY, OB	4	28	28	0	25.06
WEEKDAY, OB	5	39	39	0	25.05
WEEKDAY, OB	6	97	97	0	24.94
WEEKDAY, OB	7	255	255	0	24.25
WEEKDAY, OB	8	452	452	0	22.70
WEEKDAY, OB	9	453	453	0	22.71
WEEKDAY, OB	10	423	423	0	22.97
WEEKDAY, OB	11	457	457	0	22.65
WEEKDAY, OB	12	526	526	0	21.93
WEEKDAY, OB	13	582	582	0	21.32
WEEKDAY, OB	14	571	571	0	21.42
WEEKDAY, OB	15	597	597	0	21.06
WEEKDAY, OB	16	695	692	3	19.21
WEEKDAY, OB	17	766	755	13	16.12
WEEKDAY, OB	18	772	762	24	14.05
WEEKDAY, OB	19	576	598	2	17.59
WEEKDAY, OB	20	450	452	0	22.25
WEEKDAY, OB	21	367	367	0	23.35
WEEKDAY, OB	22	316	316	0	23.76
WEEKDAY, OB	23	227	227	0	24.34
WEEKDAY, OB	24	164	164	0	24.66
WEEKEND	1	141	141	0	24.77
WEEKEND	2	96	96	0	24.93
WEEKEND	3	63	63	0	25.01
WEEKEND	4	40	40	0	25.05
WEEKEND	5	35	35	0	25.05
WEEKEND	6	56	56	0	25.00
WEEKEND	7	111	111	0	24.77
WEEKEND	8	170	170	0	24.34
WEEKEND	9	242	242	0	23.86
WEEKEND	10	330	330	0	23.37
WEEKEND	11	413	413	0	22.78
WEEKEND	12	482	482	0	22.12
WEEKEND	13	531	531	0	21.62
WEEKEND	14	533	533	0	21.64
WEEKEND	15	536	535	0	21.55
WEEKEND	16	530	529	1	21.37
WEEKEND	17	513	513	1	21.56
WEEKEND	18	479	479	0	22.11
WEEKEND	19	428	428	0	22.73
WEEKEND	20	357	357	0	23.39
WEEKEND	21	298	298	0	23.85
WEEKEND	22	258	258	0	24.11
WEEKEND	23	207	207	0	24.41
WEEKEND	24	157	157	0	24.65

SIGNALIZED ARTERIALS, AADT/C = 11

SIGNALS/MILE = 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	78	78	0	24.98
WEEKDAY, IB	2	46	46	0	25.04
WEEKDAY, IB	3	35	35	0	25.05
WEEKDAY, IB	4	33	33	0	25.05
WEEKDAY, IB	5	62	62	0	25.02
WEEKDAY, IB	6	188	188	0	24.60
WEEKDAY, IB	7	492	492	0	22.27
WEEKDAY, IB	8	721	716	4	18.68
WEEKDAY, IB	9	630	634	1	20.01
WEEKDAY, IB	10	514	515	0	21.98
WEEKDAY, IB	11	514	514	0	22.08
WEEKDAY, IB	12	559	559	0	21.55
WEEKDAY, IB	13	604	604	0	20.93
WEEKDAY, IB	14	609	609	0	20.99
WEEKDAY, IB	15	629	629	1	20.56
WEEKDAY, IB	16	667	666	1	19.98
WEEKDAY, IB	17	684	684	1	19.72
WEEKDAY, IB	18	676	675	2	19.58
WEEKDAY, IB	19	547	549	0	21.23
WEEKDAY, IB	20	447	448	0	22.55
WEEKDAY, IB	21	349	349	0	23.50
WEEKDAY, IB	22	302	302	0	23.85
WEEKDAY, IB	23	235	235	0	24.29
WEEKDAY, IB	24	156	156	0	24.70
WEEKDAY, OB	1	96	96	0	24.93
WEEKDAY, OB	2	55	55	0	25.02
WEEKDAY, OB	3	38	38	0	25.05
WEEKDAY, OB	4	33	33	0	25.05
WEEKDAY, OB	5	47	47	0	25.04
WEEKDAY, OB	6	120	120	0	24.87
WEEKDAY, OB	7	306	306	0	23.90
WEEKDAY, OB	8	522	522	0	22.02
WEEKDAY, OB	9	523	523	0	22.01
WEEKDAY, OB	10	477	477	0	22.47
WEEKDAY, OB	11	506	506	0	22.16
WEEKDAY, OB	12	574	574	0	21.42
WEEKDAY, OB	13	632	632	1	20.60
WEEKDAY, OB	14	619	619	0	20.68
WEEKDAY, OB	15	662	661	1	20.01
WEEKDAY, OB	16	753	744	10	17.01
WEEKDAY, OB	17	806	784	33	13.36
WEEKDAY, OB	18	803	789	46	11.53
WEEKDAY, OB	19	616	654	8	14.49
WEEKDAY, OB	20	497	505	0	20.73
WEEKDAY, OB	21	412	413	0	22.90
WEEKDAY, OB	22	351	351	0	23.48
WEEKDAY, OB	23	253	253	0	24.17
WEEKDAY, OB	24	184	184	0	24.56
WEEKEND	1	155	155	0	24.71
WEEKEND	2	104	104	0	24.91
WEEKEND	3	69	69	0	25.00
WEEKEND	4	44	44	0	25.04
WEEKEND	5	39	39	0	25.04
WEEKEND	6	62	62	0	24.99
WEEKEND	7	120	120	0	24.72
WEEKEND	8	184	184	0	24.21
WEEKEND	9	264	264	0	23.86
WEEKEND	10	358	357	0	22.90
WEEKEND	11	458	458	0	22.25
WEEKEND	12	528	528	1	21.38
WEEKEND	13	592	591	2	20.41
WEEKEND	14	585	586	1	20.39
WEEKEND	15	580	581	1	20.83
WEEKEND	16	581	581	1	20.83
WEEKEND	17	573	573	1	20.67
WEEKEND	18	530	531	1	21.12
WEEKEND	19	462	462	0	22.17
WEEKEND	20	396	396	0	23.00
WEEKEND	21	327	327	0	23.62
WEEKEND	22	283	283	0	23.94
WEEKEND	23	231	231	0	24.27
WEEKEND	24	176	176	0	24.53

SIGNALIZED ARTERIALS, AADT/C = 12

SIGNALS/MILE = 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	88	88	0	24.95
WEEKDAY, IB	2	52	52	0	25.03
WEEKDAY, IB	3	39	39	0	25.05
WEEKDAY, IB	4	37	37	0	25.05
WEEKDAY, IB	5	71	71	0	25.00
WEEKDAY, IB	6	221	221	0	24.42
WEEKDAY, IB	7	550	550	0	21.64
WEEKDAY, IB	8	765	753	12	16.68
WEEKDAY, IB	9	663	673	2	18.12
WEEKDAY, IB	10	554	556	0	21.41
WEEKDAY, IB	11	562	562	0	21.58
WEEKDAY, IB	12	604	604	0	21.12
WEEKDAY, IB	13	652	651	1	20.16
WEEKDAY, IB	14	659	659	2	19.76
WEEKDAY, IB	15	689	688	2	19.28
WEEKDAY, IB	16	726	723	5	18.07
WEEKDAY, IB	17	742	738	9	16.74
WEEKDAY, IB	18	728	728	9	16.46
WEEKDAY, IB	19	604	612	1	19.08
WEEKDAY, IB	20	482	483	0	22.05
WEEKDAY, IB	21	392	392	0	23.13
WEEKDAY, IB	22	337	337	0	23.60
WEEKDAY, IB	23	263	263	0	24.12
WEEKDAY, IB	24	178	178	0	24.59
WEEKDAY, OB	1	105	105	0	24.91
WEEKDAY, OB	2	61	61	0	25.01
WEEKDAY, OB	3	44	44	0	25.04
WEEKDAY, OB	4	38	38	0	25.05
WEEKDAY, OB	5	57	57	0	25.02
WEEKDAY, OB	6	142	142	0	24.80
WEEKDAY, OB	7	373	373	0	23.38
WEEKDAY, OB	8	600	600	0	21.14
WEEKDAY, OB	9	596	596	0	21.21
WEEKDAY, OB	10	528	528	0	21.95
WEEKDAY, OB	11	553	553	0	21.63
WEEKDAY, OB	12	620	620	0	20.75
WEEKDAY, OB	13	665	663	2	19.73
WEEKDAY, OB	14	667	667	2	19.59
WEEKDAY, OB	15	721	717	6	18.05
WEEKDAY, OB	16	813	786	33	13.48
WEEKDAY, OB	17	840	807	66	10.54
WEEKDAY, OB	18	825	806	85	9.53
WEEKDAY, OB	19	670	723	32	11.15
WEEKDAY, OB	20	541	569	4	16.70
WEEKDAY, OB	21	450	453	0	21.88
WEEKDAY, OB	22	391	391	0	23.11
WEEKDAY, OB	23	279	279	0	23.98
WEEKDAY, OB	24	209	209	0	24.39
WEEKEND	1	168	168	0	24.65
WEEKEND	2	113	113	0	24.88
WEEKEND	3	74	74	0	24.98
WEEKEND	4	49	49	0	25.03
WEEKEND	5	41	41	0	25.04
WEEKEND	6	67	67	0	24.98
WEEKEND	7	132	132	0	24.67
WEEKEND	8	205	205	0	23.96
WEEKEND	9	284	284	0	23.61
WEEKEND	10	389	389	0	22.89
WEEKEND	11	503	501	2	21.06
WEEKEND	12	580	578	3	19.79
WEEKEND	13	640	637	7	18.55
WEEKEND	14	642	644	5	18.49
WEEKEND	15	644	643	6	18.45
WEEKEND	16	634	634	5	18.36
WEEKEND	17	621	621	6	18.48
WEEKEND	18	580	583	3	19.29
WEEKEND	19	505	507	0	21.32
WEEKEND	20	432	432	0	22.69
WEEKEND	21	357	357	0	23.36
WEEKEND	22	308	308	0	23.72
WEEKEND	23	247	247	0	24.13
WEEKEND	24	189	189	0	24.44

SIGNALIZED ARTERIALS, AADT/C - 13

SIGNALS/MILE - 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	124	124	0	24.84
WEEKDAY, IB	2	90	90	0	24.95
WEEKDAY, IB	3	77	77	0	24.98
WEEKDAY, IB	4	75	75	0	24.99
WEEKDAY, IB	5	109	109	0	24.90
WEEKDAY, IB	6	258	258	0	24.19
WEEKDAY, IB	7	580	579	0	21.21
WEEKDAY, IB	8	795	772	24	14.96
WEEKDAY, IB	9	692	710	5	15.73
WEEKDAY, IB	10	585	590	0	20.53
WEEKDAY, IB	11	597	597	0	21.17
WEEKDAY, IB	12	637	637	0	20.60
WEEKDAY, IB	13	687	684	4	19.12
WEEKDAY, IB	14	688	688	3	18.73
WEEKDAY, IB	15	720	716	7	17.62
WEEKDAY, IB	16	762	754	15	15.61
WEEKDAY, IB	17	778	769	24	13.91
WEEKDAY, IB	18	762	762	24	13.49
WEEKDAY, IB	19	635	652	6	16.26
WEEKDAY, IB	20	530	535	0	20.57
WEEKDAY, IB	21	425	426	0	22.75
WEEKDAY, IB	22	365	365	0	23.37
WEEKDAY, IB	23	296	296	0	23.86
WEEKDAY, IB	24	209	209	0	24.41
WEEKDAY, OB	1	140	140	0	24.78
WEEKDAY, OB	2	99	99	0	24.92
WEEKDAY, OB	3	81	81	0	24.98
WEEKDAY, OB	4	76	76	0	24.99
WEEKDAY, OB	5	94	94	0	24.95
WEEKDAY, OB	6	179	179	0	24.64
WEEKDAY, OB	7	405	405	0	23.10
WEEKDAY, OB	8	631	631	0	20.77
WEEKDAY, OB	9	632	633	0	20.74
WEEKDAY, OB	10	564	564	0	21.55
WEEKDAY, OB	11	584	584	0	21.29
WEEKDAY, OB	12	654	653	2	20.09
WEEKDAY, OB	13	709	706	5	18.36
WEEKDAY, OB	14	702	701	6	17.71
WEEKDAY, OB	15	753	746	12	16.13
WEEKDAY, OB	16	838	802	49	11.90
WEEKDAY, OB	17	874	819	104	9.03
WEEKDAY, OB	18	865	822	147	8.10
WEEKDAY, OB	19	704	772	78	9.03
WEEKDAY, OB	20	570	632	15	13.04
WEEKDAY, OB	21	484	498	1	19.34
WEEKDAY, OB	22	426	427	0	22.57
WEEKDAY, OB	23	314	314	0	23.71
WEEKDAY, OB	24	245	245	0	24.15
WEEKEND	1	203	203	0	24.45
WEEKEND	2	150	150	0	24.74
WEEKEND	3	113	113	0	24.88
WEEKEND	4	86	86	0	24.96
WEEKEND	5	79	79	0	24.96
WEEKEND	6	102	102	0	24.86
WEEKEND	7	166	166	0	24.46
WEEKEND	8	237	237	0	23.40
WEEKEND	9	323	323	1	22.80
WEEKEND	10	436	436	1	21.97
WEEKEND	11	540	538	3	20.38
WEEKEND	12	610	607	6	18.85
WEEKEND	13	672	668	9	17.29
WEEKEND	14	670	671	8	17.11
WEEKEND	15	666	666	8	17.45
WEEKEND	16	675	672	11	16.99
WEEKEND	17	658	654	15	16.59
WEEKEND	18	612	618	9	17.42
WEEKEND	19	542	549	1	19.80
WEEKEND	20	459	461	0	22.18
WEEKEND	21	395	395	0	22.81
WEEKEND	22	346	346	0	23.41
WEEKEND	23	288	288	0	23.85
WEEKEND	24	227	227	0	24.16

SIGNALIZED ARTERIALS, AADT/C - 14

SIGNALS/MILE - 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	161	161	0	24.69
WEEKDAY, IB	2	130	130	0	24.81
WEEKDAY, IB	3	118	118	0	24.87
WEEKDAY, IB	4	117	117	0	24.87
WEEKDAY, IB	5	151	151	0	24.76
WEEKDAY, IB	6	293	293	0	23.95
WEEKDAY, IB	7	613	612	1	20.70
WEEKDAY, IB	8	825	790	35	13.51
WEEKDAY, IB	9	729	748	16	13.42
WEEKDAY, IB	10	624	639	1	18.20
WEEKDAY, IB	11	628	629	0	20.53
WEEKDAY, IB	12	673	672	2	19.66
WEEKDAY, IB	13	714	710	6	18.08
WEEKDAY, IB	14	719	716	9	17.02
WEEKDAY, IB	15	751	745	15	15.65
WEEKDAY, IB	16	788	776	27	13.64
WEEKDAY, IB	17	805	790	42	11.96
WEEKDAY, IB	18	789	785	46	11.39
WEEKDAY, IB	19	662	694	14	13.61
WEEKDAY, IB	20	559	571	1	18.81
WEEKDAY, IB	21	465	466	0	22.16
WEEKDAY, IB	22	403	403	0	22.99
WEEKDAY, IB	23	338	338	0	23.51
WEEKDAY, IB	24	253	253	0	24.11
WEEKDAY, OB	1	181	181	0	24.59
WEEKDAY, OB	2	137	137	0	24.78
WEEKDAY, OB	3	123	123	0	24.85
WEEKDAY, OB	4	117	117	0	24.87
WEEKDAY, OB	5	135	135	0	24.82
WEEKDAY, OB	6	220	220	0	24.43
WEEKDAY, OB	7	440	440	0	22.78
WEEKDAY, OB	8	663	662	1	20.14
WEEKDAY, OB	9	664	664	1	19.98
WEEKDAY, OB	10	595	596	0	21.10
WEEKDAY, OB	11	613	613	0	20.97
WEEKDAY, OB	12	688	684	3	19.20
WEEKDAY, OB	13	736	729	10	16.95
WEEKDAY, OB	14	733	732	12	15.86
WEEKDAY, OB	15	777	766	23	14.24
WEEKDAY, OB	16	877	813	87	10.05
WEEKDAY, OB	17	897	827	157	8.06
WEEKDAY, OB	18	882	827	213	7.48
WEEKDAY, OB	19	730	800	143	7.86
WEEKDAY, OB	20	611	704	50	10.13
WEEKDAY, OB	21	516	559	7	15.31
WEEKDAY, OB	22	457	463	1	21.04
WEEKDAY, OB	23	349	350	0	23.22
WEEKDAY, OB	24	281	281	0	23.91
WEEKEND	1	248	248	0	24.18
WEEKEND	2	190	190	0	24.54
WEEKEND	3	155	155	0	24.71
WEEKEND	4	127	127	0	24.82
WEEKEND	5	120	120	0	24.83
WEEKEND	6	147	147	0	24.62
WEEKEND	7	204	204	0	24.08
WEEKEND	8	279	276	3	22.45
WEEKEND	9	358	358	3	21.40
WEEKEND	10	467	469	1	21.17
WEEKEND	11	566	562	5	19.57
WEEKEND	12	645	638	12	17.39
WEEKEND	13	708	701	20	15.34
WEEKEND	14	703	705	17	15.02
WEEKEND	15	709	710	16	15.21
WEEKEND	16	707	703	20	15.08
WEEKEND	17	687	688	19	15.18
WEEKEND	18	642	646	15	16.08
WEEKEND	19	572	583	4	18.18
WEEKEND	20	501	504	1	21.07
WEEKEND	21	432	433	0	22.41
WEEKEND	22	382	382	0	23.07
WEEKEND	23	327	327	0	23.46
WEEKEND	24	267	267	0	23.85

SIGNALIZED ARTERIALS, AADT/C = 15

SIGNALS/MILE = 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	213	213	0	24.40
WEEKDAY, IB	2	177	177	0	24.60
WEEKDAY, IB	3	164	164	0	24.68
WEEKDAY, IB	4	166	166	0	24.68
WEEKDAY, IB	5	198	198	0	24.53
WEEKDAY, IB	6	340	340	0	23.59
WEEKDAY, IB	7	642	641	1	20.23
WEEKDAY, IB	8	850	802	49	12.39
WEEKDAY, IB	9	751	772	29	11.71
WEEKDAY, IB	10	647	672	4	16.05
WEEKDAY, IB	11	656	659	2	19.20
WEEKDAY, IB	12	696	693	5	18.47
WEEKDAY, IB	13	742	736	11	16.61
WEEKDAY, IB	14	749	744	16	15.22
WEEKDAY, IB	15	780	769	28	13.63
WEEKDAY, IB	16	818	794	51	11.52
WEEKDAY, IB	17	825	805	72	10.21
WEEKDAY, IB	18	813	801	84	9.77
WEEKDAY, IB	19	694	734	43	11.04
WEEKDAY, IB	20	588	620	12	14.94
WEEKDAY, IB	21	501	513	0	19.93
WEEKDAY, IB	22	442	442	0	22.63
WEEKDAY, IB	23	372	372	0	23.20
WEEKDAY, IB	24	302	302	0	23.74
WEEKDAY, OB	1	228	228	0	24.31
WEEKDAY, OB	2	186	186	0	24.55
WEEKDAY, OB	3	170	170	0	24.65
WEEKDAY, OB	4	165	165	0	24.69
WEEKDAY, OB	5	183	183	0	24.60
WEEKDAY, OB	6	265	265	0	24.14
WEEKDAY, OB	7	478	478	0	22.39
WEEKDAY, OB	8	691	688	2	19.42
WEEKDAY, OB	9	691	692	2	19.24
WEEKDAY, OB	10	623	625	0	20.58
WEEKDAY, OB	11	644	644	1	20.28
WEEKDAY, OB	12	708	704	5	18.58
WEEKDAY, OB	13	765	753	16	15.67
WEEKDAY, OB	14	759	755	20	14.18
WEEKDAY, OB	15	802	784	38	12.41
WEEKDAY, OB	16	886	820	104	9.37
WEEKDAY, OB	17	920	829	196	7.68
WEEKDAY, OB	18	905	830	271	7.19
WEEKDAY, OB	19	757	813	215	7.47
WEEKDAY, OB	20	640	746	109	8.75
WEEKDAY, OB	21	553	634	28	11.87
WEEKDAY, OB	22	491	516	3	17.66
WEEKDAY, OB	23	392	395	0	22.51
WEEKDAY, OB	24	321	321	0	23.55
WEEKEND	1	286	286	0	23.88
WEEKEND	2	237	237	0	24.24
WEEKEND	3	203	203	0	24.46
WEEKEND	4	173	173	0	24.61
WEEKEND	5	168	168	0	24.60
WEEKEND	6	190	190	0	24.35
WEEKEND	7	250	250	0	23.35
WEEKEND	8	313	312	2	22.06
WEEKEND	9	400	398	4	20.83
WEEKEND	10	494	493	4	19.99
WEEKEND	11	586	583	7	18.73
WEEKEND	12	669	659	17	16.29
WEEKEND	13	732	721	28	14.17
WEEKEND	14	733	730	31	13.35
WEEKEND	15	728	727	31	13.37
WEEKEND	16	727	726	33	13.27
WEEKEND	17	713	713	33	13.33
WEEKEND	18	671	679	24	14.15
WEEKEND	19	606	621	9	16.27
WEEKEND	20	538	543	3	19.40
WEEKEND	21	461	464	0	21.59
WEEKEND	22	414	415	0	22.67
WEEKEND	23	373	372	0	22.88
WEEKEND	24	307	307	0	23.40

SIGNALIZED ARTERIALS, AADT/C - 16

SIGNALS/MILE - 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	265	265	0	24.04
WEEKDAY, IB	2	231	231	0	24.29
WEEKDAY, IB	3	221	221	0	24.37
WEEKDAY, IB	4	219	219	0	24.41
WEEKDAY, IB	5	248	248	0	24.23
WEEKDAY, IB	6	380	380	0	23.25
WEEKDAY, IB	7	674	670	4	19.27
WEEKDAY, IB	8	870	810	63	11.54
WEEKDAY, IB	9	777	791	49	10.47
WEEKDAY, IB	10	676	712	14	13.56
WEEKDAY, IB	11	681	689	6	17.09
WEEKDAY, IB	12	730	725	11	16.59
WEEKDAY, IB	13	767	755	22	14.37
WEEKDAY, IB	14	772	764	31	13.14
WEEKDAY, IB	15	792	782	41	12.00
WEEKDAY, IB	16	834	807	68	10.38
WEEKDAY, IB	17	840	814	94	9.23
WEEKDAY, IB	18	830	812	112	8.74
WEEKDAY, IB	19	728	769	71	9.61
WEEKDAY, IB	20	618	665	24	12.81
WEEKDAY, IB	21	536	555	4	17.89
WEEKDAY, IB	22	481	485	1	21.39
WEEKDAY, IB	23	422	422	0	22.65
WEEKDAY, IB	24	344	344	0	23.34
WEEKDAY, OB	1	278	278	0	23.95
WEEKDAY, OB	2	238	238	0	24.24
WEEKDAY, OB	3	226	226	0	24.35
WEEKDAY, OB	4	218	218	0	24.41
WEEKDAY, OB	5	236	236	0	24.32
WEEKDAY, OB	6	314	314	0	23.80
WEEKDAY, OB	7	515	515	0	22.03
WEEKDAY, OB	8	718	713	5	18.51
WEEKDAY, OB	9	721	721	5	17.82
WEEKDAY, OB	10	656	660	1	19.27
WEEKDAY, OB	11	676	676	2	19.56
WEEKDAY, OB	12	736	727	11	17.11
WEEKDAY, OB	13	781	765	27	13.92
WEEKDAY, OB	14	779	772	34	12.49
WEEKDAY, OB	15	822	794	61	10.87
WEEKDAY, OB	16	906	825	142	8.54
WEEKDAY, OB	17	937	831	248	7.32
WEEKDAY, OB	18	920	832	336	6.97
WEEKDAY, OB	19	776	825	287	7.06
WEEKDAY, OB	20	664	786	165	7.82
WEEKDAY, OB	21	593	695	63	9.98
WEEKDAY, OB	22	527	580	10	14.51
WEEKDAY, OB	23	432	441	1	20.90
WEEKDAY, OB	24	368	368	0	22.88
WEEKEND	1	342	342	0	23.41
WEEKEND	2	287	287	0	23.85
WEEKEND	3	255	255	0	24.13
WEEKEND	4	225	225	0	24.31
WEEKEND	5	225	225	0	24.25
WEEKEND	6	246	246	0	23.83
WEEKEND	7	298	296	1	22.37
WEEKEND	8	363	358	6	20.43
WEEKEND	9	453	451	8	19.27
WEEKEND	10	537	539	6	18.62
WEEKEND	11	622	616	12	17.33
WEEKEND	12	704	689	27	14.88
WEEKEND	13	761	745	43	13.02
WEEKEND	14	757	751	49	12.05
WEEKEND	15	753	750	53	11.74
WEEKEND	16	754	746	60	11.65
WEEKEND	17	731	731	60	11.61
WEEKEND	18	692	709	44	12.28
WEEKEND	19	637	661	20	14.44
WEEKEND	20	567	581	5	17.65
WEEKEND	21	500	504	1	20.70
WEEKEND	22	462	463	1	21.74
WEEKEND	23	404	405	0	22.61
WEEKEND	24	359	359	0	23.05

SIGNALIZED ARTERIALS, AADT/C - 17

SIGNALS/MILE - 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	318	318	0	23.61
WEEKDAY, IB	2	287	287	0	23.88
WEEKDAY, IB	3	277	277	0	23.99
WEEKDAY, IB	4	279	279	0	24.00
WEEKDAY, IB	5	305	305	0	23.81
WEEKDAY, IB	6	428	428	0	22.79
WEEKDAY, IB	7	697	692	5	18.66
WEEKDAY, IB	8	880	813	72	11.00
WEEKDAY, IB	9	793	800	64	9.74
WEEKDAY, IB	10	706	743	28	11.89
WEEKDAY, IB	11	709	722	15	14.72
WEEKDAY, IB	12	742	740	18	15.10
WEEKDAY, IB	13	779	768	29	13.64
WEEKDAY, IB	14	789	776	43	12.11
WEEKDAY, IB	15	811	795	59	10.89
WEEKDAY, IB	16	853	815	97	9.37
WEEKDAY, IB	17	865	822	140	8.36
WEEKDAY, IB	18	854	822	172	7.92
WEEKDAY, IB	19	752	793	130	8.40
WEEKDAY, IB	20	655	724	61	10.12
WEEKDAY, IB	21	573	619	15	13.93
WEEKDAY, IB	22	523	535	3	19.14
WEEKDAY, IB	23	463	466	0	21.57
WEEKDAY, IB	24	399	399	1	22.39
WEEKDAY, OB	1	330	330	0	23.53
WEEKDAY, OB	2	300	300	0	23.76
WEEKDAY, OB	3	285	285	0	23.93
WEEKDAY, OB	4	278	278	0	24.01
WEEKDAY, OB	5	292	292	0	23.92
WEEKDAY, OB	6	365	365	0	23.37
WEEKDAY, OB	7	555	555	0	21.56
WEEKDAY, OB	8	740	733	7	17.91
WEEKDAY, OB	9	739	739	8	16.82
WEEKDAY, OB	10	685	689	3	18.26
WEEKDAY, OB	11	703	702	4	18.52
WEEKDAY, OB	12	758	747	16	15.80
WEEKDAY, OB	13	797	775	37	12.87
WEEKDAY, OB	14	801	785	53	11.33
WEEKDAY, OB	15	841	808	86	9.92
WEEKDAY, OB	16	916	827	175	8.05
WEEKDAY, OB	17	942	832	285	7.13
WEEKDAY, OB	18	932	833	385	6.88
WEEKDAY, OB	19	797	828	355	6.96
WEEKDAY, OB	20	688	805	237	7.42
WEEKDAY, OB	21	611	738	110	8.80
WEEKDAY, OB	22	569	643	36	11.87
WEEKDAY, OB	23	478	508	7	16.86
WEEKDAY, OB	24	422	428	2	20.63
WEEKEND	1	384	384	0	22.97
WEEKEND	2	340	340	0	23.41
WEEKEND	3	308	308	0	23.71
WEEKEND	4	290	290	0	23.79
WEEKEND	5	288	288	0	23.67
WEEKEND	6	304	304	1	22.90
WEEKEND	7	356	351	6	20.55
WEEKEND	8	427	414	19	17.96
WEEKEND	9	480	482	17	17.28
WEEKEND	10	579	581	15	16.89
WEEKEND	11	662	654	23	15.40
WEEKEND	12	723	709	37	13.42
WEEKEND	13	773	755	55	12.00
WEEKEND	14	781	768	68	11.03
WEEKEND	15	783	773	78	10.57
WEEKEND	16	774	767	85	10.34
WEEKEND	17	767	764	89	10.23
WEEKEND	18	720	741	68	10.68
WEEKEND	19	674	699	43	12.19
WEEKEND	20	606	631	18	14.83
WEEKEND	21	537	551	4	18.35
WEEKEND	22	495	497	2	20.72
WEEKEND	23	453	453	1	21.44
WEEKEND	24	397	397	2	21.69

SIGNALIZED ARTERIALS, AADT/C = 18

SIGNALS/MILE = 2

TIME PERIOD	HOUR	AVG. DEMAND VOLUME	AVG. ACTUAL VOLUME	AVG. QUEUE LENGTH (VEHS)	SPEED
WEEKDAY, IB	1	377	377	0	23.02
WEEKDAY, IB	2	351	351	0	23.05
WEEKDAY, IB	3	345	345	0	23.35
WEEKDAY, IB	4	338	338	0	23.52
WEEKDAY, IB	5	363	363	0	23.35
WEEKDAY, IB	6	477	477	0	22.31
WEEKDAY, IB	7	726	716	10	17.41
WEEKDAY, IB	8	889	815	85	10.53
WEEKDAY, IB	9	808	810	82	9.21
WEEKDAY, IB	10	727	767	42	10.65
WEEKDAY, IB	11	734	749	27	12.83
WEEKDAY, IB	12	773	769	32	12.98
WEEKDAY, IB	13	797	782	47	11.89
WEEKDAY, IB	14	805	790	61	10.85
WEEKDAY, IB	15	825	804	83	9.91
WEEKDAY, IB	16	858	817	124	8.82
WEEKDAY, IB	17	868	824	168	7.99
WEEKDAY, IB	18	861	825	204	7.62
WEEKDAY, IB	19	769	804	169	7.89
WEEKDAY, IB	20	680	757	93	9.19
WEEKDAY, IB	21	611	668	36	12.16
WEEKDAY, IB	22	569	593	12	16.31
WEEKDAY, IB	23	510	518	3	19.68
WEEKDAY, IB	24	447	448	1	21.20
WEEKDAY, OB	1	392	392	0	22.94
WEEKDAY, OB	2	362	362	0	23.25
WEEKDAY, OB	3	341	341	0	23.47
WEEKDAY, OB	4	343	343	0	23.44
WEEKDAY, OB	5	353	353	0	23.44
WEEKDAY, OB	6	421	421	0	22.83
WEEKDAY, OB	7	589	588	0	21.14
WEEKDAY, OB	8	766	752	14	16.39
WEEKDAY, OB	9	760	758	16	14.76
WEEKDAY, OB	10	709	718	7	16.06
WEEKDAY, OB	11	724	722	9	16.77
WEEKDAY, OB	12	782	765	25	14.18
WEEKDAY, OB	13	813	789	50	11.62
WEEKDAY, OB	14	820	798	72	10.25
WEEKDAY, OB	15	846	814	105	9.22
WEEKDAY, OB	16	923	829	199	7.82
WEEKDAY, OB	17	943	832	310	7.08
WEEKDAY, OB	18	931	833	408	6.88
WEEKDAY, OB	19	822	829	400	6.93
WEEKDAY, OB	20	717	814	303	7.24
WEEKDAY, OB	21	652	771	185	8.07
WEEKDAY, OB	22	597	699	83	9.84
WEEKDAY, OB	23	520	580	23	13.46
WEEKDAY, OB	24	473	491	5	18.13
WEEKEND	1	440	440	0	22.25
WEEKEND	2	396	396	0	22.69
WEEKEND	3	366	366	0	23.15
WEEKEND	4	343	343	0	23.37
WEEKEND	5	342	342	0	22.94
WEEKEND	6	369	366	3	21.31
WEEKEND	7	421	416	9	18.71
WEEKEND	8	455	442	21	17.05
WEEKEND	9	525	525	21	16.46
WEEKEND	10	609	606	24	15.89
WEEKEND	11	680	670	35	14.37
WEEKEND	12	749	729	55	12.40
WEEKEND	13	795	768	82	11.01
WEEKEND	14	801	782	102	10.06
WEEKEND	15	800	787	115	9.61
WEEKEND	16	788	781	122	9.54
WEEKEND	17	789	779	132	9.45
WEEKEND	18	754	764	122	9.57
WEEKEND	19	701	731	91	10.44
WEEKEND	20	632	675	48	12.23
WEEKEND	21	575	602	21	15.14
WEEKEND	22	540	553	8	17.85
WEEKEND	23	495	498	5	19.59
WEEKEND	24	453	453	5	19.61

APPENDIX D

COMPARISONS OF QSIM RESULTS WITH FIELD DATA FOR CONGESTED FREEWAYS

Note: The capacity values used in the V/C calculations were computed using the 1994 *HCM* and are 2,211 vphpl for Orlando and 2,181 vphpl for Denver.

CITY=DENVER DAY_NO=1

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7090	1.06	27.0000	41.1552	0.52427	0.52427
2	4437	0.66	42.6000	55.4680	0.30207	0.30207
3	2870	0.42	61.2000	62.3632	0.01901	0.01901
TOTAL	14397	.	38.6254	49.7940	0.28915	0.28915

CITY=DENVER DAY_NO=2

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7437	1.10	31.8000	28.1442	-0.11496	0.11496
2	4594	0.68	55.0000	43.0907	-0.21653	0.21653
3	2931	0.43	62.1000	62.2912	0.00308	0.00308
TOTAL	14962	.	44.8591	39.4227	-0.12119	0.12119

CITY=DENVER DAY_NO=3

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7344	1.09	33.2000	30.9985	-0.06631	0.06631
2	4543	0.67	57.2000	46.6394	-0.18463	0.18463
3	3012	0.44	61.9000	62.1946	0.00476	0.00476
TOTAL	14899	.	46.3201	42.0743	-0.09166	0.09166

CITY=DENVER DAY_NO=4

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7403	1.10	35.1000	29.1367	-0.16990	0.16990
2	4613	0.69	50.6000	44.2490	-0.12551	0.12551
3	3100	0.46	61.7000	62.0885	0.00630	0.00630
TOTAL	15116	.	45.2853	40.5063	-0.10553	0.10553

CITY=DENVER DAY_NO=5

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7055	1.05	27.2000	42.7742	0.57258	0.57258
2	4383	0.65	53.2000	56.4859	0.06177	0.06177
3	2996	0.44	60.7000	62.2138	0.02494	0.02494
TOTAL	14434	.	42.0486	50.9728	0.21224	0.21224

CITY=DENVER DAY_NO=6

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7101	1.06	28.1000	40.6526	0.44671	0.44671
2	4288	0.64	53.2000	55.4664	0.04260	0.04260
3	3045	0.45	62.3000	62.1550	-0.00233	0.00233
TOTAL	14434	.	42.7715	49.5896	0.15941	0.15941

CITY=DENVER DAY_NO=7

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7214	1.08	35.1000	35.7659	0.01897	0.01897
2	4571	0.68	61.0000	51.2327	-0.16012	0.16012
3	3094	0.46	62.4000	62.0958	-0.00488	0.00488
TOTAL	14879	.	48.7337	45.9926	-0.05625	0.05625

CITY=DENVER DAY_NO=8

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7083	1.06	47.9000	41.4829	-0.13397	0.13397
2	4605	0.68	61.9000	55.2908	-0.10677	0.10677
3	3018	0.44	62.0000	62.1874	0.00302	0.00302
TOTAL	14706	.	55.1776	50.0557	-0.09283	0.09283

CITY=DENVER DAY_NO=9

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7391	1.09	43.7000	29.4997	-0.32495	0.32495
2	4845	0.72	60.8000	43.7739	-0.28004	0.28004
3	3135	0.46	61.5000	62.0460	0.00888	0.00888
TOTAL	15371	.	52.7204	40.6370	-0.22920	0.22920

CITY=DENVER DAY_NO=10

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7024	1.05	29.0000	44.2113	0.52453	0.52453
2	4499	0.67	51.4000	56.9833	0.10862	0.10862
3	2872	0.42	62.0000	62.3609	0.00582	0.00582
TOTAL	14395	.	42.5848	51.8241	0.21696	0.21696

CITY=DENVER DAY_NO=11

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6438	0.96	29.0000	57.3051	0.97604	0.97604
2	4088	0.61	39.0000	60.8175	0.55942	0.55942
3	2893	0.43	61.4000	62.3362	0.01525	0.01525
TOTAL	13419	.	39.0315	59.4598	0.52338	0.52338

CITY=DENVER DAY_NO=12

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7261	1.08	39.8000	33.9376	-0.14730	0.14730
2	4600	0.68	61.3000	49.4827	-0.19278	0.19278
3	2916	0.43	62.6000	62.3090	-0.00465	0.00465
TOTAL	14777	.	50.9920	44.3753	-0.12976	0.12976

CITY=DENVER DAY_NO=13

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6373	0.95	25.2000	57.4097	1.27816	1.27816
2	4137	0.61	25.1000	60.7508	1.42035	1.42035
3	2580	0.38	62.1000	62.6975	0.00962	0.00962
TOTAL	13090	.	32.4413	59.5078	0.83433	0.83433

CITY=DENVER DAY_NO=14

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7132	1.07	42.3000	39.2556	-0.07197	0.07197
2	4578	0.68	61.0000	53.9192	-0.11608	0.11608
3	3040	0.45	62.7000	62.1610	-0.00860	0.00860
TOTAL	14750	.	52.3084	48.5276	-0.07228	0.07228

CITY=DENVER DAY_NO=15

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7434	1.10	37.6000	28.2284	-0.24925	0.24925
2	4345	0.65	60.9000	43.9989	-0.27752	0.27752
3	2827	0.42	62.1000	62.4137	0.00505	0.00505
TOTAL	14606	.	49.2733	39.5364	-0.19761	0.19761

CITY=DENVER DAY_NO=16

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7046	1.05	38.0000	43.1922	0.13664	0.13664
2	4495	0.67	62.2000	56.4828	-0.09192	0.09192
3	2919	0.43	62.0000	62.3054	0.00493	0.00493
TOTAL	14460	.	50.3676	51.1820	0.01617	0.01617

CITY=DENVER DAY_NO=17

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7360	1.09	37.3000	30.4744	-0.18299	0.18299
2	4745	0.71	60.5000	45.3372	-0.25062	0.25062
3	2944	0.43	62.4000	62.2758	-0.00199	0.00199
TOTAL	15049	.	49.5253	41.3819	-0.16443	0.16443

CITY=DENVER DAY_NO=18

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7179	1.07	33.5000	37.2137	0.11086	0.11086
2	4674	0.69	60.6000	52.1392	-0.13962	0.13962
3	3103	0.46	60.6000	62.0849	0.02450	0.02450
TOTAL	14956	.	47.5918	47.0383	-0.01163	0.01163

CITY=DENVER DAY_NO=19

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7232	1.08	32.6000	35.0543	0.07528	0.07528
2	4956	0.74	61.3000	49.2979	-0.19579	0.19579
3	3169	0.47	62.4000	62.0045	-0.00634	0.00634
TOTAL	15357	.	48.0114	45.2123	-0.05830	0.05830

CITY=ORLANDO DAY_NO=1

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6578	0.99	50.6000	48.7305	-0.03695	0.03695
2	6637	1.00	38.6000	41.1011	0.06480	0.06480
3	6064	0.91	22.5000	42.4372	0.88610	0.88610
4	5247	0.79	29.3000	53.3316	0.82019	0.82019
5	4114	0.62	57.6000	56.1200	-0.02569	0.02569
TOTAL	28640	.	38.9727	47.5344	0.21968	0.21968

CITY=ORLANDO DAY_NO=2

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6349	0.96	50.0000	53.0119	0.06024	0.06024
2	6308	0.95	33.7000	52.6939	0.56362	0.56362
3	5971	0.90	22.7000	53.7282	1.36688	1.36688
4	5421	0.82	25.2000	54.5252	1.16370	1.16370
5	4481	0.68	48.0000	55.6862	0.16013	0.16013
TOTAL	28530	.	35.6561	53.7991	0.50883	0.50883

CITY=ORLANDO DAY_NO=3

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7289	1.10	49.7000	30.0280	-0.39582	0.39582
2	7135	1.08	46.4000	23.3043	-0.49775	0.49775
3	5992	0.90	38.4000	25.6181	-0.33286	0.33286
4	5870	0.88	54.3000	32.9004	-0.39410	0.39410
5	4769	0.72	56.3000	46.5908	-0.17246	0.17246
TOTAL	31055	.	48.6445	30.7187	-0.36851	0.36851

CITY=ORLANDO DAY_NO=4

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7042	1.06	51.4000	35.4523	-0.31027	0.31027
2	6934	1.05	50.8000	27.4537	-0.45957	0.45957
3	5861	0.88	36.5000	30.5535	-0.16292	0.16292
4	5390	0.81	55.4000	44.0358	-0.20513	0.20513
5	4619	0.70	56.9000	55.5072	-0.02448	0.02448
TOTAL	29846	.	49.9082	37.2859	-0.25291	0.25291

CITY=ORLANDO DAY_NO=5

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6617	1.00	45.2000	47.7100	0.05553	0.05553
2	5972	0.90	35.9000	49.9339	0.39092	0.39092
3	6139	0.93	23.3000	53.5955	1.30023	1.30023
4	5632	0.85	38.4000	54.2555	0.41290	0.41290
5	4185	0.63	56.0000	56.0370	0.00066	0.00066
TOTAL	28545	.	38.7862	51.9533	0.33948	0.33948

CITY=ORLANDO DAY_NO=6

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6261	0.94	49.0000	53.4343	0.09050	0.09050
2	6739	1.02	43.9000	44.1236	0.00509	0.00509
3	6300	0.95	47.3000	40.6393	-0.14082	0.14082
4	5388	0.81	44.5000	51.8665	0.16554	0.16554
5	4445	0.67	48.5000	55.7293	0.14906	0.14906
TOTAL	29133	.	46.5441	48.5739	0.04361	0.04361

CITY=ORLANDO DAY_NO=7

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7297	1.10	48.3000	29.8763	-0.38144	0.38144
2	6951	1.05	39.7000	23.9624	-0.39641	0.39641
3	5813	0.88	29.2000	27.7269	-0.05045	0.05045
4	5583	0.84	50.4000	38.7175	-0.23180	0.23180
5	4808	0.72	55.5000	53.8345	-0.03001	0.03001
TOTAL	30452	.	44.2127	33.5197	-0.24185	0.24185

CITY=ORLANDO DAY_NO=8

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6599	0.99	46.0000	48.1743	0.04727	0.04727
2	6494	0.98	36.8000	42.7272	0.16106	0.16106
3	6162	0.93	32.1000	44.4382	0.38437	0.38437
4	5495	0.83	52.0000	52.9481	0.01823	0.01823
5	5163	0.78	55.0000	54.8506	-0.00272	0.00272
TOTAL	29913	.	43.7950	48.2514	0.10176	0.10176

CITY=ORLANDO DAY_NO=9

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7313	1.10	51.7000	29.5825	-0.42780	0.42780
2	6868	1.04	38.7000	24.1413	-0.37619	0.37619
3	5734	0.86	33.0000	28.6973	-0.13038	0.13038
4	5520	0.83	36.9000	41.5872	0.12702	0.12702
5	4341	0.65	53.2000	55.5381	0.04395	0.04395
TOTAL	29776	.	42.5754	34.1665	-0.19751	0.19751

CITY=ORLANDO DAY_NO=10

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6770	1.02	50.0000	43.1760	-0.13648	0.13648
2	6511	0.98	35.2000	36.7297	0.04346	0.04346
3	6505	0.98	29.4000	37.1835	0.26475	0.26475
4	5776	0.87	45.1000	41.9306	-0.07027	0.07027
5	4492	0.68	55.2000	54.8405	-0.00651	0.00651
TOTAL	30054	.	42.1704	41.9865	-0.00436	0.00436

CITY=ORLANDO DAY_NO=11

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6872	1.04	49.0000	40.0914	-0.18181	0.18181
2	6512	0.98	33.2000	33.9586	0.02285	0.02285
3	5402	0.81	24.8000	44.8786	0.80962	0.80962
4	5983	0.90	49.5000	53.8003	0.08688	0.08688
5	5416	0.82	54.1000	54.5315	0.00798	0.00798
TOTAL	30185	.	42.2746	44.9333	0.06289	0.06289

CITY=ORLANDO DAY_NO=12

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6856	1.03	50.1000	40.5619	-0.19038	0.19038
2	6908	1.04	35.1000	30.8326	-0.12158	0.12158
3	6777	1.02	29.6000	29.1986	-0.01356	0.01356
4	6143	0.93	47.6000	30.8329	-0.35225	0.35225
5	4768	0.72	54.5000	40.8806	-0.24990	0.24990
TOTAL	31452	.	42.5670	34.1246	-0.19833	0.19833

CITY=ORLANDO DAY_NO=13

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6722	1.01	48.4000	44.6520	-0.07744	0.07744
2	6635	1.00	31.9000	36.6484	0.14885	0.14885
3	6431	0.97	29.0000	36.3657	0.25399	0.25399
4	5718	0.86	40.2000	42.3502	0.05349	0.05349
5	4397	0.66	55.0000	55.2262	0.00411	0.00411
TOTAL	29903	.	39.9692	42.2087	0.05603	0.05603

CITY=ORLANDO DAY_NO=14

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6612	1.00	45.5000	47.8379	0.05138	0.05138
2	6210	0.94	24.0000	47.0109	0.95879	0.95879
3	6274	0.95	25.7000	50.1290	0.95055	0.95055
4	5568	0.84	31.8000	53.9051	0.69513	0.69513
5	4071	0.61	55.3000	56.1700	0.01573	0.01573
TOTAL	28735	.	35.2642	50.5155	0.43249	0.43249

CITY=ORLANDO DAY_NO=15

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6643	1.00	47.6000	46.9586	-0.01347	0.01347
2	6839	1.03	35.2000	35.9911	0.02248	0.02248
3	6266	0.94	27.1000	35.2686	0.30142	0.30142
4	5857	0.88	41.5000	41.9770	0.01149	0.01149
5	4668	0.70	54.7000	54.3349	-0.00668	0.00668
TOTAL	30273	.	40.4702	42.2349	0.04361	0.04361

CITY=ORLANDO DAY_NO=16

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6516	0.98	47.7000	50.2456	0.05337	0.05337
2	6807	1.03	35.5000	39.2882	0.10671	0.10671
3	6320	0.95	27.8000	37.1148	0.33506	0.33506
4	6128	0.92	47.7000	41.7573	-0.12459	0.12459
5	4810	0.73	54.5000	52.7664	-0.03181	0.03181
TOTAL	30581	.	41.9413	43.7885	0.04404	0.04404

CITY=ORLANDO DAY_NO=17

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	6910	1.04	48.0000	38.9885	-0.18774	0.18774
2	7084	1.07	35.3000	28.4093	-0.19520	0.19520
3	6327	0.95	29.2000	28.4671	-0.02510	0.02510
4	5786	0.87	45.4000	34.2553	-0.24548	0.24548
5	4948	0.75	53.9000	48.3781	-0.10245	0.10245
TOTAL	31055	.	41.7284	35.0459	-0.16014	0.16014

CITY=ORLANDO DAY_NO=18

HOUR	VOLUME	V/C	FIELD SPEED	QSIM SPEED	PERCENT ERROR	ABS PCT ERROR
1	7028	1.06	45.3000	35.7994	-0.20973	0.20973
2	6458	0.97	36.3000	30.9196	-0.14822	0.14822
3	6173	0.93	26.1000	35.9561	0.37763	0.37763
4	5565	0.84	31.3000	46.1223	0.47356	0.47356
5	4976	0.75	53.4000	55.0701	0.03128	0.03128
TOTAL	30200	.	38.2057	39.8653	0.04344	0.04344

APPENDIX E

KNOXVILLE NETWORK LINK COMPARISONS OF SPEEDS AND EMISSIONS

***** PEAK HOUR SPEED POST-PROCESSING, KNOXVILLE 2020 MINUTP NETWORK *****

FACILITY TYPE-FREWAY

NOE1	NOE2	AAOT_C	PEAK HR VMT	V_C	BPR SPEED	MINUTP SPEED	QSIM SPEED	% DIFF. BPR VS QSIM	% DIFF. MINUTP VS QSIM	CO EMIS FAC. QSIM	VOC EMIS FAC. QSIM	NOx EMIS FAC (LDGV). QSIM	NOx EMIS FAC (HDDV). QSIM
240	1001	7.22	1.254	0.72	53.53	53.98	50.56	0.059	0.068	5.12	0.73	1.23	5.07
241	5070	9.37	3.502	0.94	51.08	48.32	39.03	0.309	0.238	6.35	0.88	1.05	4.23
245	1020	5.88	2.665	0.59	54.34	54.20	52.51	0.035	0.032	4.96	0.71	1.28	5.32
255	1407	5.23	3.294	0.52	54.58	54.71	52.57	0.038	0.041	4.95	0.71	1.28	5.33
259	259	8.22	824	0.82	54.58	78.28	46.38	0.038	0.038	5.50	0.71	1.15	4.65
262	1113	5.23	1.490	0.52	54.58	51.77	52.57	0.038	0.015	4.95	0.71	1.28	5.33
262	1113	5.23	11.605	0.51	54.65	54.65	52.56	0.039	0.040	4.95	0.71	1.28	5.33
527	528	8.00	1.598	0.80	52.82	52.87	47.49	0.112	0.113	5.39	0.76	1.17	4.74
527	527	8.00	3.056	0.80	52.82	52.81	47.50	0.112	0.112	5.39	0.76	1.17	4.74
528	527	8.04	1.606	0.80	52.77	52.86	47.29	0.116	0.118	5.41	0.76	1.17	4.72
528	529	7.50	1.497	0.75	53.30	53.41	49.66	0.073	0.076	5.19	0.74	1.21	4.96
529	528	7.53	1.504	0.75	53.27	53.41	49.53	0.075	0.078	5.21	0.74	1.21	4.95
529	527	7.35	1.849	0.73	53.43	53.43	50.18	0.065	0.065	5.15	0.73	1.23	5.02
557	527	7.96	3.040	0.80	52.86	52.94	47.71	0.108	0.110	5.37	0.76	1.18	4.76
570	241	12.40	12.912	1.24	30.35	44.89	21.46	0.415	1.092	10.47	1.36	0.96	4.63
570	241	9.37	3.502	0.94	51.08	48.32	39.03	0.309	0.238	6.35	0.88	1.05	4.23
570	557	12.20	12.708	1.22	30.88	45.34	22.23	0.389	1.039	10.17	1.32	0.96	4.57
570	617	7.43	2.823	0.74	53.35	55.18	49.89	0.070	0.126	5.17	0.73	1.22	4.99
570	1001	6.67	9.264	0.67	53.92	53.91	51.80	0.041	0.041	5.01	0.71	1.26	5.23
595	617	6.86	3.522	0.69	53.79	41.05	51.45	0.046	0.202	5.04	0.72	1.25	5.18
595	621	7.51	3.172	0.75	53.29	47.59	49.61	0.074	0.041	5.20	0.74	1.21	4.96
617	570	7.39	2.805	0.74	53.39	53.48	50.05	0.067	0.069	5.16	0.73	1.22	4.96
617	595	6.91	3.546	0.69	53.76	41.05	51.35	0.047	0.201	5.05	0.72	1.25	5.17
621	595	7.56	3.191	0.76	53.25	47.59	49.44	0.077	0.038	5.21	0.74	1.21	4.94
621	622	6.46	1.491	0.65	54.05	48.16	52.09	0.037	0.075	4.99	0.71	1.27	5.27
622	621	6.50	1.500	0.65	54.02	48.14	52.05	0.038	0.075	4.99	0.71	1.27	5.26
622	623	6.79	2.062	0.68	53.84	48.14	51.68	0.044	0.067	5.03	0.72	1.26	5.20
623	622	6.74	2.048	0.67	53.87	48.14	51.68	0.042	0.068	5.02	0.71	1.26	5.21
623	625	8.86	1.050	0.89	51.80	45.78	42.50	0.219	0.077	5.92	0.82	1.09	4.38
625	623	8.81	1.044	0.88	51.87	45.79	42.83	0.211	0.069	5.88	0.82	1.10	4.40
625	1004	5.71	1.382	0.57	54.41	51.93	52.56	0.035	0.012	4.95	0.71	1.28	5.33
625	1005	0.00	0	0.00	55.00	50.20	55.00	0.000	0.087	4.77	0.68	1.35	5.71
644	727	6.52	238	0.65	54.01	48.88	52.02	0.038	0.060	5.00	0.71	1.27	5.26
644	734	8.62	1.296	0.86	52.11	43.66	44.04	0.183	0.009	5.74	0.80	1.12	4.47
700	699	0.30	6	0.03	55.00	39.40	54.99	0.000	0.284	4.77	0.68	1.35	5.71
703	1115	9.43	1.146	0.94	50.99	46.33	38.82	0.320	0.199	6.41	0.88	1.05	4.22
703	703	13.10	438	1.31	28.57	46.33	38.82	0.497	1.150	11.55	1.48	1.05	4.84
706	705	6.91	116	0.69	53.76	36.49	19.08	0.477	0.159	11.55	1.48	1.05	4.84
707	705	9.64	469	0.96	50.65	48.86	51.34	0.047	0.315	5.05	0.91	1.25	5.17
708	1046	572	572	0.90	51.66	48.86	37.14	0.364	0.315	6.62	0.91	1.04	4.19
708	1055	8.96	14.20	1.42	26.11	39.87	41.82	0.236	0.239	6.00	0.83	1.08	4.35
708	1055	14.20	669	1.42	26.11	39.87	16.55	0.236	1.409	13.01	1.64	0.97	5.13
710	708	11.58	809	1.16	32.65	43.85	25.06	0.303	0.578	9.20	1.21	0.97	4.38
711	710	14.25	433	1.42	26.00	38.52	16.46	0.380	1.340	13.07	1.64	0.97	5.14
713	711	10.99	868	1.10	34.50	43.87	28.30	0.219	0.550	8.31	1.11	0.98	4.24
714	713	9.13	139	0.91	51.43	40.51	40.67	0.284	0.004	6.14	0.85	1.07	4.29
715	713	6.42	390	0.64	54.07	50.69	52.14	0.037	0.028	4.99	0.71	1.27	5.27
716	714	4.57	111	0.46	54.76	48.97	52.50	0.043	0.067	4.96	0.71	1.28	5.32
717	715	2.03	111	0.20	54.99	52.00	53.95	0.019	0.036	4.85	0.69	1.32	5.54
718	717	2.03	185	0.20	54.99	52.00	53.95	0.019	0.036	4.85	0.69	1.32	5.54
726	727	6.70	672	0.67	53.90	45.15	51.74	0.042	0.127	5.02	0.71	1.26	5.22

***** PEAK HOUR SPEED POST-PROCESSING. KNOXVILLE 2020 MINUTP NETWORK *****

FACILITY TYPE=FREEWAY
(continued)

MODEL	NODE2	ADOT_C	PEAK HR VMT	V_C	BPR SPEED	MINUTP SPEED	QSIM	% DIFF. BPR VS QSIM	% DIFF. MINUTP VS QSIM	CO. EMIS FAC. QSIM	VOC EMIS FAC. QSIM	NOx EMIS FAC. (LDGV). QSIM	NOx EMIS FAC. (HDDV). QSIM
726	1280	8.24	3.830	0.82	52.56	44.08	46.26	0.136	0.047	5.51	0.77	1.15	4.64
727	644	6.81	248	0.68	53.83	48.86	51.56	0.044	0.052	5.03	0.72	1.26	5.19
727	726	6.42	643	0.64	54.07	45.17	52.14	0.037	0.134	4.99	0.71	1.27	5.27
734	644	7.26	1,092	0.73	53.50	44.68	50.45	0.060	0.114	5.13	0.73	1.23	5.05
734	735	8.62	1,453	0.86	52.11	43.48	44.04	0.183	0.013	5.74	0.80	1.12	4.47
735	736	15.62	285	1.55	14.74	22.72	14.98	0.016	0.516	14.14	1.76	0.97	5.34
735	1035	10.24	451	1.02	37.02	46.73	33.03	0.121	0.415	7.30	0.99	1.00	4.15
736	737	1.03	34	0.10	55.00	46.00	54.78	0.004	0.160	4.79	0.69	1.34	5.67
736	1040	14.60	266	1.46	25.31	33.75	15.94	0.588	1.117	13.42	1.68	0.97	5.21
855	716	4.57	208	0.46	54.76	48.97	52.50	0.043	0.067	4.96	0.71	1.28	5.32
857	861	5.17	896	0.52	54.60	48.59	52.56	0.039	0.076	4.95	0.71	1.28	5.33
861	861	5.18	897	0.52	54.60	48.59	52.56	0.039	0.076	4.95	0.71	1.28	5.33
861	1101	5.45	547	0.55	54.51	36.82	52.58	0.037	0.300	4.95	0.71	1.28	5.33
861	1101	5.45	547	0.55	54.51	36.82	52.58	0.037	0.300	4.95	0.71	1.28	5.33
1001	240	7.22	1,254	0.72	53.53	53.98	50.55	0.059	0.068	5.12	0.73	1.23	5.07
1001	570	6.59	9,151	0.66	53.97	53.98	51.32	0.039	0.040	5.00	0.71	1.27	5.24
1001	1002	5.12	14,322	0.51	54.62	47.51	52.56	0.096	0.096	4.95	0.71	1.28	5.33
1002	1001	5.10	14,266	0.51	54.62	47.52	52.56	0.039	0.096	4.95	0.71	1.28	5.33
1002	1003	5.70	7,714	0.57	54.42	54.45	52.56	0.035	0.036	4.95	0.71	1.28	5.33
1003	1002	5.68	7,690	0.57	54.42	54.45	52.56	0.035	0.036	4.95	0.71	1.28	5.33
1003	1004	6.24	6,541	0.62	54.17	54.06	52.31	0.035	0.033	4.97	0.71	1.27	5.30
1004	625	4.52	6,302	0.45	54.77	51.97	52.50	0.043	0.010	4.96	0.71	1.28	5.32
1004	1003	6.22	6,525	0.62	54.17	54.06	52.32	0.035	0.033	4.97	0.71	1.28	5.32
1004	1006	6.39	2,883	0.64	54.09	60.23	52.17	0.037	0.154	4.98	0.71	1.27	5.28
1004	1213	7.08	1,549	0.71	53.63	50.51	50.94	0.053	0.008	5.08	0.72	1.24	5.12
1005	625	4.29	847	0.43	54.81	50.18	52.50	0.044	0.044	4.96	0.71	1.28	5.32
1005	1004	5.85	2,764	0.59	54.35	57.38	52.52	0.035	0.093	4.96	0.71	1.28	5.33
1006	1107	7.76	6,955	0.78	53.06	52.90	48.60	0.092	0.089	5.29	0.75	1.19	4.85
1007	1005	7.73	6,818	0.77	53.09	58.96	48.74	0.089	0.210	5.28	0.74	1.20	4.87
1008	1098	7.64	1,538	0.76	53.17	40.08	49.13	0.082	0.184	5.24	0.74	1.20	4.91
1009	1008	10.71	8,590	1.07	35.41	48.76	29.37	0.181	0.627	7.92	1.06	0.99	4.20
1009	1109	1.98	31	0.20	54.99	52.00	53.99	0.019	0.037	4.84	0.69	1.32	5.55
1009	1109	1.98	31	0.20	54.99	52.00	53.99	0.019	0.037	4.84	0.69	1.32	5.55
1010	1109	8.71	15,782	0.87	52.00	57.50	43.49	0.156	0.322	5.80	0.81	1.11	4.44
1010	1110	5.99	15,187	0.60	54.29	51.31	52.47	0.035	0.011	4.96	0.71	1.28	5.32
1011	1010	10.51	15,980	1.05	36.09	51.54	31.25	0.155	0.652	7.65	1.03	0.99	4.17
1011	1012	13.03	5,359	1.30	28.75	42.14	19.30	0.490	1.184	11.44	1.46	0.96	4.82
1011	1059	5.30	3,895	0.53	54.56	49.85	52.57	0.038	0.052	4.95	0.71	1.28	5.33
1011	1114	0.00	0	0.00	55.00	45.00	55.00	0.000	0.164	4.77	0.68	1.35	5.71
1012	1011	11.79	4,852	1.18	32.03	45.09	24.03	0.333	0.876	9.52	1.25	0.97	4.44
1012	1036	14.38	3,819	1.44	25.74	42.46	16.26	0.584	1.612	13.20	1.66	0.97	5.17
1013	1014	8.30	3,674	0.83	52.50	52.29	45.33	0.143	0.138	5.54	0.78	1.14	4.61
1013	1051	8.50	3,974	0.85	52.26	54.66	44.77	0.167	0.221	5.66	0.79	1.13	4.52
1014	1013	8.50	3,763	0.85	52.26	52.26	44.77	0.167	0.167	5.66	0.79	1.13	4.52
1014	1015	7.19	7,791	0.72	53.55	50.08	50.65	0.057	0.011	5.11	0.73	1.24	5.08
1015	1014	7.05	7,636	0.70	53.66	50.22	51.03	0.052	0.016	5.08	0.72	1.24	5.13
1015	1016	5.33	2,695	0.53	54.55	53.39	52.58	0.038	0.015	4.95	0.71	1.28	5.33
1016	1015	5.31	2,680	0.53	54.56	53.39	52.57	0.038	0.015	4.95	0.71	1.28	5.33
1016	1017	8.41	4,728	0.84	52.37	60.55	45.32	0.156	0.336	5.61	0.79	1.13	4.56
1016	1087	4.48	2,602	0.45	54.77	60.55	52.50	0.043	0.153	4.96	0.71	1.28	5.32
1017	1016	8.40	4,725	0.84	52.38	60.55	45.35	0.155	0.335	5.60	0.79	1.14	4.56

***** PEAK HOUR SPEED POST-PROCESSING, KNOXVILLE 2020 MINUTP NETWORK *****

FACILITY TYPE-FREWAY
(continued)

MODEL	MODE2	ADOT_C	PEAK HR VMT	V_C	BPR SPEED	MINUTP SPEED	OSIM SPEED	% DIFF. BPR vs OSIM	% DIFF. MINUTP vs OSIM	CO EMIS FAC. OSIM	VOC EMIS FAC. OSIM	NOx EMIS FAC (LDGV). OSIM	NOx EMIS FAC (HDDV). OSIM
1017	1018	6.02	12.952	0.60	54.27	58.33	52.45	0.035	0.112	4.96	0.71	1.28	5.32
1018	1017	6.02	12.950	0.60	54.28	58.33	52.45	0.035	0.112	4.96	0.71	1.28	5.32
1018	1019	6.08	14.808	0.61	54.25	63.13	52.42	0.035	0.204	4.96	0.71	1.28	5.31
1019	1018	6.07	14.806	0.61	54.25	63.13	52.43	0.035	0.204	4.96	0.71	1.28	5.31
1019	1407	5.23	3.267	0.52	54.58	54.65	52.57	0.038	0.040	4.95	0.71	1.28	5.33
1020	245	5.88	2.665	0.59	54.34	54.20	52.51	0.035	0.032	4.96	0.71	1.28	5.32
1020	529	7.35	1.849	0.73	53.43	53.43	50.18	0.065	0.065	5.15	0.73	1.23	5.02
1020	1021	4.91	11.838	0.49	54.68	51.12	52.53	0.041	0.027	4.96	0.71	1.28	5.33
1020	1021	4.92	11.873	0.49	54.67	51.12	52.54	0.041	0.027	4.97	0.71	1.28	5.33
1021	1022	6.21	5.692	0.62	54.18	53.10	52.33	0.035	0.015	4.97	0.71	1.28	5.30
1022	1021	7.10	6.506	0.71	53.62	52.43	50.90	0.053	0.030	5.09	0.72	1.24	5.11
1022	1021	7.01	6.570	0.70	53.69	52.43	50.90	0.050	0.028	5.07	0.72	1.25	5.14
1023	1022	7.23	6.774	0.72	53.52	49.54	50.55	0.059	0.020	5.12	0.73	1.23	5.07
1023	1024	8.25	1.977	0.83	52.55	35.74	46.19	0.138	0.206	5.22	0.78	1.15	4.63
1024	1023	8.52	2.041	0.85	52.24	35.58	44.65	0.170	0.203	5.28	0.79	1.12	4.51
1024	1024	8.25	1.504	0.83	52.55	35.58	44.65	0.138	0.203	5.22	0.78	1.15	4.63
1025	1026	7.03	8.78	0.70	53.67	32.98	46.19	0.138	0.206	5.22	0.78	1.15	4.63
1025	1074	7.10	296	0.71	53.62	42.42	51.08	0.054	0.077	5.09	0.72	1.24	5.11
1026	1025	6.04	3.888	0.60	54.27	50.11	52.44	0.035	0.044	4.96	0.71	1.28	5.31
1026	1027	6.27	3.397	0.63	54.15	50.10	52.28	0.036	0.042	4.98	0.71	1.27	5.29
1027	1026	6.24	3.528	0.62	54.17	50.22	52.31	0.035	0.040	4.97	0.71	1.27	5.30
1027	1028	6.16	1.559	0.62	54.21	50.22	52.37	0.035	0.041	4.97	0.71	1.28	5.30
1028	1027	6.16	1.540	0.62	54.21	50.22	52.37	0.035	0.041	4.97	0.71	1.28	5.30
1028	1029	6.89	1.717	0.69	53.77	40.37	51.40	0.046	0.215	5.05	0.72	1.25	5.17
1029	1028	6.89	6.65	0.64	53.09	40.37	51.40	0.037	0.226	4.98	0.71	1.27	5.28
1029	1030	6.89	323	0.69	53.77	45.85	51.40	0.046	0.108	5.05	0.72	1.25	5.17
1030	1031	5.17	951	0.52	54.60	56.63	52.56	0.039	0.077	4.95	0.71	1.28	5.33
1030	1031	5.16	717	0.52	54.61	54.95	52.56	0.039	0.045	4.95	0.71	1.28	5.33
1031	1032	7.29	886	0.73	53.47	55.41	50.34	0.062	0.101	5.14	0.73	1.23	5.04
1032	1033	7.87	929	0.79	52.95	57.75	48.11	0.101	0.200	5.33	0.75	1.18	4.80
1033	1032	2.59	180	0.26	54.97	46.00	53.39	0.030	0.139	4.89	0.70	1.30	5.45
1033	1034	8.77	1.827	0.88	51.92	43.59	53.08	0.205	0.244	5.85	0.82	1.10	4.41
1034	1033	8.77	1.827	0.88	51.92	43.59	53.08	0.205	0.244	5.85	0.82	1.10	4.41
1034	1035	10.16	4.107	1.02	37.30	52.81	33.58	0.111	0.573	11.62	0.98	1.01	4.15
1035	1012	13.14	4.107	1.31	28.46	44.72	18.95	0.502	1.359	11.62	1.48	0.96	4.86
1036	744	1.33	44	0.13	55.00	49.00	54.58	0.008	0.102	4.80	0.69	1.33	5.64
1036	1037	13.99	656	1.40	26.55	42.88	16.93	0.568	1.533	12.76	1.61	0.97	5.08
1037	1038	16.55	679	1.66	12.63	25.79	14.74	0.143	0.750	14.33	1.78	0.97	5.38
1037	1039	9.16	1.145	0.92	51.39	53.52	40.48	0.269	0.322	6.16	0.85	1.07	4.29
1038	734	7.26	893	0.73	53.50	44.44	50.45	0.060	0.119	5.13	0.73	1.23	5.05
1039	737	2.01	208	0.20	54.99	46.00	53.97	0.019	0.148	4.95	0.69	1.32	5.54
1039	1040	7.99	874	0.80	52.83	56.11	47.56	0.019	0.180	5.38	0.76	1.17	4.75
1040	1041	9.18	2.232	0.92	51.35	51.54	47.56	0.011	0.180	5.38	0.76	1.17	4.75
1041	1042	3.52	183	0.35	54.91	57.39	52.70	0.042	0.089	4.94	0.70	1.28	5.35
1041	1125	9.90	1.444	0.99	50.22	50.18	35.34	0.421	0.420	6.90	0.94	1.02	4.16
1042	1043	5.40	731	0.54	54.53	53.86	52.58	0.037	0.024	4.95	0.71	1.28	5.33
1043	1044	7.11	1.074	0.71	53.61	53.45	50.86	0.054	0.051	5.09	0.72	1.24	5.11
1044	1045	8.84	2.165	0.88	51.83	51.84	42.61	0.216	0.217	5.09	0.82	1.10	4.39
1045	707	9.49	332	0.95	50.89	48.17	38.18	0.333	0.262	6.47	0.89	1.05	4.21
1045	1046	6.08	1.740	0.61	54.25	54.37	52.42	0.035	0.037	4.96	0.71	1.28	5.31

***** PEAK HOUR SPEED POST-PROCESSING. KNOXVILLE 2020 MINUTP NETWORK *****

FACILITY TYPE-FREEMAY
(continued)

NOE1	NOE2	AAOT_C	PEAK HR VMT	V_C	BPR SPEED	MINUTP SPEED	QSIM SPEED	% DIFF. BPR VS QSIM	% DIFF. MINUTP VS QSIM	CO EMIS FAC. QSIM	VOC EMIS FAC. QSIM	NOx EMIS (LDGV). QSIM	NOx EMIS FAC. (HDDV). QSIM
1046	1047	8.69	453	0.87	52.03	54.33	43.60	0.193	0.246	5.79	0.81	1.11	4.45
1047	1048	7.61	436	0.76	53.20	54.78	49.23	0.081	0.113	5.23	0.74	1.21	4.92
1048	1049	7.86	655	0.79	52.96	55.65	48.16	0.100	0.155	5.33	0.75	1.18	4.81
1049	1013	8.30	1.037	0.83	52.30	54.93	45.93	0.143	0.136	5.54	0.78	1.14	4.61
1050	840	0.76	18	0.08	55.00	46.00	54.90	0.002	0.162	4.78	0.68	1.34	5.70
1050	1048	0.76	5	0.08	55.00	43.00	54.90	0.002	0.217	4.78	0.68	1.34	5.70
1051	837	1.12	12	0.11	55.00	44.20	54.72	0.005	0.192	4.79	0.69	1.34	5.67
1051	1052	8.17	724	0.82	52.64	55.73	46.62	0.129	0.129	5.48	0.77	1.16	4.67
1052	838	1.06	18	0.11	55.00	49.00	54.76	0.004	0.105	4.79	0.69	1.34	5.67
1052	1053	7.87	901	0.79	52.96	56.19	48.15	0.100	0.167	5.33	0.75	1.18	4.81
1053	1054	9.12	143	0.91	51.44	56.95	40.76	0.262	0.397	6.13	0.85	1.07	4.30
1054	707	9.79	788	0.98	50.41	50.33	36.10	0.396	0.394	6.78	0.93	1.03	4.17
1054	1055	6.27	1.795	0.63	54.15	54.36	52.29	0.036	0.040	4.97	0.71	1.27	5.29
1055	1056	10.41	2.114	1.04	36.43	48.79	31.91	0.142	0.529	7.52	1.02	1.00	4.16
1056	1057	10.41	759	1.04	36.43	49.27	31.91	0.142	0.529	7.52	1.02	1.00	4.16
1057	1058	3.58	647	0.36	54.91	54.99	52.67	0.042	0.044	4.94	0.70	1.28	5.35
1057	1124	8.02	209	0.80	52.80	54.73	47.42	0.114	0.154	5.40	0.76	1.17	4.74
1058	1029	9.57	266	0.96	50.77	42.04	37.64	0.349	0.117	6.55	0.90	1.04	4.20
1059	1011	6.20	4.552	0.62	54.18	49.50	52.34	0.035	0.054	4.97	0.71	1.28	5.30
1059	1060	6.22	4.696	0.62	54.18	51.24	52.33	0.035	0.021	4.97	0.71	1.28	5.30
1060	1059	6.32	4.769	0.63	54.13	51.23	52.24	0.035	0.019	4.98	0.71	1.27	5.29
1060	1061	6.22	486	0.62	54.13	56.70	52.33	0.035	0.084	4.97	0.71	1.28	5.30
1061	1062	4.02	391	0.40	54.85	56.78	52.53	0.044	0.081	4.96	0.71	1.28	5.33
1061	1071	9.34	422	0.93	51.13	51.69	39.26	0.302	0.317	6.32	0.87	1.06	4.24
1062	1063	5.06	298	0.51	54.64	54.96	52.55	0.040	0.046	4.95	0.71	1.28	5.33
1063	1064	7.82	814	0.78	53.01	55.53	48.37	0.096	0.148	5.31	0.75	1.19	4.83
1064	1065	10.12	1.370	1.01	37.43	53.24	33.84	0.106	0.574	7.16	0.97	1.01	4.15
1065	1066	10.64	1.256	1.06	35.65	50.34	30.42	0.172	0.655	7.82	1.05	0.99	4.19
1065	1083	6.75	7.624	0.67	53.87	59.78	51.67	0.043	0.137	5.02	0.71	1.26	5.21
1066	1067	5.36	652	0.54	54.54	54.95	52.58	0.037	0.045	4.95	0.71	1.28	5.33
1066	1076	5.28	275	0.53	54.57	54.95	52.57	0.038	0.045	4.95	0.71	1.28	5.33
1067	1068	4.21	161	0.42	54.82	54.98	52.51	0.044	0.047	4.96	0.71	1.28	5.32
1068	1069	8.61	149	0.86	52.13	54.64	44.11	0.182	0.239	5.73	0.80	1.12	4.48
1069	1070	8.88	832	0.89	51.78	51.95	42.38	0.222	0.226	5.93	0.83	1.09	4.37
1070	1060	6.32	789	0.63	54.13	55.13	52.24	0.036	0.055	4.98	0.71	1.27	5.29
1071	1072	1.92	40	0.19	54.99	55.00	54.05	0.017	0.018	4.84	0.69	1.32	5.56
1071	1077	7.42	695	0.74	53.37	53.18	49.95	0.069	0.065	5.17	0.73	1.22	5.00
1072	1073	6.05	284	0.61	54.26	54.31	52.44	0.035	0.036	4.96	0.71	1.28	5.31
1073	1025	7.03	110	0.70	53.67	51.84	52.44	0.051	0.015	5.07	0.72	1.25	5.13
1074	1075	4.80	383	0.48	54.70	57.96	52.52	0.042	0.104	4.96	0.71	1.28	5.33
1075	1076	3.90	1.707	0.39	54.87	51.98	52.56	0.044	0.011	4.95	0.71	1.28	5.33
1075	1064	4.61	232	0.46	54.75	57.97	52.50	0.043	0.104	4.96	0.71	1.28	5.32
1076	1072	4.13	337	0.41	54.84	54.98	52.51	0.044	0.047	4.96	0.71	1.28	5.32
1076	1077	6.44	168	0.64	54.06	54.89	52.12	0.037	0.053	4.99	0.71	1.27	5.27
1077	1078	6.93	313	0.69	53.75	54.85	51.31	0.047	0.069	5.05	0.72	1.25	5.16
1078	1024	8.52	1.331	0.85	52.24	35.52	44.65	0.170	0.205	5.68	0.79	1.12	4.51
1079	1068	8.80	1.504	0.88	51.89	52.09	42.92	0.209	0.214	5.87	0.82	1.10	4.41
1079	1081	5.32	1.275	0.53	54.55	51.53	52.58	0.038	0.020	4.95	0.71	1.28	5.33
1080	1062	2.06	39	0.21	54.99	55.00	53.92	0.020	0.020	4.85	0.69	1.32	5.53

***** PEAK HOUR SPEED POST-PROCESSING, KNOXVILLE 2020 MINUTP NETWORK *****

FACILITY TYPE=FREEWAY
(continued)

MODEL	NODE2	ADOT_C	PEAK HR VHT	V_C	BPR SPEED	MINUTP SPEED	OSIM SPEED	% DIFF. BPR VS OSIM	% DIFF. MINUTP VS OSIM	CO EMIS FAC QSIM	VOC EMIS FAC QSIM	NOx EMIS FAC (LDGV) QSIM	NOx EMIS FAC (HDDV) QSIM
1080	1082	2.29	88	0.23	54.98	55.00	53.68	0.024	0.025	4.87	0.70	1.31	5.50
1081	1063	2.76	48	0.28	54.97	55.00	53.24	0.033	0.033	4.90	0.70	1.30	5.43
1082	1082	3.48	218	0.35	54.92	51.99	52.72	0.042	0.014	4.94	0.71	1.28	5.35
1083	1073	5.01	678	0.50	54.65	51.96	52.55	0.040	0.011	4.95	0.71	1.28	5.33
1083	1065	7.09	8 016	0.71	53.63	59.39	50.92	0.053	0.167	5.09	0.72	1.24	5.11
1083	1084	4.81	4 739	0.48	54.70	57.06	52.52	0.041	0.086	4.96	0.71	1.28	5.33
1084	1083	4.84	4 761	0.48	54.69	57.06	52.53	0.041	0.086	4.96	0.71	1.28	5.33
1084	1085	4.81	2 716	0.48	54.70	54.96	52.52	0.041	0.046	4.96	0.71	1.28	5.33
1085	1086	3.59	2 675	0.36	54.91	60.99	52.52	0.043	0.158	4.94	0.70	1.28	5.35
1086	1087	4.98	311	0.50	54.66	51.36	52.54	0.040	0.023	4.95	0.71	1.28	5.33
1087	1016	4.46	2 787	0.45	54.78	60.55	52.50	0.043	0.153	4.96	0.71	1.28	5.32
1087	1088	5.01	339	0.50	54.65	51.36	52.55	0.040	0.023	4.95	0.71	1.28	5.33
1088	1089	3.01	1 880	0.30	54.95	60.99	53.03	0.036	0.150	4.92	0.70	1.29	5.40
1089	1084	7.26	856	0.73	53.50	53.20	50.46	0.060	0.054	5.12	0.73	1.23	5.06
1092	1086	2.08	181	0.21	54.99	44.80	53.89	0.020	0.169	4.85	0.69	1.32	5.53
1095	1089	2.74	229	0.27	54.97	44.80	53.25	0.032	0.159	4.90	0.70	1.30	5.45
1098	1097	7.25	6 343	0.72	53.51	40.24	50.48	0.060	0.203	5.32	0.73	1.23	5.06
1099	1108	7.96	1 714	0.80	52.86	40.44	47.70	0.108	0.161	5.37	0.76	1.18	4.76
1101	861	5.46	547	0.55	54.51	36.82	52.58	0.037	0.300	4.95	0.71	1.28	5.33
1101	1102	3.17	144	0.32	54.94	37.59	52.91	0.038	0.290	4.93	0.70	1.29	5.38
1102	1101	3.06	139	0.31	54.95	37.59	52.99	0.037	0.291	4.92	0.70	1.29	5.39
1102	1103	2.75	735	0.27	54.97	43.00	53.25	0.032	0.193	4.90	0.70	1.30	5.43
1103	1102	2.63	703	0.26	54.97	43.00	53.35	0.030	0.194	4.89	0.70	1.30	5.45
1107	1099	7.53	6 436	0.75	53.27	40.09	49.52	0.076	0.191	5.21	0.74	1.21	4.95
1108	1109	10.72	8 657	1.07	35.36	48.63	29.89	0.183	0.627	7.94	1.06	0.99	4.20
1109	1009	1.08	17	0.11	55.00	52.00	54.74	0.005	0.050	4.79	0.69	1.34	5.67
1110	1110	9.07	16 064	0.91	51.51	58.58	41.09	0.254	0.426	6.08	0.84	1.08	4.31
1110	1010	2.06	65	0.21	54.99	52.00	53.91	0.020	0.035	4.85	0.69	1.32	5.53
1111	1114	10.76	16 890	1.08	35.23	51.14	29.65	0.188	0.725	7.99	1.07	0.99	4.20
1111	1112	4.97	3 465	0.50	54.66	54.72	52.54	0.040	0.041	4.96	0.71	1.28	5.33
1111	1213	5.01	4 258	0.50	54.65	54.60	52.55	0.040	0.039	4.95	0.71	1.28	5.33
1112	1252	5.13	1 462	0.51	54.61	51.77	52.56	0.039	0.015	4.95	0.71	1.28	5.33
1112	1111	4.99	3 482	0.50	54.65	52.54	52.54	0.040	0.041	4.95	0.71	1.28	5.33
1113	259	8.22	824	0.82	52.59	78.28	46.38	0.134	0.688	5.50	0.77	1.15	4.65
1113	262	5.23	11 826	0.52	54.58	54.59	52.57	0.038	0.038	4.95	0.71	1.28	5.33
1113	1276	7.91	2 450	0.79	52.91	49.88	47.95	0.103	0.040	5.35	0.75	1.18	4.79
1114	1011	14.35	224	1.44	25.80	33.00	16.30	0.583	1.025	13.18	1.66	0.97	5.16
1115	702	4.78	58	0.48	54.71	49.57	52.52	0.042	0.056	4.96	0.71	1.28	5.32
1115	855	4.65	353	0.47	54.74	48.97	52.51	0.043	0.067	4.96	0.71	1.28	5.32
1124	1031	8.71	2 178	0.87	52.00	52.46	43.47	0.196	0.207	5.81	0.81	1.11	4.44
1125	1043	6.23	1 454	0.82	54.17	54.90	52.32	0.035	0.049	4.97	0.71	1.27	5.30
1213	1004	7.07	1 547	0.71	53.64	50.97	52.32	0.052	0.009	5.08	0.72	1.24	5.12
1213	1111	4.99	4 244	0.50	54.66	54.72	52.54	0.040	0.041	4.95	0.71	1.28	5.33
1216	1113	7.98	2 473	0.80	52.84	49.87	47.60	0.110	0.048	5.38	0.76	1.17	4.75
1276	1276	6.38	1 250	0.64	54.09	51.11	52.18	0.037	0.021	4.98	0.71	1.27	5.28
1276	1277	6.35	1 244	0.63	54.11	51.11	52.21	0.036	0.036	4.98	0.71	1.27	5.28
1277	1278	6.38	3 459	0.64	54.09	45.29	52.18	0.037	0.132	4.98	0.71	1.27	5.28
1278	1277	6.35	3 442	0.63	54.11	45.29	52.21	0.036	0.133	4.98	0.71	1.27	5.28
1278	1279	6.46	4 154	0.63	54.04	45.16	52.08	0.038	0.133	4.99	0.71	1.27	5.28

***** PEAK HOUR SPEED POST-PROCESSING. KNOXVILLE 2020 MINUTP NETWORK *****

FACILITY TYPE-FREWAY
(continued)

NOE1	NOE2	ADOT_C	PEAK HR VMT	V_C	BPR SPEED	MINUTP SPEED	OSIM SPEED	% DIFF. BPR vs OSIM	% DIFF. MINUTP vs OSIM	CO EMIS FAC OSIM	VOC EMIS FAC OSIM	NOx EMIS FAC (LDGV) OSIM	NOx EMIS FAC (HDDV) OSIM
1279	1278	6.41	4.120	0.64	54.07	45.29	52.15	0.037	0.132	4.99	0.71	1.27	5.27
1279	1280	7.40	3.003	0.74	53.38	44.66	49.99	0.068	0.107	5.17	0.73	1.22	5.00
1280	1276	8.64	4.016	0.86	52.09	43.78	43.92	0.186	0.003	5.76	0.80	1.11	4.47
1280	1279	7.26	2.945	0.73	53.50	44.68	50.44	0.061	0.114	5.13	0.73	1.23	5.05
1407	255	5.23	3.294	0.52	54.58	54.71	52.57	0.038	0.041	4.95	0.71	1.28	5.33
1407	1019	5.23	3.267	0.52	54.58	54.65	52.57	0.038	0.040	4.95	0.71	1.28	5.33
FAC_TYPE			680.951										

FACILITY TYPE-SIGNALIZED

NOE1	NOE2	ADOT_C	PEAK HR VMT	V_C	BPR SPEED	MINUTP SPEED	OSIM SPEED	% DIFF. BPR vs OSIM	% DIFF. MINUTP vs OSIM	CO EMIS FAC OSIM	VOC EMIS FAC OSIM	NOx EMIS FAC (LDGV) OSIM	NOx EMIS FAC (HDDV) OSIM
242	557	9.81	1.047	0.98	41.22	43.85	22.11	0.865	0.984	12.09	1.61	1.05	4.58
253	1364	13.19	751	1.32	23.20	32.99	15.60	0.487	1.115	16.18	2.07	1.06	5.25
257	1281	10.20	2.232	1.02	30.39	40.71	22.55	0.347	0.805	11.89	1.59	1.06	4.54
504	505	7.52	2.611	0.75	43.59	37.81	36.34	0.200	0.040	7.98	1.12	1.12	4.17
505	504	7.51	2.609	0.75	43.60	37.81	36.38	0.198	0.039	7.98	1.12	1.13	4.17
505	506	7.10	1.221	0.71	43.87	38.08	36.16	0.213	0.052	8.01	1.12	1.12	4.17
506	505	7.10	1.220	0.71	43.87	38.08	36.21	0.212	0.052	8.01	1.12	1.12	4.17
506	507	14.06	403	1.41	21.60	29.30	10.84	0.993	1.703	21.94	2.70	1.08	6.04
507	506	14.14	405	1.41	21.46	29.02	10.78	0.992	1.693	22.04	2.71	1.09	6.05
507	508	15.37	220	1.54	12.57	21.25	8.33	0.509	1.550	27.33	3.27	1.11	6.58
508	507	15.39	220	1.54	12.53	21.23	8.32	0.506	1.551	27.36	3.28	1.11	6.58
510	545	11.42	691	1.14	27.13	35.84	18.83	0.440	0.903	13.82	1.81	1.05	4.87
513	514	12.90	547	1.29	23.78	31.25	12.41	0.916	1.519	19.59	2.45	1.08	5.75
513	1402	14.00	708	1.40	21.70	31.19	11.90	0.823	1.620	20.28	2.52	1.07	5.84
514	513	12.60	535	1.26	24.39	31.84	12.72	0.918	1.504	19.20	2.41	1.07	5.69
514	543	13.24	535	1.32	23.10	28.39	14.27	0.619	0.983	17.43	2.21	1.07	5.44
533	569	8.84	1.323	1.32	23.40	28.39	14.27	0.485	0.100	9.77	1.34	1.07	4.23
533	1021	7.44	668	0.88	42.40	31.41	28.55	0.463	0.100	9.77	1.34	1.07	4.23
534	1022	12.31	192	0.74	43.65	43.15	29.84	0.463	0.446	9.41	1.29	1.08	4.20
535	536	11.96	304	1.23	25.02	34.83	12.76	0.961	1.731	19.15	2.40	1.07	5.69
536	535	13.41	341	1.34	22.77	31.71	14.96	0.726	1.120	16.76	2.14	1.06	5.34
536	1023	22.38	219	2.24	22.77	29.42	13.19	0.726	1.231	18.62	2.34	1.07	5.62
536	777	12.00	186	1.30	4.01	8.91	6.54	0.388	0.362	33.44	3.90	1.13	7.04
539	814	12.61	179	1.26	24.37	35.89	11.76	1.004	2.052	20.49	2.55	1.08	5.86
542	514	12.90	279	1.26	24.37	32.02	13.63	0.787	1.349	18.11	2.29	1.07	5.54
543	1021	10.38	1.095	1.29	23.78	28.85	14.69	0.618	0.964	17.01	2.17	1.07	5.38
544	1021	11.60	4.163	1.04	29.88	34.25	18.48	0.244	0.425	11.28	1.83	1.06	4.44
545	546	11.59	702	1.16	26.67	35.49	18.49	0.443	0.921	14.05	1.83	1.05	4.91
545	546	11.65	705	1.17	26.69	34.53	18.49	0.443	0.867	14.05	1.83	1.05	4.90
546	545	10.85	438	1.17	26.55	34.39	18.39	0.444	0.871	14.11	1.84	1.05	4.92
547	546	10.85	438	1.17	26.60	35.58	18.58	0.540	0.915	13.99	1.83	1.05	4.90
550	551	14.21	139	1.42	21.34	32.88	9.69	1.202	2.393	24.09	2.93	1.09	6.27

***** PEAK HOUR SPEED POST-PROCESSING. KNOXVILLE 2020 MINUTP NETWORK *****

FACILITY TYPE=SIGNALIZED
(continued)

NODE1	NODE2	ADOT_C	PEAK_HR VMT	V_C	BPR SPEED	MINUTP SPEED	OSIM SPEED	% DIFF. BPR vs OSIM	% DIFF. MINUTP vs OSIM	CO EMIS FAC OSIM	VOC EMIS FAC OSIM	NOx EMIS FAC (LDGV) OSIM	NOx EMIS FAC (HDDV) OSIM
551	550	13 97	136	1.40	21.75	33.54	9.86	1.206	2.402	23.74	2.90	1.09	6.24
551	552	11 09	281	1.11	27.97	38.81	16.28	0.718	1.384	15.62	2.01	1.06	5.16
552	536	10 95	556	1.09	28.33	40.29	19.21	0.475	1.097	13.60	2.03	1.05	4.83
552	551	11 22	285	1.12	27.62	38.48	16.06	0.720	1.396	15.79	2.03	1.06	5.19
557	242	9 80	1,047	0.98	43.85	43.85	22.11	0.864	0.983	12.09	2.71	1.05	4.58
557	558	16 17	821	1.62	11.01	19.09	10.80	0.019	0.767	21.99	2.71	1.08	6.05
558	557	16 38	832	1.64	10.64	18.57	10.66	0.002	0.741	22.24	2.73	1.09	6.07
559	569	9 33	1,422	0.93	41.84	42.38	10.66	0.679	0.700	10.94	1.47	1.06	4.39
561	586	12 87	327	1.29	23.84	42.38	24.92	0.727	0.970	17.92	1.47	1.07	5.52
564	567	9 65	578	0.97	41.43	43.82	19.84	1.088	1.209	13.24	1.74	1.05	4.77
564	567	15 37	921	1.54	12.57	20.89	13.34	0.058	0.566	18.44	2.32	1.07	5.59
567	564	10 26	615	1.03	30.22	42.92	18.50	0.633	1.319	14.03	1.83	1.05	4.90
567	1023	11 77	460	1.18	26.27	35.61	14.23	0.846	1.503	17.47	2.22	1.07	5.45
569	533	8 79	2,288	0.88	42.47	31.42	28.79	0.475	0.911	9.70	1.33	1.08	4.23
569	533	9 40	1,433	0.94	41.75	42.24	24.69	0.601	0.711	11.03	1.48	1.06	4.40
573	590	6 89	197	0.69	44.00	34.02	20.94	1.101	0.624	12.65	1.67	1.05	4.67
574	575	6 90	781	0.69	43.99	40.44	32.88	0.338	0.230	8.68	1.21	1.10	4.15
575	574	6 91	782	0.69	43.99	40.44	32.87	0.338	0.230	8.68	1.21	1.10	4.16
575	576	8 06	1,599	0.81	43.15	47.17	31.12	0.387	0.516	9.09	1.25	1.09	4.17
576	575	8 06	1,596	0.81	43.15	47.17	31.21	0.383	0.512	9.07	1.25	1.09	4.17
576	577	9 09	900	0.91	42.12	39.36	23.86	0.765	0.649	11.34	1.52	1.06	4.45
577	576	9 01	891	0.90	42.22	39.55	24.14	0.749	0.638	11.24	1.51	1.06	4.44
577	578	9 46	136	0.95	41.67	36.41	13.48	2.093	1.702	18.29	2.31	1.07	5.57
578	577	9 43	135	0.94	41.72	36.42	13.52	2.085	1.693	18.23	2.30	1.07	5.56
578	578	11 14	2,384	1.11	27.82	35.68	20.89	0.332	0.708	12.68	1.68	1.05	4.67
580	579	11 17	2,400	1.12	27.74	35.61	20.82	0.333	0.710	12.71	1.68	1.05	4.68
580	581	14 61	647	1.46	20.68	29.26	11.64	0.776	1.513	20.66	2.57	1.08	5.89
581	580	14 64	648	1.46	20.64	29.25	11.62	0.776	1.517	20.70	2.57	1.08	5.89
581	582	15 78	883	1.58	11.76	19.82	11.33	0.038	0.750	21.14	2.62	1.08	5.94
582	581	15 61	874	1.56	12.08	20.19	11.45	0.055	0.763	20.95	2.60	1.08	5.92
582	609	10 06	982	1.01	30.80	45.90	21.09	0.461	1.176	12.58	1.66	1.05	4.66
582	1059	20 18	630	2.02	5.68	12.13	7.84	0.275	0.547	28.76	1.42	1.11	6.70
583	584	11 91	630	1.19	25.94	33.11	18.55	0.390	0.775	13.94	1.82	1.05	4.89
583	771	14 10	560	1.41	21.53	30.00	13.73	0.568	1.184	18.00	2.28	1.07	5.53
584	583	12 18	984	1.22	25.30	32.66	18.15	0.394	0.799	14.26	1.86	1.05	4.94
586	561	13 06	332	1.31	23.45	26.93	13.58	0.727	0.983	18.17	2.29	1.07	5.55
587	564	14 71	881	1.47	20.52	29.15	14.02	0.464	1.080	17.70	2.24	1.07	5.48
590	573	6 87	197	0.69	44.00	34.02	20.96	1.099	0.623	12.64	1.67	1.05	4.67
598	599	7 99	250	0.80	43.23	34.70	20.16	1.144	0.721	13.05	1.72	1.05	4.74
599	598	7 73	241	0.77	43.44	34.73	20.86	1.082	0.665	12.69	1.68	1.05	4.68
600	601	8 51	377	0.65	42.75	37.16	21.01	1.034	0.768	12.62	1.67	1.05	4.66
601	600	8 71	386	0.87	42.54	37.13	20.49	1.076	0.812	12.89	1.70	1.05	4.71
601	602	10 06	707	1.01	30.79	36.54	19.67	0.566	0.858	13.33	1.75	1.05	4.79
602	601	10 38	729	1.04	29.90	36.29	18.98	0.575	0.912	13.74	1.80	1.05	4.85
602	603	8 32	845	0.83	42.93	38.56	26.74	0.606	0.442	10.31	1.40	1.07	4.30
603	602	7 24	735	0.72	43.79	39.27	21.79	0.377	0.235	9.93	1.24	1.09	4.16
603	604	8 05	912	0.81	43.17	27.37	28.48	0.516	0.039	9.78	1.34	1.07	4.24
604	603	8 48	960	0.85	42.78	27.20	26.71	0.601	0.018	10.32	1.40	1.07	4.30
604	605	13 30	589	1.33	22.98	32.76	12.87	0.786	1.546	19.00	2.38	1.07	5.67

***** PEAK HOUR SPEED POST-PROCESSING, KNOXVILLE 2020 MINUTP NETWORK *****

FACILITY TYPE-SIGNALIZED
(continued)

MODEL	MODEL2	AAOT_C	PEAK HR VMT	V_C	BPR SPEED	MINUTP SPEED	QSIM SPEED	% DIFF. BPR VS QSIM	% DIFF. MINUTP VS QSIM	CO. EMIS FAC. QSIM	VOC EMIS FAC. QSIM	NOx EMIS FAC. (LDGV). QSIM	NOx EMIS FAC. (HDDV). QSIM
604	631	7.10	601	0.71	43.87	38.20	31.14	0.409	0.227	9.08	1.25	1.09	4.17
605	604	14.00	620	1.40	21.70	31.43	12.18	0.782	0.782	19.90	2.48	1.08	5.79
606	606	9.90	1.382	0.99	41.10	38.49	22.90	0.794	0.681	11.74	1.57	1.06	4.52
607	605	10.62	1.493	1.06	29.22	37.49	21.02	0.390	0.784	12.61	1.67	1.05	4.66
608	607	7.85	746	0.78	43.34	34.24	28.31	0.531	0.209	9.84	1.34	1.07	4.24
609	633	8.62	483	0.86	42.64	30.48	22.17	0.923	0.375	12.06	1.61	1.05	4.57
610	606	7.25	689	0.73	43.77	34.59	31.21	0.403	0.108	9.07	1.25	1.09	4.17
611	607	10.54	1.221	1.05	29.45	37.51	20.58	0.431	0.823	12.84	1.70	1.05	4.70
612	608	12.84	1.354	1.28	23.90	33.61	16.06	0.489	1.094	15.80	2.03	1.06	5.19
613	609	8.22	1.509	0.82	43.03	40.14	30.12	0.428	0.332	12.80	1.28	1.08	4.19
614	608	10.67	1.042	1.07	29.07	44.65	19.65	0.479	1.283	13.34	1.75	1.05	4.79
615	609	8.22	1.360	1.29	23.78	33.47	15.97	0.489	1.095	15.86	2.04	1.05	5.20
616	609	12.89	2.189	1.46	20.72	28.32	14.15	0.484	1.000	17.55	2.23	1.07	5.46
617	629	6.82	577	0.68	44.03	38.22	30.52	0.443	0.252	9.24	1.27	1.08	4.18
618	631	8.85	784	0.89	42.39	38.07	24.08	0.760	0.581	11.26	1.51	1.06	4.44
619	632	8.85	781	0.88	42.43	38.08	24.18	0.755	0.575	11.22	1.51	1.06	4.43
620	632	8.85	161	0.89	42.39	36.33	15.36	1.176	1.365	16.39	2.10	1.06	5.29
621	633	9.92	555	0.99	41.06	29.61	18.91	1.172	0.566	13.78	1.80	1.05	4.86
622	633	10.73	755	1.07	28.91	29.79	18.26	0.584	0.632	14.19	1.85	1.05	4.93
623	640	13.25	828	1.33	23.07	32.00	14.01	0.647	1.284	17.70	2.24	1.07	5.48
624	641	11.60	755	1.16	26.68	35.21	16.27	0.640	1.409	15.62	2.01	1.06	5.16
625	640	13.17	823	1.32	23.24	32.22	14.11	0.647	1.283	17.60	2.23	1.07	5.47
626	641	14.31	1.360	1.43	21.17	28.88	13.95	0.518	1.070	17.77	2.23	1.07	5.49
627	642	14.31	1.353	1.42	21.30	29.03	14.03	0.518	1.069	17.68	2.24	1.07	5.48
628	668	7.21	1.207	0.72	43.80	38.13	21.72	1.016	0.755	12.27	1.63	1.05	4.61
629	668	7.04	247	0.70	43.91	35.21	23.92	0.836	0.472	11.32	1.52	1.06	4.45
630	689	10.46	204	1.05	29.67	34.77	13.25	1.239	1.624	18.55	2.33	1.07	5.60
631	697	10.25	400	1.02	30.26	32.84	15.54	0.829	0.985	15.41	1.99	1.06	5.13
632	704	17.12	111	1.71	9.41	13.13	7.39	0.273	0.776	30.20	3.57	1.12	6.81
633	703	17.12	111	1.71	9.41	13.13	7.39	0.273	0.776	30.20	3.57	1.12	6.81
634	706	18.16	96	0.82	43.08	38.04	14.78	1.914	1.573	16.93	2.16	1.06	5.37
635	709	12.47	146	1.25	24.67	32.97	9.80	1.517	2.364	23.86	2.91	1.09	6.25
636	709	13.94	73	1.39	21.81	25.16	7.96	1.738	2.158	23.38	3.38	1.11	6.67
637	710	12.45	81	1.25	24.71	27.70	10.04	1.462	1.760	23.39	2.86	1.09	6.20
638	743	11.17	73	1.12	27.75	34.35	11.19	1.481	2.071	21.37	2.64	1.08	5.97
639	745	12.19	262	1.22	25.28	34.63	14.04	0.801	1.467	17.67	2.24	1.07	5.48
640	745	17.68	180	0.77	43.47	33.59	19.09	1.278	0.760	13.67	1.79	1.05	4.84
641	746	17.07	189	0.77	43.47	33.59	19.09	1.278	0.760	13.67	1.79	1.05	4.84
642	746	13.88	154	1.39	21.92	35.92	10.26	1.137	2.503	31.18	3.67	1.12	6.89
643	747	11.09	224	1.11	27.96	36.47	15.32	0.826	1.382	16.43	2.10	1.09	6.16
644	751	7.71	181	0.77	43.45	33.59	19.01	1.286	0.767	13.72	1.80	1.06	5.29
645	752	11.46	224	1.15	27.01	29.41	12.06	1.239	1.438	20.06	2.50	1.08	4.85
646	753	9.12	178	0.91	42.09	31.49	15.21	1.767	1.070	16.52	2.11	1.06	5.31
647	753	10.29	241	1.03	30.14	31.21	14.19	1.123	1.199	17.51	2.22	1.07	5.46
648	758	10.77	379	1.11	28.00	38.22	13.75	1.037	1.780	17.99	2.27	1.07	5.53
649	758	10.77	697	1.11	28.00	38.22	13.75	1.037	1.780	17.99	2.27	1.07	5.53
650	759	7.63	179	0.76	43.51	33.24	19.20	1.266	0.721	13.60	1.85	1.05	4.93
651	759	9.42	932	0.94	41.73	37.98	19.20	1.266	0.721	13.60	1.85	1.05	4.93
652	760	6.94	687	0.69	43.96	39.95	22.67	0.825	0.661	11.75	1.57	1.06	4.83
653	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
654	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
655	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
656	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
657	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
658	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
659	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
660	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
661	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
662	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
663	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
664	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
665	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
666	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
667	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
668	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
669	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
670	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
671	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
672	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
673	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
674	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
675	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
676	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
677	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
678	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
679	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
680	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
681	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
682	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
683	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
684	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
685	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
686	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
687	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
688	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
689	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
690	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
691	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
692	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	4.52
693	761	9.77	305	0.98	41.28	37.62	16.33	0.387	1.304	8.95	1.24	1.09	

***** PEAK HOUR SPEED POST-PROCESSING. KNOXVILLE 2020 MINUTP NETWORK *****

FACILITY TYPE=SIGNALED
(continued)

MODEL	MODE2	AAOT_C	PEAK HR VMT	V_C	BPR SPEED	MINUTP SPEED	OSIM SPEED	% DIFF. BPR vs OSIM	% DIFF. MINUTP vs OSIM	CO. EMIS FAC. QSIM	VOC EMIS FAC. QSIM	NOx EMIS FAC. (LDGV). QSIM	NOx EMIS FAC. (HDDV). QSIM
761	760	7.52	235	0.75	43.59	39.43	21.44	1.033	0.839	12.40	1.64	1.05	4.63
761	762	9.84	336	0.98	41.17	34.24	17.91	0.912	0.129	14.42	1.88	1.06	4.97
762	761	7.59	336	0.76	43.54	36.06	23.83	0.827	0.513	11.36	1.52	1.06	4.46
762	763	9.87	283	0.99	41.13	34.36	15.73	1.615	1.184	16.07	2.06	1.06	5.24
763	762	7.68	220	0.77	43.47	36.23	20.39	1.132	0.777	12.94	1.71	1.05	4.72
763	764	7.76	167	0.78	43.41	35.60	16.27	1.669	1.201	15.63	2.01	1.06	5.17
764	763	6.24	134	0.62	44.32	37.12	17.40	1.547	1.133	14.77	1.91	1.06	5.03
764	764	13.23	525	1.32	23.11	28.83	14.75	0.568	0.955	16.96	2.16	1.07	5.37
764	1059	7.13	752	0.71	43.85	39.94	29.43	0.490	0.357	9.52	1.31	1.08	4.21
771	583	14.01	556	1.40	21.68	30.22	13.83	0.568	1.186	17.90	2.26	1.07	5.51
771	764	13.22	525	1.32	23.13	28.84	14.76	0.568	0.954	16.95	2.16	1.07	5.37
775	1080	17.73	427	1.77	8.49	16.33	9.73	0.127	0.679	24.01	2.92	1.09	6.27
775	774	11.86	85	1.19	26.05	34.98	10.77	1.419	2.249	22.06	2.72	1.09	6.05
777	539	12.94	185	1.29	23.68	35.91	11.81	1.005	2.040	20.41	2.54	1.08	5.85
777	778	13.00	305	1.30	23.57	29.95	13.38	0.761	1.238	18.40	2.32	1.07	5.58
778	777	12.94	303	1.29	23.68	29.97	13.45	0.761	1.229	18.32	2.31	1.07	5.57
778	779	7.31	362	0.73	43.74	36.33	25.74	0.699	0.411	10.65	1.44	1.06	4.35
779	778	7.25	359	0.72	43.78	36.33	25.98	0.685	0.398	10.57	1.43	1.06	4.34
779	780	7.61	357	0.76	43.53	40.14	24.21	0.798	0.658	11.21	1.43	1.06	4.43
780	779	7.00	328	0.70	43.93	40.61	24.94	0.762	0.629	10.93	1.47	1.06	4.39
780	781	8.44	505	0.84	42.82	37.71	23.14	0.850	0.630	11.64	1.56	1.06	4.50
781	780	7.82	468	0.78	43.36	38.76	25.35	0.717	0.515	10.82	1.46	1.06	4.37
781	782	7.57	296	0.76	43.56	38.58	22.95	0.898	0.681	11.72	1.57	1.06	4.51
782	781	7.15	279	0.72	43.84	38.62	24.37	0.799	0.585	11.15	1.50	1.06	4.42
782	783	9.29	181	0.93	41.89	33.50	14.94	1.804	1.242	16.78	2.14	1.06	5.35
782	782	16.37	160	1.64	10.66	15.82	8.44	0.263	0.874	27.03	3.24	1.11	6.56
782	817	11.93	210	1.19	25.88	29.74	13.62	0.900	1.183	18.12	2.29	1.07	5.54
783	782	8.86	173	0.89	42.39	33.57	15.67	1.706	1.143	16.12	2.07	1.06	5.24
783	784	8.44	160	0.94	41.70	33.18	14.11	1.955	1.351	17.59	2.23	1.07	5.47
784	783	8.97	152	0.90	42.27	33.25	14.85	1.846	1.240	16.86	2.15	1.06	5.36
784	785	8.81	161	0.88	42.44	32.08	15.42	1.751	1.680	16.34	2.09	1.06	5.28
785	784	10.18	186	1.02	30.46	31.05	13.37	1.279	1.324	18.41	2.32	1.07	5.59
785	786	9.47	136	0.95	41.66	31.73	13.47	2.094	1.324	18.30	2.31	1.07	5.57
786	785	10.76	154	1.08	28.82	30.50	11.87	1.429	1.570	20.34	2.53	1.08	5.84
786	786	10.76	170	0.93	41.84	31.58	14.57	1.870	1.167	17.13	2.18	1.07	5.40
787	786	10.67	194	1.07	29.08	30.58	12.74	1.283	1.400	19.16	2.40	1.07	5.69
787	791	8.59	548	0.86	42.67	34.33	23.06	0.850	0.489	11.67	1.56	1.06	4.51
787	804	12.11	197	1.21	25.46	30.52	13.12	0.940	1.325	18.69	2.35	1.07	5.63
790	689	9.97	195	1.00	41.00	35.48	13.92	1.946	1.550	17.80	2.25	1.07	5.50
790	791	12.15	158	1.22	25.37	30.21	13.68	1.468	1.808	22.92	2.81	1.09	6.15
791	787	10.01	638	1.00	30.95	33.07	19.34	0.600	0.710	13.52	1.77	1.05	4.82
791	790	8.68	113	0.87	42.58	34.08	14.40	1.977	1.382	17.40	2.21	1.07	5.44
795	782	15.04	147	1.50	13.27	18.70	9.16	0.449	1.041	25.25	3.05	1.10	6.39
795	796	16.89	132	1.69	9.77	16.00	7.78	0.256	1.056	28.94	3.44	1.11	6.72
796	795	15.33	120	1.53	12.65	19.86	8.52	0.485	1.331	26.83	3.22	1.10	6.54
796	1027	17.65	138	1.77	8.61	14.37	7.48	0.151	0.921	29.91	3.54	1.12	6.79
796	804	11.61	189	1.16	26.66	31.10	13.74	0.940	1.264	18.00	2.27	1.07	5.53
806	807	8.56	457	0.86	42.70	35.47	22.06	0.936	0.608	12.11	1.61	1.05	4.58
806	835	13.14	154	1.31	23.30	30.91	11.01	1.115	1.807	21.64	2.67	1.08	6.00

***** PEAK HOUR SPEED POST-PROCESSING. KNOXVILLE 2020 MINUTP NETWORK *****

FACILITY TYPE=SIGNALIZED
(continued)

NOE1	NOE2	AAOT_C	PEAK HR VMT	V_C	BPR SPEED	MINUTP SPEED	OSIM SPEED	% DIFF. BPR vs OSIM	% DIFF. MINUTP vs OSIM	CO EMIS FAC. QSIM	VOC EMIS FAC. QSIM	NOx EMIS FAC. (LDGV). QSIM	NOx EMIS FAC. (HDDV). QSIM
807	806	8.63	461	0.86	42.63	35.46	18.85	0.951	0.623	12.21	1.62	1.05	4.60
807	808	9.02	177	0.90	42.21	34.93	14.45	0.951	0.623	12.21	1.62	1.05	4.60
808	808	8.52	167	0.85	42.74	35.00	15.26	1.007	1.293	17.25	2.19	1.07	5.42
808	809	9.53	171	0.95	41.59	32.80	13.39	2.107	1.450	16.48	2.11	1.06	5.30
809	808	9.34	168	0.93	41.83	32.84	13.65	2.064	1.405	18.39	2.32	1.07	5.58
809	810	8.77	344	0.88	42.48	35.68	18.28	1.323	0.952	18.09	1.85	1.05	4.93
810	809	8.29	325	0.83	42.96	36.11	19.40	1.315	0.861	14.17	1.77	1.05	4.81
810	811	8.81	345	0.88	42.44	35.68	18.21	1.331	0.959	13.49	1.85	1.05	4.94
811	810	8.37	328	0.84	42.89	36.10	19.22	1.232	0.879	14.22	1.78	1.05	4.83
811	812	7.99	430	0.80	43.22	36.32	22.32	0.937	0.627	13.59	1.85	1.05	4.83
812	811	7.50	404	0.75	43.60	36.67	23.91	0.824	0.534	12.00	1.52	1.06	4.45
812	1401	7.69	263	0.77	43.47	36.71	20.06	0.960	0.830	11.33	1.52	1.06	4.45
813	814	10.22	319	1.02	30.35	34.35	15.56	1.167	1.207	13.11	1.73	1.05	4.75
813	1401	9.06	425	0.91	42.17	35.64	19.96	0.950	0.786	16.21	2.08	1.06	5.26
814	842	13.59	301	1.36	22.45	30.24	12.58	1.113	0.784	13.17	1.73	1.05	4.76
814	813	9.66	302	0.97	41.42	34.82	16.51	1.508	1.108	19.37	2.42	1.07	5.72
815	1083	7.71	221	0.77	43.45	37.13	20.31	1.139	0.828	15.43	1.99	1.06	5.13
817	782	13.29	234	1.33	23.00	27.91	12.14	0.895	1.299	12.98	2.49	1.05	4.73
825	1014	8.14	117	0.81	43.10	29.10	15.56	1.769	0.870	19.96	2.08	1.08	5.80
835	806	12.52	147	1.25	24.56	32.17	11.57	1.222	0.780	16.21	2.58	1.06	5.26
835	836	13.14	120	1.31	23.30	33.31	10.31	1.260	2.232	20.76	2.50	1.08	5.90
837	835	12.52	171	1.25	24.56	33.31	12.08	1.034	1.808	22.88	2.50	1.09	6.15
846	709	12.03	63	1.20	25.66	28.03	9.18	1.794	2.053	20.04	2.50	1.08	5.81
846	847	10.91	427	1.09	28.43	39.40	14.51	0.960	2.053	25.20	3.05	1.10	6.39
847	846	9.67	379	0.97	41.40	41.54	16.49	1.510	1.716	17.19	2.19	1.07	5.41
847	848	8.45	345	0.85	42.81	42.75	19.26	1.223	1.519	15.45	1.99	1.06	5.14
848	847	7.41	302	0.74	43.67	44.30	22.07	0.978	1.220	13.57	1.78	1.05	4.83
848	886	6.97	398	0.70	43.95	43.61	13.32	0.777	1.007	12.11	1.61	1.05	4.58
871	872	12.80	275	1.28	23.98	28.53	13.32	0.801	0.763	11.01	1.48	1.06	4.40
872	871	12.64	272	1.26	24.31	28.83	13.50	0.801	1.142	18.47	2.33	1.07	5.59
882	883	5.43	354	0.54	44.61	44.59	27.99	0.594	1.135	18.26	2.30	1.07	5.56
883	884	5.39	354	0.54	44.62	44.59	27.99	0.594	0.925	9.93	1.36	1.07	4.25
884	885	5.56	202	0.56	44.57	44.53	23.35	0.911	0.925	11.55	1.35	1.06	4.49
885	884	5.33	563	0.53	44.63	44.54	31.61	0.410	0.409	8.97	1.24	1.09	4.17
886	884	6.49	371	0.65	44.20	44.18	25.48	0.402	0.399	8.91	1.23	1.09	4.16
894	1093	13.57	292	1.36	22.48	30.97	12.50	0.735	0.734	10.74	1.45	1.06	4.36
895	896	8.62	337	0.86	42.64	45.43	19.97	0.798	1.477	19.47	2.44	1.07	5.73
895	1361	7.83	703	0.78	43.36	45.00	28.04	1.135	0.641	13.16	1.73	1.05	4.76
896	895	8.67	339	0.87	42.69	45.42	28.04	0.547	0.641	9.92	1.35	1.07	4.25
896	1015	9.55	298	0.95	41.57	40.90	19.84	1.147	1.290	12.24	1.74	1.05	4.77
908	1276	9.06	730	0.91	42.17	29.64	16.72	1.486	1.290	13.24	1.74	1.05	4.77
908	1296	9.29	697	0.93	41.88	36.50	21.56	0.865	0.311	15.27	1.97	1.06	5.11
909	681	17.18	492	1.72	9.31	15.53	8.87	0.942	0.311	11.87	1.58	1.06	4.54
910	607	9.83	1139	0.98	41.19	38.45	22.38	0.050	0.718	12.35	1.64	1.05	4.62
910	608	5.40	1532	0.83	42.91	40.12	29.53	0.453	0.718	25.93	3.13	1.10	6.46
910	911	7.30	714	0.54	44.61	41.47	33.89	0.316	0.359	11.97	1.59	1.05	4.56
912	1226	7.36	131	0.73	43.74	44.25	17.19	1.545	0.316	8.46	1.18	1.10	4.21
912	1227	7.36	408	0.74	43.71	45.02	24.65	0.773	1.545	14.92	1.93	1.06	5.05
1001	1232	11.30	1096	1.13	27.42	32.81	20.31	0.350	0.616	11.04	1.49	1.06	4.41
										12.98	1.71	1.05	4.73

***** PEAK HOUR SPEED POST-PROCESSING. KNOXVILLE 2020 MINUTP NETWORK *****

FACILITY TYPE=SIGNALIZED
(continued)

MODEL	MODEL2	ADOT_C	PEAK HR VMT	V_C	BPR SPEED	MINUTP SPEED	OSIM SPEED	% DIFF. BPR VS OSIM	% DIFF. MINUTP VS OSIM	CO EMIS FAC. OSIM	VOC EMIS FAC. OSIM	NOx EMIS FAC. (LDGV). OSIM	NOx EMIS FAC. (HDDV). OSIM
1002	1233	11.65	979	1.17	26.55	41.47	19.24	0.380	1.155	13.58	1.78	1.05	4.83
1003	1234	7.65	749	0.76	43.50	44.46	27.87	0.561	0.595	9.96	1.36	1.07	4.26
1007	629	13.65	2,049	1.36	22.33	30.09	15.26	0.463	0.972	16.48	2.11	1.06	5.30
1007	1107	8.03	78	0.80	43.19	47.78	13.61	2.509	2.509	18.13	2.29	1.07	5.55
1008	632	8.82	161	0.88	42.43	36.34	15.41	1.753	1.358	16.35	2.09	1.06	5.28
1014	825	8.24	118	0.82	43.00	29.09	15.38	1.795	0.891	16.37	2.09	1.06	5.28
1015	896	9.57	299	0.96	41.53	40.89	16.68	1.491	1.452	15.30	1.98	1.06	5.11
1017	1351	13.25	1,760	1.33	25.64	38.94	16.62	0.543	1.343	15.35	1.98	1.06	5.12
1021	533	10.78	969	1.08	28.77	39.25	19.11	0.505	1.054	13.66	1.79	1.05	4.84
1021	544	10.53	4,222	1.05	29.47	34.10	23.60	0.249	0.445	11.45	1.53	1.06	4.47
1023	534	22.44	219	2.24	3.97	8.89	6.53	0.392	0.360	33.48	3.91	1.13	7.04
1023	567	11.94	466	1.19	25.87	35.26	14.01	0.846	1.516	17.70	2.24	1.07	5.48
1027	796	16.08	126	1.61	11.18	17.93	8.14	0.373	1.202	27.86	3.33	1.11	6.63
1027	796	16.08	126	1.61	11.18	17.93	8.14	0.373	1.202	27.86	3.33	1.11	6.64
1059	582	19.40	606	1.94	6.45	13.55	8.11	0.204	0.672	9.24	1.27	1.08	4.18
1059	784	5.52	582	0.55	44.58	40.57	30.49	0.462	0.331	12.82	1.69	1.05	4.70
1083	815	7.60	218	0.76	43.53	37.14	20.61	1.112	1.481	19.70	2.46	1.08	5.76
1093	894	13.75	295	1.37	22.15	30.59	12.33	0.757	0.842	18.42	1.17	1.11	4.15
1096	894	13.75	295	1.37	22.15	30.59	12.33	0.757	0.842	18.42	1.17	1.11	4.15
1096	1243	6.69	853	0.67	44.11	42.37	34.07	0.294	0.243	17.07	2.17	1.07	5.39
1106	1285	10.82	424	1.08	28.67	38.88	14.64	0.959	1.656	12.56	1.66	1.05	4.65
1106	1286	7.42	266	0.74	43.66	42.62	21.12	1.067	1.018	12.02	1.60	1.05	4.56
1107	668	7.04	202	0.70	43.91	38.69	22.27	0.972	0.738	19.69	2.46	1.08	5.76
1107	1007	8.96	88	0.90	42.27	43.40	12.34	2.426	2.517	19.69	1.69	1.05	4.69
1109	1222	6.79	278	0.68	44.05	27.13	20.74	1.124	0.308	12.75	2.94	1.09	6.28
1110	1236	17.05	666	1.70	9.52	18.96	9.64	0.013	0.966	24.18	1.94	1.09	6.28
1112	1245	6.41	722	0.64	44.24	44.31	31.57	0.851	0.404	8.98	2.60	1.08	4.17
1125	909	14.34	541	1.43	21.13	28.68	11.41	0.851	1.513	21.01	1.24	1.09	5.93
1201	1202	6.63	791	0.66	44.13	46.76	31.77	0.389	0.472	8.93	1.24	1.09	4.16
1202	1201	6.64	791	0.66	44.13	46.76	31.76	0.389	0.472	8.93	1.24	1.09	4.16
1202	1203	9.53	2,207	0.95	41.60	41.68	24.96	0.667	0.670	10.93	1.47	1.06	4.39
1203	1202	9.53	2,209	0.95	41.58	41.68	24.92	0.668	0.672	10.94	1.47	1.06	4.39
1203	1204	12.45	1,726	1.24	24.73	38.80	16.78	0.474	1.313	15.23	1.97	1.06	5.10
1204	1203	12.45	1,729	1.25	24.68	38.80	16.74	0.474	1.317	15.25	1.97	1.06	5.11
1204	1205	12.47	1,722	1.21	25.48	39.58	14.26	0.767	1.776	17.44	2.21	1.07	5.45
1205	1204	12.10	673	1.21	25.43	39.58	14.23	0.767	1.781	17.47	2.22	1.07	5.45
1205	1206	12.13	1,350	1.20	25.74	39.74	16.89	0.524	1.353	15.14	1.96	1.06	5.09
1206	1205	11.99	1,353	1.20	25.69	39.73	16.85	0.524	1.358	15.17	1.96	1.06	5.09
1206	1207	8.13	637	0.81	43.11	42.79	24.45	0.763	0.750	11.12	2.78	1.09	6.12
1206	1233	14.25	186	1.43	21.27	35.44	10.42	1.041	2.401	22.67	2.50	1.06	4.42
1207	1206	8.14	637	0.81	43.10	42.78	24.41	0.766	0.753	11.13	2.49	1.08	5.80
1207	1208	13.64	668	1.36	22.34	33.69	12.14	0.841	1.777	19.96	2.09	1.06	5.27
1207	1255	13.80	997	1.38	22.05	34.04	15.46	0.426	1.202	19.96	2.49	1.06	5.80
1208	1207	13.65	668	1.36	22.34	33.69	12.13	0.841	1.777	19.96	2.49	1.06	5.27
1208	1209	14.40	1,316	1.44	21.02	32.07	13.20	0.593	1.430	18.61	2.34	1.07	5.61
1209	1208	14.40	1,316	1.44	21.02	32.07	13.19	0.593	1.431	18.61	2.34	1.07	5.61
1209	1210	14.40	987	1.44	21.02	32.01	12.42	0.693	1.577	19.58	2.45	1.08	5.75
1210	1209	14.40	987	1.44	21.02	32.01	12.42	0.693	1.578	19.58	2.45	1.08	5.75
1211	1210	9.24	512	0.92	41.96	41.61	19.21	1.184	1.166	13.60	1.86	1.05	4.83
1211	1211	7.64	187	0.76	43.51	47.82	18.09	1.405	1.643	14.30	1.86	1.06	4.95
1211	1210	9.23	512	0.92	41.96	41.61	19.22	1.183	1.165	13.59	1.78	1.05	4.83

***** PEAK HOUR SPEED POST-PROCESSING. KNOXVILLE 2020 MINUTP NETWORK *****

FACILITY TYPE= SIGNALIZED
(continued)

NOE1	NOE2	ADOT_C	PEAK HR VHT	V_C	BPR SPEED	MINUTP SPEED	OSIM SPEED	% DIFF. BPR VS OSIM	% DIFF. MINUTP VS OSIM	CO EMIS FAC OSIM	VOC EMIS FAC OSIM	NOx EMIS FAC (LDGV) OSIM	NOx EMIS FAC (HDDV) OSIM
1211	1212	8.95	906	0.90	42.28	41.66	23.27	0.817	0.790	11.58	1.55	1.06	4.49
1212	1211	8.95	906	0.90	42.28	41.66	23.27	0.817	0.790	11.58	1.55	1.06	4.49
1213	1212	10.33	573	1.03	30.03	40.08	16.98	0.768	1.361	15.07	1.95	1.06	5.08
1212	1213	10.33	573	1.03	30.03	40.08	16.98	0.768	1.361	15.07	1.95	1.06	5.08
1213	1214	8.19	321	0.82	43.05	42.42	19.65	1.191	1.159	13.34	1.74	1.05	4.79
1214	1213	8.19	321	0.82	43.05	42.42	19.65	1.191	1.159	13.34	1.74	1.05	4.79
1214	1216	6.72	1063	0.67	44.09	43.57	33.96	0.398	0.283	8.45	1.18	1.11	4.15
1216	1214	6.72	1063	0.67	44.09	43.57	33.96	0.398	0.283	8.45	1.18	1.11	4.15
1215	15.23	15.23	198	1.52	12.88	16.92	9.75	0.321	0.281	23.97	2.92	1.09	6.26
1216	1215	6.68	1057	0.67	44.11	43.57	9.75	0.321	0.281	23.97	2.92	1.09	6.26
1216	1217	7.97	910	0.80	43.25	44.06	27.53	0.571	0.600	10.07	1.37	1.07	4.27
1217	1216	7.97	910	0.80	43.25	44.06	27.53	0.571	0.600	10.07	1.37	1.07	4.27
1217	668	7.21	254	0.79	43.80	35.19	23.31	0.879	0.589	11.57	1.55	1.06	4.49
1217	1216	7.92	905	0.80	43.28	44.07	27.73	0.561	0.589	10.01	1.36	1.07	4.26
1218	1217	10.95	610	1.10	28.21	39.08	15.85	0.780	1.465	15.97	2.06	1.06	5.22
1218	1217	10.95	610	1.10	28.21	39.08	15.85	0.780	1.465	15.97	2.06	1.06	5.22
1218	1219	10.21	1050	1.11	27.97	39.05	15.70	0.781	1.487	16.09	2.06	1.06	5.24
1219	1218	10.21	1050	1.11	27.97	39.05	15.70	0.781	1.487	16.09	2.06	1.06	5.24
1219	1220	11.67	400	1.02	30.37	40.11	20.00	0.518	1.005	13.15	1.73	1.05	4.75
1220	1219	11.67	400	1.02	30.37	40.11	20.00	0.518	1.005	13.15	1.73	1.05	4.75
1220	1221	10.29	758	1.03	26.50	37.50	13.01	1.038	1.884	18.84	2.37	1.07	5.65
1221	1220	10.29	758	1.03	26.50	37.50	13.01	1.038	1.884	18.84	2.37	1.07	5.65
1221	1222	8.04	706	0.80	43.18	42.56	18.01	0.672	1.219	14.35	1.87	1.06	4.96
1222	1221	8.04	706	0.80	43.18	42.56	18.01	0.672	1.219	14.35	1.87	1.06	4.96
1222	1223	8.56	434	0.86	42.70	42.37	21.04	0.981	0.839	11.68	1.56	1.06	4.51
1223	1222	8.56	434	0.86	42.70	42.37	21.04	0.981	0.839	11.68	1.56	1.06	4.51
1223	1224	11.08	835	1.11	27.99	38.82	14.28	0.961	1.719	17.43	2.21	1.07	5.44
1224	1223	11.08	835	1.11	27.99	38.82	14.28	0.961	1.719	17.43	2.21	1.07	5.44
1224	1225	12.10	474	1.21	25.50	36.53	16.26	0.800	0.753	15.63	2.01	1.06	5.17
1225	1224	12.10	474	1.21	25.50	36.53	16.26	0.800	0.753	15.63	2.01	1.06	5.17
1225	1226	7.68	978	0.77	43.47	43.55	29.51	0.962	1.811	18.85	2.37	1.07	5.65
1226	1225	7.68	978	0.77	43.47	43.55	29.51	0.962	1.811	18.85	2.37	1.07	5.65
1226	1227	9.33	525	0.93	41.84	41.78	23.25	0.799	0.476	9.50	1.55	1.06	4.49
1227	1226	9.33	525	0.93	41.84	41.78	23.25	0.799	0.476	9.50	1.55	1.06	4.49
1227	1228	7.87	437	0.79	43.32	42.75	22.90	0.892	0.867	11.74	1.82	1.05	4.88
1228	1227	7.87	437	0.79	43.32	42.75	22.90	0.892	0.867	11.74	1.82	1.05	4.88
1228	1229	9.47	548	0.95	41.67	41.09	18.69	1.229	1.198	13.91	1.36	1.07	4.26
1229	1228	9.47	548	0.95	41.67	41.09	18.69	1.229	1.198	13.91	1.36	1.07	4.26
1229	1230	6.24	105	0.62	44.32	43.90	27.85	0.591	0.575	10.44	1.88	1.06	4.97
1230	1229	6.24	105	0.62	44.32	43.90	27.85	0.591	0.575	10.44	1.88	1.06	4.97
1230	1231	5.87	105	0.59	44.46	46.74	17.88	1.486	1.613	14.44	1.47	1.06	4.28
1231	1230	5.87	105	0.59	44.46	46.74	17.88	1.486	1.613	14.44	1.47	1.06	4.28
1231	1232	7.77	558	0.78	43.40	42.94	25.10	0.729	0.711	10.87	1.64	1.05	4.62
1232	1231	7.77	558	0.78	43.40	42.94	25.10	0.729	0.711	10.87	1.64	1.05	4.62
1232	1233	8.30	461	0.83	42.95	44.33	21.61	0.988	1.052	12.33	1.69	1.05	4.69
1233	1232	8.30	461	0.83	42.95	44.33	21.61	0.988	1.052	12.33	1.69	1.05	4.69
1233	1234	10.27	1307	1.03	30.21	40.04	20.73	0.457	0.931	12.76	1.69	1.07	4.30
1234	1233	10.27	1307	1.03	30.21	40.04	20.73	0.457	0.931	12.76	1.69	1.07	4.30
1234	1235	7.74	682	0.77	43.43	40.67	26.74	0.624	0.521	10.32	1.40	1.05	4.66
1235	1234	7.74	682	0.77	43.43	40.67	26.74	0.624	0.521	10.32	1.40	1.05	4.66
1235	1236	10.15	1031	1.02	30.53	34.48	21.01	0.453	0.641	12.85	1.70	1.05	4.70
1236	1235	10.15	1031	1.02	30.53	34.48	21.01	0.453	0.641	12.85	1.70	1.05	4.70
1236	1237	10.34	1316	1.03	30.00	40.02	20.56	0.584	0.553	10.03	1.37	1.07	4.27
1237	1236	10.34	1316	1.03	30.00	40.02	20.56	0.584	0.553	10.03	1.37	1.07	4.27
1237	1238	7.23	544	0.72	43.79	42.93	27.64	0.584	0.553	10.06	1.37	1.07	4.27
1238	1237	7.23	544	0.72	43.79	42.93	27.64	0.584	0.553	10.06	1.37	1.07	4.27
1238	1239	5.61	393	0.56	44.55	43.75	28.43	0.587	0.539	9.80	1.34	1.07	4.24
1239	1238	5.61	393	0.56	44.55	43.75	28.43	0.587	0.539	9.80	1.34	1.07	4.24
1239	1240	5.52	387	0.55	44.58	43.75	28.52	0.563	0.534	9.77	1.34	1.07	4.24
1240	1239	5.52	387	0.55	44.58	43.75	28.52	0.563	0.534	9.77	1.34	1.07	4.24
1240	1241	11.33	708	1.13	27.34	39.89	16.70	0.637	1.388	15.28	2.02	1.06	5.11
1241	1240	11.33	708	1.13	27.34	39.89	16.70	0.637	1.388	15.28	2.02	1.06	5.11
1241	1242	11.68	730	1.17	26.48	39.18	16.14	0.641	1.428	15.14	1.96	1.06	5.09
1242	1241	11.68	730	1.17	26.48	39.18	16.14	0.641	1.428	15.14	1.96	1.06	5.09
1242	1243	11.22	701	1.12	27.63	40.22	16.90	0.635	1.380	15.73	1.71	1.05	4.73
1243	1242	11.22	701	1.12	27.63	40.22	16.90	0.635	1.380	15.73	1.71	1.05	4.73
1243	1244	11.31	1097	1.13	27.39	32.81	20.28	0.350	0.618	13.54	1.78	1.05	4.82
1244	1243	11.31	1097	1.13	27.39	32.81	20.28	0.350	0.618	13.54	1.78	1.05	4.82
1244	1245	11.62	976	1.16	26.63	41.48	10.39	0.379	2.408	22.72	2.79	1.09	6.13
1245	1244	11.62	976	1.16	26.63	41.48	10.39	0.379	2.408	22.72	2.79	1.09	6.13
1245	1246	14.29	186	1.43	21.21	35.43	10.39	1.041	0.593	9.95	1.36	1.07	4.26
1246	1245	14.29	186	1.43	21.21	35.43	10.39	1.041	0.593	9.95	1.36	1.07	4.26
1246	1247	7.64	748	0.76	43.51	44.46	27.90	0.559	0.593	9.95	1.36	1.07	4.26
1247	1246	7.64	748	0.76	43.51	44.46	27.90	0.559	0.593	9.95	1.36	1.07	4.26

***** PEAK HOUR SPEED POST-PROCESSING. KNOXVILLE 2020 MINUTP NETWORK *****

FACILITY TYPE= SIGNALIZED
(continued)

MODEL	NOE2	ADT_C	PEAK HR WMT	V_C	BPR SPEED	MINUTP SPEED	OSIM SPEED	% DIFF. BPR vs OSIM	% DIFF. MINUTP vs OSIM	CO EMIS FAC OSIM	VOC EMIS FAC OSIM	NOx EMIS FAC (LDGV) OSIM	NOx EMIS FAC (HDDV) OSIM
1234	1210	7.65	187	0.76	43.50	47.82	18.07	1.407	1.646	14.31	1.86	1.06	4.95
1235	1216	11.82	185	0.78	26.13	30.92	13.32	0.963	1.322	18.47	2.33	1.07	5.59
1236	1110	15.61	610	1.56	12.09	22.78	10.54	0.147	1.161	22.45	2.76	1.09	6.10
1236	1227	8.70	767	0.87	42.55	39.77	12.79	0.828	0.708	11.58	1.55	1.06	4.49
1236	1235	12.28	192	1.23	25.09	30.34	12.79	0.962	0.196	9.01	2.40	1.09	5.68
1242	1243	7.96	1472	0.80	43.25	37.58	31.43	0.343	1.372	8.67	1.25	1.10	4.17
1242	1255	6.48	867	0.65	44.21	38.84	32.91	0.294	0.180	8.42	1.20	1.11	4.15
1243	1096	6.69	854	0.67	44.10	42.37	34.07	0.373	0.244	8.99	1.24	1.09	4.17
1243	1242	7.95	1469	0.79	43.26	37.59	31.50	0.399	0.193	8.99	1.24	1.09	4.17
1245	1112	6.37	717	0.64	44.26	44.31	31.63	0.381	0.401	8.96	1.24	1.09	4.17
1250	1251	7.49	897	0.75	43.62	39.61	31.58	0.381	0.254	8.98	1.24	1.09	4.17
1251	1227	7.49	1019	0.75	43.62	39.61	31.58	0.381	0.254	8.98	1.24	1.09	4.17
1251	1250	10.03	910	1.00	30.88	34.57	21.32	0.449	0.622	12.47	1.65	1.05	4.64
1251	1250	7.80	999	0.76	43.53	39.60	30.97	0.406	0.279	16.12	1.26	1.09	4.18
1255	1207	13.83	999	1.38	22.01	34.03	15.43	0.426	1.205	16.33	2.09	1.06	5.28
1255	1242	6.49	868	0.65	44.21	38.84	32.91	0.343	0.180	8.67	1.20	1.10	4.15
1262	1263	7.37	1227	0.74	43.70	36.32	32.89	0.329	0.104	8.68	1.20	1.10	4.15
1262	1264	7.04	253	0.70	43.91	38.15	22.26	0.973	0.714	12.02	1.60	1.05	4.56
1263	1262	7.53	1253	0.75	43.59	36.19	32.00	0.362	0.131	8.88	1.23	1.09	4.16
1264	1262	6.87	247	0.69	44.00	38.16	20.96	1.099	0.820	12.64	1.67	1.05	4.67
1269	1253	5.47	563	0.55	44.59	34.51	21.83	0.401	0.084	8.92	1.23	1.09	4.16
1269	1272	7.01	549	0.70	43.93	31.79	29.01	0.514	0.096	9.64	1.32	1.08	4.22
1272	1269	6.95	544	0.70	43.96	31.79	29.01	0.592	0.151	10.04	1.37	1.07	4.27
1276	908	8.74	704	0.87	42.52	29.81	23.58	0.803	0.264	11.46	1.53	1.06	4.47
1281	257	10.20	231	1.02	30.39	40.71	22.55	0.347	0.805	11.89	1.59	1.06	4.54
1281	1282	9.68	345	0.97	41.39	36.07	25.38	0.631	0.422	10.78	1.46	1.06	4.37
1282	1281	9.68	345	0.97	41.39	36.07	25.38	0.631	0.421	10.78	1.46	1.06	4.37
1282	1281	10.36	929	1.04	29.95	38.27	18.02	0.575	1.013	13.71	1.80	1.05	4.85
1283	1282	10.54	929	1.05	29.43	38.05	18.63	0.579	1.042	13.95	1.82	1.05	4.89
1283	1284	10.81	423	1.08	28.69	37.39	14.63	0.959	1.552	17.06	2.17	1.07	5.39
1284	11.02	10.81	431	1.10	28.15	36.85	14.36	0.961	1.567	17.34	2.20	1.07	5.43
1284	1285	10.81	1376	1.08	28.69	38.71	19.50	0.472	0.985	13.43	1.76	1.05	4.80
1285	1106	10.62	416	1.06	29.23	39.47	14.94	0.957	1.643	16.78	2.14	1.06	5.35
1285	1284	11.02	1402	1.10	28.15	38.35	19.07	0.476	1.011	13.68	1.79	1.05	4.84
1285	1106	7.55	271	0.75	43.57	41.83	20.75	1.099	1.015	12.75	1.68	1.05	4.69
1286	1287	7.50	795	0.75	43.61	43.57	29.13	0.497	0.496	9.60	1.32	1.08	4.22
1286	1287	7.50	809	0.76	43.51	43.56	28.51	0.526	0.528	9.78	1.34	1.07	4.24
1287	1286	7.63	708	0.75	43.62	41.63	28.35	0.539	0.539	9.82	1.34	1.07	4.24
1287	1288	7.48	730	0.75	43.62	41.63	28.35	0.539	0.539	9.82	1.34	1.07	4.24
1288	1287	7.72	730	0.77	43.45	43.61	27.32	0.590	0.596	10.13	1.38	1.07	4.28
1288	1289	9.44	832	0.94	41.70	36.30	21.17	0.969	0.714	12.54	1.66	1.05	4.65
1289	1400	8.50	1109	0.85	42.76	42.74	26.19	0.633	0.632	10.49	1.42	1.07	4.33
1290	1289	9.57	843	0.96	41.54	36.09	20.84	0.993	0.732	12.70	1.68	1.05	4.68
1290	1291	7.91	387	0.79	43.29	40.29	21.89	0.978	0.841	12.19	1.62	1.05	4.59
1291	1290	8.56	419	0.86	42.70	39.73	20.11	1.123	0.976	13.09	1.72	1.05	4.74
1291	1292	10.80	687	1.08	28.73	31.21	16.76	0.714	0.862	15.24	1.97	1.06	5.10
1292	1291	11.64	741	1.16	26.57	30.19	15.41	0.724	0.959	16.35	2.09	1.06	5.28
1292	1293	11.47	636	1.15	26.99	30.42	15.13	0.784	1.011	16.60	2.12	1.06	5.32
1293	1292	12.41	689	1.24	24.80	29.16	13.88	0.787	1.101	17.84	2.26	1.07	5.50
1293	1294	12.58	595	1.26	24.43	29.03	13.12	0.863	1.213	18.70	2.35	1.07	5.63
1294	1293	13.76	651	1.38	22.13	27.22	11.92	0.856	1.283	20.25	2.52	1.08	5.83

***** PEAK HOUR SPEED POST-PROCESSING. KNOXVILLE 2020 MINUTP NETWORK *****

FACILITY TYPE-SIGNALIZED
(continued)

MODEL	NODE2	ADOT_C	PEAK HR VMT	V_C	BPR SPEED	MINUTP SPEED	QSIM SPEED	% DIFF. BPR vs QSIM	% DIFF. MINUTP vs QSIM	CO. EMIS FAC. QSIM	VOC. EMIS FAC. QSIM	NOx. EMIS FAC. (LDGV). QSIM	NOx. EMIS FAC. (HDDV). QSIM
1296	908	9.61	721	0.96	41.48	36.09	20.73	1.001	0.741	12.76	1.69	1.05	4.69
1303	1296	6.33	765	0.63	44.28	43.17	33.55	0.320	0.287	8.53	1.19	1.10	4.15
1303	1304	6.34	1.303	0.63	44.27	46.11	37.26	0.188	0.238	7.82	1.10	1.13	4.19
1304	1303	6.46	1.327	0.65	44.22	45.93	37.16	0.190	0.236	7.84	1.10	1.13	4.19
1304	1305	6.44	697	0.64	44.23	31.95	32.56	0.358	0.019	8.75	1.21	1.10	4.16
1305	1304	6.57	712	0.66	44.17	31.94	32.40	0.363	0.014	8.79	1.22	1.09	4.16
1332	1333	7.19	629	0.72	43.81	40.78	30.38	0.442	0.342	9.27	1.28	1.08	4.19
1333	1332	7.17	627	0.72	43.83	40.78	30.51	0.436	0.336	9.24	1.27	1.08	4.18
1349	1350	8.23	2.433	0.82	43.02	48.65	31.63	0.360	0.538	8.96	1.24	1.09	4.17
1349	1349	7.18	1.605	0.72	43.82	40.84	36.78	0.191	0.110	7.90	1.11	1.13	4.18
1350	1349	8.21	2.430	0.82	43.03	48.66	31.69	0.358	0.535	8.95	1.24	1.09	4.17
1350	1351	7.86	3.940	0.79	48.15	48.15	38.18	0.261	0.261	7.66	1.08	1.14	4.21
1351	1350	7.85	1.760	0.78	48.16	48.15	38.27	0.258	0.258	7.64	1.08	1.14	4.21
1361	895	7.63	686	0.76	43.51	46.38	28.92	0.505	0.604	9.66	1.32	1.08	4.22
1364	253	13.18	750	1.32	23.22	33.00	15.61	0.487	1.114	16.17	2.07	1.06	5.25
1364	1365	7.19	1.078	0.72	43.82	39.22	34.35	0.276	0.142	8.37	1.17	1.11	4.15
1365	1349	7.19	1.077	0.72	43.82	40.84	36.71	0.194	0.112	7.92	1.11	1.13	4.18
1365	1364	7.18	1.077	0.72	43.82	39.22	34.41	0.273	0.140	8.35	1.17	1.11	4.15
1391	1392	10.03	1.421	1.00	30.89	40.93	24.32	0.270	0.683	11.16	1.50	1.06	4.43
1392	1391	10.03	1.421	1.00	30.89	40.93	24.32	0.270	0.683	11.16	1.50	1.06	4.43
1392	1393	13.16	206	1.32	23.25	32.52	11.88	0.556	1.736	20.31	2.53	1.08	5.84
1393	1392	13.07	204	1.31	23.42	32.86	11.97	0.557	1.745	20.19	2.51	1.08	5.83
1400	1289	8.52	1.112	0.85	42.74	42.74	26.12	0.636	0.636	10.52	1.42	1.06	4.33
1401	812	7.23	248	0.72	43.79	36.75	21.34	1.052	0.722	12.45	1.65	1.05	4.64
1401	813	9.63	452	0.96	41.45	35.30	18.63	1.225	0.895	13.95	1.82	1.05	4.89
1402	513	13.94	705	1.39	21.80	31.21	11.96	0.824	1.611	20.21	2.52	1.08	5.83
FAC_TYPE			283.726										
			964.676										

APPENDIX G

QSIM COMPUTER CODE (FREEWAYS)

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/* PROGRAM "QSIM.SAS" -- QSIM FOR FREEWAYS                               */

/* READ IN FILE FOR THE HOURLY TRAFFIC COEFFICIENTS OF VARIATION      */
FILENAME CV_INP 'C:\RAM\DISSERT\QSIM\CV_FRE.DAT';

DATA TRAF_VAR(DROP=I J);
  RETAIN CV1-CV72;
  INFILE CV_INP MISSEVER END=LASTONE;
  ARRAY TRAF_CV {72} CV1-CV72;
  IF N = 1 THEN I = 49;
  INPUT @13 TRAF_CV {I} 5.2 @;
  J = I - 48;
  I + 1;
  INPUT @21 TRAF_CV {J} 5.2;
  TRAF_CV {J + 24} = TRAF_CV {J};
  IF LASTONE THEN OUTPUT;
  * 1-24 ARE WEEKDAY AM;
  * 25-48 ARE WEEKDAY PM;
  * 49-72 ARE WEEKEND;

RUN;

/* READ IN FILE WITH TEMPORAL DISTRIBUTIONS                           */
FILENAME TD_INP 'C:\RAM\DISSERT\QSIM\QS2_TD.DAT';

DATA TEMPDIST;
  INFILE TD_INP MISSEVER;
  INPUT HOUR LO_PCT MED_PCT HI_PCT;
  * PREADJUSTED TEMPORAL DISTRIBUTIONS;
  * (ADJ FOR 2C, AWDT/AHDT, AND BALANCED BY DIR);

PROC SORT;
  BY HOUR;

RUN;

DATA QSIM(KEEP=AADT C HOUR HOUR_PCT DEM_VOL ACT_VOL AVG_Q AVG_QLEN
              Q2 VMT VMT2 VMT2);
  CAPAC = ROUND(2300/1.08);
  CAP = CAPAC;
  BNECKCAP = ROUND(2000/1.08);
  FFS = 60;
  Q_SPACE = 43.9;
  Q_SPEED = (BNECKCAP * Q_SPACE)/5280;
  AWDTAADT = 1.0757;
  AHDTAADT = 0.8360;
  LINK_LEN = 5280 * 1.5;
  LENGTH AADT C HOUR DEM_VOL ACT_VOL AVG_QLEN 3;
  ARRAY TRAF_CV {72} CV1-CV72;
  PTR = 1;
  IF N = 1 THEN SET TRAF_VAR;
  DO REP = 1 TO 1000;
    DO AADT_C = 10,15;
      Q1 = 0;
      DO HOUR = 1 TO 72;
        SET TEMPDIST POINT=PTR;
        IF ERROR THEN ABORT;
        IF HOUR <= 72 THEN DO;
          IF AADT_C <= 7 THEN HOUR_PCT = LO_PCT;
          IF AADT_C = 8 THEN HOUR_PCT = (LO_PCT + MED_PCT)/2;
          IF AADT_C = 9 THEN HOUR_PCT = MED_PCT;
          IF AADT_C = 10 THEN HOUR_PCT = ((2 * MED_PCT)/3) + (HI_PCT/3);
          IF AADT_C = 11 THEN HOUR_PCT = (MED_PCT/3) + ((2 * HI_PCT)/3);
          IF AADT_C = 12 THEN HOUR_PCT = HI_PCT;
        END;
      END;
    END;
  END;
  * 1.08 IS HCM FACTOR FOR 8% TRUCKS;
  * 25 gap + 18 veh len;
  *15.5;

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      IF AADT C >= 13 THEN DO;
        TERM1 = HI PCT * (24 - AADT C);
        TERM2 = (1724) * (AADT C - 12);
        HOUR_PCT = (TERM1 + TERM2)/12;
      END;
    END;
    ELSE HOUR_PCT = MED PCT;
    MEAN_VOL = AADT C * CAPAC * HOUR_PCT;
    RANNUM = RANNOR(943252671);
    DEM_VOL = MEAN_VOL + (RANNUM *
      (MEAN_VOL * (TRAF_CV {HOUR} * 0.01)));

    V_C = DEM_VOL/CAPAC;
    NOQ_DEL = (4.46 * V_C) - (1.55 * (V_C ** 2)) -
      (0.05 * FFS * V_C) + (0.044 * FFS * (V_C ** 2));
    NOQ_SPD = ((1/FFS) + (NOQ_DEL/1000)) ** -1;
    qchange = dem_vol - bneckcap;
    q2 = q1 + qchange;
    if q2 < 0 or (q1 = 0 and dem_vol <= capac) then q2 = 0;
    Q1_LEN = Q1 * Q_SPACE;
    Q2_LEN = Q2 * Q_SPACE;
    QCHG_LEN = QCHANGE * Q_SPACE;
    IF QCHG_LEN < 0 THEN QCHG_LEN = -1 * QCHG_LEN;

/* DETERMINE AVERAGE QUEUE LENGTH ON THE SEGMENT DURING THE TIME PERIOD */
    IF Q1_LEN = 0 THEN DO;
      IF Q2_LEN <= LINK_LEN THEN AVG_QLEN = Q2_LEN/2;
      ELSE DO;
        F = LINK_LEN/Q2_LEN;
        AVG_QLEN = F * LINK_LEN/2 + (1 - F) * LINK_LEN;
      END;
    END;
    ELSE IF Q1_LEN < LINK_LEN THEN DO;
      IF Q2_LEN = 0 THEN AVG_QLEN = (Q1_LEN/QCHG_LEN) * Q1_LEN/2;
      ELSE IF Q2_LEN < LINK_LEN THEN AVG_QLEN = (Q1_LEN + Q2_LEN)/2;
      ELSE DO;
        F = (LINK_LEN - Q1_LEN)/QCHG_LEN;
        AVG_QLEN = F * (Q1_LEN + LINK_LEN)/2 + (1 - F) * LINK_LEN;
      END;
    END;
    ELSE DO;
      IF Q2_LEN = 0 THEN AVG_QLEN = (LINK_LEN/QCHG_LEN) * (Q1_LEN -
        LINK_LEN/2);
      ELSE IF Q2_LEN <= LINK_LEN THEN DO;
        F = (LINK_LEN - Q2_LEN)/QCHG_LEN;
        AVG_QLEN = F * (LINK_LEN + Q2_LEN)/2 + (1 - F) * LINK_LEN;
      END;
      ELSE AVG_QLEN = LINK_LEN;
    END;
    AVG_Q = AVG_QLEN/Q_SPACE;

    SPA = 0.004636 - (0.00005495 * FFS);
    SPB = -0.00169 + (0.0000462 * FFS);
    AHVM = 1/FFS + SPA * V_C + SPB * V_C * V_C;
    ASPD = 1/AHVM;
    UTI = DEM_VOL * AHVM/5280;
    AUL = LINK_LEN - AVG_QLEN;
    VMT = ((AUL * DEM_VOL) + (AVG_QLEN * BNECKCAP))/5280;
    VHT = AUL * UTI + AVG_QLEN/Q_SPACE;

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SPEED = VMT/VHT;

SPEED2 = (Q SPEED * (AVG_QLEN/LINK_LEN)) +
          (ASPD * (1 - (AVG_QLEN/LINK_LEN)));
IF AVG_QLEN >= LINK_LEN THEN SPEED = Q SPEED;
ACT_VOL = (BNECKCAP * (AVG_QLEN/LINK_LEN)) +
          (DEM_VOL * (1 - (AVG_QLEN/LINK_LEN)));
VMT2 = ACT_VOL * LINK_LEN;
VHT2 = VMT2/SPEED2;
OUTPUT;
IF Q2 > 0 THEN CAP = BNECKCAP;
ELSE CAP = CAPAC;
Q1 = Q2;
PTR + 1;
IF HOUR = 24 OR HOUR = 48 THEN DO;
  Q1 = 0;
  CAP = CAPAC;
END;
END;
PTR = 1;
END;
END;
STOP;

RUN;
/*
PROC PRINT NOOBS;
  VAR HOUR VMT VMT2 VHT VHT2 SPEED SPEED2;
  FORMAT VMT VHT VMT2 VHT2 COMMA7.0 SPEED SPEED2 5.2;
  WHERE (7 <= HOUR <= 11);
RUN;
*/
PROC SUMMARY NWAY;
  CLASS AADT C HOUR;
  VAR VMT VHT DEM_VOL ACT_VOL AVG_Q AVG_QLEN HOUR PCT Q2 VMT2 VHT2;
  OUTPUT OUT=SUM1 SUM(VMT VHT VHT2 VMT2)= MEAN(HOUR_PCT DEM_VOL ACT_VOL AVG_QLEN
AVG_Q Q2) =;
RUN;
DATA SUM1;
  SET SUM1;
  SPEED = VMT/VHT;
  SPEED2 = VMT2/VHT2;
  IF (25 <= HOUR <= 48) THEN HOUR = HOUR - 24;
  IF HOUR > 48 THEN HOUR = HOUR - 48;
RUN;
PROC PRINT NOOBS;
  VAR AADT C HOUR DEM_VOL ACT_VOL AVG_QLEN SPEED SPEED2; * HOUR PCT;
  FORMAT DEM_VOL ACT_VOL AVG_Q Q2 COMMA7.0 AVG_QLEN SPEED SPEED2 5.2;
RUN;

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VITA

Richard Margiotta was born in Suffern, New York on January 1, 1955. He attended public schools in the North Rockland School District and graduated from North Rockland High School in June, 1973. He attended Lafayette College in Easton, Pennsylvania for two years and graduated from the State University of New York at Albany in June 1978 where he received a Bachelor of Science degree in Biology, with a second major in geography. He then entered graduate school at the University of Tennessee in September, 1978 and received a Master of Science degree in Civil Engineering in June, 1982. He then worked with the Knoxville Metropolitan Planning Commission, the National Academy of Sciences in Washington, D.C., and Science Applications International Corporation in Oak Ridge, Tennessee. In 1989, he returned to the University of Tennessee to work as a Program Manager at the Transportation Center and to pursue a doctoral degree, which he received in December, 1996.

Mr. Margiotta is currently working as a Senior Transportation Analyst with Science Applications International Corporation in Oak Ridge, Tennessee.