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DEVELOPMENT FOR IMPROVED MOTORIST USER COST DETERMINATIONS FOR FDOT CONSTRUCTION PROJECTS

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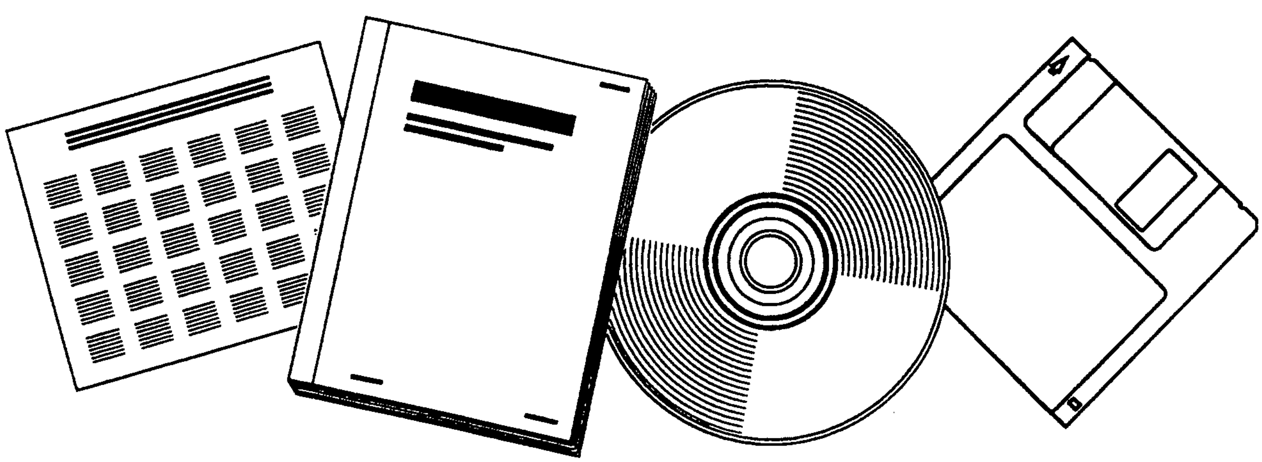

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Development for Improved Motorist User Cost Determinations for FDOT Construction Projects

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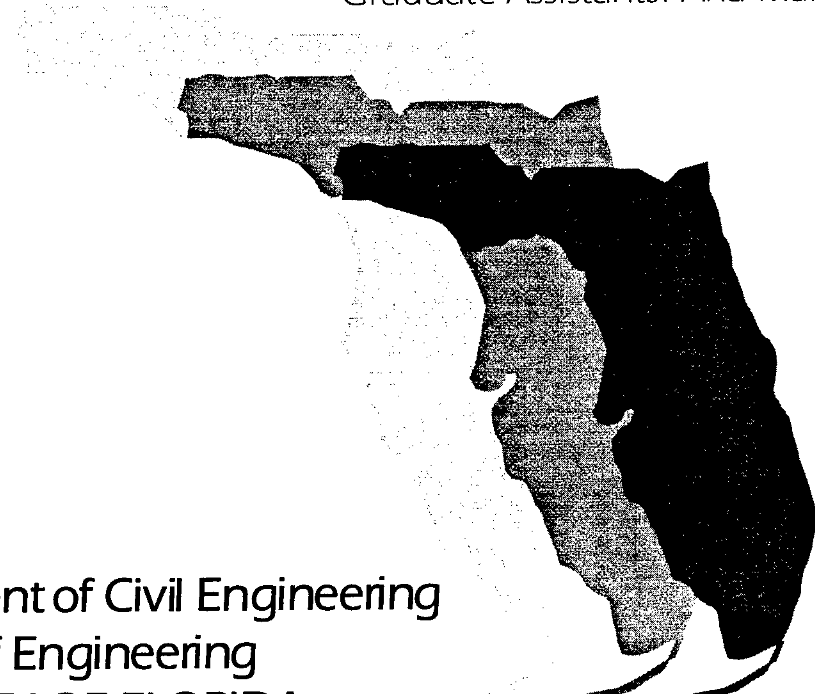

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16. Abstract

When a motorist encounters a highway construction work zone, there are some additional Road User Costs that are incurred as a consequence of the traffic flow interruptions and delays associated with the construction site. User costs are becoming a critical cost component for Florida Department of Transportation (FDOT) construction projects. Most of the innovative contracting practices for highway construction projects include User Costs. Decisions about day versus night shifts, and alternative maintenance traffic plans should also consider Road User Costs. As a result, there is a growing engineering and legal requirement for accurate and defendable user cost calculations.

This report provides a detailed analysis of the variables involved in the calculation of Road User Costs. Also, a thorough study about the current state-of-the-art tools for analyzing road user costs in work zones is included, as well as a survey on the current practices among the State Highway Agencies of the United States. Finally, the report presents a discussion and a practical example of the applicability of one specific tool (QUEWZ model) that has been found to be quite suitable for the needs of the FDOT.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	l
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3

NOTE: Volumes greater than 1000 l shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	l
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
psi	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	ac
ha	hectares	2.47	acres	mi^2
km^2	square kilometers	0.386	square miles	
		VOLUME		
ml	milliliters	0.034	fluid ounces	fl oz
l	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg	megagrams	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	psi

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised August 1992)

DISCLAIMER

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EXECUTIVE SUMMARY

When a motorist encounters a highway construction work zone, there are some additional Road User Costs that are incurred as a consequence of the traffic flow interruptions and delays associated with the construction site. User costs are becoming a critical cost component for Florida Department of Transportation (FDOT) construction projects. Most of the innovative contracting practices for highway construction projects, include User Costs. Decisions about day versus night shifts, and alternative maintenance traffic plans should also consider Road User Costs. As a result, there is a growing engineering and legal requirement for accurate and defendable user cost calculations.

The present report provides a detailed analysis of the variables involved in the calculation of Road User Costs. Also, a thorough study about the current state-of-the-art tools for analyzing road user costs in work zones is included, as well as a survey on the current practices among the States Highway Agencies of the United States. Finally, the report present a discussion and a practical example on the applicability of one specific tool (QUEWZ model) that has been found to be quite suitable for the needs of the FDOT.

INTRODUCTION

1.1 General Comments

The highway systems in the United States have become an essential part of today's life, and the majority of America's total transportation needs are met by these systems. However, the growth in traffic volume has an undesirable effect on the motorists, decreasing their ability to effectively utilize the transportation network. During the past decades, the number of vehicles on the roadways has increased dramatically, but the total miles of new highways have not kept pace with this growth. Consequently, the public is facing increasing congestion problems, especially in urban areas.

The benefits from highway improvements, or their adverse consequences, affect not only those who travel the highways, but the society in general. These benefits reach the users of the roads primarily through the savings on the operating costs of their vehicles, the reduction in highway accidents, and reduction in travel time, and some other factors that cannot be quantified as easily such as better air quality, comfort and convenience. From this point of view, any highway project should be considered an investment, the main objective of which is the highest possible return at a given funding level. Based on a combination of potential costs and benefits from alternative projects, an economic analysis will identify the appropriate alternative that can best utilize the available resources.

Currently, the attention of the State Highway Agencies is shifting from the building of new highways to the maintenance and restoration of existing facilities. When these types of projects are undertaken in urbanized areas, they generate heavy traffic congestion during the time that construction is taking place. These congestion problems have a major impact on the traveling public by increasing their travel time. The speed changes inside the congested areas also have an impact on the operating expenses of the vehicles. Furthermore, there are some other more subtle impacts such as increase in accidents, pollution, noise, and even a negative effect on the surrounding business community due to road closures and/or detours.

Over the past several years, a variety of new contracting and bidding methods have been introduced in the United States. These innovative practices specifically address the reduction in construction time, as a means to minimize the negative effect that road work areas have on the motorists and the general public. The four most popular methods being currently used are: "Bidding on cost/time" (also called "A+B Method"), "Incentive/Disincentive" (I/D), "Bidding on cost/time combined with incentive/disincentive", and "Lane Rental". Each of these methods considers the value of construction time; therefore, its determination becomes very important. Since in highway construction the time value basically represents the additional costs for the public due to the existence of a work zone, the determination of road user costs provides an excellent means to assign value to the construction time.

1.2 Problem Statement

Tightening budgets, and the need for evaluating the impact of road construction and maintenance activities have been some of the driving forces behind much of the advancement in the evaluation of road user costs. Highway designers, planners, and policy makers have embraced the user cost analysis as a means to help the justification and priority ranking of projects, economic viability studies, evaluation of different road investment alternatives, and the determination of the "time" value for the new contracting methods in highway construction, among others.

Although the road user cost calculations have been performed routinely by most State Highway Agencies for many years, no formal computational procedures have been instituted nationwide, and therefore, many states have developed their own procedures. Many other states, however, due to regulatory constraints and hard-to-quantify values, do not even consider the costs of the users in their calculations.

In recent years, a tremendous amount of research studies of the subject of user costs have been conducted. As a result of those research projects, several techniques to evaluate road user costs have been developed, and a few of those techniques have been adopted by the State Highway Agencies. However, those methods are not being used to a desirable degree, partly because some of their support data have become obsolete, and also because some procedures are so cumbersome that they are inefficient.

With work zones, the problem is even worse since each highway construction or maintenance project is unique, and its own set of conditions and constraints demands individualized analyses and customized solutions. There are several models which attempt to measure the additional costs originated at construction sites, but they usually have several limitations, or are so intricate that they cannot be easily applied.

1.3 Research Objectives

The overall goal of this research project was to study the effects of work zones on road user cost calculations, and to make recommendations on a systematic approach to address this issue. The main purpose of this research is, therefore, to analyze existing available tools to perform road user cost calculations. A second objective is to select those methods that are capable of modeling the work zone scenario, and at the same time are applicable to the local conditions of the State of Florida highway system.

1.4 Research Methodology

1.4.1 Breakdown of the Research Methodology Phases

1.4.1.1 Phase 1

At the beginning of the project, questionnaires were distributed to all State Highway Agencies in the United States, as well as to each Canadian provincial highway agency, Hong Kong, and the Virgin Islands. The questionnaires requested information regarding the way these agencies address the road user cost calculations. The results from this survey, and the conclusions drawn from all returned questionnaires are presented in Chapter 3 of this report.

1.4.1.2 Phase 2

An extensive literature search was performed through a variety of related publications and electronic databases in an attempt to uncover the most up-to-date literature written on this subject. This literature review had two major outcomes. In the first place, it allowed a meticulous understanding of the different variables associated with road user costs, their evaluation, and their inclusion into the calculations. This topic is presented in detail in Chapter 2. The second main output was a detailed analysis of the principal methods available to evaluate and compute road user costs. A description of the major methods analyzed is presented in Chapter 4.

1.4.1.3 Phase 3

After the different methods were examined, the next step was to analyze the work zone scenario, and to evaluate the capability of those methods to model the construction zone characteristics. When the appropriate tool was selected, an application was performed to verify the applicability of the model to the local conditions. This process is explained in Chapter 5.

1.4.1.4 Phase 4

Results from the research effort encompassing Phase 1 through Phase 4 were analyzed, and are being presented in this report. Conclusions and recommendations are presented in Chapter 6.

CHAPTER 2

REVIEW OF ROAD USER COST VARIABLES

2.1 Introduction

2.1.1 Background

Economic analysis of a road project is required to evaluate the life-cycle costs and benefits of that project. The time stream of costs and benefits are used to compare the economic viability of different project alternatives and to provide the criteria needed for economic decision making.

Benefit-cost analysis can be used over a broad spectrum of projects and at different levels of detail. There are many methods and techniques available to calculate the benefits to motorists and society of an improved highway. Generally, the computations are based on some changes in the before-after situations that motorists face, and they assign dollar value to those changes, and calculate the total dollar value over the life of the improvement. These benefits are then discounted to present time and by a comparison to the costs of the improvement, an economical decision can be made.

2.1.2 Road User Cost Elements

The benefits of transportation improvement projects represent the difference between the improved and the existing facilities in terms of time costs, vehicle operating costs, and accident costs from the point of view of motorists. Hence, any improvement that can reduce one, several or all of these costs receives "benefits" from such improvements. The wide ranging elements of road user costs can be generally classified into three major categories as follows:

a) Unquantified costs (e.g. effect on social welfare, ecological impacts).

b) Quantified costs not converted to monetary terms (for instance: road safety, pollution from emissions, and traffic noise).

c) Costs converted into monetary terms (e.g. vehicle operating costs, savings in travel time and accident costs).

A schematic view of the above classification is depicted in Figure 2.1.

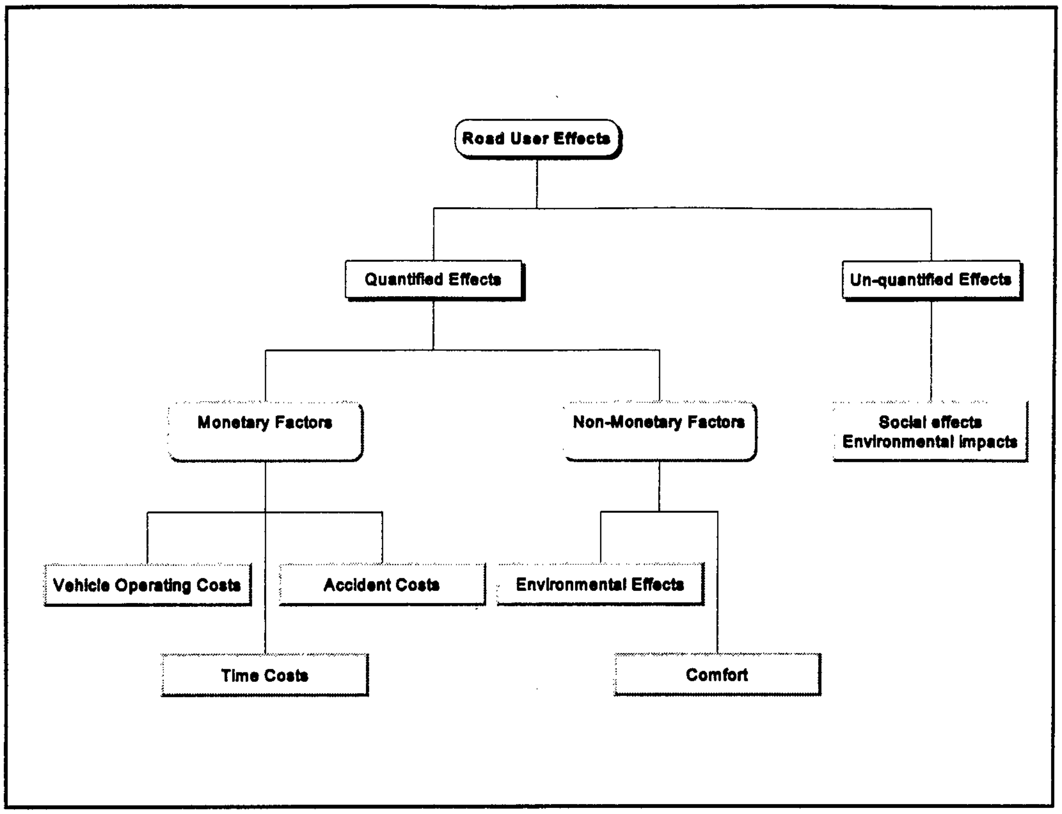

Figure 2.1 Classification of Road User Effects.

2.2 Vehicle Operating Costs

2.2.1 General Comments

Since early times of 19th century (1920) continuous research on the subject of operating motor vehicle costs has been performed. It is not an easy matter to determine motor vehicle operating costs because those costs are affected by many factors and each one of those factors can vary over wide range.

The general objective of a study of motor vehicle operating costs is to match each of the elements of highway design and traffic operation with each of the factors of motor vehicle operating cost. The highway factors are usually the following:

1. Distance
2. Grades (+/-)
3. Horizontal Curvature
4. Speed and speed changes (stops and slowdowns)
5. Roadway surface

The vehicle factors generally considered are:

1. Fuel
2. Tires
3. Engine Oil
4. Maintenance
5. Depreciation

2.2.2 Fuel consumption

The fuel consumption of a motor vehicle is affected by several factors. Those factors can be grouped according to the elements influencing the ride: a) the vehicle, b) the highway, c) the operator or driver, and d) the weather and altitude.

The fuel consumption rate is determined in part by the characteristics of the vehicle in terms of its weight, tires, body size and design, engine, power transmission to the driving wheels, etc.. The weight on the wheels produces a rolling resistance which is proportional to the weight of the vehicle. Therefore, the heavier the vehicle, the more power required to move it. The body size controls the frontal area projected to the resisting air, and the body design controls the air friction. Air resistance is proportional to the square of the vehicle speed when measured in pounds, and to the cube of the speed when measured in horsepower. Thus, when riding at high speed, a high percentage of the engine power is used to overcome air resistance. Tires have some effect on fuel consumption due to their stiffness component. The tires deflect when in contact with the roadway surface, and then they expand to the normal contour. This continuous deflection/expansion movement absorbs energy and generates heat. A tire at high pressures has less rolling resistance than a tire at lower pressure.

There are several engine design factors that affect the rate of fuel consumption. One of the characteristics of the internal combustion engine is that it builds up in horsepower developed as revolutions per minute of the engine increase to a maximum; the horsepower then falls with further increase in revolutions per minute. This characteristic creates the need for a system of gear ratios in the power train whereby moderate engine speed can be obtained at low road speed in order to develop the required horsepower for starting and for steep plus grades. [Winfrey, R.; 1969]

It can easily be observed that fuel consumption varies with the mechanical condition and adjustment of the engine and with the grade of fuel. In terms of the effects of the driver, those are practically null under constant speed, but they become important during speed changes according to the driver's rate of acceleration and deceleration.

2.2.3 Tire Wear

There are different factors that affect the wear of the tire. One of them is the rolling friction which is developed between the tire and the highway surface. There are also some frictional resistance forces (longitudinal and horizontal) developed in the contact area of the tire with the surface (patch). These two resistance forces (rolling and frictional) are increased when the car accelerates and brakes, or when it is negotiating a curve or changing paths from a straight line. Another force appearing in the contact area is caused by the slippage of the driving wheels when moving the vehicle against air resistance and by gravity (when going up or down). In this case, the driving force at the contact area causes the wheels to slip as they roll. [Winfrey, R.; 1969]

2.2.4 Oil Consumption

Oil and lubricant consumption is a minor item in the total calculation of vehicle operating costs. Oil, lubricants, and associated labor could be included with other consumables in the models of vehicle maintenance costs. This would make the data collection in vehicle operating cost surveys simpler and would reduce the total number of cost calculations.

2.2.5 Maintenance Parts and Labor

Vehicle maintenance costs usually need an empirical basis, although collection of such data is cumbersome, particularly as a function of road conditions and changing vehicle technology. These costs require closer examination because jointly with vehicle capital costs, they reflect choices by vehicle owners in a given economic road environment.

2.2.6 Depreciation and Interest

For the analysis of vehicle operating costs as a function of road investment alternatives, vehicle capital costs of depreciation and interest should be related to vehicle usage rather than passage of time. Flaws in data and their interpretation are common, for example when accounting for different degrees of vehicle utilization or by ignoring residual value.

2.3 Time Costs

2.3.1 General Comments

Time is an economic commodity that is valuable [Winfrey, R.; 1969], and it is valuable because quantity and quality of production depends on time. It is a factor that determines the relative worth of current goods as compared with future goods. Therefore, time is one of the controlling factors in computing the interests and discounts on financial transactions. Likewise, time is a major factor in the economy of highway improvements, but unlike other common market products, time has no standard price. However, since time is consumed during travel, it is essential to find some method to calculate the cost of highway travel time.

2.3.2 Characteristics of Time Factor

Time is a item that cannot be altered, transferred, controlled, saved or stored. Due to these characteristics, and since time is not exchangeable, it cannot be purchased or sold. In fact, marketable products are those that have been accomplished over a span of time. This nature of time is important in understanding the concept of "value of time". It is quite obvious now, that the expression "value of time" is a substitute for the general one "value of items produced or services performed over this particular span of time". [Winfrey, R.; 1969]

In terms of travel, time is used or consumed while moving from one place to another. Any difference in the total travel time from one trip to another does not mean that the time was "saved", but actually used in different occupations either before starting the trip or after arriving. The key to the value of travel time, specially passenger travel time, is found in this concept.

When analyzing the economy on highway improvements, travel time is placed as a market item in the direct consequence group. It has already been established that time is identifiable and that it has demonstrated value. However, time is not always effectively priced in the market.

2.3.3 General Factors Affecting Travel Time Values

Many factors which affect the value of travel time vary with each person and each trip. Some of the factors relevant to the value of travel time are:

1. Characteristics of persons traveling in the car (ages, number, occupations, wage earnings, etc.)
2. The trip (distance, number of stops, purpose —e.g. business and pleasure— total travel time, etc.)
3. Environmental (day of week, hour of day, local land use, speed limit, traffic volume and composition, type and design of highway)
4. Factors of Value (e.g. activities before and after the trip, amount of consecutive time available, productive time, utilization of lost time)

For the calculation of time value of commercial vehicles more accurate data exist. Commercial trips are made by paid drivers, and the owners of the vehicles have reliable records of their operating costs. These data may be used as a basis for calculating the value of travel time.

2.3.4 Different Categories of Time Values

2.3.4.1 Working Time

The most usual approach to estimate the value of working time is the marginal productivity theory. The costs of employers can be used to measure the value of the additional production an employee will contribute when the time spent in traveling to work is shortened. Based on this reasoning, the estimation of value for time savings for work trips has focused on the calculation of average rates, fringe benefits and overhead allowances that are underutilized while the employees are in transit during work hours (going to meetings or to purchase work supplies). [Hickling Lewis Brod Inc.; 1995]

2.3.4.2 Commuting Time

The major factor affecting the value of commuting time is the productive use of time while commuting. If a vehicle occupant is engaged in a business related activity like cellular phone conversations, planning or scheduling the day ahead, etc., the cost of the time decreases. The reason is that the individual has not lost or wasted as much time as he would have lost in a vehicle not similarly equipped. With on-board electronic and communication technologies, and the arrival of Intelligent Vehicle Highway System (IVHS) technologies, this productivity factor may have a significant impact on the value of commuting time. [Hickling Lewis Brod Inc.; 1995]

2.3.4.3 Leisure Time

The non-working time valuation theoretical framework is based on the foundations of welfare economics. In a model of welfare economics, an individual derives utility from the consumption of a group of commodities and from undertaking a group of working and non-working activities [Bruzelius, N.,1979]. Consumers will maximize utility according to money and time constraints. The monetary budget constraint establishes that the income must be greater or at least equal to the total expenditure. The time constraint requires that the total available time must also be greater than or equal to the total time spent in various activities. Besides, there are two time allocation constraints: they set the lower limit of the number of hours designated to work, and also of the time spent on all other non-working activities [Hickling Lewis Brod Inc.; 1995].

The value of time spent on any task or activity is then calculated as the willingness of an individual to pay for a saving of a marginal unit of time, at a certain income level. If the non-work activity represents no value for the individual, the marginal value of time equals the marginal value of time as a resource because it indicates how much the person agrees to pay in order to marginally increase the personal total time budget.

2.3.4.4 Commercial Time

This time is evaluated according to traditional cost-benefit analysis of transportation projects, and it represents only approximately 0.1 percent of the total value (carrier plus shipper/receiver) of shipment of goods. This calculation considers direct savings of time as a benefit to the shipper/receiver from transportation infrastructure improvements.

The value of commercial time is believed to be equivalent to the costs coming from storage, carrying, and losses of productivity associated with the storage of goods. Additionally, this commercial time includes, for instance, the closing of warehouses as an outcome of major structural logistic changes resulting from an improved highway network. According to that, the improved reliability of a transportation system may influence industry productivity and the value of commercial time over the long run [Hickling Corporation, 1994].

2.3.5 Estimating the Value of Time

It has been stated that the consideration of time costs should be included in the economic evaluation of highway projects. The potential savings on time from even a minor highway improvement can be translated into significant user cost savings over the life of the highway. It has been estimated, based upon a vast number of highway improvement project that, in general, the 80 percent of total estimated highway project benefits derives from the projected dollar value of time savings; this percentage can be split as 51 percent for savings in working time, and 29 percent for non-working time [MVA Consultancy, Institute of Transport Studies, University of Oxford, 1987]. Therefore, determining the appropriate value of time (or time savings) requires the application of reasoned judgement in implementing the equations to evaluate the monetary value of the time savings.

In obtaining a value of time estimate, first a baseline value has to be selected and then this baseline will be scaled according to the conditions of the evaluation [Hickling Lewis Brod Inc., 1995]. This method generates a price which represents the "opportunity cost" of time spent on the highways. This opportunity cost is based on the value of the "next best" alternative. In economy In transportation, this can be interpreted as the value of not spending time traveling on the highway.

The basic assumption of measuring this value (next best alternative) is that individuals and corporations are willing to pay either for time savings or for the avoidance of "wasting" time while traveling. As expressed before, the value placed on the time saved or wasted, will depend on the alternative use of individual or corporation times, i.e. leisure or work. The value of each alternative use of the time is based on several considerations such as income, occupation and transportation mode, as it was already explained in 2.3.4.

Hickling Lewis Brod established in the draft report "Value of Time Practitioner's Guide" (1995) a three-step process to calculate the value of time (Figure 2.2).

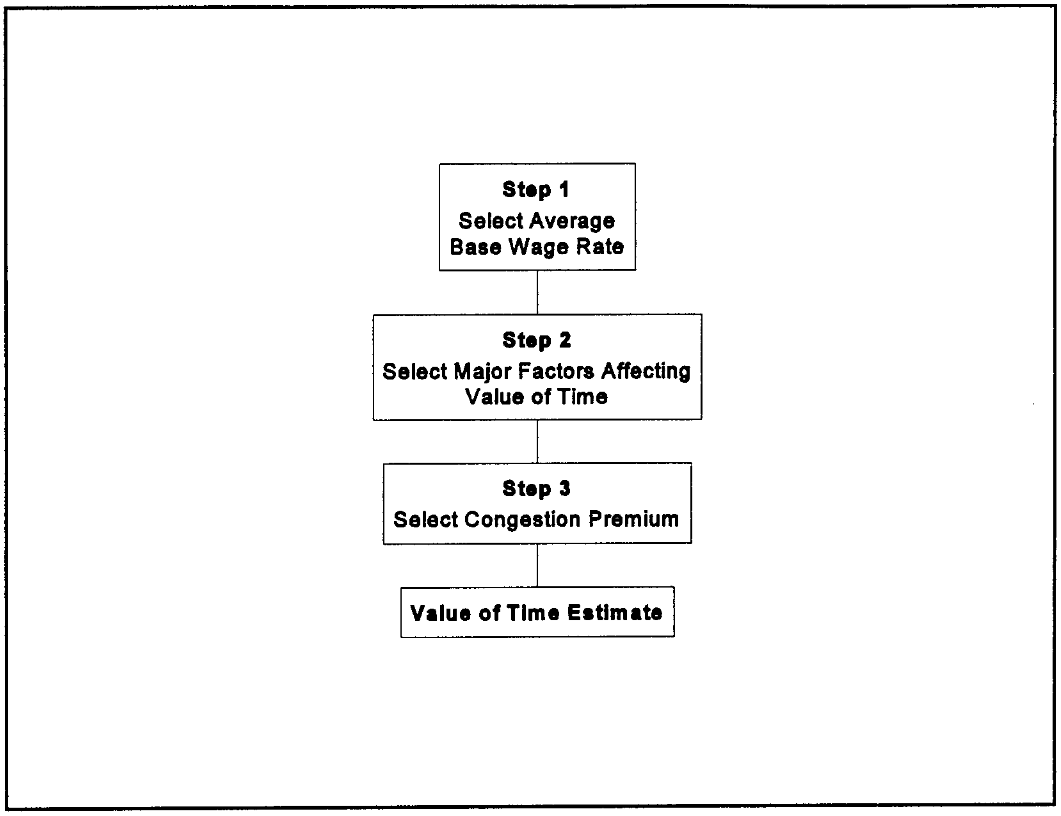

Figure 2.2 Methodology to Calculate Value of Time [Hickling Lewis Brod Inc., 1995]

Step 1: Selecting the Average Base Wage Rate

Data from state wage rates compiled into a national average rate can be used, but only when more detailed regional or local data are unavailable. It is also important that the analyst determines the level of certainty required for the analysis. This average base wage rate is used as the baseline for evaluating the opportunity cost of travel-related time. It represents the willingness to pay to save time spent on the road depending upon individual levels of income.

The average annual wage of a region provides an initial figure for the value of time in that area, considering several socio-economic factors. For instance, major metropolitan areas usually have higher average base wage rates than rural areas. This reflects the higher percentage of highly paid professional occupations in the cities.

It has been observed that the value that people assign to the time varies with their income level: the higher the income of the traveler, the higher the value of time. The use of this information may have important differences when forecasting travel demand, or evaluating competing projects by means of cost-benefits estimations.

Step 2: Selecting Major Factors Affecting Time Value

Once the average base wage rate has been established, it must be scaled according to a wide range of factors and be finally converted into the value used in highway evaluations.

It is quite obvious that the value of time used in evaluating a transportation project is affected by the trip purpose distribution across the traffic volume. This distribution change during the day and among the geographical regions. When considering the relationship between trip purpose and value of time, usually the most economically feasible projects (in terms of value of time savings) are those that influence peak-hour, work-related automobile trips. However, the ratio of work versus non-work related trips has decreased during the last 30 years [Hickling Lewis Brod, Inc.; 1995], and the value of time (and consequently, the potential benefits from time saving) should reflect the current trends and the growing importance of non-work trips.

Furthermore, the recent technological advances allow many travelers to be engaged in work-related activities while on route through the use of laptop computers, cellular telephones, and other devices. Obviously, not all travelers will remain productive when in transit, but it is their ability to do so that makes less significant the potential loss of work time during the trip. As an example, urban train commuters may be more productive than car drivers in terms of office-oriented output, and agricultural workers driving on rural roads may be completely non-productive during their trips. This indicates that the analyst should assign a relatively large productivity factor to that urban train commuter and a marginal factor to the agricultural worker.

Step 3: Assigning the Congestion Premium Factor

When driving in a congested area, people tend to assign a higher value to the time savings. This extra value accounts for the frustration of bumper-to-bumper traffic for an uncertain length of road. The congestion premium considers the costs of delays in traffic volumes that exceed the facility capacity.

Unfortunately, there is no adequate theory or empirical basis to measure the change (if it exists) in the opportunity cost of travel due to delay, unreliability, or unpredictability, at least on an individual basis. However, certain studies reveal that travelers might add an extra value of about 40 percent to the value of time savings during congested conditions in comparison with equivalent time savings during non-congested periods [MVA Consultancy, Institute of Transport Studies, University of Oxford, 1987]. These numbers might indicate that transportation investments in infrastructure that reduce congestion could produce considerable benefits in terms of value of time savings.

2.4 Accident Costs

2.4.1 General Comments

Safety is a very important part of both user and non-user costs of highway travel. In addition to economics, highway safety is an object of public concern and a major social issue. Improved safety requires the use of real resources and, therefore, like other user costs, can impact the design of highways and influence the choice of which alternative to implement.

Following, there is a brief introduction to estimating the safety costs of transportation projects. The section presents a basic methodology for evaluating the economic costs associated with given levels of fatalities, injuries, and "property damage only" (PDO) accidents.

2.4.2 Estimating Safety Costs and Benefits

Accounting for the total safety costs associated with any transportation project, involves the determination of the economic cost of the current level of accidents and the forecast of the change in accident frequency and severity associated with the new facility. The impact of safety improvements, is then unique because, unlike other user cost components, the use of the resources is not certain. Safety costs are a probabilistic calculation involving the degree of exposure to risk. The "benefits" in safety then are generated by lessening the risk of accidents and reducing the severity and consequences of them. [Hickling Lewis Brod, Inc.; 1995].

2.4.2.1 Estimating Life and Injury Values

The statistical values of life and injury may be the basis for calculating the costs of traffic accidents. These values are comprehensive estimates of the direct and indirect costs associated with fatalities, injuries, and Property Damage Only (PDO) accidents. Direct costs include expenses such as medical, emergency services, administrative, and legal costs. However, one of the many components of accident costs is the intangible cost of pain, suffering, and lost quality of life. This latter value can be derived through a willingness-to-pay method which estimates the amount of money society would pay for a reduction in exposure to accident risks.

The use of probabilistic estimates for each category allows the analyst to select the degree of certainty associated with actual costs of the accidents that occur. This practical aspect enables policy judgments regarding the value used in the analysis.

These valuations of life and injury are very important for the economic analysis of highway investment projects, since all economic costs must be converted to dollars. Also, using monetary values of safety benefits allows the comparison of these benefits to other user cost estimates, such as environmental or value of time estimates. Following, there is a brief explanation of the costs considered in each accident type, based on a draft report from the NCHRP and Hickling Lewis Brod Inc. (1995).

a) Fatality. The costs of a traffic accident fatality are attributed to the statistical value of life. The statistical value of life, however, does not represent a "value" of certain individuals or their worth to society. This value is derived from empirical studies that seek to quantify how much an individual would be willing to pay for a reduction in his exposure to risk. Therefore, the "statistical value of life" is another way to express "value per statistical death avoided" , which is basically the amount that the population would be willing to pay to avoid a statistical death.

b) Non-Fatal Injury. The total cost of injuries exceeds the total cost of fatalities. Injury costs can be approximated by extrapolating from the value of life. Injury comprises loss of functioning time in the same way that death does. On one hand, the average number of years lost in a highway accident is known, and also, the value of saving a life is known, therefore, for a given discount rate, the value of a lost functioning year can be calculated. Using this value together with the number of lost years for an injury of any given level, will return the value of injury at that level, or the amount of money the society would pay to prevent an injury of that specific level.

c) Property Damage Only Accident. PDO accidents represent the smallest share of comprehensive accident costs. Although these are the most common types of accidents in terms of cases reported by the police injury scheme (A: Incapacitating Injury, B: Non-Incapacitating Injury, and C: Possible Injury), they account for a small amount of direct costs in comparison with fatalities and injuries. PDO accidents derive most of their costs from insurance and administrative charges, and also property damage.

2.4.2.2 Calculating Accident Rates

Collecting accurate accident rate data is another step of the methodology to estimate safety costs. This step provides the quantity or number of accidents that can be expected to occur along a given roadway or on a certain highway facility. This expected number of accidents, combined with the cost estimates, is used to forecast the safety costs-benefits (in monetary terms) that will occur in the future on the road segment under study. Gathering data on incident rates by accident category is, however, more problematic since not all roads or facilities have an accurate record of incident rates. The analyst must use, then, the available data to make assumptions for the accident rates under different scenarios.

a) *When Data are Available.* For many existing roads and facilities, there are reliable accident data available. Although the classification of car crashes by accident severity may differ a bit, the essential data on fatalities, injuries, and PDO accidents are normally available either per person or per crash. In this case, the analyst is able to calculate the current level of accidents, by frequency and severity, that occur along the road segment.

b) *When Data are Unavailable.* Proposed road segments, for instance, do not have any relevant accident rate data available. Besides, some existing routes may have outdated or partial data that are insufficient for analysis. In those cases, the analyst needs to forecast accident frequencies and severities to be able to develop the safety user cost-benefit of the given road segment or facility. One good approach to develop these forecasts is to use national averages which are available for some categories of accidents, and then adjust these values to reflect local conditions according to roadway and flow characteristics.

2.4.3 Detailed Safety Costs

At the planning level, the evaluation of safety benefits is relatively simple. It involves taking a number representing cost per accident and multiplying by the accident rate. This situation, however, becomes much more complex when considering the correct application of costs and rates for different kinds of accidents (fatalities, injuries by level) and under varying contingencies.

Among the many variables affecting those contingencies, the most obvious are road types, traffic volume, fleet characteristics, driver characteristics, and maintenance level. Measuring safety benefits or accident costs involve the correct identification of both the losses involved and the value of the benefit to the population due to the change in its exposure to physical risk. The identification of losses is a direct process which involves analysis of existing data. The value to the population, however, includes the statistical assessment of what people would pay for safety benefits. Even though the willingness-to-pay approach is being widely accepted, there is not yet a methodology that correctly appraises the benefits for the consumer that are associated with better safety.

2.4.3.1 Life Value

The willingness-to-pay approach has gained acceptance as the most appropriate methodology for estimating the cost of life in cost-benefit analysis, and although there may be growing agreement within the research community as to the correct range for the value of life, there is still a long way to go. It should be noted that the "value of life" estimates are supposed to represent the revealed benefits from saving a statistical life, However, no distinction is made in the literature for valuing different kinds of safety. This is in contradiction to a common sense awareness that in fact there exist social preferences for different kinds of safety (for instance, safety of children, or safety on public carriers, etc.), and even the question about whether or not this classification should be considered in user-cost methodology is still unanswered.

In terms of the issue of the "value of injury" for different injury levels, this is based on measures derived using lost functioning years and the value of life as a basis. Little work has been done in valuing injury, and there is no way to evaluate if the derived measures approximate actual costs. Establishing accurate measures of the value of injury for different levels of injury is critical to rank the different types of safety improvements .[Hickling Lewis Brod, Inc.; 1995].

2.4.3.2 Injury Value

The principal sources for data on injury are the Fatal Accident Reporting System (FARS) and the National Accident Sampling System (NASS). The NASS uses of the Maximum Abbreviated Injury Scale (MAIS) to record severity of injury. The MAIS scale ranks injuries on a one-to-five basis according the severity of the injury related to the threat to life. However, this distinction does not take into account the cost, disability or trauma that the injury involves. [Hickling Lewis Brod, Inc.; 1995]

2.5 Environmental Effects

2.5.1 Introduction

The inclusion of environmental costs in the economic evaluation of transportation projects is gaining acceptance. The environmental impacts of vehicle use, such as exhaust emissions and noise, add some extra social costs to people, material, and vegetation. Recent federal legislation, such as the Clean Air Act (CAA) of 1990 and the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, are directly addressing the environmental impacts of proposed transportation investments. Since public and private sectors are becoming more aware of environmental issues, transportation planners and policy makers are required to include the monetary costs associated with highway traffic pollution when evaluating highway projects.

Although there is general agreement about the fact that environmental impacts are important, there are still ongoing discussions about the methods to evaluate and apply the economic costs produced by environmental effects in traditional user cost analyses. There are some reasons for that. One of them is the limited amount of experimental data, since environmental cost research has only started over the last twenty years. Another reason is that environmental effects are complex in nature, since these effects depend not only on the quantity of pollution, but on the types of pollutants emitted, and on the conditions in which the pollutants are released. The few studies that have been completed have concluded, therefore, that the results are only applicable to the areas studied.

It is obviously important, then, to find a methodology that allows the inclusion of environmental costs without misrepresenting their importance in comparison with other user costs. Following, a methodology from Hickling Lewis Brod, Inc. (1995) is briefly discussed. Since the method is based on risk analysis techniques, it presents a range of values along with their associated statistical certainty. The values are grouped by major pollutant types, with the pollutant emission rates produced by models such as Mobile 5 and EFRAM (Caltrans).

2.5.2 Estimating Environmental Costs

Forecasting the environmental economic costs associated with future traffic flows calls for a method that comprises not only the measurement of pollution emissions, but also creditable valuation techniques for resources such as clean air and water. This method employs a strategic approach for estimating environmental user costs incorporating both known and uncertain variables that impact local environmental conditions. The approach uses the typical elements to model environmental costs such as the quantity of pollutants, the ambient air quality, dose response effect, and the value of life and property. As a result, this procedure produces an estimate of the environmental costs associated with given road segments or highway facilities that can be used for strategic level analysis.

The principal costs considered are those involving human and ecological health, and they are derived from four basic steps. The first step is to obtain a physical measure of emissions from automobiles, usually nitrogen oxide, and particulate matter. This initial quantity of pollutants is then combined with existing atmospheric pollutants. The degree to which these emissions are dispersed is function of local topographic and climatic conditions. Medical epidemiology studies have documented the level of pollutants that imposes social costs on the local population and property values. Finally, the effect of the ambient pollution is valued by multiplying the percentage change in mortality by the statistical value of life and by the percentage change in housing values against a standardized house value.

As may be inferred, several of the steps rely on specialized, technical data and techniques that are difficult and costly to incorporate into general highway evaluation programs. Because of these limitations, there is a rising need for practical and simplified processes to estimate environmental costs when assessing transportation investment alternatives.

The implication of the described approach to model environmental economic costs is that the major uncertainties surrounding environmental effects are incorporated in the relative price of pollution, allowing the planner to determine the relative price of pollution that will be used in the analysis of transportation investment alternatives without complicated environmental analysis.

2.5.3 Characteristics of the Local Environment

A broad range of factors impact air quality and therefore the relative price of air pollution in terms of local conditions. The planner should consider the local impact of pollution and then choose the degree of uncertainty that exists for the local condition. This procedure would produce a relative price that can be used directly with the quantity of pollution to forecast the environmental costs of a given road segment.

2.5.3.1 Pollution Sensitivity

First of all, the pollution sensitivity of the population where the transportation investment is going to take place has to be determined. Given a broad range of physical factors affecting environmental conditions, a framework that allows relative comparisons between cities and rural areas in terms of the effect of highway pollution should be available, since the same amount of pollution may cause different levels of costs in different areas.

2.5.3.2 Pollution and Human Health

Air pollution with concentrations of specific elements has been correlated to human mortality rates. There are several well-known studies regarding transportation that focus on particulate concentrations and their associated epidemiologic impact. Depending on the measure of the particulate, (SO_4, Total Suspended Particles, and Fine Particles), experts have attributed the environmental costs for each element based on its effect on mortality. These findings imply that areas with relatively high concentrations of these elements may have a higher degree of pollution sensitivity.

2.5.3.3 Pollution and Housing Values

The value of property is also affected by the quality of its surroundings, including the level of air pollution. Studies on Hedonic-price method have been developed over the years to assess the value of various non-market resources, including air quality. Some of the findings of those studies suggest that the more polluted the area, the stronger the impact on housing value produced by increased levels of air pollution. Some studies, for instance, reveal that for a one percent increase in pollution, the pollution sensitivity of cities such as Los Angeles was greater than in Washington D.C.. The method being described provides a simple scale of reaction to an identical increase in the ambient level of pollution to account for the apparent range of pollution sensitivity, varying from marginally sensitive to highly sensitive. In summary, the increased air pollution associated with a road investment may produce significant environmental costs in an area that is highly sensitive to air pollution, while its impact may be negligible in a area with only marginal sensitivity to air pollution.

In characterizing geographic areas according to their pollution sensitivity, two criteria have to be considered. Objective criteria that measure general air quality could be used to address the area sensitivity, even more sophisticated rankings could be used based on indicators such as levels of ozone, particulates, and carbon monoxide. Subjectively, there are some other factors that should also be contemplated such as recreational value of the area and social and community factors.

Recreational value is closely related to environmental conditions. The quality or recreational value of a natural beauty (lake, forest or park), may be significantly degraded due to an increase in traffic pollution. Social factors refer to the attitude of the general community towards environment. This attitude can be measured, for instance, by surveying the number of active environmental organizations, or noting the existence of recycling programs, etc.. These social factors may significantly influence the sensitivity towards increased air and noise pollution resulting from additional traffic.

2.5.4 Uncertainty in Environmental Conditions

The cause-effect link between highway traffic emissions and local air pollution levels is not precise. There are so many factors playing different and sometimes critical roles in the matter that there is an inevitable uncertainty when forecasting the costs of different levels of pollution. Some of those factors are vehicle and age composition of the traffic flow, weather patterns, and geographic characteristics.

2.5.4.1 Geographic and Climatic Conditions

The fact that geographic and climatic issues influence the environmental conditions in a region is quite obvious. For instance, cities located in interior basins or valleys are ususally more subject to the impact of stagnant masses of air that remain trapped in the region for indeterminate periods. Residents, plants, and wildlife of these areas may be at a greater risk of suffering from illness from the accumulated concentration of pollutants. From the point of view of the geographic location and climatic weather patterns, some regions may be more pollution sensitive than others.

2.5.4.2 Highway Traffic Effects

The contribution in percentage of highway traffic to air pollution shows the impact of transportation on the environment. There have been important technological improvements over the last decade that have reduced the amount of CO, and NOx emitted from automobiles. However, highway traffic may still represent the largest source of pollution in many areas. As a result, those areas where traffic contribution to overall pollution level is important will tend to be more pollution sensitive. The environmental impact of traffic pollution is a function of total vehicle flow (principally during periods of greatest environmental effect), vehicle speeds, proportions of different vehicle classes in traffic, and stability of speeds, among others.

2.5.4.3 Air quality

The quality of the air is a function of various factors such as geographic and climatic conditions, city size and population density, the location of heavy industry, etc.. Air quality can be described by indices which measure the relative levels of chemical components, such as CO, CO2, NOx, and also the existence of Volatile Organic Compounds (VOC's), Hydrocarbons (HC's), and Particulate Matter (PM). Some other measures include indices based on visibility distances. Again, areas with moderate air quality may be more pollution sensitive than others.

2.5.5 Emissions Related to Transportation Improvements

There are several methodologies to model the relationship between traffic noise and emissions and different highway and traffic conditions. However, none allows making predictions about environmental quality changes or about changes in health risks and other effects that are functions of environmental quality. Making air quality comparable with user cost estimates would provide a means to estimate expected pollutant concentrations as a function of traffic variability, meteorology, and highway features.

2.5.6 Regulatory Issues

In recent years, U.S. environmental legislation has been directed towards improving the quality of air and promoting alternative, non-automobile modes of transportation. Both legislative acts mentioned before, CAA and ISTEA, contain sections intended to decrease transportation-related emissions.

The CAA specifies strict ambient air quality requirements and milestones, mandates future improvements to vehicles and fuels, requires greater integration of transportation and air quality planning procedures, and establishes penalties for failing to meet its requirements. The CAA's National Ambient Air Quality Standards (NAAQS) may compel urban areas to adopt specific measures to decrease automobile emissions. Urban areas that exceed these NAAQS are judged non-attainment areas and are classified according to the severity of their air quality problems, (marginal to extreme), measured by levels of ozone, carbon monoxide, and particulates. On the other hand, the ISTEA primarily addresses the upgrade and improvement of the U.S. transportation infrastructure and provides the funding and flexibility necessary to improve the quality of air through the development of a balanced transportation program.

CHAPTER 3

SURVEY OF CURRENT PRACTICES

3.1 Background

3.1.1 Introduction

At the beginning of this project, questionnaires were sent to forty-nine state highway agencies in the United States, eight provinces of Canada, Hong Kong, and the Virgin Islands. A copy of this questionnaire has been included in Appendix A. These questionnaires requested any information that they could provide concerning how their agency computed and used roadway user costs. Twenty-nine responded to the questionnaires. The State Highway Agencies (SHAs) of the United States which provided information, as well as the Ministries of Transportation of the Canadian provinces which answered the survey, are shadowed in the maps displayed in Figures 3.1a and 3.1b. It should be noted that although Hong Kong also answered the request, it is not showed in the following maps. The information received from these organizations is summarized below.

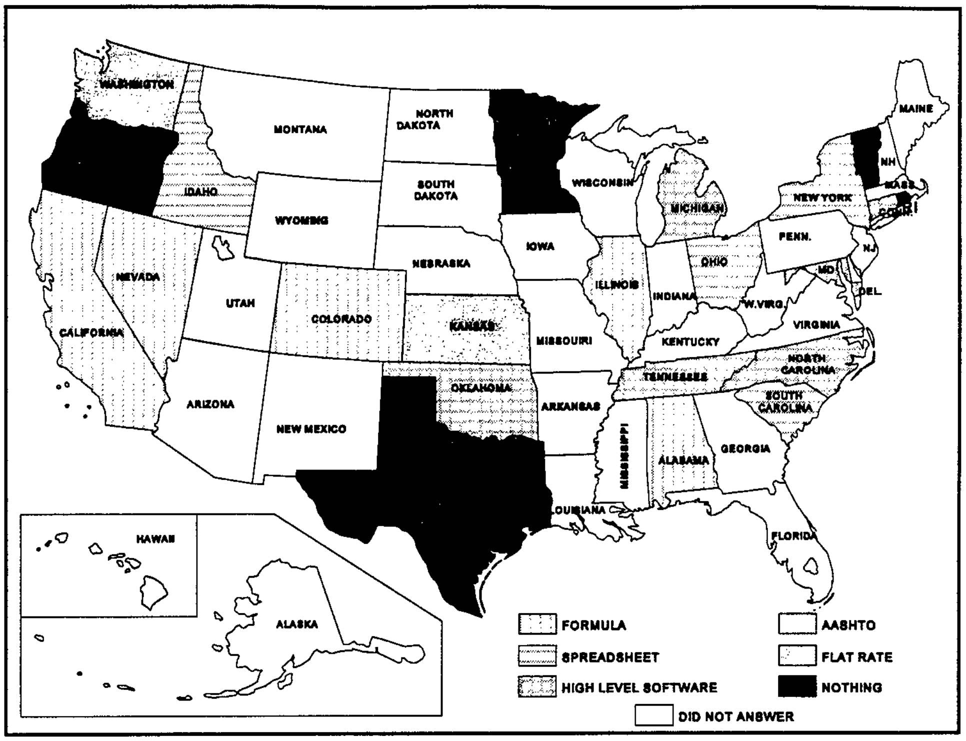

Figure 3.1a U.S. State Highway Agencies that provided information

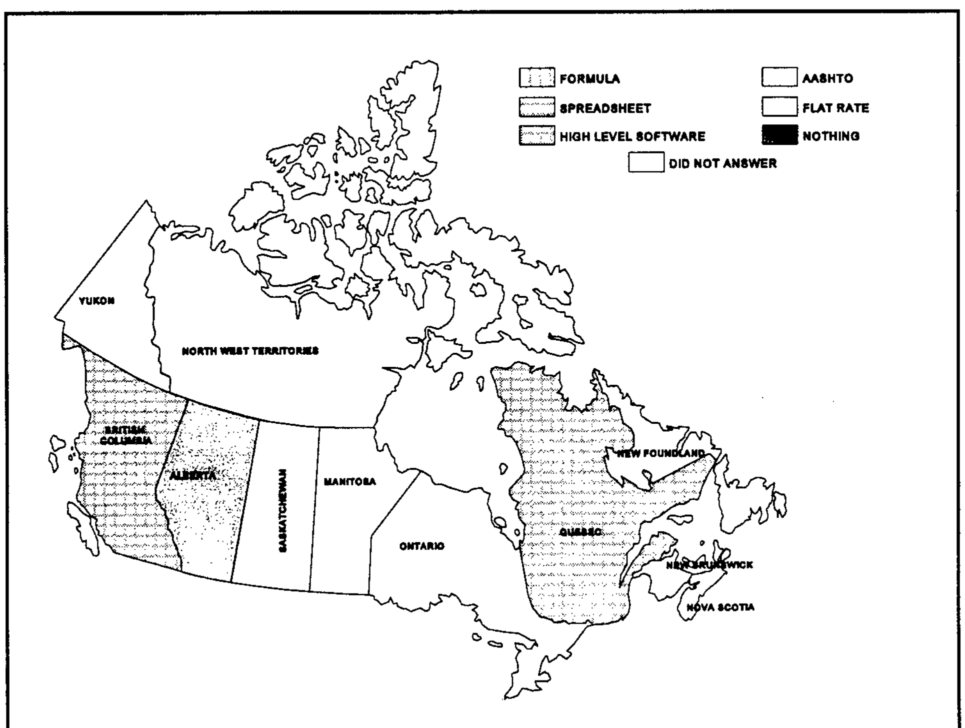

Figure 3.1b Canadian Provinces that provided information

3.1.2 Summary of Information Received

The responses of the questionnaire were categorized into six groups, according to the type of method that the corresponding State Highway Agency (SHA) used to calculate highway user costs. These six groups are:

1) *Simple formulas*. In this group were included those calculation methods which are a rather simple combination of mathematical operations.

2) *Spreadsheets*. This group includes those SHAs which are using spreadsheets either developed in-house, or specially for the SHA (AASHTO and other general methods do not count).

3) *High Level Software*. There are some SHAs that use high level software to evaluate road user costs. To be included in this group, the method used by the agency must include the use of some sophisticated software package, usually of a commercial type.

4) *AASHTO Red Book Method*. This well-known method has been and still is widely used for road user costs calculations. Some agencies mentioned that they follow the AASHTO guideline; others have developed their own spreadsheet based on this method.

5) *Flat Rates*. This group includes those agencies which, although they do include road user costs in their economic equations, do not specifically calculate those costs. Instead, the SHA uses some rate defined by legislators, national guidelines, etc..

6) *Do Not Have Any Formal Method*: This group comprises those agencies that responded that they do not use any method, and/or they do not include road user costs in the economic appraisal of their projects.

This six-group division had the objective to give a general idea as to what extent the agencies calculate or estimate road user costs. The result of this classification is depicted in Figure 3.2.

It should be noted, however, that some agencies use two methods. For instance, some of them use AASHTO Red Book method, but for calculation purposes they developed a spreadsheet to do the procedure. In cases like this, and since the agency did not develop any special procedure, the method counted was the AASHTO.

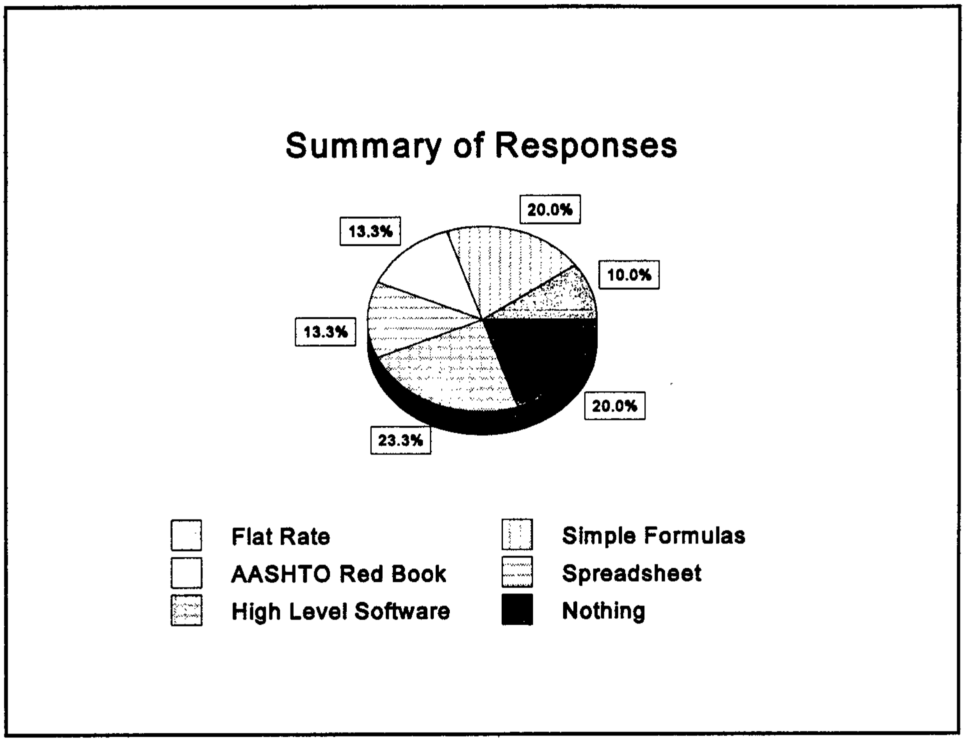

Figure 3.2 Summary of Responses from SHAs

3.2 Survey of Government Highway Agencies

3.2.1 Alabama

The Alabama Department of Transportation currently uses two methods for determining user costs. The first, used in urban conditions, is based on a method developed by both the FHWA and The Alabama Department of Transportation. The algebraic formula that was adopted is shown in Figure 3.3.

The Following is an excerpt from a memo written by T. Paul Weldon, Assis Urban Planning Engineer, on January 3, 199:l

The following procedure uses VMT and VHT output from the transportation model (PLANPAC) applies cost for time or delay, and vehicle operating costs.

$$\left[VHT\,(8.80\text{dollars}) + VMT\left(\%_{PC}\right)\cdot 0.13 + VMT\cdot\left(\%_{T}\right)\cdot 0.38\right]\cdot 300\text{days} = \text{Annual Road User Costs}$$

VHT=Vehicle Hours Traveled
VMT=Vehicle Miles Traveled (avg. weighted vol.)
$\%_{pc}$=Percent Passenger Cars
$\%_{t}$=Percent Trucks

NOTE:
The \$8.80 and the $\%_{PC}$ terms are based on "A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements" 1977, and "Road User Benefit Analysis for Highway Improvements" 1960. Updated based on CPI.

The 300 days term accounts for weekends.

Figure 3.3 Algebraic formula used by Alabama DOT

The second method is used when rural conditions govern. This formula is based on the cost per mile driven on interstate, \$0.24/mile; paved road, \$0.36/mile; or unpaved roads. Stop signs and lights are assigned values of \$0.06 each. The user costs are determined by merely multiplying the distances under evaluation by the appropriate cost factor and adding up the cost for stops.

3.2.2 Alberta

When evaluating potential projects, the Alberta Transportation and Utilities Department utilizes classical benefit-cost analysis that includes vehicle operating costs, travel time costs, and collision costs. This technique is employed in both urban and rural situations throughout Alberta. While generalized data is available for the rural locations, each city provides its own location specific user cost data.

Portions of Alberta's Benefit-Cost Analysis Guide were also reviewed. The guide provides an insightful view of the development of benefit cost analysis within the Alberta Transportation and Utilities. The guide recognizes the value of roadway users time because drivers routinely choose to operate their vehicles between 90 and 110 km/hr when it has been widely proven that the optimum operating efficiency is between 50 to 70 km/hr.

> It is recommended that average wage rates [in 1987 Cdn. Dollars] of $22.00 per hour for bus, truck and transport driver, $12.00 per hour for working occupants of all vehicles and $5.50 per hour for everyone else, including the occupants of buses and recreational vehicles, be used for all travel time differentials (Alberta 3).

Safety costs were also included in this guide. A breakdown of accident data for the entire province of Alberta showed that 2% of all accidents resulted in a death, 35% resulted in injuries, and 63% of accidents cause only property damage. Therefore, the average cost per collision is (1990 Cdn. dollars) $66,120.

A breakdown of accident statistics reveals that, "for each crash involving a fatality, on average 1.35 people die, 0.57 are seriously injured and 0.69 are moderately injured. Including property damage, the average cost for a fatal collision, using the above figures, is [1990 Cdn. dollars] $1,114,000" (Alberta 14-15). Non-fatal crashes typically yield 0.26 serious injuries, 1.43 victims with moderate injuries, and a price tag of (1990 Cdn. dollars) $118,831. See Table 3.1 for a complete breakdown of accident costs.

> On average, in 1987 [Cdn.] dollars, the societal cost of a fatality including family/community and market losses is $640,000, and excluding these losses is $17,700. Comparatively the cost for a serious injury is $425,000 and for a moderate injury is $1,400. Including property damage and using overall provincial numbers, the average cost per collision is $66,120 if the above losses for fatalities are included and $49,320 if they are not included (Alberta 4).

Table 3.1 Accident costs - Alberta Transportation and Utilities Department

ALBERTA				
SOCIETAL COSTS OF TRAFFIC CRASHES*				
PER VICTIM OR CRASH				
-1985 (with 1987 est. values in Canadian dollars)				
		SERIOUS	**MODERATE**	**PROPERTY**
	FATAL	**INJURY**	**INJURY**	**DAMAGE**
Market Losses	$449,331	$268,629	$138	
Family/Community	$134,798	$80,597	$43	
Medical	$924	$23,906	$213	
Rehabilitation		$12,887		
Funeral	$1,962			
Legal	$4,920	$3,488	$297	$16
Insurance	$626	$626	$142	$142
Law Enforcement	$170	$170	$59	$14
Public Liability	$7,985	$8,995	$406	$233
TOTALS	$600,716	$399,298	$1,298	$405
1987 est. value	$639,988	$425,402	$1,383	$431
(CPI of 132/123.9)				
Property Damage**	$6,941	$6,249	$6,249	$3,138
per crash				
* Based on data supplied by B.C. Department of the Attorney General				
** Based on Alberta primary highway collisions in 1983 Canadian dollars factored by 132.0/116.6 to obtain 1987.				

Vehicle operating costs components were also determined by a committee. While the cost of fuel is the single largest factor, the cost of depreciation and maintenance also require substantial consideration.

> The cost for oil and tires is, on average, about 4% of the total cost for passenger vehicle operation and about 11% of the total cost for truck operation. The cost of tires for large trucks increases significantly on steeper grades - up to one-third of the total cost on an 8% upgrade. The greatest efficiency for passenger car operation is on a downgrade of 5 to 6% and for trucks, a downgrade of 2 to 3% is most efficient. Cost data for operating on gravel varies greatly and the conclusion by members of this committee [Executive and a Guidelines

> Committee] is that, generally speaking, the operating costs used for passenger vehicles and light trucks on gravel should be about 18% higher than the cost of operating on a smooth pavement, and that costs for large trucks operating on gravel should be about 30% higher than the costs used for operating on a smooth pavement (Alberta 6).

3.2.3 Arkansas

In the Arkansas State Highway and Transportation Department, the Statewide Planning section uses an Excel spreadsheet to calculate user costs. The spreadsheet is based on A Manual on User Benefit of Highway and Bus Transit Improvements AASHTO, 1977. The agency uses the Consumer Price Index (CPI) to update historical cost data to reflect current economic conditions.

If lane closures are required, the computer software program QUEWZ-92 is used. This software, developed at the Texas Transportation Institute, determines queue lengths and the associated costs.

3.2.4 California

The California Department of Transportation Division of Construction has conducted research investigating the potential benefits of A+B contract bidding. The initial report outlines, among other things, the methodology that was used to compute user costs in pilot contracts. This procedure is highlighted in Figure 3.4.

In the mid-1950s, the California Division of Highways conducted a study to determine the value of travel time. The research recommended values of three cents per minute per vehicle for automobiles and eight cents per minute per vehicle for trucks. The results of this study form the basis of current procedure. The original values are periodically adjusted for inflation using the CPI. These values have been validated through comparisons with similar studies preformed in the United Kingdom, Australia, Norway, and the Netherlands.

"The recommended 1995 travel time value for automobiles is 15.3 cents per minute per vehicle" [Tom, G., 1995]. "The recommended 1995 travel time value for trucks, rounding down

Determination of Road User Costs:
Road user costs were determined using the following calculation guidelines:

Road User Costs = D x E, where
D = Daily reduction in delay (vehicle-hours/day or person-hours/day).
E = Dollar value of delay ($/vehicle-hour or $/person - hour).

- Use person/hours in lieu of vehicle/hours where HOVs become significant.
- Use $6.00/person-hour or $7.20/vehicle-hour when the % of 2 to 5 axle trucks is not more than 3%.
- Trucks = vehicles with 6 or more tires excluding all recreational vehicles and pickups.
- Average $/vehicle-hour for 2 to 5 axle trucks = $19.20
- Average $/vehicle-hour for all other vehicles = $7.20
- Consider empty buses as trucks and treat loaded buses as HOVs using person/hour costs.

The daily reduction in delay (D) is the total daily delay before the project is implemented less the total daily delay after the project is implemented. It is calculated as follows:

D = (L1/S1 - L2/S2) x AADT, where
L1 = Length of project before improvement (miles - minimum 1 mile).
L2 = Length of project after improvement (miles - minimum 1 mile).
S1 = Average operating speed before improvement (mph).
S2 = Average operating speed after improvement (mph) which can not exceed the geometric speed, the posted speed limit, or 50 mph, whichever is least.
AADT = Benefited AADT - only that portion of the AADT that receives a delay reduction as a result of the project.

Figure 3.4 Road user costs determination - California DOT

to the nearest cent, is 40 cents per minute per vehicle" [Tom, G., 1995]. The travel time values for trucks were determined using data from the Bureau of Labor Statistics regarding wage and fringe benefits of truck drivers. These values were confirmed by applying the appropriate CPI to the original 1950 report.

3.2.5 Colorado

Colorado computes the delay per vehicle under existing conditions, then calculates the delay for construction. The difference between these values is then multiplied by the average cost per hour delay. For cars, the 1991 value of delay time was $6.25 per hour. Trucks were valued at $17.80 per vehicle per hour.

3.2.6 Connecticut

The Connecticut Department of Transportation primarily uses user costs in the context of determining liquidated damages. The Division of Traffic Engineering recommends the use of the computer model QUEWZ, developed by the Texas Department of Highways and Public Transportation in 1981, to estimate queue lengths and additional road user costs resulting from work zone lane closures.

The software requires user input to define the conditions being modeled. The department recommends using either the posted speed limit or the 85th percentile speed as the free flow speed. The level-of-service (LOS) D/E speed is determined by using Table 3-1 of the 1985 Highway Capacity Manual. Speed after queue formation is determined by the same table (LOS F). A capacity of 1800 vehicles per hour per lane (vphpl) is typical on Connecticut roadways. The remaining inputs required by QUEWZ can be easily determined from the project's plans and specifications.

3.2.7 Hawaii

The Hawaii Department of Transportation has adopted the methodology presented in AASHTO'S A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements for computing user costs. This technique generates national cost factors, based on January 1975 prices, which account for various conditions such as highway type, vehicle type, speed changes, curvature, etc. These cost factors are then adjusted to represent current local conditions. The Consumer Price Index (CPI) is used to adjust values for automobiles, and the National Producer Price Index (PPI) is used to modify trucking costs.

3.2.8 Hong Kong

The Highways Department of Hong Kong is not currently using or keeping any user costs records.

3.2.9 Idaho

Idaho uses a user cost worksheet to compute the impact that a project will have on user costs. Distance and speed are inputted into the simple algebraic model to determine both the original travel time and the construction travel time. The difference between these values is the resulting delay time caused by the project. The time costs are determined by use of auto and truck average daily traffic (ADT) as well as time values that have been updated using the appropriate CPI.

3.2.10 Illinois

The Illinois Department of Transportation's primary use of user cost evaluation is in Incentive/Disincentive programs. The user cost is based on the change in travel time, passengers per vehicle, and an hourly cost per person. First, the change in travel time is computed. Then, the number of vehicles affected is multiplied by 1.25 passengers per vehicle, this variable has been determined by the Chicago Area Transportation Study. Finally, an hourly rate of $10.00/hour (1990 dollars), based on figures provided by the Department of Employment Security is applied to the computation. An example borrowed from design memorandum No 90-53 is shown in Figure 3.5.

Taken from Example 1 of Design Memorandum No. 90-53

Example 1:
60,000 ADT
Project Length 1.75 miles
Average Normal Speed 55 mph
Average Construction Speed 35 mph

$$\text{Motorist Time (normal conditions)} = \frac{\text{Project Length X ADT}}{\text{Average Normal Speed}}$$

$$\text{Motorist Time (NC)} = \frac{1.75 \cdot 60000}{55} = 1909.1 \text{ Hours}$$

$$\text{Motorist Time (Under Const.)} = \frac{1.75 \cdot 60000}{35} = 3000 \text{ Hours}$$

$$\text{Motorist time lost} = 3000 - 1909 = 1091 \text{ Hours}$$

Total Road User Delay Cost =1091hrs * 1.25 passangers*$10/h
Total Road User Delay Cost = $13,637.50

Figure 3.5 Road user delay costs - Illinois DOT

3.2.11 Kansas

The Kansas Department of Transportation does not routinely use user costs. On occasion they do compute the cost to the user of a construction detour using the FHWA's Cost of Owning and Operating Automobiles, Vans and Light Trucks - 1991. This method does not account for user's time.

3.2.12 Maryland

The state of Maryland uses user cost in the computation of liquidated damages. The components of user cost being evaluated are cost of delay, cost of energy, and cost of accidents.

The cost of delay is based on the difference in travel time between a roadway during construction and the completed project. The percentage of passenger cars and trucks is used in conjunction with trip type factors Table 3.2 to yield the number of people hours affected by the construction. The formulas used to derive these various component values, in 1975 dollar values, are shown in Figure 3.6.

Table 3.2 Vehicle occupancy factors - Maryland DOT

Trip Type	Persons per Vehicle
Work	1.2
Social-Recreational	2.0
Personal Business	1.6

$$\text{Passenger Cars} \times \frac{\text{Persons}}{\text{PC}} \times \frac{\text{Delay (hours)}}{\text{Person}} \times \frac{\text{Cost (\$)}}{\text{Hour}} \times \text{PF} = \text{Delay Cost (\$)} \qquad (1)$$

$$\text{Trucks} \times \frac{\text{Delay (hours)}}{\text{Truck}} \times \frac{\text{Cost (\$)}}{\text{Hour}} \times \text{PF} = \text{Delay Cost (\$)} \qquad (2)$$

$$\text{Vehicles} \times \Delta \frac{\text{Cost (\$)}}{\text{1000 Vehicles}} \times \text{PF} = \text{Energy Cost (\$) per unit time} \qquad (3)$$

$$\text{ADT} \times \text{Length (miles)} \times \frac{\text{Accident Increase}}{\text{1,000,000 veh. mi.}} \times \frac{\text{Cost (\$)}}{\text{Accident}} \times \text{PF} = \text{Accident Cost (\$)} \qquad (4)$$

Figure 3.6 Road user costs - Maryland DOT

3.2.13 Michigan

Michigan uses the Freeway Incident Management Program, developed by FHWA, to evaluate freeway lane reductions and/or total closures. Simulation models such as NETSIM, FREESIM, and DYNEV have also been used to develop user costs for interchange closures. In addition, detour routes are physically driven to determine the increased travel time and distance.

3.2.14 Minnesota

Currently, the Minnesota Department of Transportation does not formally analyze user costs as they relate to work zones and construction time periods.

3.2.15 Nevada

Nevada uses user costs primarily in cost benefit analysis. This analysis is used statewide during the process of project selection. The three components of user cost evaluated are travel time, accident cost, and vehicle operating costs.

> In the interest of consistency, in as much as the large regional models form the basis for many projects, the user costs...utilize the speed and VMT matrix as applied in the capacity restraint program from the FHWA PlanPac transportation planning computer analysis package (Unknown, 1995).

Once these costs are determined they are updated annually using the CPI. Currently, travel time is valued at $6.25 per hour. Fuel consumption is assumed to be 15 mpg and cost to be $1 per gallon. Accident rates are determined by examining accident rates at similar facilities throughout the state as well as county statistics from the Annual Statewide Accident Report. Accident costs are differentiated by type and outlined in a June 30, 1988 U.S. DOT memo. The values reported are as follows: $1.7 million/fatal accident, $14,000/injury accident, and $3,000 per property damage accident. A sample formula is outlined in Figure 3.7.

```
 ab   c d  e      f    g    h    i     j    k    l    m
(((X/Y)-(X/Z))*3*(334.4/162.8)*365*PWF*ADT)*(1.55/1.25)*(146.7/108.8)
```

a) X = Length of project in miles
b) Y = Speed adjusted for v/c ratio
c) Z = Free flow speed - posted speed limit
d) 3 = Time cost per Red Book @ $3.00 / hour (page 17)
e),f) 334.4/162.8 = Consumer Price Index (CPI) increase from 1974 (f) to 1986 (e)
g) 365 = Number of days in a year
h) PWF = Present worth factor per Red Book formula (page 31)
i) ADT = Current year average daily traffic volume
j), k) 1.87/1.25 = Vehicle occupancy factor for Nevada actual count (j) vs. Red Book (k) (pg
l), m) 146.7/108.8 = CPI increase from 1986 (m) to 1994 (l)

Included in the benefits calculated for a project is the estimate of accident benefits obtained on the type of improvement proposed. These are obtained from the NDOT safety Engineerir Division for each individual project.

The accident benefits are added to the time benefits

These two benefits, calculated for a twenty (20) year time frame, are then divided by the corresponding cost of the project to come up with the benefit/cost rato (B/C)

Figure 3.7 Sample formula - Nevada DOT

3.2.16 New York

The New York Department of Transportation has developed a Lotus 1-2-3 spreadsheet to determine user costs. The Highway User Cost Accounting micro-computer package (HUCA) is currently being revised and the updated version is due out in 1996.

3.2.17 North Carolina

The North Carolina Department of Transportation is currently using Technical Report #8. Transportation Project Evaluation Using the Benefits Matrix Model as the basis of user cost analysis. This model quantifies five elements which are used to evaluate competing urban highway projects. These five elements are user benefits, costs, economic development potential, environmental impact, and relationship of the project to the State arterial system. The user benefits are computed as total dollar savings resulting from an improvement project through reductions in vehicle operating cost, travel time, and accident costs. The savings are accumulated over a-20 year design period and the future benefits are not discounted. A computer program P57204 (QPBEN) has been developed for computation of user benefits occurring from vehicle operating cost savings, travel time cost savings, and accident cost savings. An example of how the costs are evaluated is provided in Figure 3.8.

The department uses publications from the Federal Highway Administration and the U.S. Department of Transportation to evaluate the cost of owning and operating an automobile. A representative traffic stream has been developed, based on 1981 conditions in Charlotte, which includes the following mix of vehicles: "2.10 percent 25 ton trucks, 2.20 percent 20 ton trucks, 1.00 percent six ton trucks, 10.41 percent two ton trucks, 24.14 percent standard autos, 24.15 percent intermediate autos, 25.00 percent compact autos, and 11.0 percent subcompact autos" (Poole, 7). These running costs for gas, tires, oil, maintenance, and depreciation have been computed for freeway, arterial, and collector street operation and are listed in Table 3.3.

Benefit Computation

$$B = \sum_{i=1}^{20} VCS_i + \sum_{i=1}^{20} VCS_i + \sum_{i=1}^{20} VCS_i$$

B = benefits

VCS_i = vehicle cost savings for year i

TCS_i = travel time cost savings for year i

ACS_i = accident cost savings for year i

Vehicle Operating Cost

$$VOC_i = \frac{(ADT_{bi} + EADT_{di})}{2} \times 365 \times 20 \times L_i \times OC_i$$

VOC_i = vehicle operating cost for section i

ADT_{bi} = annual average daily traffic estimated or existing on section i in base year

$EADT_{di}$ = estimated annual average daily traffic on section i in design year

L_i = length of section i in miles

OC_i = operating cost in dollars per mile for composite vehicle on section i for assumed average operating speed.

Time Cost

$$TC_i = \frac{(ADT_{bi} + EADT_{di})}{2} \times 365 \times 20 \times \frac{L_i}{S_i} \times O_j \times H_j$$

TC_i = time cost on section i

S_i = average speed on section i in miles per hour

O_j = average vehicle occupancy for urban area

H_j = hourly value of time in dollars for urban area j

Accident Cost

$$AC_i = \sum_{n=1}^{3} N_{ni}\, \gamma_n$$

AC_i = estimated accident cost for roadway seciton i

N_{ni} = estimated number of n type accidents occuring during design period on seciton i

Figure 3.8 Benefit and cost evaluation - North Carolina DOT

Table 3.3 Running costs by road type - North Carolina DOT

Average Speed [a]	Freeway	Arterials	Collectors
10	25.40	30.25	29.25
15	24.20	28.19	27.17
20	23.30	26.53	25.54
25	22.71	24.96	24.40
30	22.32	23.90	23.25
35	22.11	22.96	22.28
40	22.01	22.17	21.66
45	22.03	22.04	22.00
50	22.09	22.10	22.10
55	22.20	22.20	22.20

[a] Average operating speeds considering acceleration and deceleration. Excludes idle time while stopped.

(Poole 7).

3.2.18 Ohio

The Ohio Department of Transportation has adopted a modified version of the New York State Department of Transportation's highway user cost and economic analysis models.

3.2.19 Oklahoma

Oklahoma is currently using two different software packages, Evaluation of Highway User Benefits and MicroBENCOST, which were developed by the Texas Transportation Institute.

3.2.20 Oregon

The state of Oregon responded to our questionnaire and provided us with a detailed motor vehicle cost responsibility study. This report was prepared for the state legislature and although its scope was different from the present study, it provided a detailed breakdown of highway costs.

3.2.21 Quebec

The department is currently implementing the adaptation of MicroBENCOST into their organization. The data that the Ministére des Transports du Québec uses to compute user costs is obtained from Statistics Canada, the Highway Performance Monitoring System (HPMS) model, comparable studies done by other transport organizations, automobile associations, and dealers in automobile parts.

3.2.22 Rhode Island

The Rhode Island Department of Transportation currently does not determine user costs for project reviews or analysis.

3.2.23 South Carolina

The South Carolina Department of Transportation has developed a Lotus 1-2-3 spreadsheet to compute user costs. These costs are primarily used in projects where A+B contracts are utilized.

3.2.24 Tennessee

The Tennessee Department of Transportation gave the University of Tennessee Transportation Center the task of either identifying or developing potential software programs to be used in economic studies. The result of the survey was that the University of Tennessee recommended that MicroBENCOST be adopted and used by TDOT.

3.2.25 Texas

The Texas Department of Transportation has not made a determination of user costs since 1989.

3.2.26 Utah

The Transportation Planning Division of the Utah Department of Transportation has developed a spreadsheet based on data and tables from the AASHTO 1977 Manual on User Benefit Analysis of Highway and Bus Transit Improvement (Red Book). This spreadsheet uses concepts of the Red Book, but has been simplified for ease of use. It is updated annually using the Consumer Price Index (CPI). Both operating costs and time costs are broken down to include autos, light trucks, and heavy trucks. When applied to particular projects, the software yields an output of the total annual running and user costs by vehicle type.

3.2.27 Vermont

The state of Vermont responded to our request for information and provided us with a detailed highway cost allocation study that was prepared for the state legislature. While it provides much useful information, it does not coincide exactly with the scope of our research.

3.2.28 Washington

The user benefit cost parameter for autos is set at $10.00 /hour. This figure is estimated in two parts, the value of in-vehicle time, and vehicle operating costs. The in-vehicle value of time is established based upon reports that suggest using ⅓ the average hourly wage of the commuters as the base value. We use the mean annual wage per household from 1990 Census data to establish this hourly wage (Peach 1).

As a result, in 1992 dollars, the value of time is $6.12 /hour, and the auto operating costs are $0.0749 /mi (for speeds between 40 and 60 mph). This results in a composite value of $3.74 /hour.

The cost parameters for trucks is set at $50.00 /hour. Again, this figure is estimated in two parts, the value of in-vehicle time, and vehicle operating costs. The value of driver time was estimated through conversations with the Teamsters Union staff and other trucking industry officials. This value ranges from $12 - 20.00+, with $17.22 hourly rate for line haul drivers as a bottom line hourly rate they negotiate (Peach 2).

The operating cost for trucks are also 1977 AASHTO based on average running speed of 50 mph. In 1992 dollars total cost = $0.657 /mi or $32.87 /hour (Peach 2).

3.2.29 Wyoming

The Wyoming Department of Transportation has not calculated User Costs for a number of years. If they were to do so, they would use the AASHTO A Manual on User Benefit Analysis of Highway and Bus Transit Improvements as a base framework.

CHAPTER 4

REVIEW OF MAJOR ROAD USER COST METHODS

4.1 Introduction

For this research endeavor, major methods and studies have been revised, not only those formulated in the United States, but also several models developed abroad. The present chapter outlines the findings on the different techniques which have been used in the United States, United Kingdom, New Zealand, and South Africa. The following major methods are analyzed in detail: the 1977 American Association of State Highway and Transportation Officials (AASHTO) Red Book, the software MicroBENCOST developed by the Transportation Texas Institute (TTI) in 1990, the model QUEWZ developed also by TTI in 1982 and successively updated until 1993, the 1979-1982 Texas Research and Development Foundation (TRDF) Relationships, the Highway Design and Maintenance Standards Model (HDM) developed by the World Bank between 1975 and 1984, the ARFCOM model, and several other models.

4.2 AASHTO Red Book

4.2.1 General Comments

The American Association of State Highway and Transportation Officials (AASHTO) published in 1977 “A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements”, also known as the AASHTO Red Book. The manual presents a methodology and cost factors for estimating the user benefits produced by highway improvements. It addresses the question of whether the benefits from decreased highway (and transit) user costs (operating costs, fares, travel time value, and accident costs) actually exceed the costs of the improvements.

The scope of the manual in relation to total highway (and transit) planning is shown in Figure 4.1. The double arrows in the figure mean that the analysis will always entail comparison of two or more alternatives (usually one of the alternatives is doing nothing).

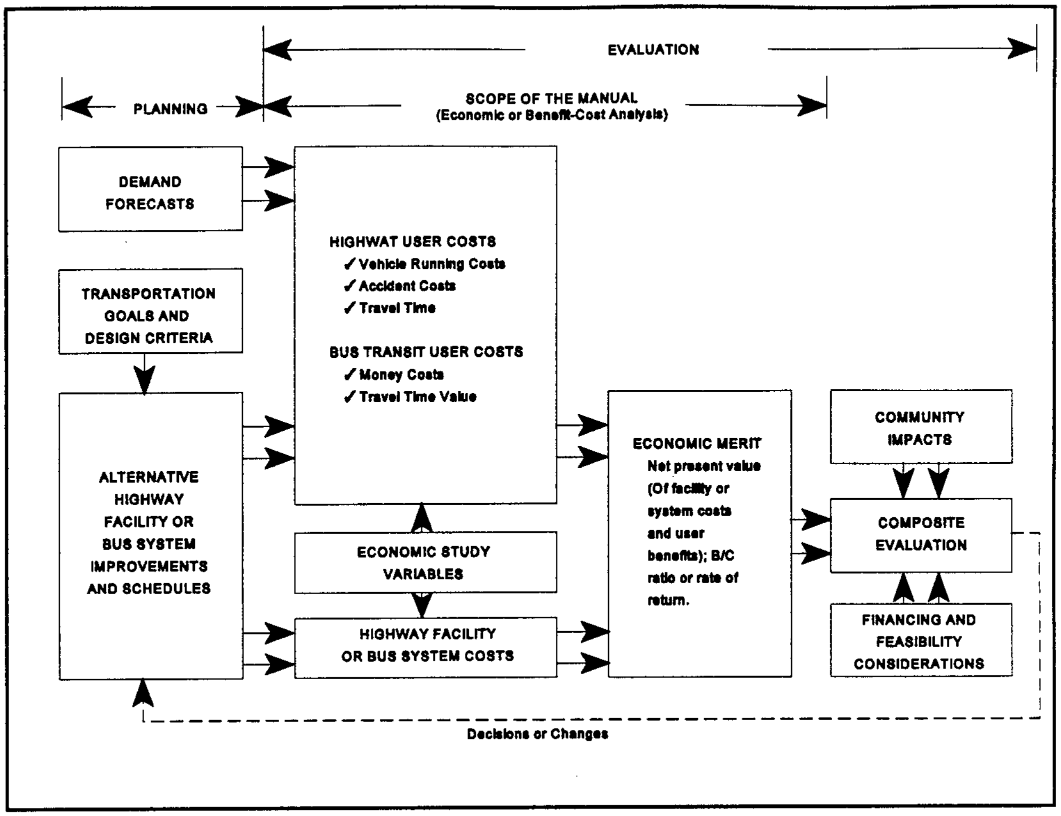

Figure 4.1 AASHTO Red Book scope

This publication provides corrected cost factors and short-cut procedures for many of the problems which have been interpreted and expanded by Winfrey (1969) and by Claffey (1971). This information is complemented by highway and traffic engineering experience in traffic flow. Several of the user cost factors that the manual shows are functions of traffic speed or the volume/capacity ratio. The Red Book was an ambitious planning tool developed to cover vehicle operation on uniform sections of highway, in transition between sections with different characteristics, and at intersections. The user cost data of the Red Book have been and still are widely used in applications such as road planning and design both in the USA and abroad.

4.2.2 Unit User Cost Calculation

The methodology calculates first 'unit' user costs, which are computed on a per unit of traffic (either vehicle or trips) basis over the length of each analyzed road. For flexibility purposes, the manual provides nomographs and tables that can be used to estimate user costs on a one-way hourly traffic basis. In other words, the analysts can make estimations for different times of the day and for separate directions, as needed.

4.2.2.1 Hourly and Daily Traffic

Usually, the traffic volumes are expressed in terms of average daily traffic (ADT). For user cost calculations, however, it may be better to model the diurnal traffic pattern in periods smaller than a day. This is important since highway user costs are at least partly a function of specific traffic conditions, and, therefore, they are only valid when the same conditions are maintained.

4.2.2.2 One-Way and Two-Way Traffic

The manual generally relates to one-way traffic in the user cost calculation procedures. In those cases where the implementation of a road improvement affects the traffic going in one direction in a different way from the traffic going in the opposite direction, two separate analyses should be performed. However, in most cases, improvements on the road affect both directions basically in the same way, and then the results from the one-way analysis can simply be duplicated to account for both directions of traffic.

4.2.2.3 Basic Section Costs

The costs of a basic section are associated with the flow of the vehicles, and the basic geometry (grades and curves) of the section being analyzed. These costs are expressed as functions of volume/capacity ratio and/or average vehicle speed.

The relationships for the total operating costs (fuel, oil, tires and maintenance) and travel time on uniform sections are provided in nomographs, figures, and tables. A procedure for calculation of vehicle depreciation is also outlined. Total cost factors for different speeds on level tangents and on grades can be incremented for different curvatures and for speed change cycles.

4.2.2.4 Transition Section Costs

The manual provides data to calculate transition section costs. These costs are related to vehicles passing among analysis sections with different characteristics (either physical or traffic). When such transitions occur, there usually are some speed changes in the traffic flow, and hence some costs associated with these speed changes. For transitional sections, additional operating costs are calculated from differences in the average running speeds on the adjacent sections.

4.2.2.5 Intersection Delay Costs

The delays at intersections, due to the existence of traffic devices such as signals or stop signs, have associated costs. The manual also provides data to calculate those delay costs.

Intersection delay costs of stopping and idling while stopped are based on Webster's equations for computing delays at signalized intersections with fixed time signals. The nomographs in the Red Book encode relationships between the type and configuration of the traffic control device employed, the level of traffic on the section, and the vehicle approach speed.

4.2.2.6 Accident Costs

Even though the manual has some default and 'guidance' values, these data are intended to be used only when'better' data are not available. As it was stated before, the majority of the values of the manual come from surveys, and they are functions of existing traffic conditions. They are only applicable when the same traffic conditions prevail. However, if no other data are available, the values from the manual can be used with caution.

4.2.3 AASHTO Red Book Highway Variables

The Red Book considers five highway variables that affect the costs of the users:

a) Uniform vehicle speeds

b) Speed changes

c) Road curvature

d) Gradient

e) Surface material.

Since the operating cost of any vehicle depends upon the type of vehicle being analyzed, the Red Book developed procedures and data to calculate operating costs for an average car, a single unit truck, and a 3-S2 combination truck; these were considered to be representative of the total traffic population.

Average running speeds and travel time for these vehicles on uniform sections of freeways, rural multi- and two-lane highways, and urban arterials were based on speed-flow relationships from the 1965 Highway Capacity Manual (HCM). The speed nomographs include congested traffic conditions by service level F. The results can be modified by truck percentage adjustment factors. Roadway curvature is measured in degrees for individual curves. A range from zero to thirty degrees is covered by the charts provided in the handbook. Conversion factors greater than one are intended to adjust the costs computed for paved road surfaces to operating costs on gravel and on earth roads.

4.3 MicroBENCOST

4.3.1 General Comments

MicroBENCOST is a computer software developed to conduct economic analyses in a broad range of highway improvement projects. The software calculates the benefits and costs of an improvement and provides the decision makers with several economic measures.

MicroBENCOST combines inputs provided by the user or its own default data (traffic volumes, highway characteristics, etc.). Then it estimates benefits in the form of 'savings in costs' such as delay savings, operating cost savings, accident reductions, etc., and finally the software computes three economic measures (Net Present Value, Benefit/Cost Ratio, and Internal Rate of Return) for a given discount rate. This process is illustrated in Figure 4.2.

For MicroBENCOST, the benefits of a transportation improvement come from the difference between the existing facility and the projected one in terms of time costs, vehicle operating costs, and accident costs. When a proposed improvement is estimated to reduce any of those costs, then the proposed project will produce benefits.

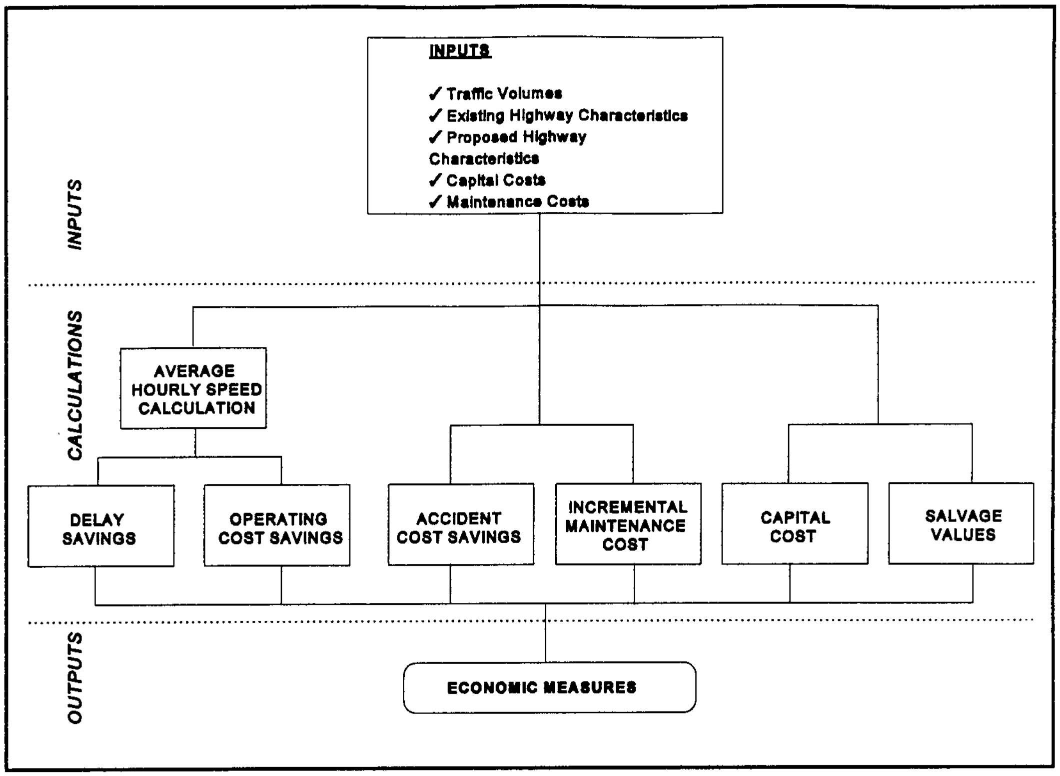

Figure 4.2 MicroBENCOST general procedure

4.3.2 Types of Projects Included in MicroBENCOST

The software is capable of handling a broad variety of projects. Eight major types of improvement projects for highways are included with three options, as explained below. The different types of improvement projects are:

a) *Added Capacity Projects*. These are improvement projects to increase capacity of the existing facility (adding more lanes, changing the original type of highway, etc.).

b) *Bypass Projects*. This type of project usually involves the construction of a new highway or bridge to bypass another road or geographical feature. In MicroBENCOST, when any new location facility with an existing road will not be replaced by the new one, it is considered a bypass.

c) *Intersection and Interchange Projects.* These projects are actual upgrades of existing facilities (intersections/interchanges) to better standards. MicroBENCOST considers three types of intersection and four types of interchange. The intersections are two-way stop, all-way stop, and signalized intersections. The interchanges are simple diamond, three-level diamond, cloverleaf, and directional interchanges.

d) *Highway Rehabilitation Projects.* In this type of project both geometric and structural improvements are included. As for geometric enhancements, they can be to improve alignments (horizontal, vertical, or both), widening lanes, or even paving the shoulders. Structural rehabilitation includes pavement rehabilitation and overlays.

e) *Bridge Projects.* This category includes any major bridge improvement project, from building a new bridge to major rehabilitation.

f) *Safety Projects.* In MicroBENCOST those projects which will allow the reduction of accident rates or accident costs are considered safety projects.

g) *Highway Railroad Crossing Projects.* These projects include all enhancement done at railroad grade crossings, even upgrading the warning devices.

h) *High Occupancy Vehicle (HOV) Projects.* MicroBENCOST considers three types of HOV projects: median HOV facility, the current HOV facility where the direction of the HOV lane is the same as the peak traffic, and the contra-flow HOV lane where the direction of the traffic in the HOV lane is opposite to the peak traffic.

The three options mentioned before, are as follows:

a) *Emission Option.* MicroBENCOST follows FHWA recommendations on emissions at project level, and it analyzes the emission only for carbon monoxide (CO). This option allows the user to analyze the impact of CO emissions caused by an improvement.

b) *Work Zone Option.* The software considers up to three construction zones on any road being analyzed on a session. The work zone option allows the analysis of the effect of closing lanes for certain time period, and the corresponding reduced capacity in that segment. The software has no default data for this matter, and so the user has to provide all the information about the work zone. If the user does not enter data by direction, the software automatically assumes that the construction zone affects both directions.

c) *Incident Option.* In the same way that with the work zones, MicroBENCOST allows up to a total o three incidents on any road being analyzed on a session. The incident option analyzes the impact of lane closure for a certain period of time when the incident happens. In this case, the data cannot be entered only for one direction; the incident option always applies to both directions. Besides, there is an extra constrain which limits the number of closed lanes due to an incident. This limit is one lane on either direction. In other words, the incident cannot produce a total closure of the road, there must be at least one lane open in both directions.

4.3.3 MicroBENCOST Assumptions and Calculations

To calculate user costs, the software uses the general procedures of the 1997 AASHTO Manual, outlined in 4.2, but it also considers some other sources for updated data. As was stated before, MicroBENCOST primarily computes three elements of the user costs: time costs, vehicle operating costs and accident costs, given certain characteristics such as traffic volume, speed, and highway features (grades, curvatures, and pavement conditions). Following, there is a brief description of computations of road user costs:

4.3.3.1 Traffic Volumes

The software uses three different methods to forecast traffic volume over the period of analysis: the annual growth rate method, the intermediate, and the forecast methods. The annual growth method uses traffic volume for the base year and the annual growth rate to calculate future traffic over the period of analysis. The intermediate and forecast volume method use the base year volume, the intermediate year and volume, and the forecast year and volume to fit a curve between the points for each year over the period of analysis.

4.3.3.2 Traffic Allocation for the New Locations

MicroBENCOST allocates traffic to each route within the improvement scenario. This traffic is allocated to the routes until the marginal trip costs of each of them are equal. The user can choose to express the trip costs in terms of user costs or delay costs only. There are eight possible allocation methods that the user can select from.

The algorithm for traffic allocation utilizes an approximation technique to reduce the computational time. For each possible route, the algorithm calculates three points of the user costs per person: nearly zero traffic, all corridor traffic, and intermediate points. The allocation is done for only one year, and the user may select either the year of completion or the year at the end of the period of analysis. It must be noted that the traffic allocation feature is an optional tool that can be used upon discretion of the user.

4.3.3.3 Traffic Distributions

It was already established that the traffic input used by MicroBENCOST is the average daily traffic (ADT). However, it is necessary to break this ADT into hourly volumes since both speed and capacity are functions of hourly traffic volumes. The software calculates those volumes as percentages of the ADT. There are built-in default distributions by rural/urban and highway type, but they can be changed by the user. The hourly distribution also involves directional splits, facilitating the analysis of unbalanced flows of traffic during peak hour periods.

The software also has another method that has been introduced in such a way that the yearly distribution will be treated as a daily distribution and used as default. There are up to twenty-four different intervals to describe this yearly distribution; for each interval there are two data needed: a percent of ADT per hour and the number of hours in the group.

In essence, the technique uses the distribution of hourly volumes over the year, which is approximated with a step function histogram using six intervals. The main advantage of this approach is that it allows the consideration of the very worst hours, which are the hours when the improvements result in the largest benefits. On the other hand, the major disadvantage is the loss of temporal continuity of the traffic volumes, which eliminates its application in those situations where the capacity changes during the day (construction zones, for example).

4.3.3.4 Calculation of Capacity

MicroBENCOST uses the default capacity for freeways, multilane rural highways, 2-lane rural highways, and urban/suburban arterials from those included in the 1985 Highway Capacity Manual (HCM). The software then adjusts this default capacity based on a truck adjustment factor, as established in the HCM. Trucks and buses are expressed as passenger car equivalents.

4.3.3.5 Calculation of Speed

To calculate the section speeds, MicroBENCOST also uses the 1985 Highway Capacity Manual (HCM). HCM gives speed estimations as a function of volume/capacity (v/c) or demand/capacity (d/c) ratio for all types of highways except urban arterials.

The software also includes an option for adding extra delays for incidents and accidents based on a procedure developed by the New York State Department of Transportation, the Highway User Cost Accounting Micro-Computer Package (HUCA).

MicroBENCOST defines speeds based on the 1985 HCM concepts. Speed is the average travel speed, which is equal to the length of the section divided by the average time to travel it. When defining capacity and speed, "ideal conditions" are used, and then the values calculated under those conditions are adjusted for truck percentages, grades, curves, geometric design, etc..

The calculations of the average speed are consistent with the 1977 AASHTO Red Book, and they are based on the hourly demand/capacity ratio. In the case of arterial streets, the relationship between d/c and average travel speed is not entirely explicit. On the other hand, the procedures established by HCM for intersection delays are too detailed and require a large amount of data (detailed signal operation, phasing, traffic flows, etc.). The software uses basically this procedure although there are some changes and simplifications included.

4.3.3.6 Calculations of Delays

MicroBENCOST computes delays in both the existing highway and the proposed improvement, and the difference between those values represents delay savings. These 'time' savings are then multiplied by the value of the time and give as a result a dollar value of delay savings. There are four different delays calculations: at intersections/interchanges, at railroad grade crossing, at constructions zones, or when incidents occur.

a) *Intersections/Interchanges.* To estimate this type of delay, MicroBENCOST uses a simulation procedure based on the model TRANSYT-7F, developed at the Transportation Research Center of the University of Florida. In this model, the average delay per vehicle is computed using the total hourly volume going through the intersection or interchange being analyzed. To calculate the default values, optimal cycle lengths and percent of green time are used as well as typical intersection geometries, phasing, and traffic flows.

The minimum delay for a given traffic volume is calculated by iterating the delay over a range of cycle length. This is then repeated over a broad range of volumes, and these points are used to select default values for the software. These defaults represent the optimal signal timing for a given traffic volume with later adjustments for type of signal and progression.

b) *Railroad Grade Crossing.* To compute the delays on this type of crossing, MicroBENCOST uses a combination of a queuing model and a formula. The software allows the user to enter the number of trains, their average speed, and their length, as well as type of warning device, time to lower and raise the gates, and percent of reduction in speed when crossing the tracks. It even has an option to specify the hourly distribution of trains, similar to the hourly traffic distribution for highway segments.

c) *Incidents and Work Zones.* MicroBENCOST has an optional feature that allows the user to include the costs of incidents of work zones into the basic program. The delays for incidents or construction zones are integrated into the calculations of the delays in the segment. In the case of incidents, the user has to enter the number of incidents blocking lanes, the number of lanes closed or blocked, and the average duration of the closure or blockage. In the case of construction zones, the user must input the beginning and the ending hour of the closure, number of lanes closed, number of days that this closure will take place, and the year.

d) *Adjustment for Discomfort.* The discomfort costs come from three sources: vehicle stopping, congestion, and pavement roughness. These costs are adjustments to the original time costs calculated. Stopping and congestion are factors that adjust the value of time in time cost computations, whereas discomfort for pavement roughness is added to the time costs.

4.3.3.7 Calculations of Vehicle Operating Costs

The software considers five vehicle operating cost components: fuel consumption, oil consumption, tire wear, vehicle depreciation, and maintenance and repair. These cost components are influenced by several highway related factors. The two more common ones to be considered are vehicle type and travel speed. Other factors are percent of grade, the roughness of the surface, and the curvature of the road. To calculate the costs of the vehicle operating components, the consumption of each one is computed for given roadway characteristics and traveling speeds, and then these values are multiplied by the corresponding unit prices.

MicroBENCOST unit prices and vehicle consumption information are based on the study performed by J.P. Zaniewski in 1982 at the Texas Research and Development Foundation (TRDF). This selection was based on the fact that, at the time of the study, Zaniewski's report contained the most recent data on vehicle consumption in the United States. Using the appropriate price indexes, the unit prices in the Zaniewski report were updated from 1980 to 1990.

There are four different operating situations. These categories represent consumption for vehicles traveling at uniform speed at a given grade, and the additional consumption due to changing speeds, idling, and negotiating a curve. The software approximates the data contained in Zaniewski tables using regression formulas. Once the consumption for the different operating conditions are calculated, the values are then adjusted to account for pavement roughness.

As for the vehicle categories, MicroBENCOST uses the same classification as Zaniewski, except for passenger cars. Zaniewski considers four types of passenger cars: small, medium, large, and pickup whereas MicroBENCOST groups them as follows: small, medium/large, pickup/van, and bus. The truck categories in MicroBENCOST matches exactly the one established by Zaniewski: 2A single-unit, 3A single-unit. 2-S2 semi's and 3-S2 semi's.

a) *Operating Costs at Uniform Speed.* The consumption data reported by Zaniewski were used to calculate regression equations which relate each consumption element to several highway factors. The relationship of each consumption element to speed is computed according to the type of vehicle at each grade level, and in this way it is possible to have estimations of component consumption at a certain uniform speed, by grade and by vehicle type. Zaniewski presents his data for 17 different grades (from -8 degrees to +8 degrees). The software equations assort these data into groups for one or more grades.

b) *Additional Operating Costs for Horizontal Curves.* Zaniewski includes data of excess consumption for curvatures of 1, 2, 3, 4, 5, 6, 8, 10, 12, 14, 16, 18, 20, 25, and 30 degrees. For the software purposes, and to better fit these data, several equations were developed for each vehicle type and for each curvature category.

c) *Roughness Adjustment Factors.* Several adjustment factors, in terms of pavement serviceability index (PSI), were developed for cost of depreciation, oil consumption, tire wear, and maintenance and repair. These factors were also based on Zaniewski's data.

d) *Cost of Speed Change Cycling.* The procedures for estimating the additional costs due to speed changes were based on the approach of the NCHRP Report 133 of 1972. This approach was believed to have the best data for estimating the number of speed changes for different vehicles, highway types, and traffic conditions.

For the calculation of the number of speed change cycles, MicroBENCOST uses the nomograph for added speed change cycle costs and unit cycling cost tables of the 1977 AASHTO Manual. As for the extra operating costs, from the data on speed change cycle operating costs presented by Zaniewski in his report, equations were developed for unit speed change cycling costs. The total costs due to speed cycling for a highway segment are calculated by multiplying the number of cycles by the unit cycling costs.

e) *Idling Costs.* This cost is computed by multiplying the average stopping time by the number of stopped vehicles and the consumption of each vehicle operation component (except for tire consumption, which is not calculated when the vehicle is idling). The data for operating cost components while idling were also taken from Zaniewski's study.

4.3.3.8 Accident Costs

In MicroBENCOST, the total accident costs are obtained by multiplying the number of accidents of each type (fatal, injury, or Property Damage Only –PDO–), by the unit accident cost of each type. In the software, the accident costs are calculated separately for highway segments, intersections and interchanges, bridges, and railroad grade crossing because of their different exposures. It should be noticed that the highway segment accident cost computation does not include the other features, even any of them may be included in the segment. Thus, when intersections, interchanges, bridges, or railroad grade crossing are part of a highway segment, the accident costs of each of them have to be computed and then added to the costs calculated for the segment.

a) *Accident Rates.* The number of accidents are computed from the accident rates in different ways. For highway segments and bridges, the accident rates are in terms of number of accidents per 100 million vehicle-miles and the total vehicle-miles traveled. In the case of railroad grade crossings, intersections and interchanges, the accident rates are in terms of number of accidents per 100 million vehicles and total number of vehicles at the intersection/interchange or railroad grade crossing. The default data contained in

MicroBENCOST was taken from the accident rate data in Highway Economic Requirement Systems, a technical report published by the Federal Highway Administration (FHWA) in 1991.

b) *Unit Costs for Accidents.* To arrive at the unit cost of accidents, the study considered several different methods such as direct cost only approach, human capital using net production cost concept, human capital using total production concept, and market or 'willingness-to-pay' approach.

For MicroBENCOST, the values recommended by Rollins and McFarland in their report "Cost of Motor Vehicle Accident and Injuries" published by the Transportation Research Board (TRB) in 1986, were updated to 1990 dollars using the Consumer Price Index, and these values are used as default data for unit accident costs.

4.3.3.9 Environmental Effects - Carbon Monoxide Emissions

At the time of MicroBENCOST development, the latest FHWA recommendations were that at project level, the analysis of carbon monoxide (CO) emissions should be done using MOBILE 4, a software developed by the Environmental Protection Agency (EPA). The data on CO emissions generated from MOBILE 4 are related to the average speed, ambient temperature, altitude, and percentage of travel by vehicles in the conditions of "cold-start" and "hot-start". The program actually computes emission factor for the current year and also for the following 20 years.

MicroBENCOST uses a regression equation to estimate CO emissions, from the emission data of 1987 generated by MOBILE 4 provided by FHWA. The equation is a function of the average speed, ambient temperature, altitude, year, and percent of vehicle-mile traveled of cold-starts engine of non-catalyst vehicles (PCCN).

The default emission data of MicroBENCOST is set for three periods during the year:

winter (including December, January and February), spring and fall (March, April, October, and November), and summer (including May, June, July, August and September). To estimate the CO emissions the total annual vehicle-miles traveled must be distributed according these three periods.

4.3.3.10 Values of Time

The values of time for passenger cars used in MicroBENCOST come from the 1986 study "The Value of Travel Time: New Estimates Developed Using a Speed-Choice Model" by Chui and McFarland, and they were updated to 1990 dollars. In the case of buses, the values used in the software were taken from the 1975 study "Benefit-Cost Analysis: Updated Unit Costs and Procedures" by Buffington and McFarland, and they were also updated to 1990 dollars.

For trucks, the travel time savings represent savings in the market cost of moving goods. In MicroBENCOST there are four categories of trucks: single-unit with 2 axles, 4-tire; other single-units; semitrailer combinations with 4 axles or less; and all the others with 5 or more axles. The values of time for these four types are also an update to 1990 of the values presented by Buffington and McFarland.

4.4 QUEWZ-PC

4.4.1 General Comments

The software QUEWZ (Queue and User Cost Evaluation of Work Zones) was developed as a tool for evaluating work zone lane closures. It was designed to compare traffic flows on freeway segments with and without lane closure, and to estimate the changes in the flow characteristics (such as average speed and queue lengths), and to compute additional road user costs resulting from those alterations in the normal traffic flow.

The model has the ability to address lane closures in freeway facilities or multilane divided highways with up to six lanes in each direction with any number of closures in one or both directions, and it can analyze 24 hours of consecutive operation. The general structure of the model is illustrated in Figure 4.3.

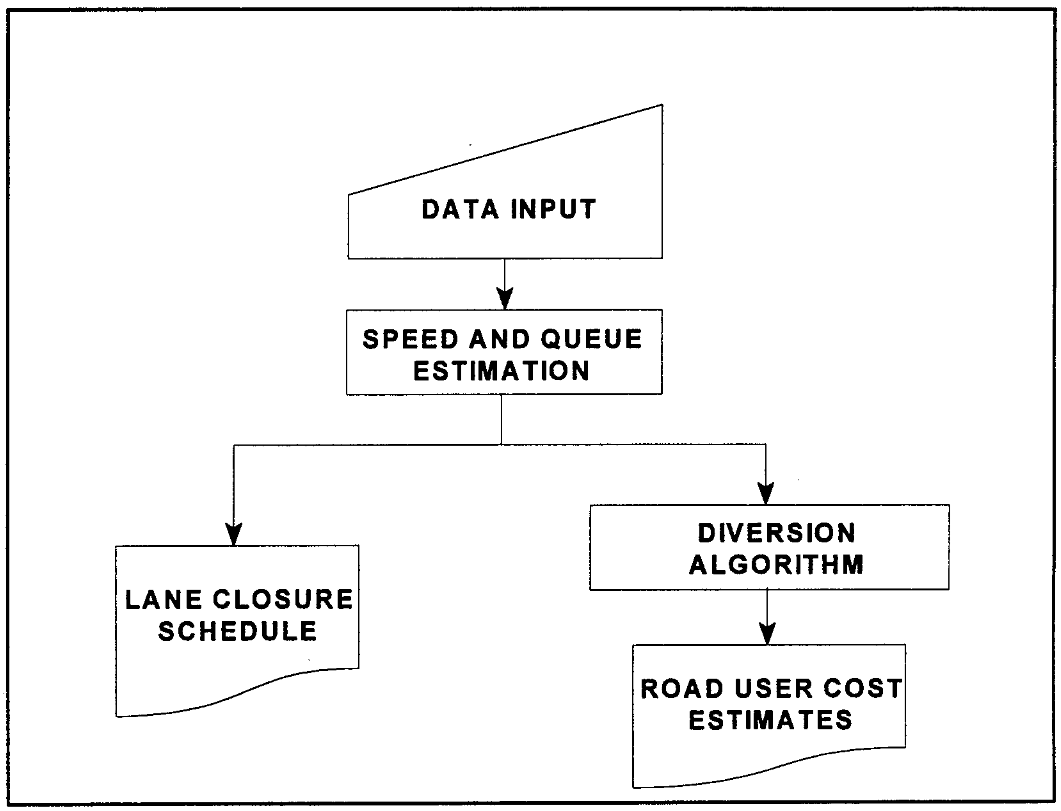

Figure 4.3 QUEWZ general structure

The software produces two types of outputs:

a) *The lane closure schedule option.* This output option summarizes the time and duration of the lane closures to avoid excessive queue formation. The analysis is done on an hourly basis allowing that the planning of lane closures can be scheduled before too long a queue occurs. The user is the one who defines the 'excessive' queue. The default values are a queue length of 2 miles (3.2 km) or a waiting time of more than 20 minutes.

b) *The road user costs option.* This option estimates the traffic volumes, capacities, speed, and queue lengths, and additional costs generated during each hour of lane closure.

For the estimation of the queues and speed, the software uses the procedures of the 1985 Highway Capacity Manual (HCM). The average speeds are based on the speed-volume relationship of the highway under study. Even though the parameters for speed-volume relationship are built as default values in QUEWZ, the user may change them. Within a time interval, the program assumes constant arrival and departure rates.

QUEWZ has incorporated two general configurations of lane closures on a work zone. These strategies are shown in Figure 4.4. The first configuration involves one or more lanes closed in one direction while traffic in the opposite direction is not affected at all. The second one involves a crossover, where all the lanes in one direction of travel are closed and two-way traffic is maintained on the other directional lanes.

4.4.2 User Cost Calculations

The user cost calculations in QUEWZ involve the calculation of three categories of costs:

a) Delay costs from slowing down and traveling the work zone at reduced speeds, including delay of vehicles in a queue.

b) Change in vehicle operating costs from a reduced average running speed.

c) Speed change cycle costs.

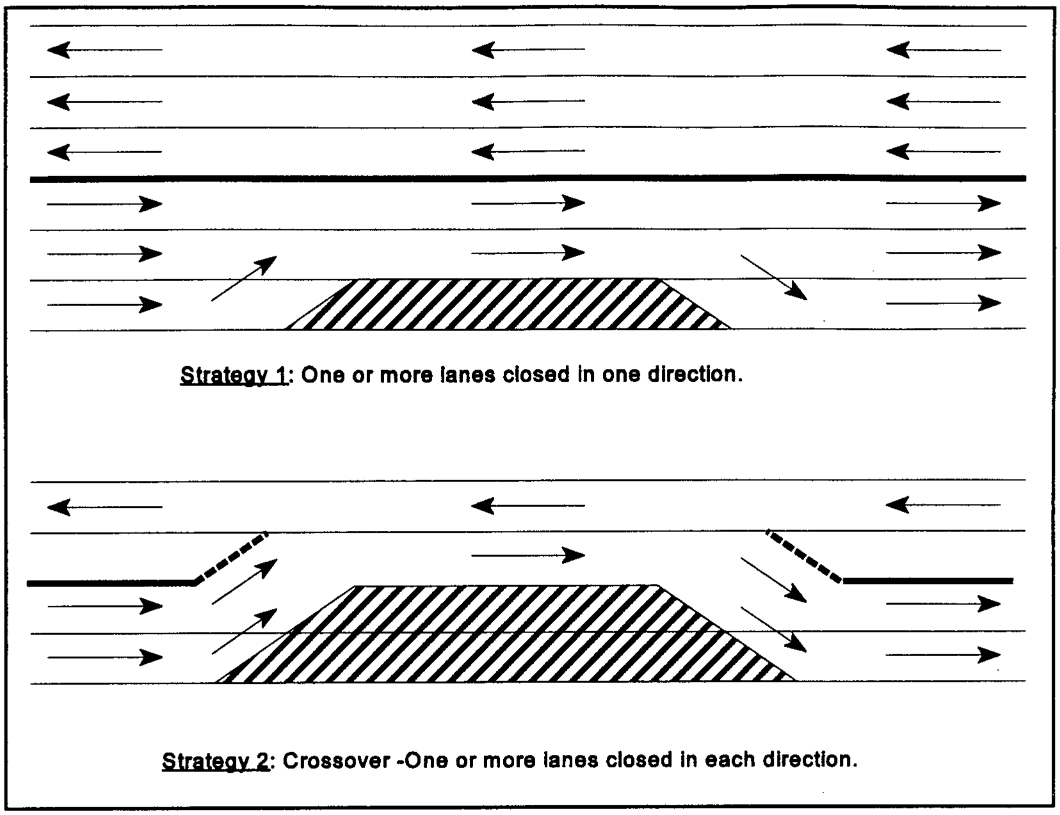

Figure 4.4 QUEWZ lane closure configurations

The costs are estimated in 1990 dollars. The dollar value of time is $12.64 per vehicle hour for passenger cars (with an average occupancy of 1.3 persons per car) and $ 23.09 per vehicle hour.

4.4.2.1 Diversion Algorithm

The diversion algorithm is used together with the road user cost option to provide a more realistic estimation of the additional user costs generated from lane closures in work zones. This algorithm basically simulates the volume of the traffic that would divert from the road due to work zone related delays.

The model for diversion was developed from field observations. When queues develop upstream of a work zone, part of the traffic approaching the zone may divert to another parallel alternative path. When this occurs even though the traffic control devices do not encourage a detour, it is called “natural diversion”. But when diversion occur, the actual queue length developed at the work zone is shorter than the one calculated based on normal approach volumes.

A diversion is expected to occur in two general situations. First, when the driver perceives that the delay that he would experience in the freeway is greater that the one he is willing to tolerate. Second, when the travel time on the alternative route is (or seems to be) less than the time the driver would spend in the queue. Despite these two general facts, it can be noticed also that some drivers simply divert because they just do not like queuing, although the total travel time in the alternative route may be even longer than the waiting time in the queue. On the other hand, some other drivers who are unfamiliar with the area may not divert at all even though the waiting time in the queue is long.

QUEWZ assumes that the first motorist would divert when the delay becomes greater than the maximum acceptable; as a default that is 20 minutes. The additional costs for the diversion of the traffic are computed based on several other assumptions:

a) The length of the alternate path is equal to the length of the work zone plus the critical length of the queue.

b) The travel time when diverting is equal to the travel time for a vehicle at the end of the queue (queue of critical length) to travel the queue and the work zone.

c) Diverting traffic travels at uniform speed. This speed is equal to the length of the alternative path divided by the travel time.

d) Trucks do not divert at all.

4.4.2.2 Queue and Speed Delays

The characteristics of the queue are estimated using the 1985 Highway Capacity Manual (HCM) relationships. The model assumes that there are no changes in demand as the queue is forming, and only when the critical length is reached, will the traffic divert.

The average delay for time intervals caused by queuing is computed from the average queue size. If the queue dissipates during the analysis interval, the delay is modified by the proportion of the hour that the queue was actually existing. The model also assumes an average vehicle spacing equal to 40 feet. The maximum queue length has a default value of 2 miles, representing a maximum number of 1050 vehicles queued in two lanes.

The average speed is estimated using the assumed speed-volume curve depicted in Figure 4.5. The user may provide specific values for the free flow speed (SP_1), for the breakpoint speed between levels of service D/E (SP_2), and the speed at capacity (SP_3).

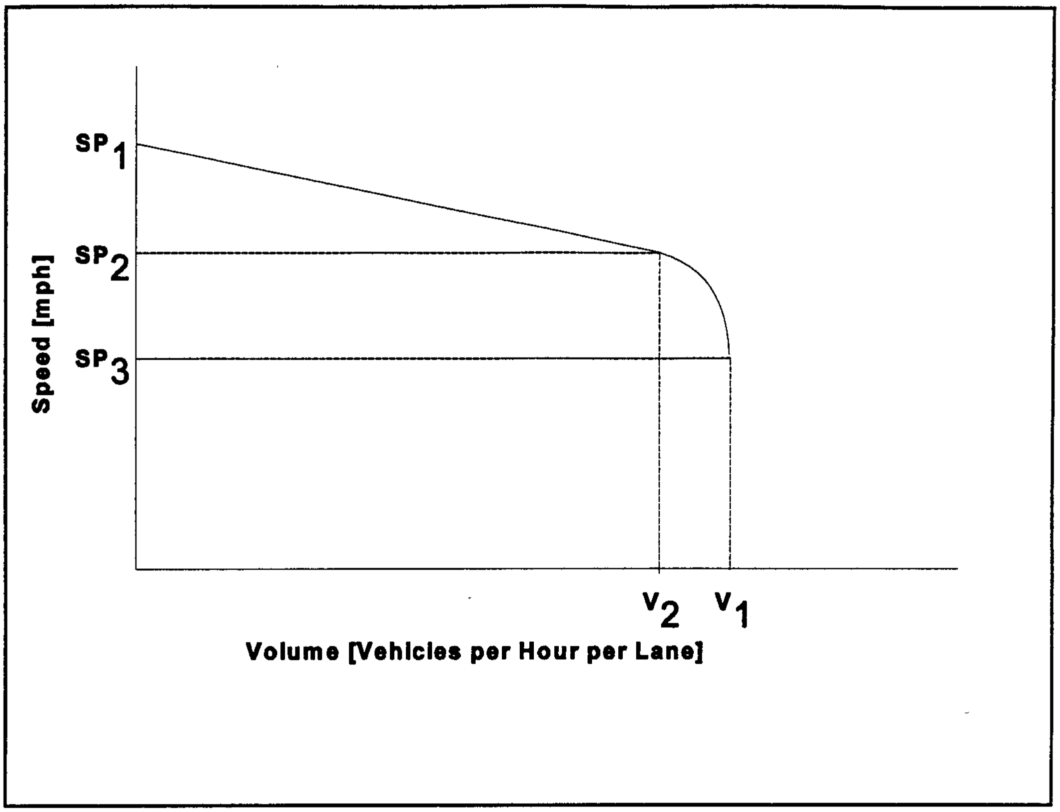

Figure 4.5 QUEWZ Speed/Volume relationship

Also, the corresponding volumes, volume at normal capacity (V_1) and the volume of the breakpoint of level of services D/E (V_2), can be specified. If the user does not enter those values, the model assumes its own default numbers for the parameters of the speed-volume relationship, represented by information provided in the 1985 Highway Capacity Manual. The relationship between volumes and speed for volumes less than or equal to V_2 is linear; for those volumes greater than V_2 but less than V_1, the realtionship is quadratic. These default values are summarized in Table 4.1.

Table 4.1 QUEWZ Speed and Volumes

Parameter	Default Value
SP_1	60 mph
SP_2	46 mph
SP_3	30 mph
V_1	2,000 vphpl
V_2	1,850 vphpl

4.4.3 Input and Output

4.4.3.1 Input Requirements

The input requirements of QUEWZ vary according to the output option selected. In general, those requirements include lane closure configuration, work activity, traffic volumes, and alternative values to change the default data and make them more suitable for the analysis site.

a) *Lane Closure Configuration.* This input includes the total number of lanes in each direction, number of lanes opened in each direction, length of closures and capacity of work site, and the directional roadways in which lanes are closed.

b) *Schedule of Work Activity.* This input includes the times that the closure of lanes begins and ends and hours when the actual work activity begins and ends. Obviously, the hours of activity must be fully included within the hours of lane closure.

c) *Traffic Volumes.* The software analyzes the traffic flow in intervals, and therefore, it requires directional traffic volumes over these intervals. The annual average daily traffic (AADT), the day of the week when the closure is effective, and the general location (urban or rural) must be entered. It should be noted that for more accurate results, the user should input the hourly traffic patterns of the area being analyzed.

d) *Default Values.* The software has several default data built in. The user may want to supply alternative values for those constants:

- Cost update factor to account for inflation effects on the Consumer Price Index (CPI).
- Percentage of trucks in the traffic stream.
- Speed-volume relationship with default values from 1985 HCM.
- Work zone capacity
- Definition of excessive queuing.

4.4.3.2 Output Options

As already mentioned, there are two different types of output: Lane Closure Schedules and Road User Costs.

a) *Lane Closure Schedule.* This output summarizes the hours of the day during which a number of lanes can be closed without producing excessive queuing.

b) *Road User Cost.* This output gives the additional road user costs arising from the lane closures. It also estimates the traffic conditions at the work zone such as volumes, capacities, speeds, and queue lengths.

4.5 Texas Research and Development Foundation (TRDF) Relationships

4.5.1 General Comments

During the period 1979-1982 the Texas Research and Development Foundation (TRDF) investigated the influence of highway design and pavement condition on vehicle operating costs and other user costs for the Federal Highway Administration (FHWA) [Zaniewski et al., 1982]. In the U.S., data were collected on truck operating costs and fuel consumption of all vehicle classes. Truck operating costs for 12,489 trucks were provided by 15 intercity line-haul carriers operating primarily on interstate highways. Data on truck ages and mileages were obtained from the Bureau of Census (1977), supplemented by historical vehicle registration data. [Bein, P., 1993]

According to other previous U.S. studies, such as Winfrey (1969) and AASHTO (1978), the TRDF relationships are broken down by four classes of vehicle operation: running at uniform speed on grades with an adjustment for the effect of pavement condition, changing speeds, navigating horizontal curves, and idling.

4.5.2 Applications

The TRDF data and relationships for vehicle operating costs have been widely used in highway investment studies. Elkins et al. (1987) have incorporated the effect of pavement condition from the TRDF data into the uniform-speed vehicle operating cost equations. They have incorporated the TRDF data into total operating cost per vehicle type for each class of operation. The aggregated equations, with minor modifications and price indexing, were included in the Highway Economic Requirements System (HERS).

NCHRP Project 7-12 included the TRDF relationships in MicroBENCOST , which has been previously discussed, with only a few modifications. In Canada, the TRDF relationships were included in the vehicle operating cost prediction module of the Highway User Benefit Assessment Model, HUBAM, which is a standard required by Transport Canada for appraisals of all federally funded or co-funded highway projects [Bein, P., 1993].

4.5.3. Vehicle Operating Cost Components

The running cost and idling cost tables by Winfrey (1969) were updated with current estimates using judgment. Where possible, the updates reflected changes in costs and advancements in vehicle technology.

The major portion of the total consumption of a vehicle cost component occurs when traveling at constant speed on a specific grade including a level road. Excess consumption is then specified for changing speeds, idling, and for navigating horizontal curves. The estimated consumption at uniform speeds is further adjusted for the effect of pavement condition.The vehicle types considered are small, medium, and large cars, a pickup truck, two- and three-axle straight trucks, and four- and five-axle combination trucks.

4.5.3.1 Fuel Consumption

The fuel consumption was tested with eight vehicles ranging from a small economy car to a 2-S2 combination truck (weight 56,000 pounds); the results for a 3-S2 unit were assumed. The tests were carried out for idling, acceleration, deceleration, and constant speed driving. Idling fuel consumption, for instance, was found higher than Winfrey's because of new emission control technology in the test vehicle fleet.

The effect of curvature on fuel consumption was approximated using the calculated horsepower needed to negotiate a curve at a constant speed. The grade that could be climbed with that horsepower and speed was determined, and the fuel consumption was then read from relationships established for each vehicle at the constant speed and grade.

The effect of curves was derived by comparing horsepower needed to traverse a curve at a constant speed with the horsepower required to climb a grade at the same speed, for which fuel consumption was measured. The effect of speed fluctuations was derived from fuel consumption of a vehicle accelerating from a stop to a top speed and then decelerating from the top speed back to a stop. [Bein, P., 1993].

4.5.3.2 Engine Oil Consumption

For cars and pickups, Winfrey's oil consumption rates were decreased to reflect the effect of improved engine technology. For trucks, oil consumption of a fleet engaged in inter-city line haul was adopted for 50 mph speed. Consumption for other speeds and for speed change cycles was then prorated from Winfrey's tables and the results were assumed to apply to all classes of single unit and articulated trucks. Oil consumption on grades was adjusted by the ratio of the horsepower required on the grade to the horsepower required for the same speed on a level section, and no correction was made for oil consumption on curves.

4.5.3.3 Tire Wear

Tire wear was estimated using a model which predicts the forces at the tire-pavement interface due to road geometry and vehicle operating mode. The model correlates the volume of tread rubber worn with the amount of slip energy consumed. This model was found to be more accurate than Winfrey's tables, since these tables were based on outdated tire technology. The selection of coefficients was done by comparison of results with Winfrey's values corrected for greater tire cost and longer tread life. Brazilian relationships developed for the World Bank

HDM-III project were used to determine tire cost adjustment factors for surface roughness between 1.0 and 4.5 SI. [Bein, P., 1993].

4.5.3.4 Maintenance and Repair

For the maintenance and repair component, three cost categories were considered: general (body, chassis and electrical), brakes (consumed in deceleration and on negative grades), drive and power train (all driving situations except when brakes are used). With these costs, correction factors to Winfrey's costs at constant speed on level segments were calculated. For acceleration, grades, and curves, excess costs were calculated from a regression between horsepower and constant-speed costs, and the adjustment for surface roughness was done using the Brazilian data.

4.5.3.5 Depreciation

The mileage-related depreciation was estimated by a method which considers that the depreciation of vehicles in the highest 3 % category of annual mileage is totally assignable to use rather than to mixed mileage and age depreciation. The age and accumulated mileage of vehicles were compiled from the 1977 census, and the number of registrations corresponding to the census data were obtained from 1945-1977 statistics [Bein, P., 1993].

4.6 HDM-III Vehicle Operating Cost Sub-model

4.6.1 General Comments

The World Bank has developed the Highway Design and Maintenance Standards Model (HDM) from data collected in a large-scale survey of road users conducted in Brazil between

1975 and 1984. The present HDM-III version of the model can aid feasibility studies of individual projects as well as policy studies of rural highway networks having a free flow of traffic [Watanatada et al., 1987]..

The research represents the largest effort to date to develop a model capturing the relationships between costs of construction, maintenance, and utilization of roads. The model is based on the premise that operating costs and speeds of vehicles are related to highway construction and maintenance standards through the effect of road geometry and pavement surface quality.

4.6.2 Generic Principles

In order to facilitate future calibrations of the model under different local conditions, the World Bank's goal was to employ generic principles. The HDM-III submodel for the prediction of vehicle operating cost basically fits a curve which is expressed as an exponential function of surface roughness. Average road geometry features are fixed parameters in the vehicle operating cost model and it relies on external computations of the average speeds.

4.6.3 Vehicle Speed Prediction

One of the major contributions of the Brazil research was the development of improved models for predicting vehicle speeds. 76,000 speed observations were made during the road user surveys to establish a database for constructing two micro and one aggregate method. By relying on a probabilistic formulation of the mechanistic and behavioral determinants of vehicle speed, the micro methods emulate detailed speed profiles along heterogeneous road alignment

4.6.4 Road and Traffic Conditions

The vehicle operating cost submodel assumes that the road segment is an homogeneous section with sufficient length for a vehicle to achieve a steady-state speed for a given road geometry and surface condition. HDM-III predicts an average speed with aggregate descriptors of road geometry and surface condition. Each descriptor is weighted by the fraction of length of the homogeneous piece of road relative to the total length of the section under analysis.

For both directions of traffic, or for a round trip journey of a vehicle using the same route to return, the given roadway has the same average surface roughness, curvature, and super elevation. The average gradient is simply the weighted sum of all rises and falls, since the up-hills in a forward direction are down-hills for the opposite direction. For analysis in one direction only, average positive and negative gradient, plus proportion of the total length in up-hill are considered [Bein, P., 1993].

4.6.4.1 Gradient

The average positive gradient is expressed as the sum of all ascents (rises) in the direction of vehicle travel weighted by the lengths of the ascents. All down-hill segments (falls) in the same direction are included in the calculation of the negative gradient.

4.6.4.2 Curvature

The average curvature is the sum of the absolute values of angular deviations (in degrees) of successive tangent lines of the road alignment, weighted by the arc lengths relative to the total length of the section along the centerline.

4.6.4.3 Super Elevation

The average super elevation is calculated from the super elevations (in percent) of the rolling sections and then weighted in the same fashion as the curvature.

4.6.4.4 Roughness

The aggregate roughness value is the weighted average of surface roughness values measured over shorter homogeneous subsections of the roadway segment under analysis.

4.6.4.5 Traffic Conditions

The speed and vehicle operating cost submodel assumes free-flow traffic conditions, and therefore its use is recommended for low volume roads. A relatively recent revision (HDM-Q) was pursued to include the effect of congestion in the calculations. Some other user costs, such as construction-related traffic delays, can also be entered from separate estimates (so-called "exogenous" benefits and costs).

4.6.5 User Cost Components

Vehicle speed and operating cost relationships were derived for ten typical vehicles: three types of cars (small, medium, and large), utility vehicle with two-axles and four tires, light truck with six tires on two-axles (gasoline), light truck with six tires on two-axles (diesel), medium two-axle truck (weight: 15 tons), heavy three-axle truck (weight: 18.5 tons), articulated five-axle truck (weight: 40 tons), and two-axle bus.

Vehicle speed, fuel, and tire consumption predictions are based on an equation which balances the driving force with aerodynamic, gravitational, and rolling resistance forces acting on a vehicle operating at a steady-state speed. Travel time is calculated from the speed. The other user cost components are oil, maintenance parts and labor, depreciation and interest, driver and passenger travel time, cargo holding, and overhead. A sum of the vehicle operating costs and travel time costs per kilometer, weighted by the percentage of the specific vehicle in the traffic mix, and multiplied by the road length, is the total cost on a road section or network link.

4.6.5.1 Fuel Consumption

HDM-III aggregates uphill and downhill road segments to predict fuel consumption. The average round trip fuel consumption is a sum of consumption calculated separately for the two road segments.

An energy-efficiency factor allows the incorporation of changes in vehicle technology. These factors are fixed parameters specific to the Brazilian study and they were obtained by correlating experimental data with actual road user fuel consumption. The user has the option of changing the parameters to calibrate the model to local conditions.

4.6.5.2 Tire Consumption

The HDM-III model uses two relationships obtained in the Brazil study for calculating tire wear: one for cars and utilities and another for trucks and buses.

4.6.5.3 Maintenance Parts and Labor

Vehicle maintenance parts and labor formulas in HDM-III are semi-mechanistic. The parts model recognizes roughness and vehicle age as the main explanatory variables. The effects of these two factors are multiplicative. With the age constant, the relationship between parts and roughness is exponential for the lower values of roughness and then it is linear. For truck parts the relationship is linear over the full range of roughness. There is no relation to vehicle speed and road gradient in the models.

Maintenance labor hours are related to maintenance parts requirements. The effect of roughness on the other vehicle types is captured through parts consumption.

4.6.5.4 Depreciation and Interest

The decrease of the market value of the vehicle with time and usage represents depreciation. An annual interest charge is incurred on the undepreciated amount of capital tied up in the vehicle. The vehicle depreciation cost is the average cost of a new vehicle divided by life mileage. The interest cost is calculated on the average vehicle market value over its lifetime divided by life mileage. HDM-III does not separate into time and mileage-related capital charges. The life mileage is a product of vehicle life in years and average annual mileage. HDM-III allows a straight line vehicle depreciation for either a "constant life" or a "variable life" dependent on operating speed changes due to road characteristics.

Annual mileage is calculated by one of three methods. "Constant annual mileage" is appropriate for private automobiles since time savings from increased speeds are not generally used for additional driving. "Constant annual hours" assumes that the annual number of hours driven is constant and the annual mileage is hence a product of the annual hours and speed. This is not the case of real truck trips since trips are of discrete lengths and cannot be increased at the operator's will when he achieves time savings. The third method is "Adjusted utilization" and it assumes baseline annual mileage, baseline annual driving hours, and available number of hours for driving and non-driving independent of speed and route. From these three user-specified parameters and vehicle speed, HDM-III predicts annual utilization adjusted for the effect of speed. [Bein, P., 1993]

4.6.5.5 Occupant and Cargo Delay Costs

In HDM-III the time spent on non-driving activities such as loading, unloading, and layovers is not charged against this cost category. The number of crew, passenger, and cargo-hours spent in travel is inversely proportional to the speed. The cargo holding cost is defined as the product of cargo-hours and a user-specified cargo holding cost per vehicle-hour delayed.

4.6.5.6 Administration Overhead Cost

Overhead cost can be included either as a lump sum per vehicle divided over the annual distance traveled or as a percentage of running costs. Only one method may be used for each vehicle group in the model.

4.7 ARFCOM Model

4.7.1 General Comments

The Australian model ARFCOM can estimate fuel consumption due to speed changes induced by curvature, grade, or traffic control devices. Only limited vehicle parameters are required, and there are three forms of the model for different levels of detail in planning applications.

ARFCOM estimates fuel consumption for a variety of vehicles from cars to the heaviest truck combinations. The required inputs are: vehicle mass, maximum engine power or engine capacity, number of wheels, tire type, frontal area, and aerodynamic drag coefficients. There are some other parameters that can be specified or default values can be used.

4.7.2 Model Forms

There are three model forms to choose from according to the different levels of aggregation desired. The instantaneous form requires second-by-second speed, grade, and curvature data and is suitable for use in micro level traffic simulation programs. The four mode elemental form requires initial and final acceleration and deceleration speeds, cruise speed, idle time, and average grade and curvature data and is suitable for use in detailed analytical type models applicable to short road sections. Finally, the aggregate form requires either running speed and idle time, or just average travel speed, and is suitable for use in macro level models applicable to long road sections or road networks.

4.7.3 Basis of the Model

ARFCOM calculates the power that the engine must produce, using the engine speed as one of the principal variables. The engine-fuel relationship in ARFCOM has been modeled to facilitate road management applications rather than vehicle performance evaluation.

ARFCOM uses a simple approach to estimate engine speed from vehicle speed and power by predicting the gear that the vehicle is in. For cruising, top gear is assumed and engine speed is a function of the maximum speed the vehicle is able to attain on a flat smooth road given its maximum rated engine power. Changes to and from top gear due to grade and slow-downs during cruise are also related to vehicle and operating parameters.

4.8 Other Methods

4.8.1 NIMPAC

4.8.1.1 General Comments

NIMPAC is a detailed computer program run by the Australian Road Research Board and has been used extensively to evaluate rural arterial road programs. There are other programs related to NIMPAC that are used at a lower than national level of road administration. For urban areas, simpler formulas have been developed to represent five typical vehicle classes.

4.8.1.2 Vehicle Operating Cost Submodel of NIMPAC:

The vehicle operating cost submodule of NIMPAC estimates fuel, oil, tire wear, repairs and maintenance, and depreciation. Where appropriate, interest is also included. There are seven vehicle types:

- cars (including utilities and station wagons)
- two-axle four-tire trucks (including vans)
- two-axle six-tire trucks
- three axle straight trucks with two pairs of dual wheels
- four-axle articulated trucks
- five-axle articulated trucks
- road trains with two three-axle trailers.

For each type of vehicle, about 20 parameters (mainly related to unit costs such as fuel and tire prices) are specified in order to estimate the vehicle operating costs. There are also several road dependent factors that also affect each vehicle operating cost component. These factors are: surface types (paved, gravel, earth), five surface conditions for paved and gravel roads, free-flow speed, volume/capacity ratio, five classes of gradient (from 0 to 10%), and five classes of horizontal curvature measured by the design speed of the curves (from 30 to 80 km/hour).

4.8.2 VETO Model

4.8.2.1 Background

The VETO model of highway vehicle transportation costs has been developed by the Swedish Road and Traffic Research Institute. VETO is a purely mechanistic model. The physical basis of the relationships allows greater freedom than other models in evaluating transportation costs as a function of various properties of the road surface, different road alignment, speed limit, vehicle type, and driving behavior. VOC relationships based on VETO are used in routine economic appraisals of road projects and are performed with the aid of EVA software.

4.8.2.2 Component Costs and Typical Vehicles

VETO calculates the following cost components: fuel consumption, tire wear, repair cost (including brake wear, roughness-dependent repair, and other types of repair), distance- and time-related vehicle depreciation, and interest charges for vehicle and cargo.

There are three types of standard vehicle in VETO are: a car, a 21.6 tons truck with and without trailer), and a 15 tons bus. The vehicles can partly be modified through the user's own input. The vehicle descriptors used by VETO are: speed regulating systems, masses, lengths and moments of inertia, damping and springing characteristics of tires, springs and shock absorbers, utilization and cost factors such as purchase price, unit fuel and tire costs, vehicle age, accumulated travel, number of passengers, value of cargo, and interest rate. Driving behavior is determined by the desired speed in relation to vehicle type, road width, speed limit, horizontal radius, surface type, and condition.

4.8.2.3 Road Descriptors

The road is described by the following statistics: average horizontal curvature, speed limit, road width and cross slope, micro and macrotexture and age of wearing course (new, medium or old), surface condition (dry, packed snow/ice, depth of water or of loose snow), average grade based on homogeneous sections, and longitudinal roughness profiles. Rut depth is accounted for by adjusting macro and microtexture, cross slope, radius of vehicle's driving track, water depth or other variables. The user can describe vertical and horizontal alignment either directly in detail or qualitatively (good, average, or poor). The indirect description is then used for selecting among three default alignments.

4.8.2.4 Model Operation

The calculations procedure has three stages. First, the model calculates all dynamic forces acting on the vehicle as a function of longitudinal roughness. Second, consumption and wear rates are determined from the force effects. Third, unit costs are applied to the consumption rates to calculate component and total costs.

a) *Roughness Effect.* Fuel consumption and tire wear are functions of the total resistance, and longitudinal roughness increases the total resistance. Also slippage increase with increased road roughness, and fuel consumption and tire wear also increase when drift and slippage increase.

b) *Vehicle Wear.* Vehicle wear can be expressed either as a function of the wheel load or as a function of a roughness measure. The first method gives a physical description which cannot be expressed in monetary terms. The other method is a statistical function of roughness, based on the Brazil study. Its weakness is that there is no variation with speed. The physical model gives a considerably greater increase in vehicle wear with a roughness increase than does the statistical model.

c) *Effect of Texture.* The texture of the road surface influences vehicle cost calculations mainly through rolling resistance, which influences fuel consumption and tire wear. This rolling resistance can be calculated as a function of macrotexture. There exists also an abrasion coefficient in tire wear model which is expressed as a function of macrotexture and microtexture of the road surface, and it also influences the operating cost of the vehicle.

d) *Capital Cost.* In VETO model, capital cost is not directly influenced by the type of road surface. The capital cost of a vehicle is function of the selling price for non-discarded vehicles and the probability of discarding expressed as a function of age and driving distance. Both the selling price and discarding probability could also be expressed as functions of road roughness if it causes a speed reduction [Bein, P., 1993].

4.8.3 COBA and British Research

4.8.3.1 Background

The Department of Transport of the United Kingdom is responsible for multi-modal transportation. During 1950s and 1960s, the expansion of roads in the country initiated the development of a formal procedure called COBA to be used for economic evaluations of inter-urban road schemes. The procedure gave the Department a rational method of allocating the available funds to achieve the best return for the investment. COBA comprises the results of research conducted in the United Kingdom and abroad, particularly by the Transport and Road Research Laboratory (TRRL). With experience gained through its applications, the method evolved to its present version, COBA9.

COBA compares the costs of road schemes with the benefits which can be derived by road users and expresses the results in monetary terms. COBA considers the total discounted user costs on a road network over a 30 year period. Recognizing that forecasts for such a long period are subject to uncertainty, the program contains default high and low projections of traffic, fuel prices, and economic growth for the country. Since COBA cannot include environmental and other considerations which are not compatible with monetary valuation, the model is viewed as only one element in the appraisal process.

4.8.3.2 Types of Application

When applied to different points in the road investment evaluation process, COBA can assess the following: the need for an upgrading of existing roads or providing a new road, the priority of an individual scheme by comparing its returns with those from other schemes, the optimal timing of a scheme (considering staged construction and other improvement proposals for the area), the selection of potentially attractive solutions for public consultation, the optimal link of design standards and junction designs from the feasible alternatives, and the selection of the preferred option for implementation.

4.8.3.3 Vehicle Operating Costs

There are four representative vehicles considered by COBA: car, light van, diesel truck and bus. In COBA the vehicle operating costs include fuel, oil, tires, maintenance and depreciation. All mileage-related resources are included in vehicle operating cost as well as vehicle capital savings, which are related to time.

a) *Fuel.* The philosophy has been that the government taxes at a higher rate the goods produced by resources shifted from fuel to compensate for fuel tax saved through road investments. Therefore, a fraction equal to the percentage level of indirect taxation throughout the economy is added back to the cost of fuel.

b) *Oil and Tires.* Although it is recognized that tire costs vary with a number of factors including speed changes, braking, cornering, and road surface, both tire and oil costs are treated as fixed costs per kilometer

c) *Maintenance.* Maintenance is partly considered to be related to distance and partly assumed to vary with speed. Two thirds of the cost are assumed to be a fixed cost per kilometer and one third to vary with speed in a similar way as fuel consumption.

d) *Depreciation and Vehicle Capital Savings.* For trucks and buses depreciation is assumed to be related only to distance traveled and it is linear over an assumed mileage life. In the case of cars, part of depreciation is related to the passage of time and only the mileage-related component is included as a depreciation cost.

e) *Payload Value.* The evidence on appropriate average values has been found insufficient to yield reliable estimates and, therefore, any allowance would be insignificant compared to the other items of vehicle operating cost. Thus, o allowance is made for any savings on value of the cargo carried by trucks. [Bein, P., 1993].

4.8.4 NZVOC

The NZVOC model was developed in 1985, and by 1986 it was incorporated into economic study procedures for New Zealand road projects. The model includes subroutines for predicting both urban and open road speeds using several submodels based on HDM-III, ARRB, and Highway Capacity Manual. The fuel consumption module offered several options based on HDM-III, ARRB and other models of fuel consumption. Other vehicle operating cost components were modeled using elements of HDM-III, except depreciation and interest which were based on the capital recovery technique. Also, the model has sub-routines for calculating the additional time and fuel costs associated with speed change cycles. Models adopted from outside New Zealand were adapted and calibrated to local conditions as far as resources allowed.[Bein, P., 1993].

4.8.5 South African VOC Models

South African work in vehicle operating costs has been directed at determining the applicability of international vehicle operating cost studies to local conditions. Reasonable conformity was found with the Brazil data and many of the HDM-III relations. In the process, new data was produced with respect to the effect of rolling resistance on fuel consumption, and effect of aggregate type on tire wear.

To model the effects of road conditions on maintenance costs, the vehicle parts are classified into a number of categories, each affected by a different road and vehicle operating condition. The South African researchers also derived depreciation and interest cost equations from an economic model of the optimal life [Bein, P., 1993].

CHAPTER 5

THE WORK ZONE SCENARIO

5.1 Introduction

The majority of the methods used for determining the additional road user costs resulting from work zone lane closures consider two main effects: the reduction in operating speed and the reduction in road capacity which results in queue development. When a queue actually develops, the effect of being queued also has to be considered.

5.1.1 Reduction in Operating Speed

Highway construction works have a number of different effects on the traffic stream. An example of these effects is illustrated in Figure 5.1 [Greenwood, Bennet and Rahman, 1995]. Vehicles travel at approach speed and somewhere in advance of the work zone they are forced to decelerate. If there is a queue, the vehicles will be stationary for some intervals and moving up through the queue in others. Once they reach the front of the queue, they will accelerate up to the speed at which they will travel through the work zone. Upon reaching the end of the work zone, they will again accelerate back to their initial speed.

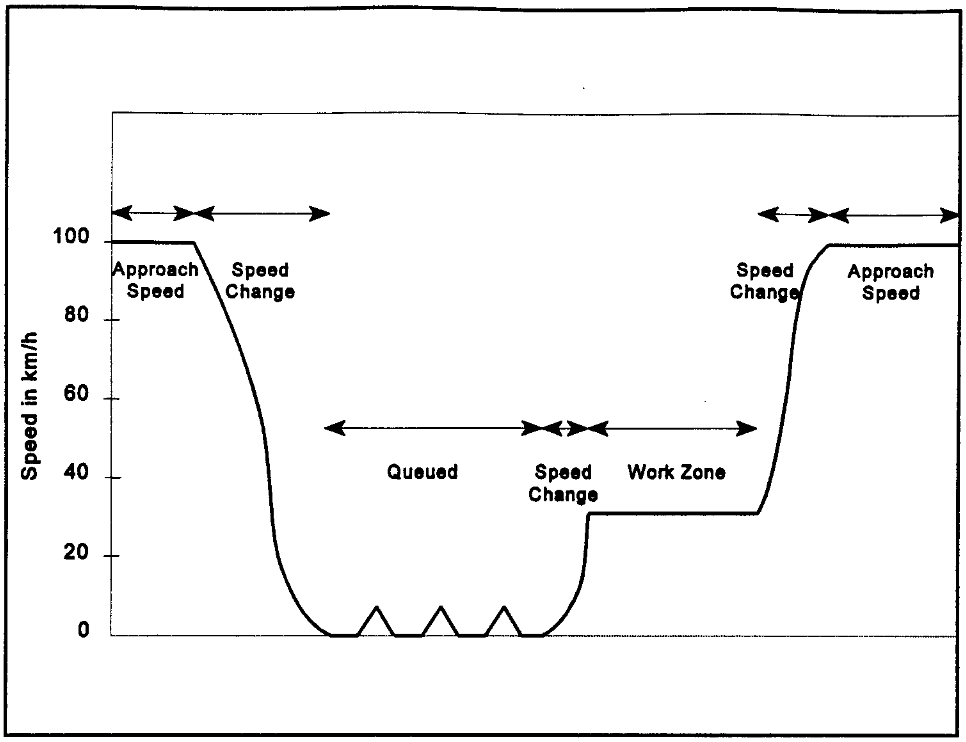

Figure 5.1 Effects of work zone on traffic.[Greenwood, Bennet and Rahman, 1995]

5.1.2 Road Capacity Reduction

The reduction in road capacity at work zones has two main components. On one hand, the lane closure results in a section of the highway that accommodates fewer vehicles. The capacity for freeways with ideal traffic and roadway conditions is 2,200 pcphpl (passenger car, per hour, per lane) for a four-lane freeway and 2,300 pcphpl for a six-lane utility.[HCM, 1993].

Another aspect of road capacity reduction can be easily understood in terms of the effect that work zones and their traffic control devices have on lane width and lateral clearance of the roadway. When lane widths are narrower than the 12-ft standard, drivers are forced to travel closer (laterally) to one another than they normally desire. Drivers tend to compensate for this discomfort by maintaining longer spacings between vehicles in the same lane [HCM, 1993].

The restricted lateral clearance has a similar effect. When roadside, median objects, or other traffic control devices are too close to the lane edge, drivers shy away from them, positioning themselves further from the edge than under normal conditions. This produces the same impact as narrow lanes, and again, drivers usually compensate the lateral closing by leaving more distance between vehicles. When for a given speed drivers leave longer spaces between cars, the volume or flow accommodated decreases. Viewing the situation from another point: for a given spacing, drivers will slow down when lateral clearance restrictions exist, resulting also in reduced flow.

5.1.3 The Queuing Effect

The rates at which the queue builds up and dissipates are particularly important to consider. As illustrated in Figure 5.2 [Memmott and Dudek, 1982] the size of the queue at any time is a function of the arrival and departure rate. Depending upon the situation, these may be governed by the capacity of the road (as in Figure 5.2), by traffic control devices, or both. Figure 5.2 shows that the size of the queue at any time is given by the difference between the top line (cumulative arrivals or demand volume) and the diagonal-base line (cumulative departures or capacity). For instance, at time T1 the queue size would be VOL1 - CAP1. The area between the two lines is the total delay to those queued, in veh-hour. This delay, multiplied by its cost in dollar per vehicle hour gives the additional road user cost due to delays.

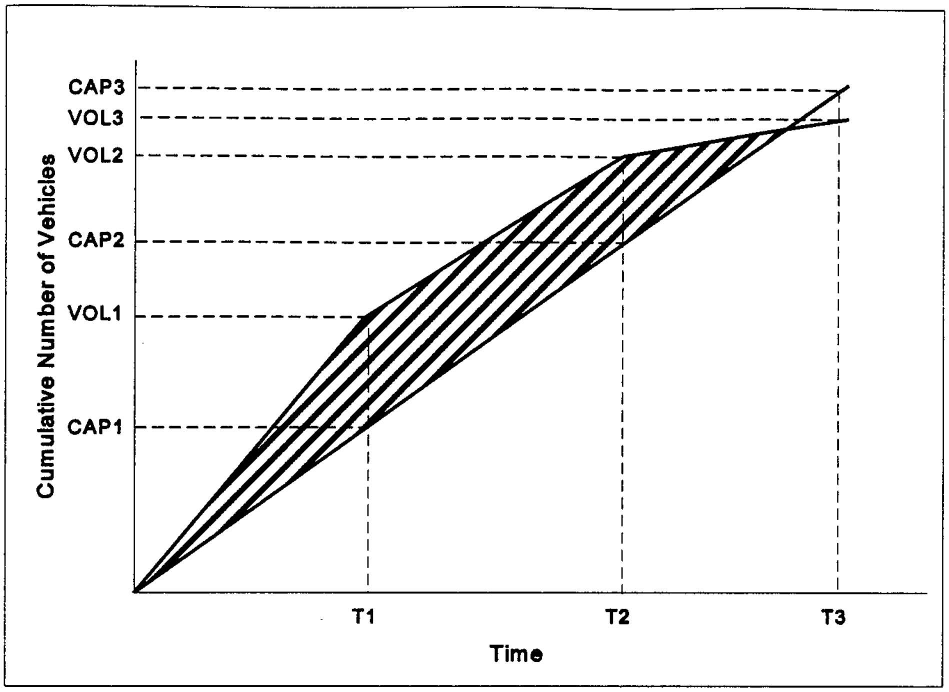

Figure 5.2 Queue development. [Memmott and Dudek, 1982]

5.1.4 Rural and Urban Areas

The work zone situation in urban areas is different from the one in rural areas. Urban areas generally have several alternative paths available which allow commuters to divert to other routes as long as these alternative routes have adequate capacity available. Under such circumstances, a practical way of modeling the effects on road user costs can be the use of diversion algorithms.

These algorithms estimate the volume of traffic diverting from the highway as a reply to the work-zone-associated delays. When queues develop upstream of a highway work zone, part of the approaching traffic may diverge from the stream to another parallel alternative route. This diversion usually occurs even if the traffic control of the work zone does not requires detour, and it is sometimes called "natural diversion".

In general, diversion is expected to occur when drivers perceive that the delays they would experience by remaining on the road would be greater than they are willing to tolerate. Another cause of diversion is when the travel time the drivers perceive they would experience on an alternative route would be less than the one on the road with work zones. Sometime, it also happens that some motorists simply get tired of queueing and decide to divert even though they may not actually reduce their travel time. In the same way, some other drivers who are unfamiliar with the area may not divert at all under any circumstances.

When diversion happens, the actual traffic volumes through the work zone are less than the normal approach volumes. Consequently, the lengths of queues that are calculated based on the normal approach traffic volumes will exceed the lengths of the queues actually observed [Krammes, Ullman and Dudek, 1989]. The chosen algorithm should account for those effects.

By comparison, in rural areas there are often few, if any, alternative routes. Consequently, the users have no other option but to queue at the road site.

5.1.5 Analysis Variables

Some of the common variables used by the different models to assess effects of work zones in road user costs are the following:

- Time of day
- Duration of highway works.
- Traffic volume (veh/day or veh/hour)
- Road capacity

Some other unique features of the different models are the following:

- Lane closure configuration
- Diversion and alternative routes
- Traffic control measures

Most of the above variables are self-explanatory. However, special attention should be given to the traffic volume.

Traffic volume estimates for a given year are often expressed in terms of average daily traffic (ADT). For purposes of user cost calculations, however, it may be useful to model the diurnal pattern of traffic in terms of shorter intervals than daily periods. Because highway user costs are partly a function of specific traffic conditions, such costs are valid only as long as relatively the same conditions prevail.

Differential user costs should be calculated where conditions of extreme congestion occur over a short period of time during the day and other parts of the day are associated with low levels of traffic. Thus, where it is estimated that significant variations in traffic flow will occur over a day, different unit user costs should be derived for each significantly different (in terms of traffic flows) time period [AASHTO Red Book, 1977].

5.1.6 Additional Road User Costs Due to Construction Zones

All the considerations included in previous chapters about vehicle operating costs, time costs, and accident costs are applicable to work zones. The work zone actually generates extra or additional user costs.

As for vehicle operating costs and time costs, it is clear that both of them are mainly dependent on traveling speed. Under congested conditions, drivers have to constantly change speeds, and vehicle operating costs are much higher than when driving at a smooth traffic flow. Furthermore, when arrivals exceed the work zone capacity, vehicles queue. To calculate the additional costs, there are two situations that might be considered:

a) *Stationary vehicles.* In this case, the fuel consumption (for the operating costs) is proportional to the idle rate. On the other hand, the travel time costs are proportional to the time stationary.

b) *Moving vehicles.* As the queue dissipates, vehicles move forward resulting in vehicle operating costs.

If instead of queuing, part of the traffic diverts (common case in urban areas), the additional user costs for this diverting traffic can be estimated by making certain assumptions such as length of the alternative route, travel time for diverting traffic, speed (uniform or not) of the diverting traffic, whether trucks divert or not, etc.. These additional costs for diverting traffic are then included into the total additional road user costs resulting from the highway work zone lane closure.

With sufficient traffic data, the above costs can be calculated with some degree of accuracy. However, it is important to use real hourly distributions of traffic instead of one ADT number, principally in those areas where the major portion of the daily traffic is highly concentrated in a few peak hours. In cases like this, using an "average" value such as ADT may lead to underestimates or overestimates that will inaccurately benefit one alternative over another.

As for accident costs, as stated before, this cost is the most uncertain component of road user costs, since its inclusion is mainly based on probabilistic calculations. Work zones are potential source for accidents. Because of the restrictions in the traffic flow that were described and also because of the presence of trucks and construction equipment entering and leaving the work zone (some of them oversized and very slow vehicles), the number of accidents would be expected to increase. Quantifying the effects, however, is not that simple. On one hand, accidents are considered casual events whose occurrence is usually deemed to be randomly distributed over some continuous variable such as time or distance. On the other hand, both variables (time and distance) are not precisely continuous in the case of work zones because of the "temporary" characteristic of highway construction works. It is very rare, then, to encounter a location or segment where there are sufficient numbers of accidents to allow a statistically significant evaluation of the effect of the work zone on the change in number of accidents.

The National Highway Traffic Safety Administration and the National Safety Council (NSC) routinely publish estimates of economic costs that result from motor vehicle accidents. However, the most reliable data on accident costs are those colleted locally; these are more suitable data than nationwide statistics. Nonetheless, since nearly every work zone is unique, the reliability of default or average accident rate data are highly questionable, especially when dealing with unique problems.

5.2 The QUEWZ Model

5.2.1 Introduction

After a careful study of available models and software to analyze road user costs, it was found that QUEWZ is a very suitable software to analyze the additional user costs resulting from work zone lane closures since it was developed specifically for work zone conditions. A previous research report prepared by Conrad Dudek in 1989 on a similar research topic also agrees in its conclusions that QUEWZ is the simplest and most directly applicable model for evaluating traffic conditions through a freeway or multilane highway work zone.

One of the main advantages of the QUEWZ model is the relatively small amount of data required for simulation purposes and that it is quite easy to use. It has limits, however, in terms of its sensitivity to basic roadway geometrics such as the presence of entrance and exit ramps. Nevertheless, for most construction projects this model should provide sufficient analysis capability for an evaluation of travel impact.

5.2.2 General Characteristics of the QUEWZ Model

QUEWZ basically compares traffic flow through a freeway segment with and without a work zone lane closure and estimates the changes in traffic flow characteristics in terms of average speeds and queue lengths and additional road user costs resulting from that lane closure. The model is capable of modeling freeways as well as multilane divided highways with up to six lanes in each direction, and it can analyze work zones with any number of lanes closed in either direction. It can also evaluate 24 consecutive hours of operation.

As described in previous chapters, the QUEWZ model has two output options: the road user cost option and the lane closure schedule option.

The road user cost option analyzes a lane closure configuration and a schedule of work activities specified by the user. The output includes estimates of traffic volumes, capacities, speeds, queue lengths, and the additional road user costs generated for each hour of lane closures. Because of the option of including a diversion algorithm, the user can also estimate the amount of traffic that might divert from the road in response to work-zone-related delays and/or queues.

The second output option (lane closure schedule option) summarizes the hours of the day when a given number of lanes can be closed to minimize the impacts on the traffic flow. In this case, the user can define what would be considered an "excessive" queue. This is a very convenient option principally for the schedulers who are responsible for determining the closure times for the lane or lanes.

Both output options use the same speed and queue estimation procedures. Those procedures are proposed in the 1985 Highway Capacity Manual. It would be desirable to have a more updated version of speed-volume relationships since some procedures have changed in the subsequent upgrades of the Highway Capacity Manual.

5.2.3 Additional User Cost Calculations

The calculation of additional user costs in the QUEWZ model is quite similar to user cost calculations in other models. The main differences can be found in several aspects such as speeds, capacities, and queues. In this matter, there are some different equations and approaches which incorporate several findings by the Texas Transportation Institute (TTI) regarding work zones.

5.2.3.1 Estimation of Vehicle Capacity Through Work Zones

Generally, the principal effect that the work zone has on traffic is the restricted capacity and the consequent effect on average speeds. The QUEWZ model assumes that the capacity under normal circumstances will be 2,000 vehicles per hour per lane (vphpl), but this default value can be changed upon the decision of the user as a part of the input data. Some previous TTI studies have found that when lanes are closed for long periods of time (e.g. longer than a day) and the work activity is not taking place, the capacity is about 90 percent of the normal capacity (1800 vphpl), the value used by the model.

Some of the original assumptions of the QUEWZ model rely on data on work zone capacities during hours with work activity going on, reported in the TTI Research Report 228-6. With these data, linear approximations of the cumulative distributions were estimated for each reported closure combination. The latest version of the QUEWZ model (1993) includes some enhancements such as a new estimating procedure for the capacity of work zones and new default values for the diversion algorithm. These new features are based on data collection and analysis which are documented in TTI Research Resport 1105-5 and 1108-6.

5.2.3.2 Calculation of Average Speeds

The average approach speed is calculated using the assumed speed-volume curve displayed in Figure 4.5. The speed of trucks is assumed to be 90 percent of car speeds. The three parameters of speed (SP_1, SP_2, and SP_3), as well as the volume parameters (V_1 and V_2) have default values that have already been shown in Table 4.1.

In the original model formulation, the hourly traffic volume specified by the user is converted into V/C ratio, and the approach speed, in mph, is then calculated using the following equations, taken from the Highway Economic Evaluation Model (HEEM).

$$\text{if } \frac{V_2}{V_1} \geq \frac{V}{C}, \text{ then}$$

$$SP = SP_1 + \frac{V_1 \, (SP_2 - SP_1)}{V_2} \times \left(\frac{V}{C} \right)$$

$$\text{if } \frac{V_2}{V_1} < \frac{V}{C} \leq 1 \text{ , then}$$

$$SP = SP_2 + (SP_2 - SP_3)\left[1 - \left(\frac{\frac{V}{C} - \frac{V_2}{V_1}}{1 - \frac{V_2}{V_1}}\right)^2\right]^{\frac{1}{2}}$$

$$\text{if } \frac{V}{C} > 1 \text{, then}$$

$$SP = SP_3 \times (2 - \frac{V}{C})$$

5.2.3.3 Calculation of Delay Through the Lane Closure Section

The queue characteristics are estimated using the HCM 1985 relationships. Therefore, the length of the queue is calculated as follows:

$$Q_{length} = \frac{VQ_i \times VSpc}{NL_{open}}$$

Where

Q_{length} = Length of the queue

VQ_i = Number of vehicles queued at time "i"

VSpc = Average vehicle space

NL_{open} = Number of approaching lanes that are open and provide the site for the queues to build up.

When the demand exceeds the capacity of the work zone a queue will form as illustrated in Figure 5.2. In this figure it may be observed that the size of the queue at any time is given by the difference between the top line which represents the cumulative arrivals and the diagonal line that represents the cumulative departures. The model assumes that the demand does not change as the queue forms and that no diversion will occur until an excessive queue is formed.

The number of vehicles in the queue at any time is computed as follows:

$$VQ_i = VQ_{i-1} + (Rarr_i - WZCap_i)\frac{Interval}{60}$$

Where

$Rarr_i$ = Rate of arrival rate for interval "i"

$WZCap_i$ = Capacity of the work zone for the interval "i"

Interval = The analysis interval in minutes.

The average delay for the time interval "i" as a result of a queue is calculated from the average queue size. The average queue size is determined by the number of queued vehicles at the beginning and at the end of the interval "i":

$$QDelay_i = \left(\frac{VQ_{i-1} + VQ_i}{2}\right) \times 60 \times Interval$$

Where:

$Qdelay_i$ = Average total delay while a queue exists during interval "i".

If the queue dissipates during the analysis interval, the delay must be recomputed to account for the proportion of the hour in which the queue was effectively present. This is modified as follows:

$$QDelay_i = \frac{VQ_{i-1}^2}{2(WZCap_i - Rarr_i)} \times 60 \times Interval$$

5.2.3.4 Total Additional User Costs

The total additional user costs per hour (THC) in each direction are the sum of several components, as follows:

$$THC = CQUE + CDWZ + CDSC + CSPC + CSPQ + OC + OCQ$$

Where

CQUE = Cost of the delay while queueing

CDWZ = Cost of driving through the work zone at reduced speed

CDSC = Cost of delay for speed-change cycles

CSPC = Additional operating costs for speed-change cycle

CSPQ = Additional operating costs for speed-change cycle in a queue

OC = Change in vehicle running costs

OCQ = Change in vehicle running costs when a queue forms

5.3 A Practical Example of QUEWZ Model Application

5.3.1 Introduction

To check the behavior of the model, several runs were made with QUEWZ-92, an enhanced version of QUEWZ3-PC from 1993. Following, there is a random example of one of those runs.

The model requires only limited input data, a notable advantage. Moreover, one of the features added to the original software was the capability to simulate hourly volumes from an Annual Average Daily Traffic (AADT) input value. However, since QUEWZ utilizes hourly direction volumes to calculate additional road user costs and to design closure schedules, when hourly data are available it is highly recommended to use these values. The use of local data is important because when the QUEWZ model estimates directional hourly traffic volumes from AADTs it uses directional, hourly, and daily distribution factors that were developed using data from all ATR stations on Interstate highways in Texas for the month of October 1985. These default distribution patterns for both rural and urban locations are compared with actual traffic data from Florida counts in the graphs included in the data analysis (Appendix C).

5.3.2 Hypothetical Scenario

For the purpose of the sample run, a 10 mile construction zone in a two-lane highway was assumed. Both rural and urban environments were analyzed. The day of the week randomly selected was Wednesday. Following there is an example of the general input data:

Model Constants

QUEWZ-92 uses a series of model constants for various calculations. Either the default values provided below may be used, or new values may be specified that better represent local conditions.

	Present Value	New Value
Cost Update Factor----------------->	1.3	1.3
Percentage of Heavy Vehicles (%)--->	8	8
Speed-Volume Relationship:		
Free Flow Speed (mph)-------------->	60	60
LOS D/E Breakpoint Speed (mph)----->	46	46
Speed at Capacity (mph)------------>	30	30
LOS D/E Breakpoint Volume (vphpl)-->	1850	1850
Volume at Capacity (vphpl)--------->	2000	2000

Work Zone Capacity

The following equations are used to estimate the capacity per open lane (C) through the work zone:

C = (1600 pcphpl - I - R) * H and H = 100 / [100 + P * (E - 1)]

The base capacity of 1600 pcphpl is adjusted for the work type and intensity (I), the presence of ramps (R), and the presence of heavy vehicles (H). The value H is based on the percentage of heavy vehicles (P) and the passenger car equivalent for heavy vehicles (E).

Present Values for Work Zone Capacity:

Inbound direction (vphpl)-----> 1515

Work Zone Capacity - [Inbound]

```
     The following equations are used to estimate the capacity per open
lane (C) through the work zone:

   C = (1600 pcphpl - I - R) * H  and  H = 100 / [100 + P * (E - 1)]

=> The current P value (percentage of heavy vehicles) is 8 %.  To change
   the P value, use the Model Constants screen.

                                                      Present    New
                                                       Value    Value

      I = Adjustment for the type and intensity-->       0        0
          of work activity [-160 to 160 pcphpl]
      R = Adjustment for the presence of ramps--->       0        0
          [0 to 160 pcphpl]
      E = Passenger car equivalent (veh/pc)------>     1.7      1.7
      C = Per-lane capacity (vphpl)-------------->    1515     1515
```

Work Zone Capacity - [Outbound]

```
     The following equations are used to estimate the capacity per open
lane (C) through the work zone:

   C = (1600 pcphpl - I - R) * H  and  H = 100 / [100 + P * (E - 1)]

=> The current P value (percentage of heavy vehicles) is 8 %.  To change
   the P value, use the Model Constants screen.

                                                      Present    New
                                                       Value    Value

      I = Adjustment for the type and intensity-->       0        0
          of work activity [-160 to 160 pcphpl]
      R = Adjustment for the presence of ramps--->       0        0
          [0 to 160 pcphpl]
      E = Passenger car equivalent (veh/pc)------>     1.7      1.7
      C = Per-lane capacity (vphpl)-------------->    1515     1515
```

The above input data remained unchanged in all the runs to establish a comparable background for the different options analyzed. The two possible outcome options were also analyzed for each scenario: additional road user costs and lane closure schedule. For the additional road user costs options, a user-defined lane closure schedule had to be entered and this work activity schedule remained constant throughout the different runs. The hypothetical work schedule input was as follows:

```
                    Schedule of Work Activity

    The Road User Cost option evaluates a time schedule specifying when
lanes are closed and when work activity is actually underway.  Work
activity may be conducted during any part or all of the time that lanes
are closed.

                                                 Present    New
                                                  Value    Value

     Hour lane closure begins------------------>    7        7
         ( 0 - 23 are acceptable)
     Hour lane closure ends-------------------->   19       19
         ( 8 - 24 are acceptable)

     Hour work activity begins----------------->    7        7
         ( 7 - 18 are acceptable)
     Hour work activity ends------------------->   19       19
         ( 8 - 19 are acceptable)
```

From this work activity data, several options were examined. The hourly traffic counts used for the example were downloaded from the database of the Transportation Statistics Office of the Florida Department of Transportation. The structure of the database, as well as the example data downloaded, are included in Appendix B. This data was processed to calculate an average hourly percentage of AADT for each direction and each day of the week for the specific traffic counter location. The data in tabulated form, as well as the average hourly values of percentage of AADT for every day of the week, are included in Appendix C. The following matrix (Table 5.1) summarizes those different options analyzed; outputs of every run are included in Appendix D.

General input data:

Day of Week: Wednesday
Number of Lanes in Each Direction = 2
AADT = 20,000 vpd
Hourly Traffic Counts = Appendixes B and C.
Excessive Queue Definition = 20 minutes of delay

Table 5.1 Different options analyzed with QUEWZ

Run #		Lanes Closed	Traffic Input	Location	Output Option
1	a	1 Inbound	AADT	Urban	RUC
	b	1 Inbound	AADT	Urban	Closure Schedule
2	a	1 Inbound	AADT	Rural	RUC
	b	1 Inbound	AADT	Rural	Closure Schedule
3	a	1 Outbound	AADT	Urban	RUC
	b	1 Outbound	AADT	Urban	Closure Schedule
4	a	1 Outbound	AADT	Rural	RUC
	b	1 Outbound	AADT	Rural	Closure Schedule
5	a	1 Inbound 1 Outbound	AADT	Urban	RUC
	b	1 Inbound 1 Outbound	AADT	Urban	Closure Schedule
6	a	1 Inbound 1 Outbound	AADT	Rural	RUC
	b	1 Inbound 1 Outbound	AADT	Rural	Closure Schedule
7	a	1 Inbound	Hourly Volumes	N/A	RUC
	b	1 Inbound	Hourly Volumes	N/A	Closure Schedule
8	a	1 Outbound	Hourly Volumes	N/A	RUC
	b	1 Outbound	Hourly Volumes	N/A	Closure Schedule
9	a	1 Inbound 1 Outbound	Hourly Volumes	N/A	RUC
	b	1 Inbound 1 Outbound	Hourly Volumes	N/A	Closure Schedule

The following Table 5.2 shows the additional road user costs obtained with the previously described analysis.

Table 5.2 Additional road user costs calculated with QUEWZ in every run

Run #	Lanes Closed	Traffic Input	Location	Additional Road User Costs [$]
1 - a	1 Inbound	AADT	Urban	882.00
2 - a	1 Inbound	AADT	Rural	423.00
3 - a	1 Outbound	AADT	Urban	1021.00
4 - a	1 Outbound	AADT	Rural	421.00
5 - a	1 Inbound 1 Outbound	AADT	Urban	882.00 1021.00
6 - a	1 Inbound 1 Outbound	AADT	Rural	423.00 421.00
7 - a	1 Inbound	Hourly Volumes	N/A	907.00
8 - a	1 Outbound	Hourly Volumes	N/A	1011.00
9 - a	1 Inbound 1 Outbound	Hourly Volumes	N/A	907.00 1011.00

According with the results from Table 5.2, it is easy to observe the differences between using the AADT input option (and consequently the default hourly traffic patterns) and using the real hour volumes that correspond to the location under analysis. If the location is urban, then the difference between the AADT input option and the Hourly Volume input is about $ 25.00 in the Inbound direction, and about $ (-10.00) for the Outbound direction. Even though these differences are not necessarily dramatic, they actually represent the additional user costs over the whole day, or the total hours of closure of the lanes. The main differences may appear during different hours, and because at the end of the day the numbers compensate for one other, the final result may not be very significant.

To better explain this concept, Figure 5.3 shows the different patterns of the hourly volumes for Wednesday (the selected day of the week in this example). It is easy to observe that the peaks actually occur at different times, which means that during some hours the default pattern of the model is overestimating the road user effects and on some others it is underestimating those effects. Since lane closure schedules are highly sensitive to hourly costs, the use of real hourly traffic volumes becomes quite important.

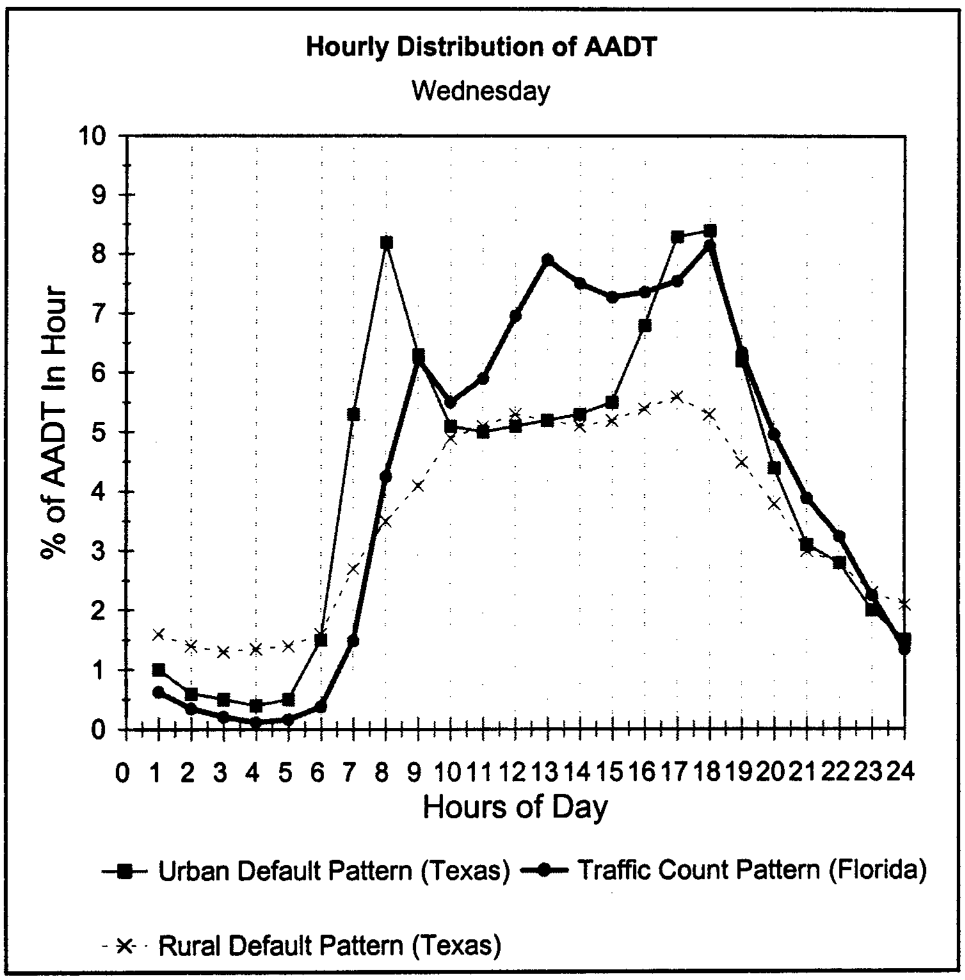

Figure 5.3 Different traffic patterns (default and actual)

For instance, the graph of Figure 5.3 shows that in the case of an urban work zone, if the scheduler uses the default pattern, he or she may be tempted to close the lane/s from 10:00 AM to 3:00 PM (hours 10 to 15), but this scheme will cause a major problem at 1:00 PM (hour 13) when the "real" peak occurs. If the work zone were in a rural area, the problem changes: both patterns (default and real) follow roughly the same trend, but in this case there is a large difference in the volumes, producing a large difference in the additional road user costs. (Table 5.2).

5.4 Accident Considerations

5.4.1 Accident Reduction Factors

Accident reduction factors are necessary to determine the benefit/cost (B/C) ratios needed in order to assess funding allocations for safety improvement projects. (Wattle). In general, the higher the B/C ratio, the more critical the project. The cost factor of the ratio is simply the cost of construction and maintenance amortized over the expected life of the project. The benefit part of the ratio is not so easy to determine. These benefits are actually the benefits to society, and they are generally considered to be the cost of the accidents that are expected to be prevented.

The Technical Advisory T-7570.1 of June 30, 1988 from the Federal Highway Administration on the subject "Motor Vehicle Accident Costs" provided information on developments in estimating motor vehicle accident costs, and it aimed to encourage the State Highway Agencies to use these accident costs for economic analysis of highway projects and programs.

When estimating the accident costs, the FHWA report pointed out that to avoid disproportionate attention to locations where a fatality occurred, the State Highway Agencies should use combined fatal-plus-injury costs (also property damage only or PDO if available). This may be done on a statewide basis, by functional system, by land use (rural/urban), by accident type, or some other combination depending upon the data available within the State's accident records system. The differences in combined costs , the report said, would reflect the variations in accident severity.

A subsequent publication of FHWA on the same subject (T-7570.2) was released on October 31, 1994 canceling the previous one of 1998. This new report provides updated information on the most current comprehensive costs of motor vehicle traffic accidents that are appropriate for use in benefit-cost analyses.

Among other things, the technical advisory report defines three measures of accident costs that are commonly used to account for the cost of accidents:

Comprehensive Cost: This is a method of measuring motor vehicle accident costs which includes the effects of injury on people's entire lives. It is probably the most useful measure of accident costs because it includes all the cost components and assigns a dollar value to each one of them. There are 11 components of these comprehensive costs:

- property damage
- lost earnings
- lost household production
- medical costs
- emergency services
- travel delay

- vocational rehabilitation
- workplace costs
- administrative
- legal
- pain and lost quality of life

These comprehensive life values are estimated by examining the risk reduction costs from which the market value of safety is deduced.

Year Lost Plus Direct Cost: This cost includes the same cost components as the previous category, but it replaces lost earnings, lost household production, and pain and lost quality of life with a non-monetary measure equivalent to lost years. The costs of the category which actually have a monetary value are known as "direct costs":

- property damage
- medical costs
- emergency services
- travel delay
- vocational rehabilitation
- workplace costs
- administrative and legal costs

Human Capital Costs: This category includes all the comprehensive cost components except pain and lost quality of life.

The FHWA report also defines the concept of "willingness-to-pay cost". This concept refers to the costs that the society is willing to pay for safety improvements to prevent fatalities or injuries. However, according to the report, a review of the economics literature revealed that these cost estimates are drawn from safety markets showing how much people actually pay to reduce safety risks, not necessarily what they are willing to pay.

The motor vehicle accident costs recommended for use by State and local highway agencies are shown in Tables 5.3 and 5.4. Table 5.3 contains comprehensive costs in police-reported crashes by Abbreviated Injury Scales (AIS) severity, in 1994 Dollars. Table 5.4 shows comprehensive costs in police-reported crashes by K-A-B-C Scale severity, also in 1994 Dollars.

Table 5.3 Comprehensive accident costs - AIS severity

Severity	Descriptor	Cost per Injury [$]
AIS 1	Minor	5,000
AIS 2	Moderate	40,000
AIS 3	Serious	150,000
AIS 4	Severe	490,000
AIS 5	Critical	1,980,000
AIS 6	Fatal	2,600,000
AIS: Abbreviated Injury Scale		

The Florida Department of Transportation (FDOT) presently has a comprehensive accident record system. Accident data from across Florida are taken on a standard Florida Traffic Crash Report form (FTCR).

Table 5.4 Comprehensive accident costs - KABC scale

Severity	Description	Cost per Injury [$]
K	Fatal	2,600,000
A	Incapacitating	180,000
B	Evident	36,000
C	Possible	19,000
PDO	Property Damage Only	2,000

The 1991 Highway Safety Improvement Program Guideline Topic No. 500-000-100-c of the FDOT states the following:

> "The Florida Statue 316.0066 requires that an investigating officer forward a written report to the Department of Highway Safety and Motor Vehicles (DHSMV) if a crash results in bodily injury to, or death of any persons, or the crash involves a violation of statutes 316.027(2), 316.061(1) or 316.193. Additionally, any crash which requires a wrecker to clear the wreckage shall be reported."

It also states:

> "In every case which does not meet the circumstances described above, the law enforcement officer may, within 24 hours after completing the investigation, forward to DHSMV and provide each party involved in the crash a short-form".

Data Processing:

Once the reports are processed by DHSMV, they are then forwarded to the Department of Transportation Safety Office to be processed regarding the location on the stated maintained highway system and the crash severity. The Department then enters these data into its electronic data base and merges it with the County Roadway Information (CRI) file. Also, the reports are microfilmed by the Safety Office for future reference and analysis.

The Florida Traffic Crash Report form (FTCR) allows the investigating officer to record the necessary information with the minimal amount of time and effort, and allows easy computer coding. This can be seen on the second page of the FTCR form in Appendix E where a corresponding number represents each contributing factor.

For the purpose of this research project, the contributing factor that was analyzed is included under the section "Contributing Causes - Road" in the bottom left corner of the second page of the form, and the coding number is "03: Road Under Repair / Construction". This will be explained later.

The Crash Record System is a cooperative effort between the Department of Transportation and the Department of Highway Safety and Motor Vehicles (DHSMV)

5.4.2 Evaluation Methods

The previously mentioned Highway Safety Improvement Program Guidelines (Topic No. 500-000-100-c) of 1991 also provides instructions about the evaluation methods to determine the effectiveness of the Highway Safety Improvement Programs. The most common method is the "Before and After Evaluations", an evaluation to determine the project's effectiveness. The second is a "Detail Evaluation", which includes an analysis of the type of crashes and their relationship to the type of improvement. The third method is a "Program Evaluation", which can be used as an aid to managers in their decision making processes.

The General Evaluation Process

There are some basic evaluation procedures that are common to all three evaluation types discussed in the previous paragraph. The following five steps are generally used in the evaluation process:

1. Selection of project
2. Selection of the evaluation method
3. Data collection
4. Statistical tests to determine the significance of the evaluation results
5. Documentation of the results

The procedures for evaluating selected projects and programs are depicted in Figure 5.4. In order to analyze the impact of the construction zones on the crash rates, the suitable method would be Before and After evaluation with some modifications.

In the regular Before and After evaluation method, the duration of the evaluation includes crash histories for three years prior to construction and three years after construction. The year the construction occurred is not included in the evaluation. The data evaluated includes the number of crashes, crash severity, adjustment for traffic, and a statistical test for significance. Each evaluation not only examines the project's effect on crash reduction, but also on the reduction of crash severity. The number of crashes for the "after" period is adjusted for the change in traffic count. For projects involving highway sections, million vehicle miles are utilized (mvm); whereas for spot projects, million vehicles are utilized (mv). In these evaluations, the traffic count only includes the number of vehicles on the highway being improved, and it does not include cross traffic.

With few exceptions, the method of evaluation used for these projects is the comparison of the crash rates before, and the crash rates after the completion of the project. The basic assumption here is that without the improvement, the crash level would remain the same as long as the traffic counts remained constant.

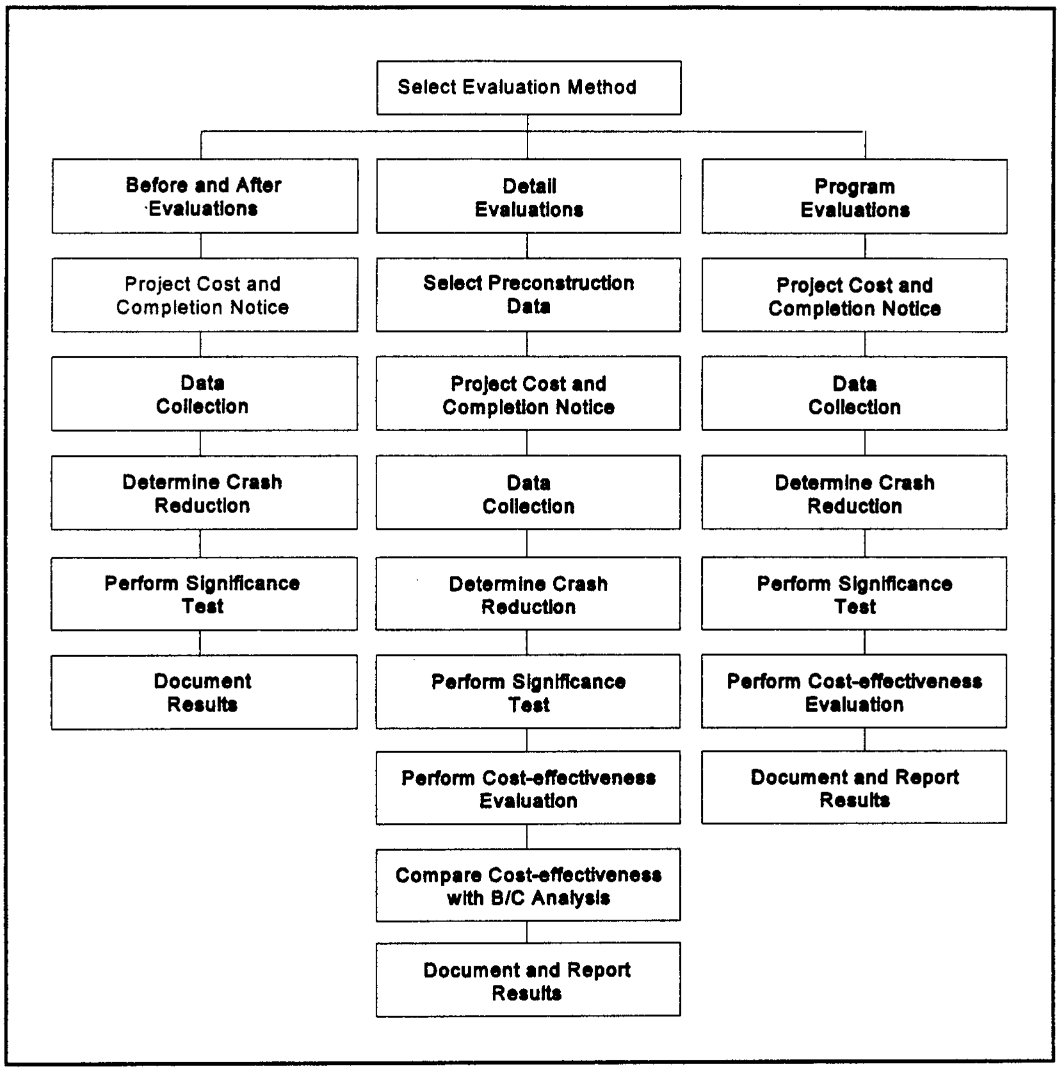

Figure 5.4 Procedures for evaluating selected projects and programs

When analyzing the effect of the construction site on the accident rates, the previously described method is not suitable because of many aspects. In the first place, the method does not consider the year when the construction is ongoing. Secondly, the comparison uses "before" as the worse situation, and the "after" as the improved situation because the goal is to examine the effectiveness of a safety improvement. For construction sites, however, the difference is in the "after" crash rate. The "before" situation still corresponds to the crash rate that the area had before the construction started, but in this case, the "after" would be the variation in the crash rate while the work zone is in place. Unfortunately, construction zones are scarce (in both time and locations) and this fact brings another difficulty to the already complex situation.

Due to the scattered characteristic of the construction sites, the number of data gathered that actually was related to a construction area (coded as "Road under Repair/Construction - 03") as a primary cause of the crash, is quite low. This can be inferred from the accident data provided by the State Safety Office of the Florida Department of Transportation. A large print-out of the accident record data base was analyzed and a summary of the findings is presented in the following tables.

Table 5.5 "a" through "e" condenses the total amount of these accidents per year whose primary causes have been reported as Road under Repair/Construction (Code 03). The crashes have been divided among "Crash" (crashes with no injuries), "Fatal" (crashes with fatalities) and "Injury" (crashes with injuries). The roads are divided according to the number of lanes, Main Interstates ("Main I.), Other Interstates ("Other I."), Main Turnpikes ("Main TP"), and Other Turnpikes ("Other TP"). Each category is split into "divided" and "undivided", and into "Urban" and "Rural" locations.

Table 5.5a Total number of accidents caused by road under construction (1991)

Year 1991	Divided Highways						Undivided Highways					
	Urban			Rural			Urban			Rural		
Road Type	Crash	Fatal	Injury	Crash	Fatal	Injury	Crash	Fatal	Injury	Crash	Fatal	Injury
< 3 lanes	44		38	11		18	55	1	50	51	1	62
3 lanes	2		2	3		5	7		3	1		1
4 lanes	429	1	410	51	1	64	63		39	2		3
5 lanes	4		2									
> 6 lanes	111		89									
Main I.	213	1	226	47	1	65						
Other I.												
Main TP	54	2	65	29	1	33						
Other TP												

Table 5.5b Total number of accidents caused by road under construction (1992)

Year 1992	Divided Highways						Undivided Highways					
	Urban			Rural			Urban			Rural		
Road Type	Crash	Fatal	Injury	Crash	Fatal	Injury	Crash	Fatal	Injury	Crash	Fatal	Injury
< 3 lanes	84		98	23		41	73	2	91	95	4	111
3 lanes	5		4	3		5	25		23			
4 lanes	549	2	564	92	3	103	79		48	1		1
5 lanes	22		18									
> 6 lanes	194		202	1			1		2			
Main I.	194	4	192	54	1	76						
Other I.												
Main TP	53		55	39		62						
Other TP												

Table 5.5c Total number of accidents caused by road under construction (1993)

Year 1993	Divided Highways						Undivided Highways					
	Urban			Rural			Urban			Rural		
Road Type	Crash	Fatal	Injury	Crash	Fatal	Injury	Crash	Fatal	Injury	Crash	Fatal	Injury
< 3 lanes	76		87	23		36	121	2	109	82	1	113
3 lanes	14		12				26		12			
4 lanes	620	7	557	70		87	50		37	7		18
5 lanes	13		8				3					
> 6 lanes	242	2	229	7		4						
Main I.	285	4	355	129	5	214						
Other I.							6		3			
Main TP	30		39	14	2	29						
Other TP	1		1	1			2		1			

Table 5.5d Total number of accidents caused by road under construction (1994)

Year 1994	Divided Highways						Undivided Highways					
	Urban			Rural			Urban			Rural		
Road Type	Crash	Fatal	Injury	Crash	Fatal	Injury	Crash	Fatal	Injury	Crash	Fatal	Injury
< 3 lanes	84	1	86	20		32	133	1	134	73	2	108
3 lanes	4		1				29		17			
4 lanes	637	8	644	47	2	51	62		48	5		3
5 lanes	26		22									
> 6 lanes	385		372									
Main I.	347	1	472	138	8	172						
Other I.							1		2			
Main TP	18		10	12		17						
Other TP	1		1							1		

Table 5.5e Total number of accidents caused by road under construction (1995)

Year 1995	Divided Highways						Undivided Highways					
	Urban			Rural			Urban			Rural		
Road Type	Crash	Fatal	Injury	Crash	Fatal	Injury	Crash	Fatal	Injury	Crash	Fatal	Injury
< 3 lanes	153		128	31		47	152	2	155	109	9	145
3 lanes	7		6				22		11	4		2
4 lanes	775	8	753	81	1	91	68	1	43	7		7
5 lanes	26		14									
> 6 lanes	473	3	413	1								
Main I.	253	1	321	139	1	178						
Other I.										1		2
Main TP	19		24	10	1	11						
Other TP												

Table 5.6 shows the average of crashes of the five-year data to be compared with the million vehicle miles by roadway class and category (Appendix F).

Table 5.6 Total number of accidents caused by road under construction (average)

Year 1995	Divided Highways						Undivided Highways					
	Urban			Rural			Urban			Rural		
Road Type	Crash	Fatal	Injury	Crash	Fatal	Injury	Crash	Fatal	Injury	Crash	Fatal	Injury
< 3 lanes	88.2	0.2	70.2	21.6		34.8	106.8	1.6	107.8	82	3.4	107.8
3 lanes	6.4		5	1.2		2	21.8		13.2	1		0.6
4 lanes	602	5.2	585.6	68.2	1.4	79.2	64.4	0.2	43	4.4		6.4
5 lanes	18.2		12.8				0.6					
> 6 lanes	209	1	261	1.8		0.8	0.2		0.4			
Main I.	258.4	2.2	313.2	101.8	3.2	141						
Other I.							1.4		1	0.2		0.4
Main TP	34.8	0.4	38.6	20.8	0.8	30.4						
Other TP				0.4			0.4			0.2		

Figure 5.5 displays the different percentages of the total crashes that have been reported as having as a primary cause the presence of road under construction.Table 5.7 shows the total number of accidents reported as due to road construction area in comparison with the total number of crashes.

Table 5.7 Total number of accidents and total number of accidents due to construction

	Total Crashes due to Road Construction (Code 03)			Total Crashes			Percentage of Crashes due to Road Construction (Code 03)		
Year	Crash	Fatal	Injury	Crash	Fatal	Injury	Crash	Fatal	Injury
1991	1175	10	1171	102821	1528	106596	1.14	0.95	1.10
1992	1587	16	1696	102946	1426	112206	1.54	1.12	1.51
1993	1822	23	1951	107885	1702	116724	1.69	1.35	1.67
1994	2023	23	2192	110041	1650	121251	1.84	1.39	1.81
1995	2331	27	2351	132147	1668	127726	1.76	1.82	1.84
Total	8938	99	9361	555840	7974	584503	1.61	1.24	1.60

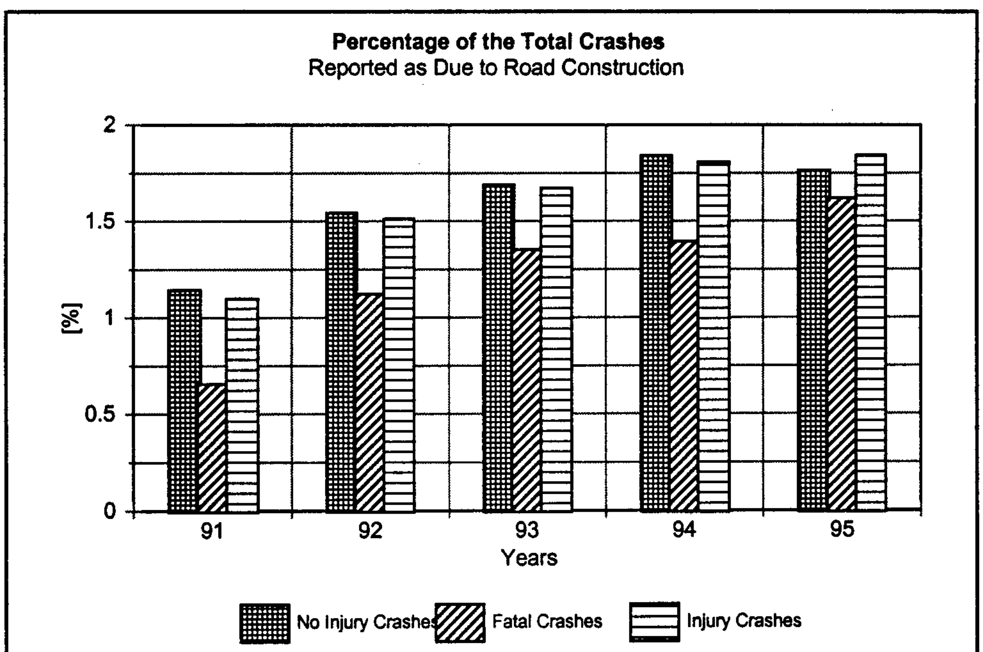

Figure 5.5 Percentages of total crashes caused by road construction

Note that the percentages of the accidents whose primary cause was the existence of a road construction zone are not dramatically high. However, a work zone is a potential location for accidents to occur, and the risk of that should be contemplated when calculating the additional road user costs. Obviously, the shorter the time a highway section is under construction, the less likelihood of accidents to occur, all the other variables being constant. To account for those risk factors, a thorough analysis should be done comparing the different construction sites on different types of road and establishing relationships between them and the number of accidents likely to occur based on historical data.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 General Comments

This research report represents a comprehensive study of the different problems and variables associated with calculations of user costs of highways in general and those particularly related to the construction work zones. A survey was undertaken to examine the methodologies in use for different State Highway Agencies in determining the road user costs used in their projects. An extensive literature review was conducted to evaluate the available methods for road user cost calculations in the United States and abroad.

6.2 Conclusions

- The subject of road user costs has two major applications. The first application is the calculation of road user costs for regular traffic conditions. In this case, road user costs are used for economic comparison of various alternatives of road improvements. The second application is the calculation of additional road user costs in work zones during construction. This second application became more important in recent years through the use of innovative contracting practices such as A+B, lane rental, etc.. The calculations for road user costs for these two applications are basically the same. The only differences are in the data collection and the importance of specific elements.

- From the survey of State Highway Agencies (SHAs), it was found that there is a broad range of methods used by the different agencies, from flat rates to elaborate computer software. There is not one generally accepted system or approach to calculate road user costs. Furthermore, from the responses received, it was found that 20% of the SHAs still do not include road user costs when analyzing their projects.
- The conclusions from the literature survey identified a list of elements that are used in the calculations of additional road user costs on construction zones. The major elements are:
  - Delay costs: This element includes the cost of the time spent by the traveling public when there is construction on the road.
  - Vehicle operating costs: This item includes the costs of operating vehicles such as fuel cost, oil cost, depreciation, etc..
  - Accident costs: Accident costs can be a major item in road user costs calculations. However, due to lack of reliable data, this item has not been incorporated to the calculations in many states.
  - Environmental costs: The environmental effects include items such as pollution and noise. Currently, there is not a widely accepted approach to assign dollar value to those environmental effects.

- Other factors: This category can include various factors such as the effect on the business community, and other exogenous elements.

6.3 Recommendations

- It is recommended that the Florida Department of Transportation (FDOT) should create a committee/task force or similar organization that will determine all the policies about the calculations of user costs based on the data presented in this report.
- The major task of the committee would be to determine which elements are going to be included in the FDOT user costs calculations.
- The issue of traffic delays and operating costs should be divided between commercial and non-commercial use. The task force of the FDOT should decide whether private traffic will be considered in the calculations. Commercial use should be considered at 100% of the values of traffic delays and operating costs. It is recommended, however, that private traffic should also be considered, but at less percentage of the value of the above mentioned components. The FDOT committee should also decide on this matter, and if it decides to include private traffic in the computations, the task force should also establish at what percentage this traffic should be considered.

- After the analysis of the different methods currently available, it was found that the 1993 version of the QUEWZ model is still suitable for the analysis of road user costs as long as the data used to feed the model represents the local conditions of the site being evaluated.
- It is recommended that in the future FDOT incorporate accident costs in the calculations of road user costs in construction zones. Using FDOT available data on accidents related to work zones, further analysis should be done to establish some rates or ratios applicable to certain road work zone conditions. These rates or ratios could then be used to account for the likelihood of accident occurrence when the construction is ongoing. The final estimations could later be related to FHWA recommended accident costs, to include the safety issue in the user cost composition.
- In the long range, when more data will be available on the environmental factors, it is recommended that FDOT consider including them in road user costs calculations.

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APPENDIX A

LETTER TO THE STATE HIGHWAY AGENCIES REQUESTING INFORMATION

COLLEGE
OF
ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING

UNIVERSITY OF FLORIDA

GAINESVILLE, FLORIDA 32611
DEPARTMENT CHAIRMAN
AREA CODE 904 PHONE 392-9537
STUDENT RECORDS
AREA CODE 904 PHONE 392-0933

Date:

Respondent's Name
Respondent's Title
Respondent's Organization
Address of Organization

RE: Road User Cost Information Request

Dear Respondent's Name:

We are sending this letter to you and we will appreciate it if you will transfer it to the people in your organization who are responsible for the calculation of User Costs. We, at the University of Florida have received a research project from the Florida Department of Transportation, to evaluate methods to determine what is known as "User Costs".

Part of the research objectives is to collect data from various departments around the United States and Canada to figure how each department is determining its user costs. We will appreciate very much is you can send us any material that shows how your department is calculating user costs. This material can include written documents, computer programs or even cases of study.
You can send the information to:

Dr. Z.J.Herbsman
College of Engineering
Department of Civil Engineering
345 Weil Hall
P.O.Box 116580
Gainesville, FL, 32611

Tel.: (904) 392-0935
Fax: (904) 392-3394
e-mail: Zohar@ce.ufl.edu

If there is any cost involved in copying (Xerox) and/or shipment of the material, we will be happy to reimburse your expenses. We also promise that at the end of the project, we will send you a copy of our report and we will share any data we find.

Sincerely,

Dr. Zohar Herbsman

APPENDIX B

TRAFFIC COUNTS SAMPLE DATA

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CO SITE        YEAR D MO DAY CALC_T    HR1       HR2     HR3       HR4
-- ---- ---------- - -- --- ------ ---------- ---------- ---------- ----------
       HR5    HR6       HR7     HR8       HR9             HR10    HR11
---------- ---------- ---------- ---------- ---------- ---------- ----------
      HR12   HR13      HR14        HR15        HR16           HR17    HR18
---------- ---------- ---------- ---------- ---------- ---------- ----------
      HR19   HR20      HR21        HR22        HR23           HR24      TOTVOL
---------- ---------- ---------- ---------- ---------- ---------- ----------
93 0010      97 N 05 SUN AVG      250       117      89        60
      32      31        68     160       231              336     475
       635     733       676     670       709              673     637
       657     519       408     348       285              205    9010

93 0010      97 N 05 SUN MINVOL         245       110      85         58
      29      30        65     159       231              331     464
       613     722       626     664       678              624     592
       619     499       404     342       259              182       0

93 0010      97 N 05 SUN MAXVOL         256       125      93         62
      36      33        71     162       232              342     486
       657     745       727     676       740              722     682
       696     539       413     354       312              228       0

93 0010      97 N 05 SUN STDEV      5          7       4          2
       3       1         3       1         0              5        11
      22      11        50       6        31               49      45
      38      20         4       6        26               23       0

93 0010      97 N 05 MON AVG       91         38      15        20
      29      34       147     503       860              731     793
       934    1149       978     985      1000             1011    1167
       900     600       426     352       218              163        13144

93 0010      97 N 05 MON MINVOL          91        38      15         20
      29      34       147     503       860              731     793
       934    1149       978     985      1000             1011    1167
       900     600       426     352       218              163       0

93 0010      97 N 05 MON MAXVOL          91        38      15         20
      29      34       147     503       860              731     793
       934    1149       978     985      1000             1011    1167
       900     600       426     352       218              163       0

93 0010      97 N 05 WED AVG       95         52      31        16
      25      42       163     467       816              752     833
       991    1150      1029     944      1059             1071    1223
       979     695       516     455       286              211        13908

93 0010      97 N 05 WED MINVOL          92        47      25         16
      25      39       157     447       799              727     804
       948    1148      1011     932      1032             1029    1201
       910     661       487     433       268              211       0

93 0010      97 N 05 WED MAXVOL          98        57      38         17
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      26        45        170     488      833               778     862
      1034    1152       1048     956     1087              1114    1245
      1049     730        546     478      305               211       0

93 0010      97 N 05 WED STDEV      3        5       6        0
       0         3          6      20       17                25      29
      43         2         18      12       27                42      22
      69        34         29      22       18                 0       0

93 0010      97 N 05 THU AVG      113       60      38       22
      22        41        150     483      758               761     765

CO SITE       YEAR D MO DAY CALC_T    HR1      HR2    HR3      HR4
-- ---- ---------- - -- --- ------ ---------- ---------- ---------- ----------
       HR5    HR6      HR7    HR8      HR9          HR10   HR11
---------- ---------- ---------- ---------- ---------- ---------- ----------
      HR12   HR13     HR14      HR15      HR16          HR17   HR18
---------- ---------- ---------- ---------- ---------- ---------- ----------
      HR19   HR20     HR21      HR22      HR23          HR24     TOTVOL
---------- ---------- ---------- ---------- ---------- ---------- ----------
       965   1081     1016      1005      1074          1074   1190
       955    710      533    455      351               229      13858

93 0010      97 N 05 THU MINVOL        92       56      33        18
      19        39        144     477      745               716     727
       963    1059        985     970     1045              1026    1155
       939     688        462     408      306               207       0

93 0010      97 N 05 THU MAXVOL       135       64      50        25
      28        45        161     488      777               795     802
       969    1118       1050      1033      1126          1124   1208
       969     754        574     489      376               248       0

93 0010      97 N 05 THU STDEV     17        3       8        2
       4         2          7       4       13                33      30
       2        26         26      26       36                40      24
      12        31         50      34       31                16       0

93 0010      97 N 05 FRI AVG      133       67      46       22
      33        42        145     454      761               765     860
       995    1154       1022      1134      1135          1186   1352
       972     802        633     565      455               373      15114

93 0010      97 N 05 FRI MINVOL       114       63      40        16
      29        40        143     448      724               748     828
       973    1129       1000      1039      1051          1153   1254
       934     791        568     508      426               357       0

93 0010      97 N 05 FRI MAXVOL       150       73      49        30
      40        44        149     464      796               784     881
      1014    1184       1044      1258      1239          1238   1508
       997     816        703     642      476               400       0

93 0010      97 N 05 FRI STDEV     14        4       4        5
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     4         1         2       6        29                14      23
    16        22        17      91        78                36     111
    27        10        55      56        21                19       0

93 0010     97 N 05 SAT AVG      257       138      103         42
    40        32        85     209       447               605     727
     890     908       891     853       835               906     860
     797     733       590     483       418               357       12211

93 0010     97 N 05 SAT MINVOL          246       124      97         41
    39        32        84     206       445               581     725
     877     882       866     803       827               870     848
     764     700       589     481       408               345       0

93 0010     97 N 05 SAT MAXVOL          268       153      110        44
    41        33        86     212       449               630     729
     903     934       917     903       843               942     872
     831     766       592     485       429               370       0

93 0010     97 N 05 SAT STDEV     11        14        6          1
     1         0         1       3         2                24       2
    13        26        25      50         8                36      12
    33        33         1       2        10                12       0

CO SITE        YEAR D MO DAY CALC_T    HR1       HR2     HR3       HR4
-- ---- ---------- - -- --- ------ ---------- ---------- ---------- ----------
       HR5     HR6       HR7     HR8       HR9             HR10    HR11
---------- ---------- ---------- ---------- ---------- ---------- ----------
      HR12    HR13      HR14        HR15        HR16           HR17    HR18
---------- ---------- ---------- ---------- ---------- ---------- ----------
      HR19    HR20      HR21        HR22        HR23           HR24    TOTVOL
---------- ---------- ---------- ---------- ---------- ---------- ----------

93 0010     97 N 06 SUN AVG      243       124      90         53
    34        33        60     154       238               346     507
     607     732       683     648       672               709     695
     704     553       425     344       259               154    9076

93 0010     97 N 06 SUN MINVOL          230       105      76         42
    24        30        46     137       223               312     489
     580     684       633     587       664               677     593
     658     479       352     285       229               134       0

93 0010     97 N 06 SUN MAXVOL          262       143      105        61
    43        38        71     172       251               383     542
     682     776       765     712       684               734     735
     755     628       463     381       283               179       0

93 0010     97 N 06 SUN STDEV     11        14       10          7
     7         2        10      12        10                26      18
    37        33        46      41         7                20      53
    35        53        39      32        21                15       0

93 0010     97 N 06 MON AVG       95        43       25         23
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28      39      148    430     717           737    834
901   1083      999    935    1002          1049   1166
857    626      473    374     245           166      13002

93 0010    97 N 06 MON MINVOL        80        29      19        22
28      35      142    420     664           713    776
871   1080      973    926     964           989   1129
834    587      410    311     231           152      0

93 0010    97 N 06 MON MAXVOL       107        52      35        24
30      45      162    436     756           760    866
948   1086     1044    945    1052          1101   1217
881    691      546    434     257           179      0

93 0010    97 N 06 MON STDEV    11        10      7        0
0        4        9      7      39            19     41
33       2       31      7      36            46     37
19      46       55     50      10            11      0

93 0010    97 N 06 TUE AVG     109        51      35        24
26      38      165    463     725           769    815
957   1114     1010    957    1000          1063   1194
956    694      516    405     286           183      13565

93 0010    97 N 06 TUE MINVOL        93        37      22        19
23      30      139    438     693           753    795
920   1071      946    899     902          1001   1162
919    682      507    391     253           156      0

93 0010    97 N 06 TUE MAXVOL       122        61      55        30
29      44      195    494     753           791    858
1019  1169     1068     1015      1052          1144   1223
1019   727      528    431     340           200      0

93 0010    97 N 06 TUE STDEV    10         9      12        3

CO SITE       YEAR D MO DAY CALC_T    HR1       HR2     HR3       HR4
-- ---- ---------- - -- --- ------ ---------- ---------- ---------- ----------
HR5    HR6       HR7    HR8      HR9            HR10   HR11
---------- ---------- ---------- ---------- ---------- ---------- ----------
HR12   HR13     HR14       HR15       HR16           HR17   HR18
---------- ---------- ---------- ---------- ---------- ---------- ----------
HR19   HR20     HR21       HR22       HR23           HR24     TOTVOL
---------- ---------- ---------- ---------- ---------- ---------- ----------
2        5       20     20      21            14     24
37      39       45     41      58            51     21
37      18        7     15      34            17      0

93 0010    97 N 06 WED AVG      96        61      33        25
27      58      154    454     751           746    795
1013  1150      996    947    1039          1020   1255
949    683      548    449     285           198      13736

93 0010    97 N 06 WED MINVOL        90        57      32        24
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     23       56       147    445      711            730     794
   1005     1135       994    945     1010           1013    1196
    947      666       544    429      266            195       0

93 0010    97 N 06 WED MAXVOL        102       66      35       26
     32       60       161    463      791            762     797
   1022     1166       998    949     1068           1028    1314
    951      700       552    470      304            201       0

93 0010    97 N 06 WED STDEV      6         4       1        1
      4        2         7      9       40             16       1
      8       15         2      2       29              7      59
      2       17         4     20       19              3       0

93 0010    97 N 06 THU AVG     123        57      39       24
     26       37       153    471      706            762     812
    983     1086       940    898      944            982    1115
    909      725       530    471      355            227      13383

93 0010    97 N 06 THU MINVOL        112       51      37       19
     22       31       144    452      689            759     783
    926      956       917    860      915            936    1000
    890      660       466    407      332            191       0

93 0010    97 N 06 THU MAXVOL        129       62      41       32
     30       44       163    495      715            770     860
   1084     1189       967    926      985           1057    1203
    930      797       575    512      369            259       0

93 0010    97 N 06 THU STDEV      7         4       1        5
      3        5         7     17       12              5      33
     71       97        20     27       29             53      85
     16       56        46     45       16             27       0

93 0010    97 N 06 FRI AVG     125        67      41       25
     26       47       162    439      739            786     854
    994     1198      1024       1001       1094          1180   1339
    994      774       603    512      408            307      14748

93 0010    97 N 06 FRI MINVOL        116       54      40       17
     22       40       158    429      717            746     826
    959     1118       995    972     1026           1147    1317
    975      722       488    475      368            276       0

93 0010    97 N 06 FRI MAXVOL        138       93      43       33
     30       51       170    457      752            807     895
   1045     1255      1054       1056       1132          1204   1372

CO SITE       YEAR D MO DAY CALC_T    HR1       HR2     HR3       HR4
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       HR5     HR6       HR7     HR8       HR9           HR10    HR11
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      HR12    HR13      HR14       HR15       HR16          HR17    HR18
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     HR19   HR20     HR21       HR22       HR23            HR24    TOTVOL
---------- ---------- ---------- ---------- ---------- ---------- ----------
     1007    804      672    593      439              343      0

93 0010      97 N 06 FRI STDEV      7        15      1        5
       3       4        4     11       13                24      25
      34      51       21     33       42                21      22
      11      31       69     47       30                24       0

93 0010      97 N 06 SAT AVG     235       129      89       48
      39      38       81    224      475               593     726
     886     919      864    836      849               951     831
     785     746      558    478      431               357       12179

93 0010      97 N 06 SAT MINVOL         220      111     73       43
      27      34       74    208      432               571     688
     857     852      802    800      812               903     787
     754     706      525    387      381               339       0

93 0010      97 N 06 SAT MAXVOL         258      143     95       55
      48      41       90    239      514               621     777
     933    1001      903    859      883               985     879
     806     871      611    559      542               387       0

93 0010      97 N 06 SAT STDEV     14        12       8        4
       7       2        5     10       28                19      31
      30      63       39     22       25                30      35
      18      62       31     54       58                18       0

93 0010      97 N 07 SUN AVG     228       125      83       46
      31      44       63    154      228               307     465
     607     731      670    631      658               681     684
     725     525      446    332      274               182    8928

93 0010      97 N 07 SUN MINVOL         220       94     64       40
      25      42       43    143      219               287     459
     569     709      656    590      613               673     649
     679     503      397    307      252               173       0

93 0010      97 N 07 SUN MAXVOL         235      138    102       61
      39      46       75    177      237               337     474
     635     773      690    652      718               692     711
     780     534      482    380      284               199       0

93 0010      97 N 07 SUN STDEV      5        18      13        8
       5       1       12     13        8                19       6
      28      24       12     24       45                7       26
      39      13       31     28       12                10       0

93 0010      97 N 07 MON AVG      94        48      26       18
      26      35      147    459      699               743     799
     945    1085      996    976      976              1019    1131
     845     629      481    393      255               183       13017
```

APPENDIX C

TRAFFIC COUNT DATA SUMMARY AND GRAPHS

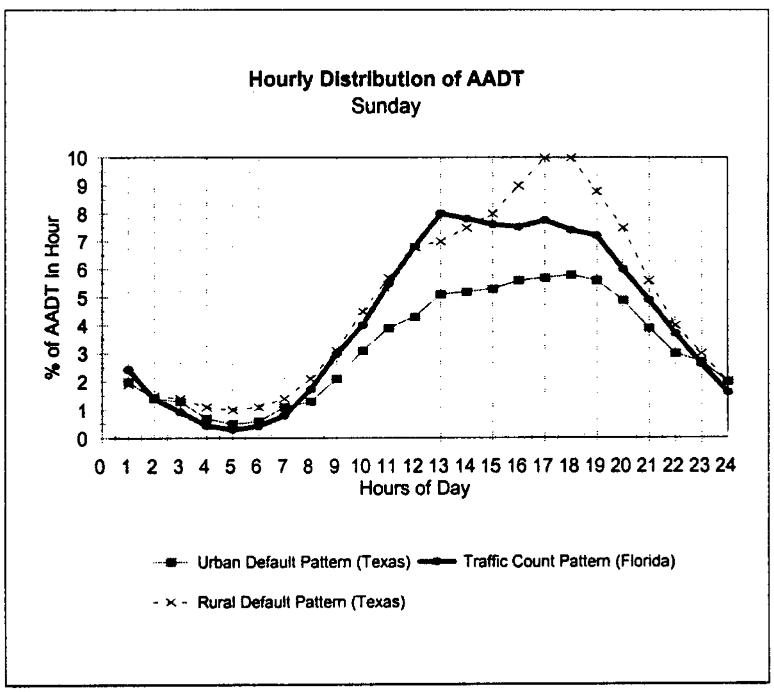
SUNDAY DIRECTION: NORTH

Hours	May [veh]	May % of ADT	June [veh]	June % of ADT	July [veh]	July % of ADT	September [veh]	September % of ADT	October [veh]	October % of ADT	November [veh]	November % of ADT	December [veh]	December % of ADT
1	250.00	2.77	243.00	2.68	228.00	2.55	224.00	2.44	240.00	2.61	249.00	2.37	274.00	2.63
2	117.00	1.30	124.00	1.37	125.00	1.40	129.00	1.40	137.00	1.49	143.00	1.36	146.00	1.40
3	89.00	0.99	90.00	0.99	83.00	0.93	95.00	1.03	84.00	0.91	92.00	0.88	93.00	0.89
4	60.00	0.67	53.00	0.58	46.00	0.52	48.00	0.52	53.00	0.58	46.00	0.44	48.00	0.46
5	32.00	0.36	34.00	0.37	31.00	0.35	37.00	0.40	27.00	0.29	31.00	0.30	28.00	0.27
6	31.00	0.34	33.00	0.36	44.00	0.49	35.00	0.38	33.00	0.36	32.00	0.30	33.00	0.32
7	68.00	0.75	60.00	0.66	63.00	0.71	63.00	0.69	60.00	0.65	82.00	0.78	74.00	0.71
8	160.00	1.78	154.00	1.70	154.00	1.72	167.00	1.82	168.00	1.82	207.00	1.97	197.00	1.89
9	231.00	2.56	238.00	2.62	228.00	2.55	292.00	3.18	274.00	2.98	317.00	3.02	304.00	2.92
10	336.00	3.73	346.00	3.81	307.00	3.44	357.00	3.89	378.00	4.10	456.00	4.34	410.00	3.94
11	475.00	5.27	507.00	5.59	465.00	5.21	544.00	5.92	546.00	5.93	650.00	6.19	641.00	6.16
12	635.00	7.05	607.00	6.69	607.00	6.80	676.00	7.36	637.00	6.92	734.00	6.99	723.00	6.95
13	733.00	8.14	732.00	8.07	731.00	8.19	785.00	8.54	794.00	8.62	911.00	8.67	879.00	8.45
14	676.00	7.50	683.00	7.53	670.00	7.50	747.00	8.13	724.00	7.86	869.00	8.27	828.00	7.96
15	670.00	7.44	648.00	7.14	631.00	7.07	690.00	7.51	675.00	7.33	812.00	7.73	793.00	7.62
16	709.00	7.87	672.00	7.40	658.00	7.37	672.00	7.31	665.00	7.22	803.00	7.64	798.00	7.67
17	673.00	7.47	709.00	7.81	681.00	7.63	687.00	7.48	739.00	8.02	832.00	7.92	828.00	7.96
18	637.00	7.07	695.00	7.66	684.00	7.66	699.00	7.61	742.00	8.06	833.00	7.93	783.00	7.52
19	657.00	7.29	704.00	7.76	725.00	8.12	697.00	7.59	722.00	7.84	768.00	7.31	795.00	7.64
20	519.00	5.76	553.00	6.09	525.00	5.88	519.00	5.65	504.00	5.47	566.00	5.39	532.00	5.11
21	408.00	4.53	425.00	4.68	446.00	5.00	385.00	4.19	368.00	4.00	392.00	3.73	419.00	4.03
22	348.00	3.86	344.00	3.79	332.00	3.72	264.00	2.87	270.00	2.93	290.00	2.76	342.00	3.29
23	285.00	3.16	259.00	2.85	274.00	3.07	218.00	2.37	216.00	2.35	230.00	2.19	254.00	2.44
24	205.00	2.28	154.00	1.70	182.00	2.04	149.00	1.62	146.00	1.59	154.00	1.47	178.00	1.71
	9010.00	100.00	9076.00	100.00	8928.00	100.00	9187.00	100.00	9210.00	100.00	10507.00	100.00	10407.00	100.00

SUNDAY DIRECTION: SOUTH

Hours	May [veh]	May % of ADT	June [veh]	June % of ADT	July [veh]	July % of ADT	August [veh]	August % of ADT	September [veh]	September % of ADT	October [veh]	October % of ADT	November [veh]	November % of ADT	December [veh]	December % of ADT
1	210.00	2.46	201.00	2.39	191.00	2.25	192.00	2.28	201.00	2.41	180.00	2.10	195.00	1.99	229.00	2.38
2	127.00	1.49	123.00	1.46	120.00	1.42	117.00	1.39	123.00	1.48	123.00	1.43	110.00	1.13	140.00	1.45
3	92.00	1.08	86.00	1.02	83.00	0.98	74.00	0.88	80.00	0.96	79.00	0.92	77.00	0.79	72.00	0.75
4	33.00	0.39	35.00	0.42	32.00	0.38	29.00	0.34	35.00	0.42	32.00	0.37	30.00	0.31	27.00	0.28
5	26.00	0.30	24.00	0.29	20.00	0.24	24.00	0.29	28.00	0.34	20.00	0.23	29.00	0.30	27.00	0.28
6	42.00	0.49	37.00	0.44	37.00	0.44	41.00	0.49	41.00	0.49	45.00	0.52	47.00	0.48	45.00	0.47
7	89.00	1.04	76.00	0.90	83.00	0.98	84.00	1.00	74.00	0.89	66.00	0.77	92.00	0.94	75.00	0.78
8	136.00	1.59	138.00	1.64	132.00	1.56	130.00	1.55	145.00	1.74	134.00	1.56	160.00	1.64	163.00	1.69
9	257.00	3.01	237.00	2.82	256.00	3.02	244.00	2.90	271.00	3.25	275.00	3.20	338.00	3.46	315.00	3.27
10	325.00	3.81	339.00	4.04	332.00	3.92	328.00	3.90	333.00	3.99	368.00	4.28	446.00	4.56	420.00	4.36
11	430.00	5.04	432.00	5.14	389.00	4.59	403.00	4.79	449.00	5.39	458.00	5.33	556.00	5.69	557.00	5.78
12	555.00	6.50	548.00	6.52	512.00	6.04	521.00	6.20	584.00	7.01	626.00	7.29	674.00	6.90	676.00	7.02
13	677.00	7.93	624.00	7.43	619.00	7.30	600.00	7.14	651.00	7.81	690.00	8.03	755.00	7.72	733.00	7.61
14	678.00	7.94	647.00	7.70	623.00	7.35	661.00	7.86	647.00	7.76	661.00	7.69	829.00	8.48	737.00	7.65
15	657.00	7.70	636.00	7.57	684.00	8.07	656.00	7.80	644.00	7.73	632.00	7.36	804.00	8.23	784.00	8.14
16	614.00	7.19	609.00	7.25	635.00	7.49	638.00	7.59	607.00	7.28	666.00	7.75	809.00	8.28	730.00	7.58
17	603.00	7.07	625.00	7.44	658.00	7.76	645.00	7.67	672.00	8.06	720.00	8.38	786.00	8.04	742.00	7.71
18	599.00	7.02	580.00	6.91	592.00	6.98	606.00	7.21	615.00	7.38	647.00	7.53	693.00	7.09	703.00	7.30
19	583.00	6.83	583.00	6.94	591.00	6.97	595.00	7.08	561.00	6.73	560.00	6.52	645.00	6.60	622.00	6.46
20	557.00	6.53	556.00	6.62	570.00	6.72	551.00	6.55	564.00	6.77	537.00	6.25	549.00	5.62	570.00	5.92
21	486.00	5.69	499.00	5.94	533.00	6.29	533.00	6.34	401.00	4.81	418.00	4.87	467.00	4.78	493.00	5.12
22	354.00	4.15	367.00	4.37	379.00	4.47	373.00	4.44	311.00	3.73	344.00	4.00	348.00	3.56	389.00	4.04
23	270.00	3.16	247.00	2.94	258.00	3.04	219.00	2.61	183.00	2.20	201.00	2.34	204.00	2.09	238.00	2.47
24	135.00	1.58	140.00	1.67	140.00	1.65	133.00	1.58	106.00	1.27	102.00	1.19	124.00	1.27	138.00	1.43
	8535.00	100.00	8399.00	100.00	8477.00	100.00	8406.00	100.00	8336.00	100.00	8590.00	100.00	9775.00	100.00	9629.00	100.00

		Sunday	
	North	South	Average
Hours			
1	2.58	2.28	2.43
2	1.39	1.41	1.40
3	0.95	0.92	0.93
4	0.54	0.36	0.45
5	0.33	0.28	0.31
6	0.37	0.48	0.42
7	0.71	0.91	0.81
8	1.81	1.62	1.72
9	2.83	3.12	2.98
10	3.89	4.11	4.00
11	5.75	5.22	5.49
12	6.96	6.68	6.82
13	8.38	7.62	8.00
14	7.82	7.81	7.81
15	7.40	7.82	7.61
16	7.50	7.55	7.53
17	7.76	7.77	7.76
18	7.64	7.18	7.41
19	7.65	6.77	7.21
20	5.62	6.37	6.00
21	4.31	5.48	4.89
22	3.32	4.10	3.71
23	2.63	2.61	2.62
24	1.77	1.46	1.61
	100.00	100.00	100.00



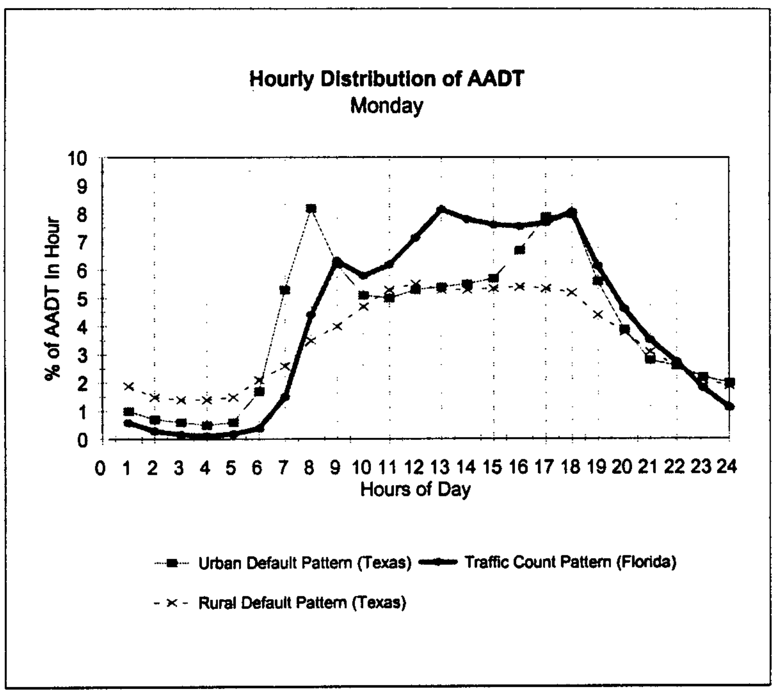
MONDAY DIRECTION: NORTH

	May		June		July		September		October		November		December	
Hours	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT
1	91.00	0.69	95.00	0.73	94.00	0.72	80.00	0.62	80.00	0.58	107.00	0.71	92.00	0.61
2	38.00	0.29	43.00	0.33	48.00	0.37	36.00	0.28	41.00	0.30	45.00	0.30	51.00	0.34
3	15.00	0.11	25.00	0.19	26.00	0.20	22.00	0.17	21.00	0.15	24.00	0.16	24.00	0.16
4	20.00	0.15	23.00	0.18	18.00	0.14	18.00	0.14	14.00	0.10	16.00	0.11	14.00	0.09
5	29.00	0.22	28.00	0.22	26.00	0.20	25.00	0.19	20.00	0.14	22.00	0.15	17.00	0.11
6	34.00	0.26	39.00	0.30	35.00	0.27	45.00	0.35	50.00	0.36	43.00	0.29	46.00	0.31
7	147.00	1.12	148.00	1.14	147.00	1.13	167.00	1.29	170.00	1.23	185.00	1.23	166.00	1.11
8	503.00	3.83	430.00	3.31	459.00	3.53	504.00	3.88	507.00	3.67	527.00	3.51	515.00	3.44
9	860.00	6.54	717.00	5.51	699.00	5.37	796.00	6.13	831.00	6.02	876.00	5.83	853.00	5.69
10	731.00	5.56	737.00	5.67	743.00	5.71	744.00	5.73	805.00	5.83	851.00	5.66	827.00	5.52
11	793.00	6.03	834.00	6.41	799.00	6.14	806.00	6.21	844.00	6.11	942.00	6.27	918.00	6.12
12	934.00	7.11	901.00	6.93	945.00	7.26	931.00	7.17	1074.00	7.78	1080.00	7.18	1159.00	7.73
13	1149.00	8.74	1083.00	8.33	1085.00	8.34	1052.00	8.11	1209.00	8.76	1293.00	8.60	1266.00	8.45
14	978.00	7.44	999.00	7.68	996.00	7.65	987.00	7.61	1036.00	7.50	1183.00	7.87	1124.00	7.50
15	985.00	7.49	935.00	7.19	976.00	7.50	989.00	7.62	1060.00	7.68	1112.00	7.40	1148.00	7.66
16	1000.00	7.61	1002.00	7.71	976.00	7.50	1003.00	7.73	1071.00	7.76	1186.00	7.89	1195.00	7.97
17	1011.00	7.69	1049.00	8.07	1019.00	7.83	1035.00	7.98	1062.00	7.69	1210.00	8.05	1232.00	8.22
18	1167.00	8.88	1166.00	8.97	1131.00	8.69	1139.00	8.78	1220.00	8.84	1336.00	8.89	1308.00	8.73
19	900.00	6.85	857.00	6.59	845.00	6.49	846.00	6.52	916.00	6.63	984.00	6.55	1000.00	6.67
20	600.00	4.56	626.00	4.81	629.00	4.83	627.00	4.83	645.00	4.67	684.00	4.55	714.00	4.76
21	426.00	3.24	473.00	3.64	481.00	3.70	431.00	3.32	406.00	2.94	483.00	3.21	488.00	3.26
22	352.00	2.68	374.00	2.88	393.00	3.02	321.00	2.47	337.00	2.44	390.00	2.59	373.00	2.49
23	218.00	1.66	245.00	1.88	255.00	1.96	209.00	1.61	225.00	1.63	269.00	1.79	266.00	1.77
24	163.00	1.24	166.00	1.28	183.00	1.41	156.00	1.20	154.00	1.12	179.00	1.19	186.00	1.24
	13144.00	100.00	13002.00	100.00	13017.00	100.00	12976.00	100.00	13806.00	100.00	15034.00	100.00	14989.00	100.00

MONDAY DIRECTION: SOUTH

	May		June		July		August		September		October		November		December	
Hours	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT
1	53.00	0.42	81.00	0.64	74.00	0.58	64.00	0.51	69.00	0.55	63.00	0.48	66.00	0.45	72.00	0.49
2	34.00	0.27	33.00	0.26	43.00	0.34	34.00	0.27	32.00	0.25	35.00	0.26	39.00	0.27	40.00	0.27
3	16.00	0.13	27.00	0.21	22.00	0.17	28.00	0.22	20.00	0.16	27.00	0.20	23.00	0.16	26.00	0.18
4	11.00	0.09	15.00	0.12	15.00	0.12	16.00	0.13	13.00	0.10	15.00	0.11	21.00	0.14	13.00	0.09
5	28.00	0.22	27.00	0.21	25.00	0.20	25.00	0.20	30.00	0.24	28.00	0.21	28.00	0.19	21.00	0.14
6	44.00	0.35	55.00	0.43	52.00	0.41	62.00	0.49	64.00	0.51	66.00	0.50	75.00	0.52	67.00	0.46
7	215.00	1.71	242.00	1.91	232.00	1.82	236.00	1.88	238.00	1.89	255.00	1.92	262.00	1.80	246.00	1.69
8	649.00	5.15	611.00	4.81	601.00	4.71	622.00	4.96	729.00	5.80	765.00	5.77	764.00	5.26	757.00	5.20
9	838.00	6.65	854.00	6.73	818.00	6.41	791.00	6.30	930.00	7.39	910.00	6.87	983.00	6.77	1044.00	7.17
10	753.00	5.97	729.00	5.74	752.00	5.89	729.00	5.81	774.00	6.15	768.00	5.80	856.00	5.90	870.00	5.98
11	784.00	6.22	784.00	6.18	763.00	5.98	786.00	6.26	810.00	6.44	801.00	6.05	904.00	6.23	891.00	6.12
12	910.00	7.22	861.00	6.78	889.00	6.97	874.00	6.97	862.00	6.85	926.00	6.99	1034.00	7.12	1015.00	6.97
13	1004.00	7.97	1018.00	8.02	1024.00	8.03	990.00	7.89	953.00	7.58	1010.00	7.62	1119.00	7.71	1157.00	7.95
14	1018.00	8.08	992.00	7.81	998.00	7.82	1048.00	8.35	990.00	7.87	1063.00	8.02	1182.00	8.14	1151.00	7.91
15	957.00	7.59	980.00	7.72	967.00	7.58	956.00	7.62	953.00	7.58	1070.00	8.08	1130.00	7.78	1124.00	7.72
16	922.00	7.32	911.00	7.18	904.00	7.08	918.00	7.32	920.00	7.31	1007.00	7.60	1109.00	7.64	1106.00	7.60
17	973.00	7.72	953.00	7.51	945.00	7.41	915.00	7.29	913.00	7.26	989.00	7.46	1084.00	7.47	1084.00	7.45
18	970.00	7.70	947.00	7.46	947.00	7.42	900.00	7.17	895.00	7.12	985.00	7.43	1048.00	7.22	1032.00	7.09
19	678.00	5.38	714.00	5.62	736.00	5.77	716.00	5.71	716.00	5.69	776.00	5.86	831.00	5.72	817.00	5.61
20	577.00	4.58	579.00	4.56	609.00	4.77	596.00	4.75	551.00	4.38	575.00	4.34	627.00	4.32	657.00	4.51
21	411.00	3.26	503.00	3.96	525.00	4.11	486.00	3.87	463.00	3.68	458.00	3.46	513.00	3.53	540.00	3.71
22	365.00	2.90	381.00	3.00	409.00	3.21	369.00	2.94	325.00	2.58	323.00	2.44	406.00	2.80	403.00	2.77
23	255.00	2.02	257.00	2.02	266.00	2.08	240.00	1.91	210.00	1.67	217.00	1.64	274.00	1.89	278.00	1.91
24	138.00	1.09	132.00	1.04	135.00	1.06	138.00	1.10	113.00	0.90	110.00	0.83	134.00	0.92	139.00	0.95
	12603.00	100.00	12695.00	100.00	12760.00	100.00	12546.00	100.00	12579.00	100.00	13250.00	100.00	14519.00	100.00	14558.00	100.00

		Monday	
	North	South	Average
Hours			
1	0.67	0.52	0.59
2	0.31	0.27	0.29
3	0.16	0.18	0.17
4	0.13	0.11	0.12
5	0.18	0.20	0.19
6	0.30	0.46	0.38
7	1.18	1.83	1.50
8	3.59	5.21	4.40
9	5.87	6.79	6.33
10	5.67	5.91	5.79
11	6.19	6.18	6.18
12	7.31	6.98	7.15
13	8.47	7.84	8.16
14	7.61	8.00	7.80
15	7.51	7.71	7.61
16	7.74	7.38	7.56
17	7.93	7.45	7.69
18	8.82	7.33	8.07
19	6.61	5.67	6.14
20	4.72	4.53	4.62
21	3.33	3.70	3.51
22	2.65	2.83	2.74
23	1.76	1.89	1.83
24	1.24	0.99	1.11
	100.00	100.00	100.00



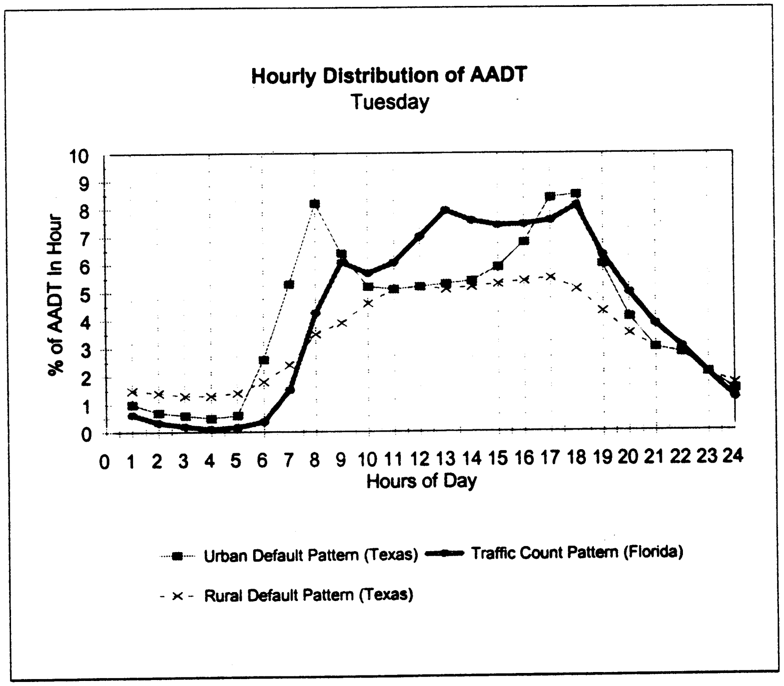
TUESDAY DIRECTION: NORTH

	June		July		August		September		October		November		December	
Hours	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT
1	109.00	0.80	94.00	0.71	125.00	0.88	89.00	0.65	101.00	0.71	100.00	0.64	102.00	0.66
2	51.00	0.38	49.00	0.37	64.00	0.45	42.00	0.31	43.00	0.30	39.00	0.25	58.00	0.37
3	35.00	0.26	25.00	0.19	42.00	0.30	27.00	0.20	24.00	0.17	30.00	0.19	33.00	0.21
4	24.00	0.18	16.00	0.12	18.00	0.13	19.00	0.14	15.00	0.11	22.00	0.14	17.00	0.11
5	26.00	0.19	27.00	0.20	34.00	0.24	25.00	0.18	28.00	0.20	23.00	0.15	24.00	0.15
6	38.00	0.28	36.00	0.27	47.00	0.33	48.00	0.35	41.00	0.29	43.00	0.28	41.00	0.26
7	165.00	1.22	166.00	1.25	186.00	1.31	186.00	1.35	185.00	1.31	195.00	1.25	178.00	1.14
8	463.00	3.41	474.00	3.58	505.00	3.57	499.00	3.63	519.00	3.66	545.00	3.50	529.00	3.40
9	725.00	5.34	711.00	5.37	745.00	5.26	751.00	5.46	811.00	5.73	866.00	5.57	843.00	5.41
10	769.00	5.67	766.00	5.78	715.00	5.05	767.00	5.57	800.00	5.65	865.00	5.56	855.00	5.49
11	815.00	6.01	798.00	6.02	828.00	5.85	829.00	6.02	870.00	6.14	909.00	5.84	952.00	6.12
12	957.00	7.05	953.00	7.19	1002.00	7.08	1008.00	7.32	1062.00	7.50	1166.00	7.50	1127.00	7.24
13	1114.00	8.21	1082.00	8.17	1138.00	8.04	1129.00	8.20	1179.00	8.32	1347.00	8.66	1291.00	8.29
14	1010.00	7.45	972.00	7.34	1008.00	7.12	993.00	7.22	1025.00	7.24	1187.00	7.63	1152.00	7.40
15	957.00	7.05	957.00	7.22	970.00	6.85	1019.00	7.40	1025.00	7.24	1172.00	7.53	1161.00	7.46
16	1000.00	7.37	964.00	7.28	1051.00	7.43	1047.00	7.61	1049.00	7.41	1209.00	7.77	1243.00	7.98
17	1063.00	7.84	1013.00	7.65	1047.00	7.40	1143.00	8.31	1137.00	8.03	1276.00	8.20	1263.00	8.11
18	1194.00	8.80	1197.00	9.04	1318.00	9.31	1231.00	8.94	1253.00	8.85	1393.00	8.95	1382.00	8.88
19	956.00	7.05	882.00	6.66	1076.00	7.60	916.00	6.66	976.00	6.89	1034.00	6.65	1065.00	6.84
20	694.00	5.12	670.00	5.06	783.00	5.53	695.00	5.05	692.00	4.89	740.00	4.76	777.00	4.99
21	516.00	3.80	489.00	3.69	525.00	3.71	492.00	3.58	501.00	3.54	487.00	3.13	538.00	3.46
22	405.00	2.99	416.00	3.14	434.00	3.07	375.00	2.72	390.00	2.75	414.00	2.66	419.00	2.69
23	286.00	2.11	298.00	2.25	289.00	2.04	260.00	1.89	255.00	1.80	298.00	1.92	295.00	1.89
24	183.00	1.35	181.00	1.37	202.00	1.43	163.00	1.18	173.00	1.22	191.00	1.23	215.00	1.38
	13565.00	100.00	13246.00	100.00	14152.00	100.00	13762.00	100.00	14164.00	100.00	15556.00	100.00	15568.00	100.00

TUESDAY DIRECTION: SOUTH

	June		July		August		September		October		November		December	
Hours	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT
1	75.00	0.58	77.00	0.59	77.00	0.59	69.00	0.52	73.00	0.53	74.00	0.49	73.00	0.49
2	55.00	0.43	47.00	0.36	52.00	0.40	39.00	0.29	37.00	0.27	45.00	0.30	48.00	0.32
3	32.00	0.25	26.00	0.20	27.00	0.21	25.00	0.19	19.00	0.14	33.00	0.22	33.00	0.22
4	15.00	0.12	14.00	0.11	13.00	0.10	19.00	0.14	17.00	0.12	15.00	0.10	15.00	0.10
5	19.00	0.15	25.00	0.19	22.00	0.17	21.00	0.16	22.00	0.16	24.00	0.16	23.00	0.15
6	51.00	0.39	50.00	0.38	62.00	0.47	64.00	0.48	70.00	0.51	70.00	0.47	63.00	0.42
7	221.00	1.71	231.00	1.77	227.00	1.74	239.00	1.80	267.00	1.94	253.00	1.69	255.00	1.71
8	622.00	4.81	579.00	4.45	611.00	4.68	716.00	5.40	749.00	5.44	766.00	5.11	758.00	5.07
9	867.00	6.70	860.00	6.61	839.00	6.43	926.00	6.98	953.00	6.93	1015.00	6.77	974.00	6.52
10	762.00	5.89	782.00	6.01	742.00	5.68	773.00	5.83	794.00	5.77	885.00	5.91	842.00	5.64
11	791.00	6.11	801.00	6.15	791.00	6.06	773.00	5.83	866.00	6.29	917.00	6.12	920.00	6.16
12	866.00	6.69	860.00	6.61	894.00	6.85	883.00	6.65	947.00	6.88	1004.00	6.70	1021.00	6.83
13	982.00	7.59	973.00	7.48	977.00	7.48	1020.00	7.69	1059.00	7.70	1155.00	7.71	1133.00	7.58
14	1006.00	7.77	1004.00	7.71	1037.00	7.94	1043.00	7.86	1074.00	7.81	1196.00	7.98	1131.00	7.57
15	971.00	7.50	983.00	7.55	966.00	7.40	1022.00	7.70	1019.00	7.41	1151.00	7.68	1151.00	7.70
16	895.00	6.92	964.00	7.41	950.00	7.28	971.00	7.32	1007.00	7.32	1132.00	7.56	1132.00	7.58
17	922.00	7.13	916.00	7.04	946.00	7.25	964.00	7.27	1008.00	7.33	1099.00	7.34	1093.00	7.31
18	928.00	7.17	931.00	7.15	970.00	7.43	982.00	7.40	989.00	7.19	1074.00	7.17	1068.00	7.15
19	748.00	5.78	781.00	6.00	760.00	5.82	742.00	5.59	776.00	5.64	856.00	5.71	863.00	5.78
20	612.00	4.73	651.00	5.00	678.00	5.19	648.00	4.88	682.00	4.96	704.00	4.70	713.00	4.77
21	555.00	4.29	578.00	4.44	564.00	4.32	544.00	4.10	536.00	3.90	565.00	3.77	605.00	4.05
22	447.00	3.45	431.00	3.31	424.00	3.25	396.00	2.98	402.00	2.92	460.00	3.07	484.00	3.24
23	319.00	2.47	304.00	2.34	278.00	2.13	266.00	2.00	250.00	1.82	336.00	2.24	360.00	2.41
24	170.00	1.31	138.00	1.06	141.00	1.08	116.00	0.87	134.00	0.97	144.00	0.96	177.00	1.18
	12940.00	100.00	13016.00	100.00	13056.00	100.00	13269.00	100.00	13760.00	100.00	14982.00	100.00	14942.00	100.00

6	0.29	0.45	0.37
7	1.26	1.77	1.51
8	3.54	4.99	4.27
9	5.45	6.70	6.08
10	5.54	5.82	5.68
11	6.00	6.10	6.05
12	7.27	6.75	7.01
13	8.27	7.60	7.94
14	7.34	7.81	7.57
15	7.25	7.56	7.41
16	7.55	7.34	7.44
17	7.93	7.24	7.58
18	8.97	7.24	8.10
19	6.91	5.76	6.33
20	5.06	4.89	4.97
21	3.56	4.12	3.84
22	2.86	3.18	3.02
23	1.99	2.20	2.09
24	1.31	1.06	1.19
	100.00	100.00	100.00



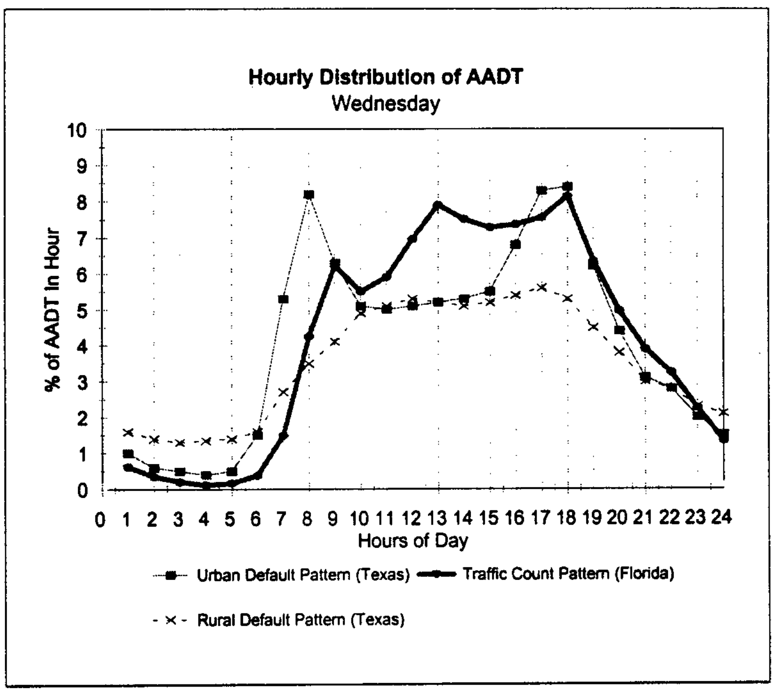
WEDNESDAY DIRECTION: NORTH

	May		June		July		August		September		October		November		December	
Hours	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT
1	95.00	0.68	96.00	0.70	100.00	0.75	102.00	0.76	86.00	0.62	100.00	0.68	114.00	0.73	102.00	0.65
2	52.00	0.37	61.00	0.44	49.00	0.37	59.00	0.44	46.00	0.33	52.00	0.36	53.00	0.34	51.00	0.33
3	31.00	0.22	33.00	0.24	36.00	0.27	27.00	0.20	28.00	0.20	31.00	0.21	36.00	0.23	36.00	0.23
4	16.00	0.12	25.00	0.18	20.00	0.15	21.00	0.16	17.00	0.12	15.00	0.10	17.00	0.11	21.00	0.13
5	25.00	0.18	27.00	0.20	22.00	0.17	23.00	0.17	24.00	0.17	26.00	0.18	20.00	0.13	23.00	0.15
6	42.00	0.30	58.00	0.42	42.00	0.32	43.00	0.32	42.00	0.30	47.00	0.32	40.00	0.26	49.00	0.31
7	163.00	1.17	154.00	1.12	149.00	1.12	176.00	1.31	184.00	1.33	174.00	1.19	172.00	1.10	163.00	1.04
8	467.00	3.36	454.00	3.31	462.00	3.47	452.00	3.37	519.00	3.76	529.00	3.61	537.00	3.44	513.00	3.28
9	816.00	5.87	751.00	5.47	714.00	5.37	734.00	5.47	833.00	6.04	866.00	5.91	914.00	5.85	875.00	5.60
10	752.00	5.41	746.00	5.43	746.00	5.61	694.00	5.18	756.00	5.48	793.00	5.41	803.00	5.14	809.00	5.18
11	833.00	5.99	795.00	5.79	756.00	5.69	770.00	5.74	792.00	5.74	850.00	5.80	935.00	5.99	940.00	6.01
12	991.00	7.13	1013.00	7.37	949.00	7.14	938.00	6.99	1024.00	7.42	1067.00	7.29	1104.00	7.07	1157.00	7.40
13	1150.00	8.27	1150.00	8.37	1094.00	8.23	1094.00	8.16	1123.00	8.14	1184.00	8.08	1322.00	8.47	1313.00	8.40
14	1029.00	7.40	996.00	7.25	971.00	7.30	946.00	7.05	960.00	6.96	1020.00	6.96	1165.00	7.46	1131.00	7.24
15	944.00	6.79	947.00	6.89	914.00	6.87	932.00	6.95	1002.00	7.26	1057.00	7.22	1152.00	7.38	1127.00	7.21
16	1059.00	7.61	1039.00	7.56	968.00	7.28	987.00	7.36	1039.00	7.53	1121.00	7.65	1201.00	7.69	1217.00	7.79
17	1071.00	7.70	1020.00	7.43	1037.00	7.80	1035.00	7.72	1112.00	8.06	1149.00	7.85	1224.00	7.84	1280.00	8.19
18	1223.00	8.79	1255.00	9.14	1140.00	8.57	1198.00	8.93	1231.00	8.92	1317.00	8.99	1371.00	8.78	1380.00	8.83
19	979.00	7.04	949.00	6.91	933.00	7.02	978.00	7.29	919.00	6.66	1008.00	6.88	1097.00	7.03	1045.00	6.69
20	695.00	5.00	683.00	4.97	722.00	5.43	718.00	5.35	695.00	5.04	748.00	5.11	795.00	5.09	773.00	4.94
21	516.00	3.71	548.00	3.99	529.00	3.98	541.00	4.03	498.00	3.61	548.00	3.74	535.00	3.43	555.00	3.55
22	455.00	3.27	449.00	3.27	433.00	3.26	436.00	3.25	404.00	2.93	447.00	3.05	469.00	3.00	487.00	3.12
23	286.00	2.06	285.00	2.07	306.00	2.30	302.00	2.25	288.00	2.09	294.00	2.01	328.00	2.10	354.00	2.26
24	211.00	1.52	198.00	1.44	193.00	1.45	197.00	1.47	172.00	1.25	195.00	1.33	202.00	1.29	224.00	1.43
	13908.00	100.00	13736.00	100.00	13295.00	100.00	13410.00	100.00	13802.00	100.00	14646.00	100.00	15612.00	100.00	15632.00	100.00

WEDNESDAY DIRECTION: SOUTH

	May		June		July		August		September		October		November		December	
Hours	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT
1	65.00	0.50	82.00	0.63	84.00	0.65	86.00	0.66	59.00	0.44	73.00	0.52	82.00	0.55	73.00	0.49
2	45.00	0.35	50.00	0.38	53.00	0.41	35.00	0.27	40.00	0.30	45.00	0.32	50.00	0.34	38.00	0.25
3	22.00	0.17	25.00	0.19	23.00	0.18	24.00	0.18	21.00	0.16	28.00	0.20	34.00	0.23	30.00	0.20
4	15.00	0.12	8.00	0.06	15.00	0.12	17.00	0.13	15.00	0.11	14.00	0.10	20.00	0.13	13.00	0.09
5	20.00	0.15	24.00	0.18	25.00	0.19	22.00	0.17	19.00	0.14	24.00	0.17	25.00	0.17	19.00	0.13
6	48.00	0.37	61.00	0.47	53.00	0.41	61.00	0.47	61.00	0.45	71.00	0.51	67.00	0.45	57.00	0.38
7	230.00	1.76	236.00	1.81	235.00	1.81	248.00	1.89	251.00	1.87	256.00	1.82	256.00	1.72	257.00	1.71
8	673.00	5.16	628.00	4.82	619.00	4.77	620.00	4.73	740.00	5.51	761.00	5.42	777.00	5.22	730.00	4.85
9	914.00	7.01	886.00	6.80	842.00	6.49	826.00	6.31	932.00	6.95	994.00	7.08	974.00	6.54	1010.00	6.71
10	742.00	5.69	717.00	5.50	747.00	5.76	713.00	5.44	751.00	5.60	777.00	5.53	862.00	5.79	895.00	5.95
11	789.00	6.05	806.00	6.18	764.00	5.89	763.00	5.83	805.00	6.00	837.00	5.96	864.00	5.81	913.00	6.07
12	869.00	6.67	893.00	6.85	854.00	6.58	870.00	6.64	889.00	6.62	926.00	6.59	977.00	6.56	1051.00	6.99
13	986.00	7.56	960.00	7.36	982.00	7.57	983.00	7.51	1013.00	7.55	1055.00	7.51	1154.00	7.75	1134.00	7.54
14	997.00	7.65	1102.00	8.45	990.00	7.63	1019.00	7.78	1053.00	7.85	1081.00	7.69	1162.00	7.81	1155.00	7.68
15	955.00	7.32	965.00	7.40	950.00	7.32	968.00	7.39	996.00	7.42	1075.00	7.65	1161.00	7.80	1130.00	7.51
16	912.00	6.99	910.00	6.98	925.00	7.13	952.00	7.27	973.00	7.25	1006.00	7.16	1081.00	7.26	1102.00	7.32
17	1015.00	7.78	923.00	7.08	890.00	6.86	919.00	7.02	963.00	7.18	1051.00	7.48	1092.00	7.34	1125.00	7.48
18	1060.00	8.13	925.00	7.10	947.00	7.30	953.00	7.28	1016.00	7.57	1004.00	7.15	1095.00	7.36	1115.00	7.41
19	696.00	5.34	721.00	5.53	757.00	5.84	778.00	5.94	789.00	5.88	862.00	6.14	867.00	5.83	846.00	5.62
20	587.00	4.50	644.00	4.94	641.00	4.94	672.00	5.13	652.00	4.86	662.00	4.71	689.00	4.63	716.00	4.76
21	509.00	3.90	537.00	4.12	601.00	4.63	583.00	4.45	510.00	3.80	537.00	3.82	565.00	3.80	565.00	3.76
22	421.00	3.23	437.00	3.35	469.00	3.62	462.00	3.53	411.00	3.06	436.00	3.10	509.00	3.42	501.00	3.33
23	298.00	2.29	319.00	2.45	325.00	2.51	339.00	2.59	295.00	2.20	288.00	2.05	346.00	2.32	378.00	2.51
24	170.00	1.30	176.00	1.35	173.00	1.33	176.00	1.34	155.00	1.16	177.00	1.26	167.00	1.12	185.00	1.23
	13038.00	100.00	13035.00	100.00	12973.00	100.00	13097.00	100.00	13419.00	100.00	14049.00	100.00	14882.00	100.00	15045.00	100.00

	Wednesday		
	North	South	Average
Hours			
1	0.70	0.55	0.63
2	0.37	0.33	0.35
3	0.23	0.19	0.21
4	0.13	0.11	0.12
5	0.17	0.16	0.17
6	0.32	0.44	0.38
7	1.17	1.80	1.49
8	3.45	5.06	4.26
9	5.70	6.74	6.22
10	5.35	5.66	5.51
11	5.84	5.97	5.91
12	7.23	6.69	6.96
13	8.26	7.54	7.90
14	7.20	7.82	7.51
15	7.07	7.48	7.27
16	7.56	7.17	7.37
17	7.82	7.28	7.55
18	8.87	7.41	8.14
19	6.94	5.76	6.35
20	5.12	4.81	4.96
21	3.75	4.04	3.90
22	3.14	3.33	3.24
23	2.14	2.36	2.25
24	1.40	1.26	1.33
	100.00	100.00	100.00



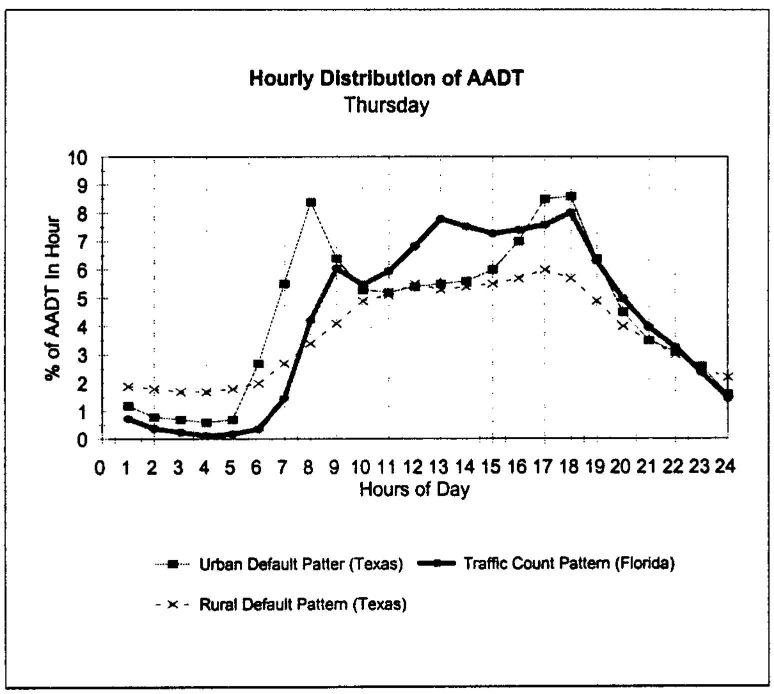
THURSDAY DIRECTION: NORTH

Hours	May [veh]	May % of ADT	June [veh]	June % of ADT	July [veh]	July % of ADT	August [veh]	August % of ADT	September [veh]	September % of ADT	October [veh]	October % of ADT	November [veh]	November % of ADT	December [veh]	December % of ADT
1	113.00	0.82	123.00	0.92	115.00	0.86	107.00	0.81	98.00	0.71	115.00	0.79	122.00	0.78	122.00	0.79
2	60.00	0.43	57.00	0.43	55.00	0.41	54.00	0.41	49.00	0.35	66.00	0.46	64.00	0.41	54.00	0.35
3	38.00	0.27	39.00	0.29	39.00	0.29	32.00	0.24	41.00	0.30	35.00	0.24	38.00	0.24	39.00	0.25
4	22.00	0.16	24.00	0.18	17.00	0.13	21.00	0.16	17.00	0.12	20.00	0.14	17.00	0.11	22.00	0.14
5	22.00	0.16	26.00	0.19	27.00	0.20	24.00	0.18	23.00	0.17	24.00	0.17	26.00	0.17	28.00	0.18
6	41.00	0.30	37.00	0.28	35.00	0.26	46.00	0.35	38.00	0.27	45.00	0.31	42.00	0.27	43.00	0.28
7	150.00	1.08	153.00	1.14	153.00	1.15	154.00	1.16	180.00	1.30	162.00	1.12	180.00	1.14	153.00	0.99
8	483.00	3.49	471.00	3.52	437.00	3.27	474.00	3.58	512.00	3.69	533.00	3.68	534.00	3.39	498.00	3.22
9	758.00	5.47	706.00	5.28	716.00	5.37	714.00	5.39	767.00	5.52	808.00	5.57	911.00	5.79	759.00	4.91
10	761.00	5.49	762.00	5.69	706.00	5.29	682.00	5.15	728.00	5.24	804.00	5.55	855.00	5.44	795.00	5.14
11	765.00	5.52	812.00	6.07	761.00	5.70	788.00	5.95	792.00	5.70	878.00	6.06	925.00	5.88	905.00	5.85
12	965.00	6.96	983.00	7.35	923.00	6.92	912.00	6.88	989.00	7.12	1067.00	7.36	1093.00	6.95	1096.00	7.09
13	1081.00	7.80	1086.00	8.11	1036.00	7.76	1097.00	8.28	1099.00	7.91	1167.00	8.05	1287.00	8.18	1277.00	8.26
14	1016.00	7.33	940.00	7.02	968.00	7.25	946.00	7.14	1025.00	7.38	1059.00	7.31	1138.00	7.23	1143.00	7.39
15	1005.00	7.25	898.00	6.71	935.00	7.01	930.00	7.02	981.00	7.06	1055.00	7.28	1149.00	7.30	1165.00	7.53
16	1074.00	7.75	944.00	7.05	1002.00	7.51	1018.00	7.68	1060.00	7.63	1084.00	7.48	1221.00	7.76	1194.00	7.72
17	1074.00	7.75	982.00	7.34	1060.00	7.94	1082.00	8.17	1106.00	7.96	1117.00	7.71	1291.00	8.21	1205.00	7.79
18	1190.00	8.59	1115.00	8.33	1153.00	8.64	1137.00	8.58	1254.00	9.03	1259.00	8.69	1432.00	9.10	1365.00	8.83
19	955.00	6.89	909.00	6.79	903.00	6.77	893.00	6.74	962.00	6.93	959.00	6.62	1098.00	6.98	1108.00	7.17
20	710.00	5.12	725.00	5.42	715.00	5.36	670.00	5.06	734.00	5.29	737.00	5.08	757.00	4.81	821.00	5.31
21	533.00	3.85	530.00	3.96	561.00	4.20	532.00	4.02	509.00	3.67	539.00	3.72	533.00	3.39	577.00	3.73
22	455.00	3.28	471.00	3.52	456.00	3.42	415.00	3.13	411.00	2.96	438.00	3.02	461.00	2.93	470.00	3.04
23	351.00	2.53	355.00	2.65	344.00	2.58	312.00	2.35	311.00	2.24	311.00	2.15	330.00	2.10	362.00	2.34
24	229.00	1.65	227.00	1.70	222.00	1.66	204.00	1.54	191.00	1.38	205.00	1.41	222.00	1.41	251.00	1.62
	13858.00	100.00	13383.00	100.00	13344.00	100.00	13250.00	100.00	13886.00	100.00	14495.00	100.00	15731.00	100.00	15462.00	100.00

THURSDAY DIRECTION: SOUTH

	May		June		July		August		September		October		November		December	
Hours	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT
1	93.00	0.69	100.00	0.77	86.00	0.66	92.00	0.71	78.00	0.59	87.00	0.63	93.00	0.62	91.00	0.60
2	57.00	0.42	51.00	0.39	51.00	0.39	49.00	0.38	42.00	0.32	48.00	0.35	58.00	0.39	46.00	0.31
3	32.00	0.24	30.00	0.23	33.00	0.25	31.00	0.24	27.00	0.20	29.00	0.21	50.00	0.34	32.00	0.21
4	19.00	0.14	16.00	0.12	20.00	0.15	18.00	0.14	14.00	0.11	16.00	0.12	17.00	0.11	15.00	0.10
5	22.00	0.16	26.00	0.20	23.00	0.18	23.00	0.18	22.00	0.17	29.00	0.21	23.00	0.15	21.00	0.14
6	45.00	0.34	55.00	0.42	48.00	0.37	63.00	0.48	59.00	0.45	69.00	0.50	73.00	0.49	72.00	0.48
7	231.00	1.72	240.00	1.84	228.00	1.76	236.00	1.81	244.00	1.84	264.00	1.91	260.00	1.75	254.00	1.69
8	643.00	4.79	615.00	4.72	568.00	4.38	622.00	4.78	730.00	5.51	734.00	5.32	758.00	5.09	762.00	5.06
9	891.00	6.64	881.00	6.77	864.00	6.67	826.00	6.35	910.00	6.87	956.00	6.93	994.00	6.67	976.00	6.48
10	770.00	5.74	725.00	5.57	717.00	5.53	721.00	5.54	741.00	5.59	767.00	5.56	834.00	5.60	809.00	5.37
11	786.00	5.86	786.00	6.04	774.00	5.97	791.00	6.08	788.00	5.95	822.00	5.96	926.00	6.22	955.00	6.34
12	887.00	6.61	783.00	6.01	848.00	6.55	854.00	6.56	866.00	6.54	942.00	6.83	990.00	6.65	1048.00	6.96
13	984.00	7.33	1067.00	8.19	944.00	7.29	986.00	7.58	1016.00	7.67	1068.00	7.74	1085.00	7.29	1102.00	7.32
14	1038.00	7.74	1006.00	7.73	1006.00	7.76	1018.00	7.82	1042.00	7.86	1079.00	7.82	1170.00	7.86	1170.00	7.77
15	994.00	7.41	936.00	7.19	908.00	7.01	965.00	7.42	978.00	7.38	1069.00	7.75	1107.00	7.43	1149.00	7.63
16	933.00	6.95	957.00	7.35	952.00	7.35	945.00	7.26	962.00	7.26	985.00	7.14	1079.00	7.25	1106.00	7.35
17	992.00	7.39	946.00	7.27	939.00	7.25	935.00	7.19	945.00	7.13	1014.00	7.35	1119.00	7.51	1111.00	7.38
18	988.00	7.36	951.00	7.30	972.00	7.50	959.00	7.37	957.00	7.22	994.00	7.21	1117.00	7.50	1074.00	7.13
19	767.00	5.72	732.00	5.62	764.00	5.90	762.00	5.86	762.00	5.75	795.00	5.76	852.00	5.72	854.00	5.67
20	638.00	4.75	645.00	4.95	604.00	4.66	634.00	4.87	664.00	5.01	626.00	4.54	717.00	4.81	705.00	4.68
21	596.00	4.44	520.00	3.99	588.00	4.54	551.00	4.24	544.00	4.11	508.00	3.68	573.00	3.85	615.00	4.08
22	482.00	3.59	437.00	3.36	470.00	3.63	436.00	3.35	400.00	3.02	416.00	3.02	502.00	3.37	514.00	3.41
23	330.00	2.46	327.00	2.51	343.00	2.65	302.00	2.32	291.00	2.20	308.00	2.23	311.00	2.09	368.00	2.44
24	194.00	1.45	182.00	1.40	200.00	1.54	183.00	1.41	159.00	1.20	162.00	1.17	179.00	1.20	198.00	1.32
	13418.00	100.00	13021.00	100.00	12956.00	100.00	13010.00	100.00	13250.00	100.00	13794.00	100.00	14893.00	100.00	15056.00	100.00

	Thursday		
	North	South	Average
Hours			
1	0.81	0.66	0.73
2	0.41	0.37	0.39
3	0.27	0.24	0.25
4	0.14	0.12	0.13
5	0.18	0.17	0.18
6	0.29	0.44	0.36
7	1.14	1.79	1.46
8	3.48	4.96	4.22
9	5.41	6.67	6.04
10	5.37	5.56	5.47
11	5.84	6.05	5.95
12	7.08	6.59	6.83
13	8.05	7.55	7.80
14	7.26	7.80	7.53
15	7.15	7.40	7.27
16	7.57	7.24	7.41
17	7.86	7.31	7.58
18	8.72	7.33	8.02
19	6.86	5.75	6.30
20	5.18	4.79	4.98
21	3.82	4.12	3.97
22	3.16	3.34	3.25
23	2.37	2.36	2.37
24	1.55	1.34	1.44
	100.00	100.00	100.00



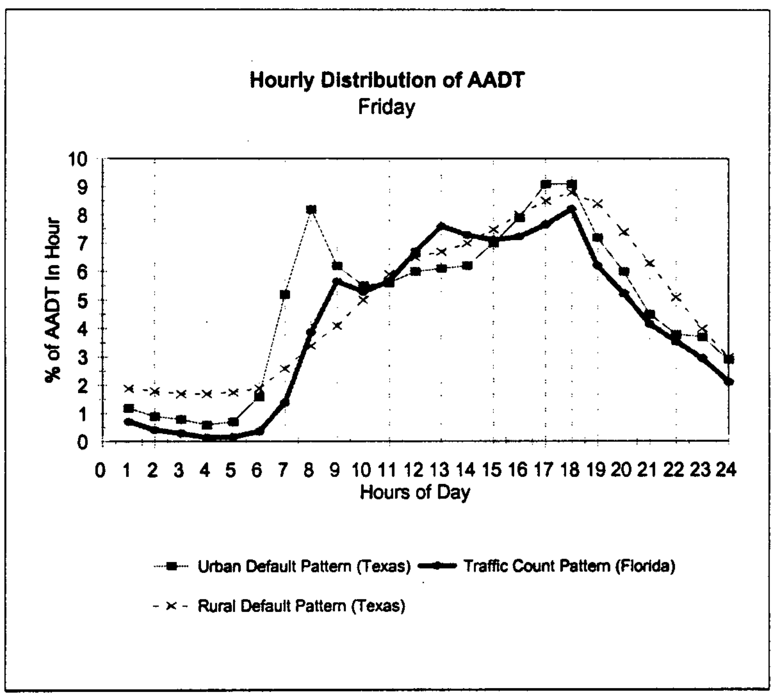
FRIDAY DIRECTION: NORTH

Hours	May [veh]	% of ADT	June [veh]	% of ADT	July [veh]	% of ADT	August [veh]	% of ADT	September [veh]	% of ADT	October [veh]	% of ADT	November [veh]	% of ADT	December [veh]	% of ADT
1	133.00	0.88	125.00	0.85	133.00	0.93	109.00	0.76	106.00	0.73	114.00	0.74	126.00	0.76	120.00	0.71
2	67.00	0.44	67.00	0.45	60.00	0.42	60.00	0.42	51.00	0.35	58.00	0.38	67.00	0.40	68.00	0.40
3	46.00	0.30	41.00	0.28	41.00	0.29	43.00	0.30	37.00	0.25	40.00	0.26	41.00	0.25	48.00	0.29
4	22.00	0.15	25.00	0.17	21.00	0.15	24.00	0.17	21.00	0.14	22.00	0.14	23.00	0.14	21.00	0.12
5	33.00	0.22	26.00	0.18	28.00	0.19	25.00	0.18	25.00	0.17	29.00	0.19	26.00	0.16	24.00	0.14
6	42.00	0.28	47.00	0.32	39.00	0.27	44.00	0.31	44.00	0.30	49.00	0.32	47.00	0.28	51.00	0.30
7	145.00	0.96	162.00	1.10	148.00	1.03	166.00	1.16	184.00	1.26	165.00	1.07	188.00	1.13	167.00	0.99
8	454.00	3.00	439.00	2.98	451.00	3.14	452.00	3.17	503.00	3.44	496.00	3.23	541.00	3.25	517.00	3.08
9	761.00	5.04	739.00	5.01	703.00	4.89	732.00	5.13	770.00	5.27	799.00	5.20	877.00	5.27	827.00	4.92
10	765.00	5.06	786.00	5.33	750.00	5.22	739.00	5.18	758.00	5.19	837.00	5.45	884.00	5.32	843.00	5.02
11	860.00	5.69	854.00	5.79	784.00	5.46	779.00	5.46	806.00	5.52	868.00	5.65	959.00	5.77	937.00	5.57
12	995.00	6.58	994.00	6.74	972.00	6.77	967.00	6.78	1013.00	6.94	1096.00	7.13	1166.00	7.01	1196.00	7.12
13	1154.00	7.64	1198.00	8.12	1135.00	7.90	1117.00	7.83	1114.00	7.63	1233.00	8.02	1345.00	8.09	1345.00	8.00
14	1022.00	6.76	1024.00	6.94	1040.00	7.24	996.00	6.99	1032.00	7.07	1089.00	7.09	1153.00	6.93	1148.00	6.83
15	1134.00	7.50	1001.00	6.79	981.00	6.83	974.00	6.83	1027.00	7.03	1088.00	7.08	1185.00	7.13	1204.00	7.16
16	1135.00	7.51	1094.00	7.42	1028.00	7.16	1043.00	7.31	1113.00	7.62	1169.00	7.61	1242.00	7.47	1270.00	7.56
17	1186.00	7.85	1180.00	8.00	1166.00	8.12	1158.00	8.12	1159.00	7.94	1215.00	7.91	1357.00	8.16	1402.00	8.34
18	1352.00	8.95	1339.00	9.08	1280.00	8.91	1243.00	8.72	1331.00	9.11	1397.00	9.09	1551.00	9.33	1533.00	9.12
19	972.00	6.43	994.00	6.74	943.00	6.57	941.00	6.60	954.00	6.53	1014.00	6.60	1161.00	6.98	1150.00	6.84
20	802.00	5.31	774.00	5.25	792.00	5.51	820.00	5.75	792.00	5.42	831.00	5.41	819.00	4.92	898.00	5.34
21	633.00	4.19	603.00	4.09	604.00	4.21	611.00	4.29	572.00	3.92	574.00	3.73	604.00	3.63	633.00	3.77
22	565.00	3.74	512.00	3.47	513.00	3.57	498.00	3.49	463.00	3.17	470.00	3.06	493.00	2.96	546.00	3.25
23	455.00	3.01	408.00	2.77	426.00	2.97	410.00	2.88	427.00	2.92	402.00	2.62	437.00	2.63	458.00	2.72
24	373.00	2.47	307.00	2.08	316.00	2.20	299.00	2.10	294.00	2.01	304.00	1.98	329.00	1.98	394.00	2.34
	15114.00	100.00	14748.00	100.00	14362.00	100.00	14259.00	100.00	14605.00	100.00	15370.00	100.00	16630.00	100.00	16809.00	100.00

FRIDAY DIRECTION: SOUTH

	May		June		July		August		September		October		November		December	
Hours	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT
1	108.00	0.76	117.00	0.83	107.00	0.76	87.00	0.62	79.00	0.56	76.00	0.51	92.00	0.58	86.00	0.54
2	83.00	0.58	71.00	0.50	59.00	0.42	57.00	0.40	54.00	0.38	53.00	0.36	53.00	0.33	57.00	0.35
3	69.00	0.49	57.00	0.40	40.00	0.28	35.00	0.25	33.00	0.23	40.00	0.27	46.00	0.29	40.00	0.25
4	23.00	0.16	22.00	0.16	21.00	0.15	24.00	0.17	19.00	0.13	18.00	0.12	20.00	0.13	23.00	0.14
5	25.00	0.18	23.00	0.16	21.00	0.15	27.00	0.19	25.00	0.18	33.00	0.22	27.00	0.17	18.00	0.11
6	59.00	0.42	55.00	0.39	51.00	0.36	58.00	0.41	69.00	0.49	68.00	0.46	77.00	0.48	74.00	0.46
7	227.00	1.60	247.00	1.74	235.00	1.67	243.00	1.72	266.00	1.87	268.00	1.81	275.00	1.72	239.00	1.49
8	639.00	4.50	614.00	4.34	585.00	4.15	636.00	4.50	729.00	5.13	698.00	4.71	761.00	4.77	720.00	4.48
9	884.00	6.23	871.00	6.15	845.00	6.00	849.00	6.01	930.00	6.55	928.00	6.26	1001.00	6.27	989.00	6.16
10	735.00	5.18	776.00	5.48	730.00	5.18	785.00	5.55	744.00	5.24	789.00	5.32	861.00	5.39	871.00	5.42
11	804.00	5.67	805.00	5.69	783.00	5.56	781.00	5.53	799.00	5.62	839.00	5.66	938.00	5.87	939.00	5.85
12	896.00	6.31	949.00	6.70	888.00	6.31	881.00	6.23	909.00	6.40	955.00	6.44	1071.00	6.71	1139.00	7.09
13	1000.00	7.05	1037.00	7.32	1028.00	7.30	1056.00	7.47	1026.00	7.22	1104.00	7.45	1174.00	7.35	1147.00	7.14
14	1097.00	7.73	1073.00	7.58	1062.00	7.54	1057.00	7.48	1079.00	7.60	1096.00	7.40	1223.00	7.66	1234.00	7.69
15	925.00	6.52	997.00	7.04	1015.00	7.21	1005.00	7.11	1046.00	7.36	1121.00	7.56	1168.00	7.32	1179.00	7.34
16	1027.00	7.24	951.00	6.72	947.00	6.73	963.00	6.81	1004.00	7.07	1075.00	7.25	1119.00	7.01	1161.00	7.23
17	993.00	7.00	1024.00	7.23	1025.00	7.28	1036.00	7.33	1029.00	7.24	1091.00	7.36	1164.00	7.29	1201.00	7.48
18	1098.00	7.74	1030.00	7.28	1061.00	7.54	1007.00	7.13	1028.00	7.24	1061.00	7.16	1196.00	7.49	1182.00	7.36
19	832.00	5.86	802.00	5.66	838.00	5.95	834.00	5.90	795.00	5.60	853.00	5.76	912.00	5.71	897.00	5.59
20	718.00	5.06	725.00	5.12	748.00	5.31	753.00	5.33	707.00	4.98	748.00	5.05	782.00	4.90	793.00	4.94
21	636.00	4.48	636.00	4.49	643.00	4.57	640.00	4.53	599.00	4.22	607.00	4.10	667.00	4.18	657.00	4.09
22	558.00	3.93	525.00	3.71	551.00	3.91	544.00	3.85	522.00	3.67	570.00	3.85	568.00	3.56	558.00	3.48
23	438.00	3.09	434.00	3.07	448.00	3.18	464.00	3.28	439.00	3.09	460.00	3.10	467.00	2.92	493.00	3.07
24	310.00	2.18	305.00	2.15	340.00	2.41	303.00	2.14	265.00	1.87	262.00	1.77	295.00	1.85	354.00	2.20
	14190.00	100.00	14158.00	100.00	14080.00	100.00	14132.00	100.00	14205.00	100.00	14819.00	100.00	15966.00	100.00	16057.00	100.00

		Friday	
	North	South	Average
Hours			
1	0.79	0.64	0.72
2	0.41	0.42	0.41
3	0.28	0.31	0.29
4	0.15	0.15	0.15
5	0.18	0.17	0.17
6	0.30	0.43	0.37
7	1.09	1.70	1.40
8	3.16	4.57	3.87
9	5.09	6.20	5.65
10	5.22	5.35	5.28
11	5.61	5.68	5.65
12	6.88	6.53	6.70
13	7.90	7.29	7.60
14	6.98	7.58	7.28
15	7.04	7.18	7.11
16	7.46	7.01	7.23
17	8.05	7.28	7.67
18	9.04	7.37	8.20
19	6.66	5.75	6.21
20	5.36	5.09	5.22
21	3.98	4.33	4.15
22	3.34	3.74	3.54
23	2.81	3.10	2.96
24	2.14	2.07	2.11
	100.00	100.00	100.00



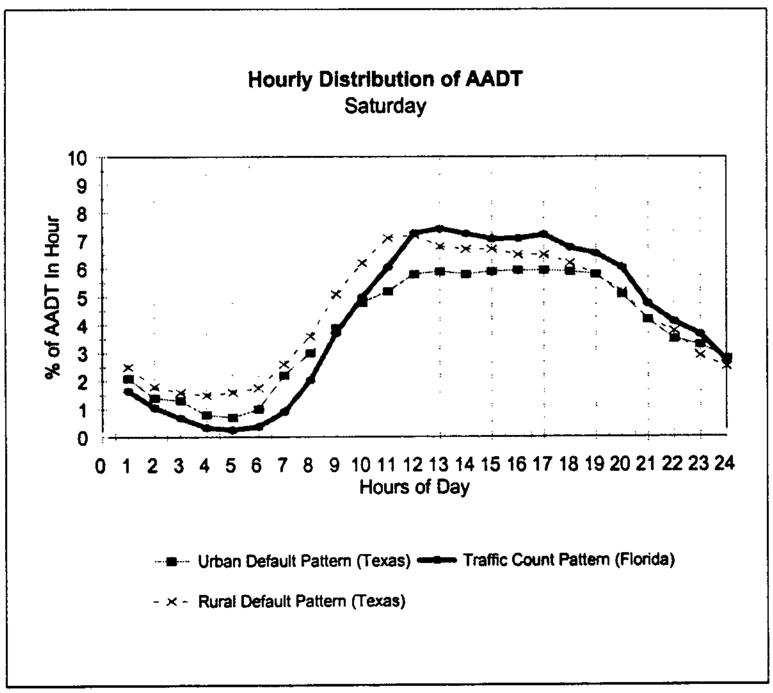
SATURDAY DIRECTION: NORTH

	May		June		July		August		September		October		November		December	
Hours	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT
1	257.00	2.10	235.00	1.93	226.00	1.95	206.00	1.77	200.00	1.63	212.00	1.66	234.00	1.69	238.00	1.69
2	138.00	1.13	129.00	1.06	137.00	1.18	137.00	1.17	139.00	1.13	134.00	1.05	145.00	1.05	143.00	1.01
3	103.00	0.84	89.00	0.73	86.00	0.74	83.00	0.71	80.00	0.65	88.00	0.69	86.00	0.62	94.00	0.67
4	42.00	0.34	48.00	0.39	53.00	0.46	42.00	0.36	48.00	0.39	44.00	0.35	54.00	0.39	55.00	0.39
5	40.00	0.33	39.00	0.32	41.00	0.35	35.00	0.30	31.00	0.25	32.00	0.25	29.00	0.21	24.00	0.17
6	32.00	0.26	38.00	0.31	37.00	0.32	37.00	0.32	40.00	0.33	36.00	0.28	45.00	0.33	40.00	0.28
7	85.00	0.70	81.00	0.67	81.00	0.70	89.00	0.76	88.00	0.72	78.00	0.61	100.00	0.72	96.00	0.68
8	209.00	1.71	224.00	1.84	186.00	1.61	207.00	1.77	236.00	1.93	235.00	1.84	263.00	1.90	252.00	1.78
9	447.00	3.66	475.00	3.90	444.00	3.83	457.00	3.92	487.00	3.97	502.00	3.94	545.00	3.94	545.00	3.86
10	605.00	4.95	593.00	4.87	546.00	4.71	568.00	4.87	616.00	5.02	634.00	4.97	712.00	5.15	710.00	5.03
11	727.00	5.95	726.00	5.96	656.00	5.66	696.00	5.97	740.00	6.04	787.00	6.17	840.00	6.07	874.00	6.19
12	890.00	7.29	886.00	7.27	817.00	7.05	841.00	7.21	868.00	7.08	963.00	7.56	1034.00	7.47	1012.00	7.17
13	908.00	7.44	919.00	7.55	857.00	7.40	853.00	7.31	957.00	7.81	1000.00	7.85	1037.00	7.49	1084.00	7.68
14	891.00	7.30	864.00	7.09	800.00	6.91	809.00	6.94	911.00	7.43	968.00	7.60	1018.00	7.36	1005.00	7.12
15	853.00	6.99	836.00	6.86	789.00	6.81	822.00	7.05	849.00	6.93	893.00	7.01	971.00	7.02	993.00	7.03
16	835.00	6.84	849.00	6.97	805.00	6.95	824.00	7.06	885.00	7.22	922.00	7.23	1000.00	7.23	1018.00	7.21
17	906.00	7.42	951.00	7.81	883.00	7.62	873.00	7.48	893.00	7.28	934.00	7.33	1063.00	7.68	1064.00	7.54
18	860.00	7.04	831.00	6.82	806.00	6.96	824.00	7.06	804.00	6.56	859.00	6.74	965.00	6.97	1054.00	7.46
19	797.00	6.53	785.00	6.45	795.00	6.86	780.00	6.69	814.00	6.64	819.00	6.43	906.00	6.55	948.00	6.71
20	733.00	6.00	746.00	6.13	734.00	6.34	760.00	6.52	804.00	6.56	801.00	6.28	815.00	5.89	857.00	6.07
21	590.00	4.83	558.00	4.58	582.00	5.03	577.00	4.95	578.00	4.71	553.00	4.34	603.00	4.36	620.00	4.39
22	483.00	3.96	478.00	3.92	479.00	4.14	436.00	3.74	455.00	3.71	487.00	3.82	524.00	3.79	484.00	3.43
23	418.00	3.42	431.00	3.54	421.00	3.64	381.00	3.27	406.00	3.31	425.00	3.33	461.00	3.33	496.00	3.51
24	357.00	2.92	357.00	2.93	313.00	2.70	319.00	2.73	322.00	2.63	330.00	2.59	377.00	2.72	407.00	2.88
	12211.00	100.00	12179.00	100.00	11581.00	100.00	11664.00	100.00	12259.00	100.00	12745.00	100.00	13836.00	100.00	14120.00	100.00

SATURDAY DIRECTION: SOUTH

	May		June		July		August		September		October		November		December	
Hours	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT	[veh]	% of ADT
1	200.00	1.71	196.00	1.69	193.00	1.72	176.00	1.55	155.00	1.31	152.00	1.23	178.00	1.35	190.00	1.42
2	144.00	1.23	125.00	1.08	123.00	1.09	108.00	0.95	107.00	0.91	104.00	0.84	126.00	0.96	129.00	0.96
3	115.00	0.98	83.00	0.72	71.00	0.63	66.00	0.58	69.00	0.58	73.00	0.59	77.00	0.59	75.00	0.56
4	41.00	0.35	35.00	0.30	34.00	0.30	32.00	0.28	31.00	0.26	32.00	0.26	27.00	0.21	38.00	0.28
5	29.00	0.25	30.00	0.26	28.00	0.25	22.00	0.19	31.00	0.26	30.00	0.24	28.00	0.21	27.00	0.20
6	45.00	0.38	43.00	0.37	43.00	0.38	50.00	0.44	56.00	0.47	59.00	0.48	57.00	0.43	54.00	0.40
7	129.00	1.10	144.00	1.24	127.00	1.13	127.00	1.12	124.00	1.05	133.00	1.08	138.00	1.05	147.00	1.10
8	251.00	2.15	266.00	2.29	244.00	2.17	254.00	2.23	264.00	2.23	278.00	2.26	299.00	2.27	323.00	2.41
9	410.00	3.51	408.00	3.52	371.00	3.30	397.00	3.49	431.00	3.65	443.00	3.60	474.00	3.60	480.00	3.59
10	575.00	4.92	584.00	5.04	510.00	4.54	532.00	4.68	617.00	5.22	614.00	4.99	701.00	5.33	712.00	5.32
11	690.00	5.90	678.00	5.85	678.00	6.03	685.00	6.02	726.00	6.14	785.00	6.38	847.00	6.44	824.00	6.16
12	842.00	7.20	791.00	6.82	784.00	6.98	808.00	7.11	862.00	7.29	947.00	7.69	1000.00	7.60	1006.00	7.52
13	840.00	7.18	864.00	7.45	793.00	7.06	812.00	7.14	851.00	7.20	900.00	7.31	974.00	7.40	1005.00	7.51
14	858.00	7.34	821.00	7.08	806.00	7.17	837.00	7.36	863.00	7.30	932.00	7.57	944.00	7.17	978.00	7.31
15	842.00	7.20	813.00	7.01	786.00	7.00	809.00	7.11	859.00	7.27	906.00	7.36	955.00	7.26	964.00	7.20
16	825.00	7.06	798.00	6.88	781.00	6.95	821.00	7.22	836.00	7.07	885.00	7.19	944.00	7.17	930.00	6.95
17	769.00	6.58	787.00	6.79	770.00	6.85	775.00	6.81	806.00	6.82	833.00	6.77	934.00	7.10	1006.00	7.52
18	753.00	6.44	760.00	6.56	748.00	6.66	740.00	6.51	753.00	6.37	821.00	6.67	875.00	6.65	884.00	6.61
19	776.00	6.64	739.00	6.38	762.00	6.78	759.00	6.67	736.00	6.23	775.00	6.30	846.00	6.43	857.00	6.40
20	701.00	6.00	714.00	6.16	678.00	6.03	676.00	5.94	702.00	5.94	712.00	5.78	733.00	5.57	745.00	5.57
21	551.00	4.71	575.00	4.96	593.00	5.28	591.00	5.20	588.00	4.97	584.00	4.74	603.00	4.58	617.00	4.61
22	517.00	4.42	518.00	4.47	569.00	5.06	526.00	4.63	527.00	4.46	522.00	4.24	550.00	4.18	529.00	3.95
23	453.00	3.87	471.00	4.06	434.00	3.86	463.00	4.07	485.00	4.10	466.00	3.79	481.00	3.65	513.00	3.83
24	330.00	2.82	337.00	2.91	302.00	2.69	299.00	2.63	330.00	2.79	316.00	2.57	360.00	2.74	342.00	2.56
	11692.00	100.00	11591.00	100.00	11236.00	100.00	11372.00	100.00	11820.00	100.00	12310.00	100.00	13161.00	100.00	13382.00	100.00

	Saturday		
	North	South	Average
Hours			
1	1.80	1.50	1.65
2	1.10	1.00	1.05
3	0.71	0.65	0.68
4	0.38	0.28	0.33
5	0.27	0.23	0.25
6	0.30	0.42	0.36
7	0.69	1.11	0.90
8	1.80	2.25	2.03
9	3.88	3.53	3.70
10	4.95	5.00	4.98
11	6.00	6.12	6.06
12	7.26	7.28	7.27
13	7.56	7.28	7.42
14	7.22	7.29	7.25
15	6.96	7.18	7.07
16	7.09	7.06	7.08
17	7.52	6.90	7.21
18	6.95	6.56	6.76
19	6.61	6.48	6.54
20	6.22	5.87	6.05
21	4.65	4.88	4.77
22	3.81	4.43	4.12
23	3.42	3.91	3.66
24	2.76	2.71	2.74
	100.00	100.00	100.00



APPENDIX D

QUEWZ MODEL OUTPUTS

LANE CLOSURE CONFIGURATION:

TOTAL NUMBER OF LANES	
INBOUND	2
OUTBOUND	2
NUMBER OF OPEN LANES	
INBOUND	1
OUTBOUND	2
LENGTH OF WORK ZONE	10.00 MILES
INBOUND CAPACITY	
NORMAL	4000. (VPH)
RESTRICTED	1800. (VPH)
WORKING HOURS	1515. (VPH)

TRAFFIC PARAMETERS:

PARAMETERS TO CALCULATE HOURLY TRAFFIC VOLUMES	
DAY OF WEEK	WEDNESDAY
MONTH	OCTOBER
DISTRICT	99
LOCATION	URBAN IN
AADT (THOUS.)	20.0
PERCENTAGE TRUCK	8.

SCHEDULE OF WORK ACTIVITY:

HOURS OF RESTRICTED CAPACITY	
BEGINNING	7
ENDING	19
HOURS OF WORK ZONE ACTIVITY	
BEGINNING	7
ENDING	19

SUMMARY OF ADDITIONAL ROAD USER COSTS
Run # 1 - a (Inbound - Urban - AADT)

QUEWZ-92

HOUR	ADDITIONAL ROAD USER COSTS ($) INBOUND	OUTBOUND	TOTAL
0- 1	0.	0.	0.
1- 2	0.	0.	0.
2- 3	0.	0.	0.
3- 4	0.	0.	0.
4- 5	0.	0.	0.
5- 6	0.	0.	0.
6- 7	0.	0.	0.
7- 8	269.	0.	269.
8- 9	102.	0.	102.
9-10	42.	0.	42.
10-11	37.	0.	37.
11-12	38.	0.	38.
12-13	39.	0.	39.
13-14	43.	0.	43.
14-15	48.	0.	48.
15-16	61.	0.	61.
16-17	82.	0.	82.
17-18	82.	0.	82.
18-19	39.	0.	39.
19-20	0.	0.	0.
20-21	0.	0.	0.
21-22	0.	0.	0.
22-23	0.	0.	0.
23-24	0.	0.	0.
TOTAL	882.	0.	882.

NOTE: LANE CLOSURE ONLY IN INBOUND DIRECTION

SUMMARY OF TRAFFIC CONDITIONS -- INBOUND DIRECTION
Run # 1 - a (Inbound - Urban - AADT)

HOUR	APPROACH VOLUME (VPH)	CAPACITY (VPH)	APPROACH SPEED (MPH)	WORK ZONE SPEED (MPH)	QUEUE LENGTH (MILES)
0- 1					
1- 2					
2- 3					
3- 4					
4- 5					
5- 6					
6- 7					
7- 8	1009.	1515.	56.	50.	0.0
8- 9	752.	1515.	57.	52.	0.0
9-10	563.	1515.	58.	54.	0.0
10-11	540.	1515.	58.	55.	0.0
11-12	545.	1515.	58.	55.	0.0
12-13	551.	1515.	58.	54.	0.0
13-14	567.	1515.	58.	54.	0.0
14-15	588.	1515.	58.	54.	0.0
15-16	638.	1515.	58.	54.	0.0
16-17	703.	1515.	57.	53.	0.0
17-18	701.	1515.	57.	53.	0.0
18-19	547.	1515.	58.	55.	0.0
19-20					
20-21					
21-22					
22-23					
23-24					

LANE CLOSURE CONFIGURATION:

TOTAL NUMBER OF LANES	
INBOUND	2
OUTBOUND	2
NUMBER OF OPEN LANES	
INBOUND	1
OUTBOUND	2
LENGTH OF WORK ZONE	10.00 MILES
INBOUND CAPACITY	
NORMAL	4000. (VPH)
RESTRICTED	1800. (VPH)
WORKING HOURS	1515. (VPH)

TRAFFIC PARAMETERS:

PARAMETERS TO CALCULATE HOURLY TRAFFIC VOLUMES	
DAY OF WEEK	WEDNESDAY
MONTH	OCTOBER
DISTRICT	99
LOCATION	RURAL IN
AADT (THOUS.)	20.0
PERCENTAGE TRUCK	8.

SCHEDULE OF WORK ACTIVITY:

HOURS OF RESTRICTED CAPACITY	
BEGINNING	7
ENDING	19
HOURS OF WORK ZONE ACTIVITY	
BEGINNING	7
ENDING	19

SUMMARY OF ADDITIONAL ROAD USER COSTS
Run # 2 - a (Inbound - Rural - AADT)

HOUR	ADDITIONAL ROAD USER COSTS ($) INBOUND	OUTBOUND	TOTAL
0- 1	0.	0.	0.
1- 2	0.	0.	0.
2- 3	0.	0.	0.
3- 4	0.	0.	0.
4- 5	0.	0.	0.
5- 6	0.	0.	0.
6- 7	0.	0.	0.
7- 8	16.	0.	16.
8- 9	22.	0.	22.
9-10	33.	0.	33.
10-11	38.	0.	38.
11-12	43.	0.	43.
12-13	39.	0.	39.
13-14	40.	0.	40.
14-15	42.	0.	42.
15-16	47.	0.	47.
16-17	44.	0.	44.
17-18	36.	0.	36.
18-19	21.	0.	21.
19-20	0.	0.	0.
20-21	0.	0.	0.
21-22	0.	0.	0.
22-23	0.	0.	0.
23-24	0.	0.	0.
TOTAL	423.	0.	423.

NOTE: LANE CLOSURE ONLY IN INBOUND DIRECTION

SUMMARY OF TRAFFIC CONDITIONS -- INBOUND DIRECTION
Run # 2 - a (Inbound - Rural - AADT) QUEWZ-92

HOUR	APPROACH VOLUME (VPH)	CAPACITY (VPH)	APPROACH SPEED (MPH)	WORK ZONE SPEED (MPH)	QUEUE LENGTH (MILES)
0- 1					
1- 2					
2- 3					
3- 4					
4- 5					
5- 6					
6- 7					
7- 8	401.	1515.	58.	56.	0.0
8- 9	445.	1515.	58.	56.	0.0
9-10	518.	1515.	58.	55.	0.0
10-11	546.	1515.	58.	55.	0.0
11-12	567.	1515.	58.	54.	0.0
12-13	550.	1515.	58.	55.	0.0
13-14	555.	1515.	58.	54.	0.0
14-15	564.	1515.	58.	54.	0.0
15-16	584.	1515.	58.	54.	0.0
16-17	573.	1515.	58.	54.	0.0
17-18	533.	1515.	58.	55.	0.0
18-19	443.	1515.	58.	56.	0.0
19-20					
20-21					
21-22					
22-23					
23-24					

LANE CLOSURE CONFIGURATION:

TOTAL NUMBER OF LANES	
INBOUND	2
OUTBOUND	2
NUMBER OF OPEN LANES	
INBOUND	2
OUTBOUND	1
LENGTH OF WORK ZONE	10.00 MILES
OUTBOUND CAPACITY	
NORMAL	4000. (VPH)
RESTRICTED	1800. (VPH)
WORKING HOURS	1515. (VPH)

TRAFFIC PARAMETERS:

PARAMETERS TO CALCULATE HOURLY TRAFFIC VOLUMES	
DAY OF WEEK	WEDNESDAY
MONTH	OCTOBER
DISTRICT	99
LOCATION	URBAN IN
AADT (THOUS.)	20.0
PERCENTAGE TRUCK	8.

SCHEDULE OF WORK ACTIVITY:

HOURS OF RESTRICTED CAPACITY	
BEGINNING	7
ENDING	19
HOURS OF WORK ZONE ACTIVITY	
BEGINNING	7
ENDING	19

SUMMARY OF ADDITIONAL ROAD USER COSTS
Run # 3 - a (Outbound - Urban - AADT)

QUEWZ-92

HOUR	ADDITIONAL ROAD USER COSTS ($) INBOUND	OUTBOUND	TOTAL
0- 1	0.	0.	0.
1- 2	0.	0.	0.
2- 3	0.	0.	0.
3- 4	0.	0.	0.
4- 5	0.	0.	0.
5- 6	0.	0.	0.
6- 7	0.	0.	0.
7- 8	0.	63.	63.
8- 9	0.	38.	38.
9-10	0.	30.	30.
10-11	0.	30.	30.
11-12	0.	38.	38.
12-13	0.	39.	39.
13-14	0.	43.	43.
14-15	0.	54.	54.
15-16	0.	101.	101.
16-17	0.	236.	236.
17-18	0.	269.	269.
18-19	0.	80.	80.
19-20	0.	0.	0.
20-21	0.	0.	0.
21-22	0.	0.	0.
22-23	0.	0.	0.
23-24	0.	0.	0.
TOTAL	0.	1021.	1021.

NOTE: LANE CLOSURE ONLY IN OUTBOUND DIRECTION

SUMMARY OF TRAFFIC CONDITIONS -- OUTBOUND DIRECTION
Run # 3 - a (Outbound - Urban - AADT) QUEWZ-92

HOUR	APPROACH VOLUME (VPH)	CAPACITY (VPH)	APPROACH SPEED (MPH)	WORK ZONE SPEED (MPH)	QUEUE LENGTH (MILES)
0- 1					
1- 2					
2- 3					
3- 4					
4- 5					
5- 6					
6- 7					
7- 8	645.	1515.	58.	54.	0.0
8- 9	544.	1515.	58.	55.	0.0
9-10	499.	1515.	58.	55.	0.0
10-11	498.	1515.	58.	55.	0.0
11-12	545.	1515.	58.	55.	0.0
12-13	551.	1515.	58.	54.	0.0
13-14	567.	1515.	58.	54.	0.0
14-15	612.	1515.	58.	54.	0.0
15-16	750.	1515.	57.	53.	0.0
16-17	971.	1515.	56.	50.	0.0
17-18	1009.	1515.	56.	50.	0.0
18-19	697.	1515.	57.	53.	0.0
19-20					
20-21					
21-22					
22-23					
23-24					

LANE CLOSURE CONFIGURATION:

TOTAL NUMBER OF LANES	
INBOUND	2
OUTBOUND	2
NUMBER OF OPEN LANES	
INBOUND	2
OUTBOUND	1
LENGTH OF WORK ZONE	10.00 MILES
OUTBOUND CAPACITY	
NORMAL	4000. (VPH)
RESTRICTED	1800. (VPH)
WORKING HOURS	1515. (VPH)

TRAFFIC PARAMETERS:

PARAMETERS TO CALCULATE HOURLY TRAFFIC VOLUMES	
DAY OF WEEK	WEDNESDAY
MONTH	OCTOBER
DISTRICT	99
LOCATION	RURAL IN
AADT (THOUS.)	20.0
PERCENTAGE TRUCK	8.

SCHEDULE OF WORK ACTIVITY:

HOURS OF RESTRICTED CAPACITY	
BEGINNING	7
ENDING	19
HOURS OF WORK ZONE ACTIVITY	
BEGINNING	7
ENDING	19

SUMMARY OF ADDITIONAL ROAD USER COSTS
Run # 4 - a (Outbound - Rural - AADT)

HOUR	ADDITIONAL ROAD USER COSTS ($) INBOUND	OUTBOUND	TOTAL
0- 1	0.	0.	0.
1- 2	0.	0.	0.
2- 3	0.	0.	0.
3- 4	0.	0.	0.
4- 5	0.	0.	0.
5- 6	0.	0.	0.
6- 7	0.	0.	0.
7- 8	0.	9.	9.
8- 9	0.	14.	14.
9-10	0.	24.	24.
10-11	0.	31.	31.
11-12	0.	38.	38.
12-13	0.	39.	39.
13-14	0.	40.	40.
14-15	0.	42.	42.
15-16	0.	47.	47.
16-17	0.	56.	56.
17-18	0.	51.	51.
18-19	0.	30.	30.
19-20	0.	0.	0.
20-21	0.	0.	0.
21-22	0.	0.	0.
22-23	0.	0.	0.
23-24	0.	0.	0.
TOTAL	0.	421.	421.

NOTE: LANE CLOSURE ONLY IN OUTBOUND DIRECTION

SUMMARY OF TRAFFIC CONDITIONS -- OUTBOUND DIRECTION
Run # 4 - a (Outbound - Rural - AADT) QUEWZ-92

HOUR	APPROACH VOLUME (VPH)	CAPACITY (VPH)	APPROACH SPEED (MPH)	WORK ZONE SPEED (MPH)	QUEUE LENGTH (MILES)
0- 1					
1- 2					
2- 3					
3- 4					
4- 5					
5- 6					
6- 7					
7- 8	315.	1515.	59.	57.	0.0
8- 9	379.	1515.	59.	56.	0.0
9-10	460.	1515.	58.	55.	0.0
10-11	504.	1515.	58.	55.	0.0
11-12	545.	1515.	58.	55.	0.0
12-13	550.	1515.	58.	55.	0.0
13-14	555.	1515.	58.	54.	0.0
14-15	564.	1515.	58.	54.	0.0
15-16	584.	1515.	58.	54.	0.0
16-17	621.	1515.	58.	54.	0.0
17-18	601.	1515.	58.	54.	0.0
18-19	499.	1515.	58.	55.	0.0
19-20					
20-21					
21-22					
22-23					
23-24					

```
INPUT DATA SUMMARY: ROAD USER COST OUTPUT                     PAGE 1 OF 4
Run # 5 - a (Inbound and Outbound - Urban - AADT)               QUEWZ-92
---------------------------------------------------------------------
LANE CLOSURE CONFIGURATION:

  TOTAL NUMBER OF LANES
    INBOUND                        2
    OUTBOUND                       2

  NUMBER OF OPEN LANES
    INBOUND                        1
    OUTBOUND                       1

  LENGTH OF WORK ZONE              10.00 MILES

  INBOUND  CAPACITY
    NORMAL                       4000. (VPH)
    RESTRICTED                   1800. (VPH)
    WORKING HOURS                1515. (VPH)

  OUTBOUND CAPACITY
    NORMAL                       4000. (VPH)
    RESTRICTED                   1800. (VPH)
    WORKING HOURS                1515. (VPH)

TRAFFIC PARAMETERS:

  PARAMETERS TO CALCULATE
  HOURLY TRAFFIC VOLUMES
    DAY OF WEEK              WEDNESDAY
    MONTH                      OCTOBER
    DISTRICT                        99
    LOCATION                 URBAN IN
    AADT (THOUS.)                  20.0

  PERCENTAGE TRUCK                  8.

SCHEDULE OF WORK ACTIVITY:

  HOURS OF RESTRICTED CAPACITY
    BEGINNING                      7
    ENDING                        19

  HOURS OF WORK ZONE ACTIVITY
    BEGINNING                      7
    ENDING                        19
---------------------------------------------------------------------
```

SUMMARY OF ADDITIONAL ROAD USER COSTS — PAGE 2 OF 4
Run # 5 - a (Inbound and Outbound - Urban - AADT) — QUEWZ-92

HOUR	ADDITIONAL ROAD USER COSTS ($) INBOUND	OUTBOUND	TOTAL
0- 1			
1- 2			
2- 3			
3- 4			
4- 5			
5- 6			
6- 7			
7- 8	269.	63.	332.
8- 9	102.	38.	140.
9-10	42.	30.	72.
10-11	37.	30.	67.
11-12	38.	38.	76.
12-13	39.	39.	79.
13-14	43.	43.	86.
14-15	48.	54.	102.
15-16	61.	101.	162.
16-17	82.	236.	318.
17-18	82.	269.	350.
18-19	39.	80.	119.
19-20			
20-21			
21-22			
22-23			
23-24			
TOTAL	882.	1021.	1903.

SUMMARY OF TRAFFIC CONDITIONS -- INBOUND DIRECTION
Run # 5 - a (Inbound and Outbound - Urban - AADT) QUEWZ-92

HOUR	APPROACH VOLUME (VPH)	CAPACITY (VPH)	APPROACH SPEED (MPH)	WORK ZONE SPEED (MPH)	QUEUE LENGTH (MILES)
0- 1					
1- 2					
2- 3					
3- 4					
4- 5					
5- 6					
6- 7					
7- 8	1009.	1515.	56.	50.	0.0
8- 9	752.	1515.	57.	52.	0.0
9-10	563.	1515.	58.	54.	0.0
10-11	540.	1515.	58.	55.	0.0
11-12	545.	1515.	58.	55.	0.0
12-13	551.	1515.	58.	54.	0.0
13-14	567.	1515.	58.	54.	0.0
14-15	588.	1515.	58.	54.	0.0
15-16	638.	1515.	58.	54.	0.0
16-17	703.	1515.	57.	53.	0.0
17-18	701.	1515.	57.	53.	0.0
18-19	547.	1515.	58.	55.	0.0
19-20					
20-21					
21-22					
22-23					
23-24					

SUMMARY OF TRAFFIC CONDITIONS -- OUTBOUND DIRECTION PAGE 4 OF 4
Run # 5 - a (Inbound and Outbound - Urban - AADT) QUEWZ-92

HOUR	APPROACH VOLUME (VPH)	CAPACITY (VPH)	APPROACH SPEED (MPH)	WORK ZONE SPEED (MPH)	QUEUE LENGTH (MILES)
0- 1					
1- 2					
2- 3					
3- 4					
4- 5					
5- 6					
6- 7					
7- 8	645.	1515.	58.	54.	0.0
8- 9	544.	1515.	58.	55.	0.0
9-10	499.	1515.	58.	55.	0.0
10-11	498.	1515.	58.	55.	0.0
11-12	545.	1515.	58.	55.	0.0
12-13	551.	1515.	58.	54.	0.0
13-14	567.	1515.	58.	54.	0.0
14-15	612.	1515.	58.	54.	0.0
15-16	750.	1515.	57.	53.	0.0
16-17	971.	1515.	56.	50.	0.0
17-18	1009.	1515.	56.	50.	0.0
18-19	697.	1515.	57.	53.	0.0
19-20					
20-21					
21-22					
22-23					
23-24					

```
INPUT DATA SUMMARY: ROAD USER COST OUTPUT                PAGE 1 OF 4
Run # 6 - a (Inbound and Outbound - Rural - AADT)          QUEWZ-92
--------------------------------------------------------------------
LANE CLOSURE CONFIGURATION:

  TOTAL NUMBER OF LANES
    INBOUND                          2
    OUTBOUND                         2

  NUMBER OF OPEN LANES
    INBOUND                          1
    OUTBOUND                         1

  LENGTH OF WORK ZONE              10.00 MILES

  INBOUND  CAPACITY
    NORMAL                       4000. (VPH)
    RESTRICTED                   1800. (VPH)
    WORKING HOURS                1515. (VPH)

  OUTBOUND CAPACITY
    NORMAL                       4000. (VPH)
    RESTRICTED                   1800. (VPH)
    WORKING HOURS                1515. (VPH)

TRAFFIC PARAMETERS:

  PARAMETERS TO CALCULATE
  HOURLY TRAFFIC VOLUMES
    DAY OF WEEK             WEDNESDAY
    MONTH                     OCTOBER
    DISTRICT                       99
    LOCATION                 RURAL IN
    AADT (THOUS.)                  20.0

  PERCENTAGE TRUCK                  8.

SCHEDULE OF WORK ACTIVITY:

  HOURS OF RESTRICTED CAPACITY
    BEGINNING                        7
    ENDING                          19

  HOURS OF WORK ZONE ACTIVITY
    BEGINNING                        7
    ENDING                          19
--------------------------------------------------------------------
```

SUMMARY OF ADDITIONAL ROAD USER COSTS
Run # 6 - a (Inbound and Outbound - Rural - AADT) QUEWZ-92

HOUR	ADDITIONAL ROAD USER COSTS ($) INBOUND	OUTBOUND	TOTAL
0- 1			
1- 2			
2- 3			
3- 4			
4- 5			
5- 6			
6- 7			
7- 8	16.	9.	25.
8- 9	22.	14.	36.
9-10	33.	24.	57.
10-11	38.	31.	69.
11-12	43.	38.	81.
12-13	39.	39.	79.
13-14	40.	40.	81.
14-15	42.	42.	85.
15-16	47.	47.	94.
16-17	44.	56.	101.
17-18	36.	51.	87.
18-19	21.	30.	51.
19-20			
20-21			
21-22			
22-23			
23-24			
TOTAL	423.	421.	844.

SUMMARY OF TRAFFIC CONDITIONS -- INBOUND DIRECTION
Run # 6 - a (Inbound and Outbound - Rural - AADT) QUEWZ-92

HOUR	APPROACH VOLUME (VPH)	CAPACITY (VPH)	APPROACH SPEED (MPH)	WORK ZONE SPEED (MPH)	QUEUE LENGTH (MILES)
0- 1					
1- 2					
2- 3					
3- 4					
4- 5					
5- 6					
6- 7					
7- 8	401.	1515.	58.	56.	0.0
8- 9	445.	1515.	58.	56.	0.0
9-10	518.	1515.	58.	55.	0.0
10-11	546.	1515.	58.	55.	0.0
11-12	567.	1515.	58.	54.	0.0
12-13	550.	1515.	58.	55.	0.0
13-14	555.	1515.	58.	54.	0.0
14-15	564.	1515.	58.	54.	0.0
15-16	584.	1515.	58.	54.	0.0
16-17	573.	1515.	58.	54.	0.0
17-18	533.	1515.	58.	55.	0.0
18-19	443.	1515.	58.	56.	0.0
19-20					
20-21					
21-22					
22-23					
23-24					

SUMMARY OF TRAFFIC CONDITIONS -- OUTBOUND DIRECTION
Run # 6 - a (Inbound and Outbound - Rural - AADT) QUEWZ-92

HOUR	APPROACH VOLUME (VPH)	CAPACITY (VPH)	APPROACH SPEED (MPH)	WORK ZONE SPEED (MPH)	QUEUE LENGTH (MILES)
0- 1					
1- 2					
2- 3					
3- 4					
4- 5					
5- 6					
6- 7					
7- 8	315.	1515.	59.	57.	0.0
8- 9	379.	1515.	59.	56.	0.0
9-10	460.	1515.	58.	55.	0.0
10-11	504.	1515.	58.	55.	0.0
11-12	545.	1515.	58.	55.	0.0
12-13	550.	1515.	58.	55.	0.0
13-14	555.	1515.	58.	54.	0.0
14-15	564.	1515.	58.	54.	0.0
15-16	584.	1515.	58.	54.	0.0
16-17	621.	1515.	58.	54.	0.0
17-18	601.	1515.	58.	54.	0.0
18-19	499.	1515.	58.	55.	0.0
19-20					
20-21					
21-22					
22-23					
23-24					

```
INPUT DATA SUMMARY: ROAD USER COST OUTPUT                    PAGE 1 OF 3
Run # 7 - a (Inbound - Hourly Volumes)                         QUEWZ-92
-----------------------------------------------------------------------
LANE CLOSURE CONFIGURATION:

  TOTAL NUMBER OF LANES
    INBOUND                        2
    OUTBOUND                       2

  NUMBER OF OPEN LANES
    INBOUND                        1
    OUTBOUND                       2

  LENGTH OF WORK ZONE             10.00 MILES

  INBOUND  CAPACITY
    NORMAL                      4000. (VPH)
    RESTRICTED                  1800. (VPH)
    WORKING HOURS               1515. (VPH)

TRAFFIC PARAMETERS:

  PERCENTAGE TRUCK                 8.

SCHEDULE OF WORK ACTIVITY:

  HOURS OF RESTRICTED CAPACITY
    BEGINNING                      7
    ENDING                        19

  HOURS OF WORK ZONE ACTIVITY
    BEGINNING                      7
    ENDING                        19
-----------------------------------------------------------------------
```

SUMMARY OF ADDITIONAL ROAD USER COSTS PAGE 2 OF 3
Run # 7 - a (Inbound - Hourly Volumes) QUEWZ-92

HOUR	ADDITIONAL ROAD USER COSTS ($) INBOUND	OUTBOUND	TOTAL
0- 1	0.	0.	0.
1- 2	0.	0.	0.
2- 3	0.	0.	0.
3- 4	0.	0.	0.
4- 5	0.	0.	0.
5- 6	0.	0.	0.
6- 7	0.	0.	0.
7- 8	11.	0.	11.
8- 9	44.	0.	44.
9-10	36.	0.	36.
10-11	47.	0.	47.
11-12	90.	0.	90.
12-13	138.	0.	138.
13-14	89.	0.	89.
14-15	84.	0.	84.
15-16	104.	0.	104.
16-17	116.	0.	116.
17-18	174.	0.	174.
18-19	79.	0.	79.
19-20	0.	0.	0.
20-21	0.	0.	0.
21-22	0.	0.	0.
22-23	0.	0.	0.
23-24	0.	0.	0.
TOTAL	1011.	0.	1011.

NOTE: LANE CLOSURE ONLY IN INBOUND DIRECTION

SUMMARY OF TRAFFIC CONDITIONS -- INBOUND DIRECTION
Run # 7 - a (Inbound - Hourly Volumes) QUEWZ-92

HOUR	APPROACH VOLUME (VPH)	CAPACITY (VPH)	APPROACH SPEED (MPH)	WORK ZONE SPEED (MPH)	QUEUE LENGTH (MILES)
0- 1					
1- 2					
2- 3					
3- 4					
4- 5					
5- 6					
6- 7					
7- 8	345.	1515.	59.	57.	0.0
8- 9	570.	1515.	58.	54.	0.0
9-10	535.	1515.	58.	55.	0.0
10-11	584.	1515.	58.	54.	0.0
11-12	723.	1515.	57.	53.	0.0
12-13	826.	1515.	57.	52.	0.0
13-14	720.	1515.	57.	53.	0.0
14-15	707.	1515.	57.	53.	0.0
15-16	756.	1515.	57.	52.	0.0
16-17	782.	1515.	57.	52.	0.0
17-18	887.	1515.	57.	51.	0.0
18-19	694.	1515.	57.	53.	0.0
19-20					
20-21					
21-22					
22-23					
23-24					

LANE CLOSURE CONFIGURATION:

TOTAL NUMBER OF LANES	
INBOUND	2
OUTBOUND	2
NUMBER OF OPEN LANES	
INBOUND	2
OUTBOUND	1
LENGTH OF WORK ZONE	10.00 MILES
OUTBOUND CAPACITY	
NORMAL	4000. (VPH)
RESTRICTED	1800. (VPH)
WORKING HOURS	1515. (VPH)

TRAFFIC PARAMETERS:

PERCENTAGE TRUCK	8.

SCHEDULE OF WORK ACTIVITY:

HOURS OF RESTRICTED CAPACITY	
BEGINNING	7
ENDING	19
HOURS OF WORK ZONE ACTIVITY	
BEGINNING	7
ENDING	19

SUMMARY OF ADDITIONAL ROAD USER COSTS
Run # 8 - a (Outbound - Hourly Volumes)

QUEWZ-92

HOUR	ADDITIONAL ROAD USER COSTS ($) INBOUND	OUTBOUND	TOTAL
0- 1	0.	0.	0.
1- 2	0.	0.	0.
2- 3	0.	0.	0.
3- 4	0.	0.	0.
4- 5	0.	0.	0.
5- 6	0.	0.	0.
6- 7	0.	0.	0.
7- 8	0.	31.	31.
8- 9	0.	72.	72.
9-10	0.	43.	43.
10-11	0.	50.	50.
11-12	0.	71.	71.
12-13	0.	103.	103.
13-14	0.	116.	116.
14-15	0.	100.	100.
15-16	0.	88.	88.
16-17	0.	92.	92.
17-18	0.	97.	97.
18-19	0.	45.	45.
19-20	0.	0.	0.
20-21	0.	0.	0.
21-22	0.	0.	0.
22-23	0.	0.	0.
23-24	0.	0.	0.
TOTAL	0.	907.	907.

NOTE: LANE CLOSURE ONLY IN OUTBOUND DIRECTION

SUMMARY OF TRAFFIC CONDITIONS -- OUTBOUND DIRECTION PAGE 3 OF 3
Run # 8 - a (Outbound - Hourly Volumes) QUEWZ-92

HOUR	APPROACH VOLUME (VPH)	CAPACITY (VPH)	APPROACH SPEED (MPH)	WORK ZONE SPEED (MPH)	QUEUE LENGTH (MILES)
0- 1					
1- 2					
2- 3					
3- 4					
4- 5					
5- 6					
6- 7					
7- 8	506.	1515.	58.	55.	0.0
8- 9	674.	1515.	57.	53.	0.0
9-10	566.	1515.	58.	54.	0.0
10-11	595.	1515.	58.	54.	0.0
11-12	669.	1515.	57.	53.	0.0
12-13	754.	1515.	57.	52.	0.0
13-14	782.	1515.	57.	52.	0.0
14-15	748.	1515.	57.	53.	0.0
15-16	717.	1515.	57.	53.	0.0
16-17	728.	1515.	57.	53.	0.0
17-18	741.	1515.	57.	53.	0.0
18-19	576.	1515.	58.	54.	0.0
19-20					
20-21					
21-22					
22-23					
23-24					

```
INPUT DATA SUMMARY: ROAD USER COST OUTPUT                  PAGE 1 OF 4
Run # 9 - a (Inbound and Outbound - Hourly Volumes)         QUEWZ-92
---------------------------------------------------------------------
LANE CLOSURE CONFIGURATION:

  TOTAL NUMBER OF LANES
    INBOUND                          2
    OUTBOUND                         2

  NUMBER OF OPEN LANES
    INBOUND                          1
    OUTBOUND                         1

  LENGTH OF WORK ZONE               10.00 MILES

  INBOUND  CAPACITY
    NORMAL                        4000. (VPH)
    RESTRICTED                    1800. (VPH)
    WORKING HOURS                 1515. (VPH)

  OUTBOUND CAPACITY
    NORMAL                        4000. (VPH)
    RESTRICTED                    1800. (VPH)
    WORKING HOURS                 1515. (VPH)

TRAFFIC PARAMETERS:

  PERCENTAGE TRUCK                   8.

SCHEDULE OF WORK ACTIVITY:

  HOURS OF RESTRICTED CAPACITY
    BEGINNING                        7
    ENDING                          19

  HOURS OF WORK ZONE ACTIVITY
    BEGINNING                        7
    ENDING                          19
---------------------------------------------------------------------
```

SUMMARY OF ADDITIONAL ROAD USER COSTS
Run # 9 - a (Inbound and Outbound - Hourly Volumes) QUEWZ-92

HOUR	ADDITIONAL ROAD USER COSTS ($) INBOUND	OUTBOUND	TOTAL
0- 1			
1- 2			
2- 3			
3- 4			
4- 5			
5- 6			
6- 7			
7- 8	11.	31.	42.
8- 9	44.	72.	116.
9-10	36.	43.	79.
10-11	47.	50.	97.
11-12	90.	71.	161.
12-13	138.	103.	241.
13-14	89.	116.	204.
14-15	84.	100.	184.
15-16	104.	88.	191.
16-17	116.	92.	208.
17-18	174.	97.	272.
18-19	79.	45.	124.
19-20			
20-21			
21-22			
22-23			
23-24			
TOTAL	1011.	907.	1919.

SUMMARY OF TRAFFIC CONDITIONS -- INBOUND DIRECTION
Run # 9 - a (Inbound and Outbound - Hourly Volumes) QUEWZ-92

HOUR	APPROACH VOLUME (VPH)	CAPACITY (VPH)	APPROACH SPEED (MPH)	WORK ZONE SPEED (MPH)	QUEUE LENGTH (MILES)
0- 1					
1- 2					
2- 3					
3- 4					
4- 5					
5- 6					
6- 7					
7- 8	345.	1515.	59.	57.	0.0
8- 9	570.	1515.	58.	54.	0.0
9-10	535.	1515.	58.	55.	0.0
10-11	584.	1515.	58.	54.	0.0
11-12	723.	1515.	57.	53.	0.0
12-13	826.	1515.	57.	52.	0.0
13-14	720.	1515.	57.	53.	0.0
14-15	707.	1515.	57.	53.	0.0
15-16	756.	1515.	57.	52.	0.0
16-17	782.	1515.	57.	52.	0.0
17-18	887.	1515.	57.	51.	0.0
18-19	694.	1515.	57.	53.	0.0
19-20					
20-21					
21-22					
22-23					
23-24					

SUMMARY OF TRAFFIC CONDITIONS -- OUTBOUND DIRECTION
Run # 9 - a (Inbound and Outbound - Hourly Volumes) QUEWZ-92

HOUR	APPROACH VOLUME (VPH)	CAPACITY (VPH)	APPROACH SPEED (MPH)	WORK ZONE SPEED (MPH)	QUEUE LENGTH (MILES)
0- 1					
1- 2					
2- 3					
3- 4					
4- 5					
5- 6					
6- 7					
7- 8	506.	1515.	58.	55.	0.0
8- 9	674.	1515.	57.	53.	0.0
9-10	566.	1515.	58.	54.	0.0
10-11	597.	1515.	58.	54.	0.0
11-12	669.	1515.	57.	53.	0.0
12-13	754.	1515.	57.	52.	0.0
13-14	782.	1515.	57.	52.	0.0
14-15	748.	1515.	57.	53.	0.0
15-16	717.	1515.	57.	53.	0.0
16-17	728.	1515.	57.	53.	0.0
17-18	741.	1515.	57.	53.	0.0
18-19	576.	1515.	58.	54.	0.0
19-20					
20-21					
21-22					
22-23					
23-24					

```
INPUT DATA SUMMARY: LANE CLOSURE SCHEDULE OUTPUT           PAGE 1 OF 2
Run # 1 - b (Inbound - Urban - AADT)                         QUEWZ-92
---------------------------------------------------------------------
LANE CLOSURE CONFIGURATION:

  TOTAL NUMBER OF LANES
    INBOUND                       2
    OUTBOUND                      2

  NUMBER OF OPEN LANES
    INBOUND                       0
    OUTBOUND                      2

  LENGTH OF WORK ZONE            10.00 MILES

  INBOUND  CAPACITY
    NORMAL                      4000. (VPH)
    WORKING HOURS
      1 OF 2 LANES CLOSED       1515. (VPH)

TRAFFIC PARAMETERS:

  PARAMETERS TO CALCULATE
  HOURLY TRAFFIC VOLUMES
    DAY OF WEEK            WEDNESDAY
    MONTH                    OCTOBER
    DISTRICT                      99
    LOCATION               URBAN IN
    AADT (THOUS.)                20.0

  PERCENTAGE TRUCK                8.
---------------------------------------------------------------------
```

ACCEPTABLE LANE CLOSURE SCHEDULES -- INBOUND DIRECTION PAGE 2 OF 2
Run # 1 - b (Inbound - Urban - AADT) QUEWZ-92

FOR WORK STARTING AT HOUR	1 OF 2 LANES MAY BE CLOSED UNTIL HOUR*
0	24 #
1	24 #
2	24 #
3	24 #
4	24 #
5	24 #
6	24 #
7	24 #
8	24 #
9	24 #
10	24 #
11	24 #
12	24 #
13	24 #
14	24 #
15	24 #
16	24 #
17	24 #
18	24 #
19	24 #
20	24 #
21	24 #
22	24 #
23	24 #

* IF WORK CONTINUES BEYOND THIS HOUR, THE DELAY WILL EXCEED 20 MINUTES.

HOUR OF THE DAY AFTER WORK STARTED

```
INPUT DATA SUMMARY: LANE CLOSURE SCHEDULE OUTPUT          PAGE 1 OF 2
Run # 2 - b (Inbound - Rural - AADT)                        QUEWZ-92
---------------------------------------------------------------------
LANE CLOSURE CONFIGURATION:

  TOTAL NUMBER OF LANES
    INBOUND                          2
    OUTBOUND                         2

  NUMBER OF OPEN LANES
    INBOUND                          0
    OUTBOUND                         2

  LENGTH OF WORK ZONE               10.00 MILES

  INBOUND  CAPACITY
    NORMAL                        4000. (VPH)
    WORKING HOURS
      1 OF 2 LANES CLOSED         1515. (VPH)

TRAFFIC PARAMETERS:

  PARAMETERS TO CALCULATE
  HOURLY TRAFFIC VOLUMES
    DAY OF WEEK              WEDNESDAY
    MONTH                      OCTOBER
    DISTRICT                        99
    LOCATION                  RURAL IN
    AADT (THOUS.)                   20.0

  PERCENTAGE TRUCK                   8.
---------------------------------------------------------------------
```

ACCEPTABLE LANE CLOSURE SCHEDULES -- INBOUND DIRECTION PAGE 2 OF 2
Run # 2 - b (Inbound - Rural - AADT) QUEWZ-92

FOR WORK STARTING AT HOUR	1 OF 2 LANES MAY BE CLOSED UNTIL HOUR*
0	24 #
1	24 #
2	24 #
3	24 #
4	24 #
5	24 #
6	24 #
7	24 #
8	24 #
9	24 #
10	24 #
11	24 #
12	24 #
13	24 #
14	24 #
15	24 #
16	24 #
17	24 #
18	24 #
19	24 #
20	24 #
21	24 #
22	24 #
23	24 #

* IF WORK CONTINUES BEYOND THIS HOUR, THE DELAY WILL EXCEED 20 MINUTES.

HOUR OF THE DAY AFTER WORK STARTED

LANE CLOSURE CONFIGURATION:

TOTAL NUMBER OF LANES	
INBOUND	2
OUTBOUND	2
NUMBER OF OPEN LANES	
INBOUND	2
OUTBOUND	0
LENGTH OF WORK ZONE	10.00 MILES
OUTBOUND CAPACITY	
NORMAL	4000. (VPH)
WORKING HOURS	
1 OF 2 LANES CLOSED	1515. (VPH)

TRAFFIC PARAMETERS:

PARAMETERS TO CALCULATE HOURLY TRAFFIC VOLUMES	
DAY OF WEEK	WEDNESDAY
MONTH	OCTOBER
DISTRICT	99
LOCATION	URBAN IN
AADT (THOUS.)	20.0
PERCENTAGE TRUCK	8.

ACCEPTABLE LANE CLOSURE SCHEDULES -- OUTBOUND DIRECTION PAGE 2 OF 2
Run # 3 - b (Outbound - Urban - AADT) QUEWZ-92

FOR WORK STARTING AT HOUR	1 OF 2 LANES MAY BE CLOSED UNTIL HOUR*
0	24 #
1	24 #
2	24 #
3	24 #
4	24 #
5	24 #
6	24 #
7	24 #
8	24 #
9	24 #
10	24 #
11	24 #
12	24 #
13	24 #
14	24 #
15	24 #
16	24 #
17	24 #
18	24 #
19	24 #
20	24 #
21	24 #
22	24 #
23	24 #

* IF WORK CONTINUES BEYOND THIS HOUR, THE DELAY WILL EXCEED 20 MINUTES.

HOUR OF THE DAY AFTER WORK STARTED

```
INPUT DATA SUMMARY: LANE CLOSURE SCHEDULE OUTPUT          PAGE 1 OF 2
Run # 4 - b (Outbound - Rural - AADT)                       QUEWZ-92
--------------------------------------------------------------------
LANE CLOSURE CONFIGURATION:

  TOTAL NUMBER OF LANES
    INBOUND                           2
    OUTBOUND                          2

  NUMBER OF OPEN LANES
    INBOUND                           2
    OUTBOUND                          0

  LENGTH OF WORK ZONE                10.00 MILES

  OUTBOUND CAPACITY
    NORMAL                         4000. (VPH)
    WORKING HOURS
      1 OF 2 LANES CLOSED          1515. (VPH)

TRAFFIC PARAMETERS:

  PARAMETERS TO CALCULATE
  HOURLY TRAFFIC VOLUMES
    DAY OF WEEK               WEDNESDAY
    MONTH                       OCTOBER
    DISTRICT                         99
    LOCATION                   RURAL IN
    AADT (THOUS.)                  20.0

  PERCENTAGE TRUCK                8.
--------------------------------------------------------------------
```

ACCEPTABLE LANE CLOSURE SCHEDULES -- OUTBOUND DIRECTION
Run # 4 - b (Outbound - Rural - AADT) QUEWZ-92

FOR WORK STARTING AT HOUR	1 OF 2 LANES MAY BE CLOSED UNTIL HOUR*
0	24 #
1	24 #
2	24 #
3	24 #
4	24 #
5	24 #
6	24 #
7	24 #
8	24 #
9	24 #
10	24 #
11	24 #
12	24 #
13	24 #
14	24 #
15	24 #
16	24 #
17	24 #
18	24 #
19	24 #
20	24 #
21	24 #
22	24 #
23	24 #

* IF WORK CONTINUES BEYOND THIS HOUR, THE DELAY WILL EXCEED 20 MINUTES.

HOUR OF THE DAY AFTER WORK STARTED

```
INPUT DATA SUMMARY: LANE CLOSURE SCHEDULE OUTPUT            PAGE 1 OF 3
Run # 5 - b (Inbound and Outbound - Urban - AADT)            QUEWZ-92
---------------------------------------------------------------------
LANE CLOSURE CONFIGURATION:

  TOTAL NUMBER OF LANES
    INBOUND                          2
    OUTBOUND                         2

  NUMBER OF OPEN LANES
    INBOUND                          0
    OUTBOUND                         0

  LENGTH OF WORK ZONE              10.00 MILES

  INBOUND  CAPACITY
    NORMAL                       4000. (VPH)
    WORKING HOURS
      1 OF 2 LANES CLOSED        1515. (VPH)

  OUTBOUND CAPACITY
    NORMAL                       4000. (VPH)
    WORKING HOURS
      1 OF 2 LANES CLOSED        1515. (VPH)

TRAFFIC PARAMETERS:

  PARAMETERS TO CALCULATE
  HOURLY TRAFFIC VOLUMES
    DAY OF WEEK             WEDNESDAY
    MONTH                     OCTOBER
    DISTRICT                       99
    LOCATION                URBAN IN
    AADT (THOUS.)                  20.0

  PERCENTAGE TRUCK                  8.
---------------------------------------------------------------------
```

ACCEPTABLE LANE CLOSURE SCHEDULES -- INBOUND DIRECTION PAGE 2 OF 3
Run # 5 - b (Inbound and Outbound - Urban - AADT) QUEWZ-92

FOR WORK STARTING AT HOUR	1 OF 2 LANES MAY BE CLOSED UNTIL HOUR*
0	24 #
1	24 #
2	24 #
3	24 #
4	24 #
5	24 #
6	24 #
7	24 #
8	24 #
9	24 #
10	24 #
11	24 #
12	24 #
13	24 #
14	24 #
15	24 #
16	24 #
17	24 #
18	24 #
19	24 #
20	24 #
21	24 #
22	24 #
23	24 #

* IF WORK CONTINUES BEYOND THIS HOUR, THE DELAY WILL EXCEED 20 MINUTES.

HOUR OF THE DAY AFTER WORK STARTED

ACCEPTABLE LANE CLOSURE SCHEDULES -- OUTBOUND DIRECTION PAGE 3 OF 3
Run # 5 - b (Inbound and Outbound - Urban - AADT) QUEWZ-92

FOR WORK STARTING AT HOUR	1 OF 2 LANES MAY BE CLOSED UNTIL HOUR*
0	24 #
1	24 #
2	24 #
3	24 #
4	24 #
5	24 #
6	24 #
7	24 #
8	24 #
9	24 #
10	24 #
11	24 #
12	24 #
13	24 #
14	24 #
15	24 #
16	24 #
17	24 #
18	24 #
19	24 #
20	24 #
21	24 #
22	24 #
23	24 #

* IF WORK CONTINUES BEYOND THIS HOUR, THE DELAY WILL EXCEED 20 MINUTES.

HOUR OF THE DAY AFTER WORK STARTED

```
INPUT DATA SUMMARY: LANE CLOSURE SCHEDULE OUTPUT          PAGE 1 OF 3
Run # 6 - b (Inbound and Outbound - Rural - AADT)          QUEWZ-92
---------------------------------------------------------------------
LANE CLOSURE CONFIGURATION:

  TOTAL NUMBER OF LANES
    INBOUND                         2
    OUTBOUND                        2

  NUMBER OF OPEN LANES
    INBOUND                         0
    OUTBOUND                        0

  LENGTH OF WORK ZONE              10.00 MILES

  INBOUND  CAPACITY
    NORMAL                        4000. (VPH)
    WORKING HOURS
      1 OF 2 LANES CLOSED         1515. (VPH)

  OUTBOUND CAPACITY
    NORMAL                        4000. (VPH)
    WORKING HOURS
      1 OF 2 LANES CLOSED         1515. (VPH)

TRAFFIC PARAMETERS:

  PARAMETERS TO CALCULATE
  HOURLY TRAFFIC VOLUMES
    DAY OF WEEK               WEDNESDAY
    MONTH                       OCTOBER
    DISTRICT                         99
    LOCATION                   RURAL IN
    AADT (THOUS.)                  20.0

  PERCENTAGE TRUCK                  8.
---------------------------------------------------------------------
```

ACCEPTABLE LANE CLOSURE SCHEDULES -- INBOUND DIRECTION PAGE 2 OF 3
Run # 6 - b (Inbound and Outbound - Rural - AADT) QUEWZ-92

FOR WORK STARTING AT HOUR	1 OF 2 LANES MAY BE CLOSED UNTIL HOUR*
0	24 #
1	24 #
2	24 #
3	24 #
4	24 #
5	24 #
6	24 #
7	24 #
8	24 #
9	24 #
10	24 #
11	24 #
12	24 #
13	24 #
14	24 #
15	24 #
16	24 #
17	24 #
18	24 #
19	24 #
20	24 #
21	24 #
22	24 #
23	24 #

* IF WORK CONTINUES BEYOND THIS HOUR, THE DELAY WILL EXCEED 20 MINUTES.

HOUR OF THE DAY AFTER WORK STARTED

ACCEPTABLE LANE CLOSURE SCHEDULES -- OUTBOUND DIRECTION
Run # 6 - b (Inbound and Outbound - Rural - AADT) QUEWZ-92

FOR WORK STARTING AT HOUR	1 OF 2 LANES MAY BE CLOSED UNTIL HOUR*
0	24 #
1	24 #
2	24 #
3	24 #
4	24 #
5	24 #
6	24 #
7	24 #
8	24 #
9	24 #
10	24 #
11	24 #
12	24 #
13	24 #
14	24 #
15	24 #
16	24 #
17	24 #
18	24 #
19	24 #
20	24 #
21	24 #
22	24 #
23	24 #

* IF WORK CONTINUES BEYOND THIS HOUR, THE DELAY WILL EXCEED 20 MINUTES.

HOUR OF THE DAY AFTER WORK STARTED

```
INPUT DATA SUMMARY: LANE CLOSURE SCHEDULE OUTPUT           PAGE 1 OF 2
Run # 7 - b (Inbound - Hourly Volumes)                       QUEWZ-92
-------------------------------------------------------------------
LANE CLOSURE CONFIGURATION:

  TOTAL NUMBER OF LANES
    INBOUND                       2
    OUTBOUND                      2

  NUMBER OF OPEN LANES
    INBOUND                       0
    OUTBOUND                      2

  LENGTH OF WORK ZONE            10.00 MILES

  INBOUND  CAPACITY
    NORMAL                      4000. (VPH)
    WORKING HOURS
      1 OF 2 LANES CLOSED       1515. (VPH)

TRAFFIC PARAMETERS:

  PERCENTAGE TRUCK                8.
-------------------------------------------------------------------
```

ACCEPTABLE LANE CLOSURE SCHEDULES -- INBOUND DIRECTION PAGE 2 OF 2
Run # 7 - b (Inbound - Hourly Volumes) QUEWZ-92

FOR WORK STARTING AT HOUR	1 OF 2 LANES MAY BE CLOSED UNTIL HOUR*
0	24 #
1	24 #
2	24 #
3	24 #
4	24 #
5	24 #
6	24 #
7	24 #
8	24 #
9	24 #
10	24 #
11	24 #
12	24 #
13	24 #
14	24 #
15	24 #
16	24 #
17	24 #
18	24 #
19	24 #
20	24 #
21	24 #
22	24 #
23	24 #

* IF WORK CONTINUES BEYOND THIS HOUR, THE DELAY WILL EXCEED 20 MINUTES.

HOUR OF THE DAY AFTER WORK STARTED

```
INPUT DATA SUMMARY: LANE CLOSURE SCHEDULE OUTPUT          PAGE 1 OF 2
Run # 8 - b (Outbound - Hourly Volumes)                     QUEWZ-92
---------------------------------------------------------------------
LANE CLOSURE CONFIGURATION:

  TOTAL NUMBER OF LANES
    INBOUND                           2
    OUTBOUND                          2

  NUMBER OF OPEN LANES
    INBOUND                           2
    OUTBOUND                          0

  LENGTH OF WORK ZONE                10.00 MILES

  OUTBOUND CAPACITY
    NORMAL                          4000. (VPH)
    WORKING HOURS
      1 OF 2 LANES CLOSED           1515. (VPH)

TRAFFIC PARAMETERS:

  PERCENTAGE TRUCK                    8.
---------------------------------------------------------------------
```

ACCEPTABLE LANE CLOSURE SCHEDULES -- OUTBOUND DIRECTION PAGE 2 OF 2
Run # 8 - b (Outbound - Hourly Volumes) QUEWZ-92

FOR WORK STARTING AT HOUR	1 OF 2 LANES MAY BE CLOSED UNTIL HOUR*
0	24 #
1	24 #
2	24 #
3	24 #
4	24 #
5	24 #
6	24 #
7	24 #
8	24 #
9	24 #
10	24 #
11	24 #
12	24 #
13	24 #
14	24 #
15	24 #
16	24 #
17	24 #
18	24 #
19	24 #
20	24 #
21	24 #
22	24 #
23	24 #

* IF WORK CONTINUES BEYOND THIS HOUR, THE DELAY WILL EXCEED 20 MINUTES.

HOUR OF THE DAY AFTER WORK STARTED

INPUT DATA SUMMARY: LANE CLOSURE SCHEDULE OUTPUT PAGE 1 OF 3
Run # 9 - b (Inbound and Outbound - Hourly Volumes) QUEWZ-92

LANE CLOSURE CONFIGURATION:

TOTAL NUMBER OF LANES	
INBOUND	2
OUTBOUND	2
NUMBER OF OPEN LANES	
INBOUND	0
OUTBOUND	0
LENGTH OF WORK ZONE	10.00 MILES
INBOUND CAPACITY	
NORMAL	4000. (VPH)
WORKING HOURS	
1 OF 2 LANES CLOSED	1515. (VPH)
OUTBOUND CAPACITY	
NORMAL	4000. (VPH)
WORKING HOURS	
1 OF 2 LANES CLOSED	1515. (VPH)

TRAFFIC PARAMETERS:

PERCENTAGE TRUCK	8.

ACCEPTABLE LANE CLOSURE SCHEDULES -- INBOUND DIRECTION PAGE 2 OF 3
Run # 9 - b (Inbound and Outbound - Hourly Volumes) QUEWZ-92

FOR WORK STARTING AT HOUR	1 OF 2 LANES MAY BE CLOSED UNTIL HOUR*
0	24 #
1	24 #
2	24 #
3	24 #
4	24 #
5	24 #
6	24 #
7	24 #
8	24 #
9	24 #
10	24 #
11	24 #
12	24 #
13	24 #
14	24 #
15	24 #
16	24 #
17	24 #
18	24 #
19	24 #
20	24 #
21	24 #
22	24 #
23	24 #

* IF WORK CONTINUES BEYOND THIS HOUR, THE DELAY WILL EXCEED 20 MINUTES.

HOUR OF THE DAY AFTER WORK STARTED

ACCEPTABLE LANE CLOSURE SCHEDULES -- OUTBOUND DIRECTION PAGE 3 OF 3
Run # 9 - b (Inbound and Outbound - Hourly Volumes) QUEWZ-92

FOR WORK STARTING AT HOUR	1 OF 2 LANES MAY BE CLOSED UNTIL HOUR*
0	24 #
1	24 #
2	24 #
3	24 #
4	24 #
5	24 #
6	24 #
7	24 #
8	24 #
9	24 #
10	24 #
11	24 #
12	24 #
13	24 #
14	24 #
15	24 #
16	24 #
17	24 #
18	24 #
19	24 #
20	24 #
21	24 #
22	24 #
23	24 #

* IF WORK CONTINUES BEYOND THIS HOUR, THE DELAY WILL EXCEED 20 MINUTES.

HOUR OF THE DAY AFTER WORK STARTED

APPENDIX E

ACCIDENT POLICE REPORT

FLORIDA TRAFFIC CRASH REPORT

☐ LONG FORM ☐ SHORT FORM

MAIL TO: DEPT. OF HIGHWAY SAFETY & MOTOR VEHICLES
TRAFFIC CRASH RECORDS
TALLAHASSEE, FLORIDA 32399-0500

DO NOT WRITE IN THIS SPACE

Time & Location

DATE OF CRASH | TIME OF CRASH ☐AM ☐PM | TIME OFFICER NOTIFIED ☐AM ☐PM | TIME OFFICER ARRIVED ☐AM ☐PM | INVEST. AGENCY REPORT NUMBER | HSMV CRASH REPORT NUMBER 50505016

COUNTY / CITY CODE | Feet or Miles N S E W of | CITY OR TOWN (Check if in City or Town) | COUNTY

AT NODE NO. or FEET / MILES FROM NODE NO. 1 ☐ 2 ☐ | NEXT NODE NO. | NO. OF LANES | 1 DIVIDED 2 UNDIVIDED | ON STREET, ROAD OR HIGHWAY

AT INTERSECTION OF or FEET / MILES 1 ☐ 2 ☐ N S E W OF INTERSECTION OF

Section 1 — Vehicle / Pedestrian

DRIVER ACTION 1 Phantom 2 Hit & Run 3 N/A | YEAR | MAKE | TYPE | USE | VEH. LICENSE NUMBER | STATE | VEHICLE IDENTIFICATION NUMBER | POINT OF IMPACT CIRCLE AREA OF DAMAGE 18 Undercarriage 19 Overturn 20 Windshield 21 Fire 22 Trailer

TRAILER OR TOWED VEHICLE INFORMATION | TRAILER TYPE

VEHICLE TRAVELING N S E W ON At | Est. MPH | Posted Speed | EST. VEHICLE DAMAGE $ 1 Disabling 2 Functional 3 No Damage | EST. TRAILER DAMAGE $

INSURANCE COMPANY (LIABILITY OR PIP) | POLICY NUMBER | VEHICLE REMOVED BY: 1 Tow Rotation List 2 Tow Owner's Request 3 Driver 4 Other

OWNER'S FULL NAME (Check if Driver) | CURRENT ADDRESS (Number and Street) | CITY AND STATE | ZIP CODE

OWNER'S FULL NAME (Trailer or Towed Vehicle) | CURRENT ADDRESS (Number and Street) | CITY AND STATE | ZIP CODE

DRIVER (Exactly as on Driver License) / Pedestrian | CURRENT ADDRESS (Number and Street) | CITY & STATE / ZIP CODE | DATE OF BIRTH

DRIVER LICENSE NUMBER | STATE | DL TYPE | REQ. END. | BAC TEST 1 Blood 2 Breath 3 Urine 4 Refused 5 None | RESULTS % | AL / DRUG | PHYS. DEF. | RES | RACE | SEX | INJ. | S. EQUIP. | EJECT.

HAZARDOUS MATERIALS BEING TRANSPORTED 1 Yes 2 No | PLACARDED 1 Yes 2 No | RECOMMEND RE-EXAM 1 Yes 2 No If YES, Explain in Narrative | DRIVER'S PHONE NO. ( )

PASSENGER'S NAME (Additional on Continuation Page) | CURRENT ADDRESS | CITY & STATE / ZIP | AGE | LOC. | INJ. | S. EQUIP | EJECT.

Section 2 — Vehicle / Pedestrian

DRIVER ACTION 1 Phantom 2 Hit & Run 3 N/A | YEAR | MAKE | TYPE | USE | VEH. LICENSE NUMBER | STATE | VEHICLE IDENTIFICATION NUMBER | POINT OF IMPACT CIRCLE AREA OF DAMAGE 18 Undercarriage 19 Overturn 20 Windshield 21 Fire 22 Trailer

TRAILER OR TOWED VEHICLE INFORMATION | TRAILER TYPE

VEHICLE TRAVELING N S E W ON At | Est. MPH | Posted Speed | EST. VEHICLE DAMAGE $ 1 Disabling 2 Functional 3 No Damage | EST. TRAILER DAMAGE $

INSURANCE COMPANY (LIABILITY OR PIP) | POLICY NUMBER | VEHICLE REMOVED BY: 1 Tow Rotation List 2 Tow Owner's Request 3 Driver 4 Other

OWNER'S FULL NAME (Check if Driver) | CURRENT ADDRESS (Number and Street) | CITY AND STATE | ZIP CODE

OWNER'S FULL NAME (Trailer or Towed Vehicle) | CURRENT ADDRESS (Number and Street) | CITY AND STATE | ZIP CODE

DRIVER (Exactly as on Driver License) / Pedestrian | CURRENT ADDRESS (Number and Street) | CITY & STATE / ZIP CODE | DATE OF BIRTH

DRIVER LICENSE NUMBER | STATE | DL TYPE | REQ. END. | BAC TEST 1 Blood 2 Breath 3 Urine 4 Refused 5 None | RESULTS % | AL / DRUG | PHYS. DEF. | RES | RACE | SEX | INJ. | S. EQUIP. | EJECT.

HAZARDOUS MATERIALS BEING TRANSPORTED 1 Yes 2 No | PLACARDED 1 Yes 2 No | RECOMMEND RE-EXAM 1 Yes 2 No If YES, Explain in Narrative | DRIVER'S PHONE NO. ( )

PASSENGER'S NAME (Additional on Continuation Page) | CURRENT ADDRESS | CITY & STATE / ZIP | AGE | LOC. | INJ. | S. EQUIP | EJECT.

Code Information

VEHICLE TYPE
01 Automobile
02 Passenger Van
03 Pickup/Light Truck (2 rear tires)
04 Medium Truck (4 rear tires)
05 Heavy Truck (2 or more rear axles)
06 Truck Tractor (Cab)
07 Motor Home (RV)
08 Bus
09 Bicycle
10 Motorcycle
11 Moped
12 All Terrain Vehicle
13 Train
77 Other

VEHICLE USE
01 Private Transportation
02 Commercial Passengers
03 Commercial Cargo
04 Public Transportation
05 Public School Bus
06 Private School Bus
07 Ambulance
08 Law Enforcement
09 Fire/Rescue
10 Military
11 Other Government
77 Other

TRAILER TYPE
01 Single Semi Trailer
02 Tandem Semi Trailer(s)
03 Tank Trailer
04 Saddle Mount / Flatbed
05 Boat Trailer
06 Utility Trailer
07 House Trailer
08 Pole Trailer
09 Towed Vehicle
77 Other

RESIDENCE (Driver Only)
1 County of Crash
2 Elsewhere in State
3 Non-Resident of State
4 Foreign 5 Unknown

DL TYPE
1 A 2 B 3 C
4 D / Chauffeur
5 E / Operator
6 E / Oper-Rest
7 None

RACE
1 White
2 Black
3 Hispanic
4 Other

REQUIRED ENDORSEMENTS
1 Yes 2 No 3 NR

SEX
1 Male
2 Female

PHYSICAL DEFECTS
1 No Defects Known
2 Eyesight Defect
3 Fatigue / Asleep
4 Hearing Defect
5 Illness
6 Seizure, Epilepsy, Blackout
7 Other Physical Defect

INJURY SEVERITY
1 None
2 Possible
3 Non-Incapacitating
4 Incapacitating
5 Fatal (Within 90 Days)
6 Non-Traffic Fatality

ALCOHOL / DRUG USE
1 Not Drinking or Using Drugs
2 Alcohol - Under Influence
3 Drugs - Under Influence
4 Alcohol & Drugs - Under Influence
5 Had Been Drinking
6 Pending BAC Test Result

SAFETY EQUIPMENT IN USE
1 Not In Use
2 Seat Belt / Shoulder Harness
3 Child Restraint
4 Air Bag
5 Safety Helmet
6 Eye Protection

LOCATION (In Vehicle)
1 Front Left
2 Front Center
3 Front Right
4 Rear Left
5 Rear Center
6 Rear Right
7 In Body of Truck
8 Bus Passenger
9 Other

EJECTED
1 No
2 Yes
3 Partial

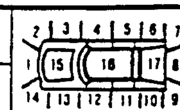
HSMV 90003 (1/95) S

Page 1 of ____ Pages

Section 3

Vehicle

DRIVER ACTION 1 Phantom 2 Hit & Run 3 N/A	YEAR	MAKE	TYPE	USE	VEH. LICENSE NUMBER	STATE	VEHICLE IDENTIFICATION NUMBER
TRAILER OR TOWED VEHICLE INFORMATION			TRAILER TYPE				



POINT OF IMPACT CIRCLE AREA OF DAMAGE
18 Undercarriage
19 Overturn
20 Windshield
21 Fire
22 Trailer

VEHICLE TRAVELING N S E W | ON | AT | Est. MPH | Posted Speed | EST. VEHICLE DAMAGE $ | 1 Disabling 2 Functional 3 No Damage | EST. TRAILER DAMAGE $

INSURANCE COMPANY (LIABILITY OR PIP) | POLICY NUMBER | VEHICLE REMOVED BY: 1 Tow Rotation List 2 Tow Owner's Request 3 Driver 4 Other

OWNER'S FULL NAME (Check if Driver) | CURRENT ADDRESS (Number and Street) | CITY AND STATE | ZIP CODE

OWNER'S FULL NAME (Trailer or Towed Vehicle) | CURRENT ADDRESS (Number and Street) | CITY AND STATE | ZIP CODE

Pedestrian

DRIVER (Exactly as on Driver License) / Pedestrian | CURRENT ADDRESS (Number and Street) | CITY & STATE / ZIP CODE | DATE OF BIRTH

DRIVER LICENSE NUMBER | STATE | DL TYPE | REQ. END. | BAC TEST 1 Blood 2 Breath 3 Urine 4 Refused 5 None | RESULTS % | AL/DRUG | PHYS. DEF. | RES | RACE | SEX | INJ. | S. EQUIP. | EJECT.

HAZARDOUS MATERIALS BEING TRANSPORTED 1 Yes 2 No | PLACARDED 1 Yes 2 No | RECOMMEND RE-EXAM 1 Yes 2 No If YES, Explain in Narrative | DRIVER'S PHONE NO. ( )

PASSENGER'S NAME (Additional on Continuation Page) | CURRENT ADDRESS | CITY & STATE / ZIP | AGE | LOC. | INJ. | S. EQUIP | EJECT.

#	PROPERTY DAMAGED - OTHER THAN VEHICLES	EST. AMOUNT	OWNER'S NAME	ADDRESS	CITY	STATE	ZIP
1		$					
2		$					

CONTRIBUTING CAUSES - DRIVER / PED. (1 2 3)

01 No Improper Driving / Action
02 Careless Driving
03 Failed to Yield Right-of-Way
04 Improper Backing
05 Improper Lane Change
06 Improper Turn
07 Alcohol-Under Influence
08 Drugs-Under Influence
09 Alcohol & Drugs-Under Influence
10 Followed Too Closely
11 Disregarded Traffic Signal
12 Exceeded Safe Speed Limit
13 Disregarded Stop Sign
14 Failed to Maintain Equip. / Vehicle
15 Improper Passing
16 Drove Left of Center
17 Exceeded Stated Speed Limit
18 Obstructing Traffic
19 Improper Load
20 Disregarded Other Traffic Control
21 Driving Wrong Side / Way
22 Fleeing Police
23 Vehicle Modified
77 All-Other (Explain)

VEHICLE DEFECT (1 2 3)

01 No Defects
02 Def. Brakes
03 Worn / Smooth Tires
04 Defective / Improper Lights
05 Puncture / Blowout
06 Steering Mech.
07 Windshield Wipers
08 Equipment / Vehicle Defect
77 All Other (Explain in Narrative)

VEHICLE MOVEMENT (1 2 3)

01 Straight Ahead
02 Slowing / Stopped / Stalled
03 Making Left Turn
04 Backing
05 Making Right Turn
06 Changing Lanes
07 Entering/Leaving Parking Space
08 Properly Parked
09 Improperly Parked
10 Making U-Turn
11 Passing
12 Driverless or Runaway Veh.
77 All Other (Explain in Narrative)

VEHICLE SPECIAL FUNCTIONS (1 2 3)

1 None
2 Farm
3 Police Pursuit
4 Recreational
5 Emergency Operation
6 Construction / Maintenance

LOCATION ON ROADWAY (1 2 3)

1 On Road
2 Not On Road
3 Shoulder
4 Median
5 Turn Lane / Safety Zone

PEDESTRIAN ACTION (1 2 3)

01 Crossing Not at Intersection
02 Crossing at Mid-block Crosswalk
03 Crossing at Intersection
04 Walking Along Road With Traffic
05 Walking Along Road Against Traffic
06 Working on Vehicle in Road
07 Other Working in Road
08 Standing/Playing in Road
09 Standing in Pedestrian Island
77 All Other (Explain)
88 Unknown

LOCATION TYPE

1 Primarily Business
2 Primarily Residential
3 Open Country

FIRST / SUBSEQUENT HARMFUL EVENT (F S)

01 Collision With MV in Transport (Rear-end)
02 Collision With MV in Transport (Head-on)
03 Collision With MV in Transport (Angle)
04 Collision With MV in Transport (Left Turn)
05 Collision With MV in Transport (Right Turn)
06 Collision With MV in Transport (Sideswipe)
07 Collision With MV in Transport (Backed Into)
08 Collision With Parked Car
09 Collision With MV on Other Roadway
10 Collision With Pedestrian
11 Collision With Bicycle
12 Collision With Bicycle (Bike Lane)
13 Collision With Moped
14 Collision With Train
15 Collision With Animal
16 MV Hit Sign/Sign Post
17 MV Hit Utility Pole/Light Pole
18 MV Hit Guardrail
19 MV Hit Fence
20 MV Hit Concrete Barrier Wall
21 MV Hit Bridge/Pier/Abutment/Rail
22 MV Hit Tree/Shrubbery
23 Collision With Construction Barricade/Sign
24 Collision With Traffic Gate
25 Collision With Crash Attenuators
26 Collision With Fixed Object Above Road
27 MV Hit Other Fixed Object
28 Collision With Moveable Object On Road
29 MV Ran Into Ditch/Culvert
30 Ran Off Road Into Water
31 Overturned
32 Occupant Fell From Vehicle
33 Tractor/Trailer Jackknifed
34 Fire
35 Explosion
77 All Other (Explain)

ROAD SYSTEM IDENTIFIER

01 Interstate
02 U.S.
03 State
04 County
05 Local
06 Turnpike / Toll
07 Forest Road
77 All Other

LIGHTING CONDITION

01 Daylight
02 Dusk
03 Dawn
04 Dark (Street Light)
05 Dark (No Street Light)
88 Unknown

ROAD SURFACE / CONDITION

01 Dry
02 Wet
03 Slippery
04 Icy
77 All Other (Explain)

WEATHER

01 Clear
02 Cloudy
03 Rain
04 Fog
77 All Other (Explain)

ROAD SURFACE TYPE

01 Slag / Gravel / Stone
02 Blacktop
03 Brick / Block
04 Concrete
05 Dirt
77 All Other (Explain)

CONTRIBUTING CAUSES - ROAD

01 No Defects
02 Obstruction With / Without Warning
03 Road Under Repair / Construction
04 Loose Surface Materials
05 Shoulders - Soft / Low / High
06 Holes / Ruts / Unsafe Paved Edge
07 Standing Water
08 Worn / Polished Road Surface
77 All Other (Explain)

CONTRIBUTING CAUSES - ENVIRONMENT

01 Vision Not Obscured
02 Inclement Weather
03 Parked / Stopped Vehicle
04 Trees / Crops / Bushes
05 Load on Vehicle
06 Building / Fixed Object
07 Signs / Billboards
08 Fog
09 Smoke
10 Glare
77 All Other (Explain)

TRAFFIC CONTROL

01 No Control
02 School Zone
03 Traffic Signal
04 Stop Sign
05 Yield Sign
06 Flashing Light
07 Railroad Signal
08 Officer / Guard / Flagman
09 Posted No U-Turn
10 Special Speed Zone
11 No Passing Zone
77 All Other (Explain)

SITE LOCATION

01 Not At Intersection / RR X'ing / Bridge
02 At Intersection
03 Influenced By Intersection
04 Driveway Access
05 Railroad Crossing
06 Bridge
07 Entrance Ramp
08 Exit Ramp
09 Parking Lot - Public
10 Parking Lot - Private
11 Private Property
77 All Other (Explain)

TRAFFICWAY CHARACTER

1 Straight-Level
2 Straight-Upgrade / Downgrade
3 Curve-Level
4 Curve-Upgrade / Downgrade

TYPE SHOULDER

1 Paved
2 Unpaved
3 Curb

VIOLATOR	FL STATUTE NUMBER	NAME	CHARGE	CITATION #

Page 2 of ______ Pages

FLORIDA TRAFFIC CRASH REPORT

☐ UPDATE ☐ CONTINUATION

MAIL TO: DEPT. OF HIGHWAY SAFETY & MOTOR VEHICLES
TRAFFIC CRASH RECORDS
TALLAHASSEE, FLORIDA 32399-0500

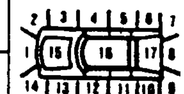
DO NOT WRITE IN THIS SPACE

COUNTY/CITY CODE	DATE OF CRASH	INVEST. AGENCY REPORT NUMBER	HSMV CRASH REPORT NUMBER

Section

DRIVER ACTION 1 Phantom 2 Hit & Run 3 N/A | YEAR | MAKE | TYPE | USE | VEH. LICENSE NUMBER | STATE | VEHICLE IDENTIFICATION NUMBER

TRAILER OR TOWED VEHICLE INFORMATION | TRAILER TYPE



POINT OF IMPACT CIRCLE AREA OF DAMAGE
18 Undercarriage
19 Overturn
20 Windshield
21 Fire
22 Trailer

VEHICLE TRAVELING N S E W | ON | At | Est. MPH | Posted Speed | EST. VEHICLE DAMAGE $ 1 Disabling 2 Functional 3 No Damage | EST. TRAILER DAMAGE $

INSURANCE COMPANY (LIABILITY OR PIP) | POLICY NUMBER | VEHICLE REMOVED BY: 1 Tow Rotation List 2 Tow Owner's Request 3 Driver 4 Other

OWNER'S FULL NAME (Check if Driver) | CURRENT ADDRESS (Number and Street) | CITY AND STATE | ZIP CODE

OWNER'S FULL NAME (Trailer or Towed Vehicle) | CURRENT ADDRESS (Number and Street) | CITY AND STATE | ZIP CODE

DRIVER (Exactly as on Driver License) / Pedestrian | CURRENT ADDRESS (Number and Street) | CITY & STATE / ZIP CODE | DATE OF BIRTH

DRIVER LICENSE NUMBER | STATE | DL TYPE | REQ. END. | BAC TEST 1 Blood 2 Breath 3 Urine 4 Refused 5 None | RESULTS % | AL / DRUG | PHYS. DEF. | RES | RACE | SEX | INJ. | S. EQUIP. | EJECT.

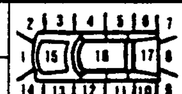
HAZARDOUS MATERIALS BEING TRANSPORTED 1 Yes 2 No | PLACARDED 1 Yes 2 No | RECOMMEND RE-EXAM 1 Yes 2 No If YES, Explain in Narrative | DRIVER'S PHONE NO. ( )

PASSENGER'S NAME (Additional on Continuation Page) | CURRENT ADDRESS | CITY & STATE / ZIP | AGE | LOC. | INJ. | S. EQUIP | EJECT.

Section

DRIVER ACTION 1 Phantom 2 Hit & Run 3 N/A | YEAR | MAKE | TYPE | USE | VEH. LICENSE NUMBER | STATE | VEHICLE IDENTIFICATION NUMBER

TRAILER OR TOWED VEHICLE INFORMATION | TRAILER TYPE



POINT OF IMPACT CIRCLE AREA OF DAMAGE
18 Undercarriage
19 Overturn
20 Windshield
21 Fire
22 Trailer

VEHICLE TRAVELING N S E W | ON | At | Est. MPH | Posted Speed | EST. VEHICLE DAMAGE $ 1 Disabling 2 Functional 3 No Damage | EST. TRAILER DAMAGE $

INSURANCE COMPANY (LIABILITY OR PIP) | POLICY NUMBER | VEHICLE REMOVED BY: 1 Tow Rotation List 2 Tow Owner's Request 3 Driver 4 Other

OWNER'S FULL NAME (Check if Driver) | CURRENT ADDRESS (Number and Street) | CITY AND STATE | ZIP CODE

OWNER'S FULL NAME (Trailer or Towed Vehicle) | CURRENT ADDRESS (Number and Street) | CITY AND STATE | ZIP CODE

DRIVER (Exactly as on Driver License) / Pedestrian | CURRENT ADDRESS (Number and Street) | CITY & STATE / ZIP CODE | DATE OF BIRTH

DRIVER LICENSE NUMBER | STATE | DL TYPE | REQ. END. | BAC TEST 1 Blood 2 Breath 3 Urine 4 Refused 5 None | RESULTS % | AL / DRUG | PHYS. DEF. | RES | RACE | SEX | INJ. | S. EQUIP. | EJECT.

HAZARDOUS MATERIALS BEING TRANSPORTED 1 Yes 2 No | PLACARDED 1 Yes 2 No | RECOMMEND RE-EXAM 1 Yes 2 No If YES, Explain in Narrative | DRIVER'S PHONE NO. ( )

PASSENGER'S NAME (Additional on Continuation Page) | CURRENT ADDRESS | CITY & STATE / ZIP | AGE | LOC. | INJ. | S. EQUIP | EJECT.

INVESTIGATOR - RANK AND SIGNATURE | ID / BADGE NUMBER | DEPARTMENT | FHP ☐ SO ☐ CPD ☐ OTHER ☐

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#	PROPERTY DAMAGED - OTHER THAN VEHICLES	EST. AMOUNT	OWNER'S NAME	ADDRESS	CITY	STATE	ZIP
1		$					
2		$					
3		$					
4		$					

CONTRIBUTING CAUSES - DRIVER / PED.

01 No Improper Driving / Action
02 Careless Driving
03 Failed to Yield Right-of-Way
04 Improper Backing
05 Improper Lane Change
06 Improper Turn
07 Alcohol-Under Influence
08 Drugs-Under Influence
09 Alcohol & Drugs-Under Influence
10 Followed Too Closely
11 Disregarded Traffic Signal
12 Exceeded Safe Speed Limit
13 Disregarded Stop Sign
14 Failed to Maintain Equip. / Vehicle
15 Improper Passing
16 Drove Left of Center
17 Exceeded Stated Speed Limit
18 Obstructing Traffic
19 Improper Load
20 Disregarded Other Traffic Control
21 Driving Wrong Side / Way
22 Fleeing Police
23 Vehicle Modified
77 All Other (Explain)

VEHICLE DEFECT

01 No Defects
02 Def. Brakes
03 Worn / Smooth Tires
04 Defective / Improper Lights
05 Puncture / Blowout
06 Steering Mech.
07 Windshield Wipers
08 Equipment / Vehicle Defect
77 All Other (Explain in Narrative)

VEHICLE MOVEMENT

01 Straight Ahead
02 Slowing / Stopped / Stalled
03 Making Left Turn
04 Backing
05 Making Right Turn
06 Changing Lanes
07 Entering/Leaving Parking Space
08 Properly Parked
09 Improperly Parked
10 Making U-Turn
11 Passing
12 Driverless or Runaway Veh.
77 All Other (Explain in Narrative)

VEHICLE SPECIAL FUNCTIONS

1 None
2 Farm
3 Police Pursuit
4 Recreational
5 Emergency Operation
6 Construction / Maintenance

LOCATION ON ROADWAY

1 On Road
2 Not On Road
3 Shoulder
4 Median
5 Turn Lane / Safety Zone

PEDESTRIAN ACTION

01 Crossing Not at Intersection
02 Crossing at Mid-block Crosswalk
03 Crossing at Intersection
04 Walking Along Road With Traffic
05 Walking Along Road Against Traffic
06 Working on Vehicle in Road
07 Other Working in Road
08 Standing/Playing in Road
09 Standing in Pedestrian Island
77 All Other (Explain)
88 Unknown

Additional Passengers / Narrative

SEC. #	PASS. #	PASSENGER NAME	ADDRESS	CITY & STATE	ZIP	Age	Loc.	Inj.	Safety Equip.	Eject

WITNESS - NAME	ADDRESS	CITY & STATE	ZIP

WAS INVESTIGATION MADE AT SCENE? 1 Yes ☐ 2 No - Where? ☐

IS INVESTIGATION COMPLETE? 1 Yes ☐ 2 No - Why? ☐

DATE OF REPORT

PHOTOS TAKEN? 1 - Yes ☐ 2 - No ☐ 3 - Investigating Agency ☐ 4 Other ☐

VIOLATOR	FL STATUTE NUMBER	NAME	CHARGE	CITATION #

FLORIDA TRAFFIC CRASH REPORT

NARRATIVE / DIAGRAM

MAIL TO: DEPT. OF HIGHWAY SAFETY & MOTOR VEHICLES
TRAFFIC CRASH RECORDS
TALLAHASSEE, FLORIDA 32399-0500

DO NOT WRITE IN THIS SPACE

EMS INFO FATALS ONLY	TIME EMS NOTIFIED AM PM	TIME EMS ARRIVED AM PM	COUNTY / CITY CODE	DATE OF CRASH	INVEST. AGENCY REPORT NUMBER	HSMV CRASH REPORT NUMBER

NARRATIVE / ADDITIONAL PASSENGERS

SEC. #	PASS. #	PASSENGER NAME	ADDRESS	CITY & STATE	ZIP	Age	Loc.	Inj.	Safety Equip.	Eject
									|	
									|	
									|	
									|	
									|	
									|	

VIOLATOR	FL STATUTE NUMBER	NAME	CHARGE	CITATION #
VIOLATOR	FL STATUTE NUMBER	NAME	CHARGE	CITATION #

WITNESS - NAME 1 — ADDRESS — CITY & STATE — ZIP

WITNESS - NAME 2 — ADDRESS — CITY & STATE — ZIP

FIRST AID GIVEN BY - NAME: 1 Physician or Nurse 2 Parametic or EMT 3 Police Officer 4 Certified 1st Aider 5 Other — INJURED TAKEN TO: — BY - NAME:

WAS INVESTIGATION MADE AT SCENE? 1 YES 2 NO — WHERE? — IS INVESTIGATION COMPLETE? 1 YES 2 NO — WHY? — DATE OF REPORT — PHOTOS TAKEN? 1 YES 2 NO 3 INVEST. AGENCY 4 OTHER

INVESTIGATOR - RANK & SIGNATURE — ID / BADGE NUMBER — DEPARTMENT — FHP SO CPD OTHER

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DIAGRAM

INDICATE NORTH
WITH ARROW

Page ________ Of ________ Pages

FLORIDA TRAFFIC CRASH REPORT

COMMERCIAL VEHICLE SUPPLEMENT

MAIL TO: DEPT. OF HIGHWAY SAFETY & MOTOR VEHICLES
TRAFFIC CRASH RECORDS
TALLAHASSEE, FLORIDA 32399-0500

DO NOT WRITE IN THIS SPACE

COUNTY/CITY CODE	DATE OF CRASH	INVEST. AGENCY REPORT NUMBER	HSMV CRASH REPORT NUMBER

DO NOT COMPLETE THIS FORM UNLESS ONE OR MORE QUALIFYING VEHICLES WAS INVOLVED, AND ONE OR MORE OF THE FOLLOWING OCCURRED:

1. ONE OR MORE PERSONS SUSTAINED A FATAL INJURY OR WAS TRANSPORTED FOR TREATMENT
2. ONE OR MORE VEHICLES WAS TOWED FROM THE SCENE
3. ONE OR MORE VEHICLES WAS PROVIDED ASSISTANCE

QUALIFYING VEHICLES: Trucks with 6 or more Tires or HAZ MAT Placard ☐ Buses Designed To Carry 16 or more Persons ☐

PERSONS: Sustaining Fatal Injuries ☐ Transported For Immediate Medical Treatment ☐

VEHICLES: Provided Assistance or Towed From the Scene Due to Damage ☐

Section I

CARRIER'S NAME

SOURCE ☐
1. Shipping Papers
2. Vehicle Side
3. Driver
4. Other

ADDRESS (Number and Street) CITY STATE ZIP

IDENTIFICATION NUMBERS: U S DOT ☐☐☐☐☐☐☐ ICC MC ☐☐☐☐☐☐ NONE ☐

STATE NUMBER ☐☐☐☐☐☐☐☐☐ STATE ☐☐

GROSS VEHICLE WEIGHT RATING
Truck, Tractor or Bus ☐☐☐☐☐
Trailer or Trailers (Total) ☐☐☐☐☐
Total Number of Axles (Incl. Trailers) ☐☐

CARGO BODY TYPE ☐
1. Bus
2. Van / Enclosed Box
3. Cargo Tank
4. Flat Bed
5. Dump
6. Concrete Mixer
7. Auto Transport
8. Garbage or Refuse
9. Other

VEHICLE CONFIGURATION ☐
0. Any 4-Tire Vehicle
1. Bus
2. Single Unit Truck (2 Axle / 6 or more Tires)
3. Single Unit Truck (3 or more Axles)
4. Truck with Trailer
5. Truck Tractor Only (Bobtail)
6. Tractor with Semi-Trailer
7. Tractor with Double Trailers
8. Tractor with Triple Trailers
9. Other - Unable To Classify

HAZARDOUS MATERIAL INVOLVEMENT
Did Vehicle Have a Hazardous Material Placard? ☐
1. Yes 2. No
If "YES", from Placard Indicate Name or 4-Digit Number From Diamond or Box
____

1 Digit Number From Bottom of Diamond ☐

Was Hazardous Material Released From This Vehicle's Cargo? ☐
1. Yes 2. No

SEQUENCE OF EVENTS (FOR THIS VEHICLE)

EVENT # 1 ☐☐ EVENT # 2 ☐☐ EVENT # 3 ☐☐ EVENT # 4 ☐☐

11. Ran Off Road
12. Jackknifed
13. Overturned or Rollover
14. Downhill Runaway
15. Cargo Loss or Shift
16. Explosion or Fire
17. Separation of Units
19. Other Events

COLLISION INVOLVING:
21. Pedestrian
22. Motor Vehicle in Transport
23. Parked Vehicle
24. Train
25. Pedalcycle
26. Animal
27. Fixed Object
29. Other Object

Section II

CARRIER'S NAME

SOURCE ☐
1. Shipping Papers
2. Vehicle Side
3. Driver
4. Other

ADDRESS (Number and Street) CITY STATE ZIP

IDENTIFICATION NUMBERS: U S DOT ☐☐☐☐☐☐☐ ICC MC ☐☐☐☐☐☐ NONE ☐

STATE NUMBER ☐☐☐☐☐☐☐☐☐ STATE ☐☐

GROSS VEHICLE WEIGHT RATING
Truck, Tractor or Bus ☐☐☐☐☐
Trailer or Trailers (Total) ☐☐☐☐☐
Total Number of Axles (Incl. Trailers) ☐☐

CARGO BODY TYPE ☐
1. Bus
2. Van / Enclosed Box
3. Cargo Tank
4. Flat Bed
5. Dump
6. Concrete Mixer
7. Auto Transport
8. Garbage or Refuse
9. Other

VEHICLE CONFIGURATION ☐
0. Any 4-Tire Vehicle
1. Bus
2. Single Unit Truck (2 Axle / 6 or more Tires)
3. Single Unit Truck (3 or more Axles)
4. Truck with Trailer
5. Truck Tractor Only (Bobtail)
6. Tractor with Semi-Trailer
7. Tractor with Double Trailers
8. Tractor with Triple Trailers
9. Other - Unable To Classify

HAZARDOUS MATERIAL INVOLVEMENT
Did Vehicle Have a Hazardous Material Placard? ☐
1. Yes 2. No
If "YES", from Placard Indicate Name or 4-Digit Number From Diamond or Box
____

1 Digit Number From Bottom of Diamond ☐

Was Hazardous Material Released From This Vehicle's Cargo? ☐
1. Yes 2. No

SEQUENCE OF EVENTS (FOR THIS VEHICLE)

EVENT # 1 ☐☐ EVENT # 2 ☐☐ EVENT # 3 ☐☐ EVENT # 4 ☐☐

11. Ran Off Road
12. Jackknifed
13. Overturned or Rollover
14. Downhill Runaway
15. Cargo Loss or Shift
16. Explosion or Fire
17. Separation of Units
19. Other Events

COLLISION INVOLVING:
21. Pedestrian
22. Motor Vehicle in Transport
23. Parked Vehicle
24. Train
25. Pedalcycle
26. Animal
27. Fixed Object
29. Other Object

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DEFINITIONS

TRUCK — A MOTOR VEHICLE DESIGNED, USED OR MAINTAINED PRIMARILY FOR THE TRANSPORTATION OF PROPERTY. FOR THE PURPOSE OF THIS FORM THE VEHICLE MUST ALSO MEET ONE OF THE FOLLOWING CRITERIA:

HAVE AT LEAST 6 TIRES ON THE GROUND
or
CARRY A HAZARDOUS MATERIAL PLACARD

BUS — A MOTOR VEHICLE PROVIDING SEATS FOR 16 OR MORE PERSONS INCLUDING THE DRIVER AND USED PRIMARILY FOR THE TRANSPORTATION OF PERSONS.

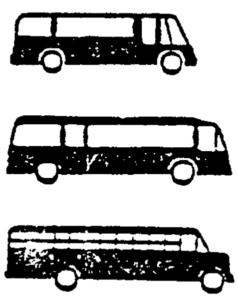
TRAILER — A NON-POWER VEHICLE TOWED BY A MOTOR VEHICLE.

REPORTABLE CRASH — A TRAFFIC CRASH REQUIRED TO BE REPORTED IN WRITING BY A LAW ENFORCEMENT OFFICER TO THE DEPARTMENT OF HIGHWAY SAFETY AND MOTOR VEHICLES INVOLVING ONE OR MORE TRUCKS OR BUSES (AS DEFINED ABOVE) WHICH RESULTS IN:

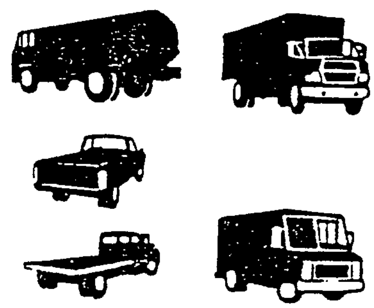
- ONE OR MORE FATALITIES
  or
- ONE OR MORE NON-FATAL INJURIES REQUIRING TRANSPORTATION FOR THE PURPOSE OF OBTAINING IMMEDIATE MEDICAL TREATMENT
  or
- ONE OR MORE OF THE VEHICLES BEING REMOVED FROM THE SCENE AS A RESULT OF DISABLING DAMAGE
  or
- ONE OR MORE VEHICLES REQUIRING INTERVENING ASSISTANCE BEFORE PROCEEDING UNDER ITS OWN POWER.

TYPICAL VEHICLE SILHOUETTES

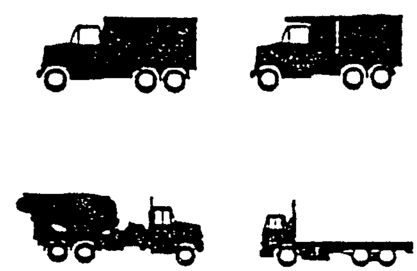
1. BUS



2. SINGLE UNIT TRUCK - 2 AXLE / 6 TIRE



3. SINGLE UNIT TRUCK - 3 AXLE



4. TRUCK WITH TRAILER

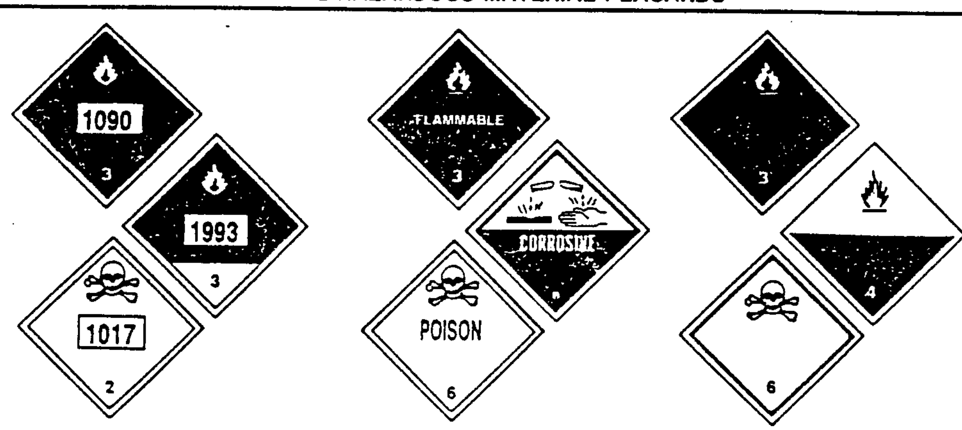
5. TRUCK TRACTOR (BOBTAIL)

6. TRACTOR WITH SEMI-TRAILER

7. TRACTOR WITH DOUBLE TRAILERS

8. TRACTOR WITH TRIPLE TRAILERS

TYPICAL HAZARDOUS MATERIAL PLACARDS



APPENDIX F

MILLION VEHICLE MILES BY ROADWAY CLASS AND CATEGORY

Road Type	Divided Roadways				Undivided Roadways			
	Urban Roads	Miles	Rural Roads	Miles	Urban Roads	Miles	Rural Roads	Miles
Less Than 3 Lanes	1,948.44	363.67	1,348.22	632.51	4,338.05	988.41	7,216.60	4,426.51
3 Lanes	231.23	29.18	17.14	5.03	363.72	66.45	38.02	13.32
4 Lanes	20,400.63	1,952.91	4,412.28	948.78	4,162.64	500.65	1,006.95	254.96
5 Lanes	538.24	41.20	1.77	0.47	27.93	3.36	0.00	0.00
6 or More Lanes	11,330.35	726.81	96.93	12.15	655.15	47.22	0.00	0.00
Main Interestate	8,728.08	510.35	9,546.46	965.39	0.00	0.00	0.00	0.00
Other Interestate	98.93	9.57	0.00	0.00	4.58	1.49	1.19	0.00
Main Turnpike	2,274.89	209.64	1,188.52	166.85	0.00	0.00	0.00	0.00
Other Turnpike	10.84	0.80	8.20	1.96	0.00	0.00	0.00	0.00

U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Technical Information Service
Springfield, VA 22161 (703) 605-6000