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16. Abstract

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CONCEPTUAL STRATEGIC ARTERIAL STREET SYSTEM FOR HARRIS COUNTY

by

William V. Ward

Research Report Number 428-1F

Research Project 3-10-88/0-428

The Effect of Mobility and the Cost-Effectiveness of Improving a Selected System of Arterial Thoroughfares in Harris County

conducted for

Texas State Department of Highways and Public Transportation

by the

CENTER FOR TRANSPORTATION RESEARCH

Bureau of Engineering Research
THE UNIVERSITY OF TEXAS AT AUSTIN

February 1990

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There was no invention or discovery conceived or first actuallly reduced to practice in the course of or under this contract, including any art, method, process, machine, manufacture, design or composition of matter, or any new and useful improvement thereof, or any variety of plant which is or may be patentable under the patent laws of the United States of America or any foreign country.

PREFACE

This report outlines the findings of Research Study 3-10-88/9-428, "The Effect on Mobility and the Cost-Effectiveness of Improving a Selected System of Arterial Thoroughfares in Harris County." This study was conducted jointly by representatives from Harris County, the City of Houston, the Texas State Department of Highways and Public Transportation, the Metropolitan Transit Authority, and the Center for Transportation Research at The University of Texas at Austin. The Center supervised the study and performed the operational and economic assessments of the thoroughfares and corridors selected for study. The other agencies recommended candidate thoroughfares and corridors for study, furnished planning data, and advised the Center during the course of the study, as well as reviewed the findings. The cooperation and contributions of all involved are acknowledged and are greatly appreciated.

William V. Ward

Austin, Texas
February 1990

ABSTRACT

This study proposes a conceptual system of 490 miles of *improved* arterial streets for Harris County, Texas. This system, which has been named the Strategic Arterial Street System (SASS), is proposed to supplement and expand the countywide *high-quality* traffic services now supplied by the freeway system. The stimulus for considering a supplemental and alternative transportation system is the anxiety of diminishing mobility due to future increasing traffic demands on the freeway system. Declining mobility is seen as detrimental to the future growth of the county, especially in growth areas not conveniently served by the existing or planned freeway system. A computer simulation of a 492-mile improved arterial street system, very similar to the proposed 490-mile SASS, shows that improving the capacity and speed of the arterials will divert a significant amount of traffic from the freeway system and the other arterials. The conceptual geometric design and operational scheme for the SASS proposes median-divided separated roadways, no left turns, grade separations, partial control of access, 40 to 50-mph design speed, and priority treatment for the strategic arterial traffic at infrequently spaced signalized intersections. The conceptual SASS is estimated to cost between $2.5 and $3.0 billion. Analysis shows that upgrading a typical segment of ordinary urban street to SASS standards will be cost-effective. The critical factor in establishing a SASS will be prioritization of route selection in anticipation of future urbanization and reserving adequate amounts of rights-of-way at the right place at the right time.

SUMMARY

In twenty to thirty years the population and motor vehicle registrations in Harris County are projected to increase from 1,500,000 to 2,000,000. Declining mobility will become a serious problem if sufficient traffic services are not provided to sustain this enormous growth.

Harris County's extraordinary growth has, to a large extent, been a fulfillment of the investment in the freeway system which currently handles about 42 percent of all the vehicle miles traveled on about 2 percent of all the roads and streets in the county. The freeway system in Harris County carries a larger share of the county's total traffic than do freeway systems in other populous urban counties. The existing freeway system as a whole is operating near tolerable capacity, and many segments sustain severe and prolonged congestion during the peak traffic periods. Although an intensive freeway improvement program is underway to restore mobility after a ten-year decline, there is a question whether the freeway system, largely planned in the 1950's and early 1960's, will be able to accommodate the demand for *high-quality* traffic services twenty to thirty years in the future. There is evidence that part of the freeway congestion problem stems from motorists dependent upon freeways for the shorter-length trips which could be accommodated on alternate routes, if available.

A plausible means of supplementing and extending the function of the freeway system would be to upgrade a selected countywide system of arterial streets. The function of this system would be to provide high-quality traffic service for short to medium (2 to 7-mile) trip lengths. This study proposes a conceptual 490-mile system of upgraded arterial streets designed to provide reliable high-quality traffic service. This service is intended to supplement freeway service and to provide service in areas of the county not conveniently accessible to the existing or planned freeway system. This conceptual system has been titled the Strategic Arterial Street System (SASS) in order to distinguish it from other systems of arterial roads and streets programmed and planned by the State Department of Highways and Public Transportation.

A computer simulation, of a 492-mile selected network of *improved* arterial streets, showed that such a system would divert a significant amount of traffic from the freeway system and from the other arterials. The simulation was based on an operating speed 5 to 10 miles per hour faster for the improved arterials than for the other arterials included in the simulation. The simulation also assumed a twenty-year projection (year 2010) of traffic growth and completion of all freeway improvements that are currently planned. The simulated network is very similar to the proposed 490-mile conceptual SASS.

The conceptual design and operational scheme for the SASS proposes design speeds of 40 to 50 mph, median-barrier-separated roadways, no left turns, grade separations at railroads and at some cross streets, partial control of access, and favored treatment for the Strategic Arterial Street (SAS) traffic where non-grade-separated signalized intersections occur. Also recommended is an auxiliary traffic lane, to the driver's right, to function as an emergency lane and a speed-change lane to facilitate traffic exiting and entering the SAS. It is expected that the SAS designed to these standards can accommodate up to 50,000 ADT at average speeds of 40 mph and peak-hour speeds of 35 mph.

The estimated cost of the conceptual 490-mile SASS ranges between $2.5 and $3.0 billion. The lower estimate assumes the minimum number of grade separations necessary to enhance travel speed and reliability so that the SASS will have a significant impact on mobility. The higher estimate provides for additional grade separations which may be desirable to ensure that the system be more reliable and productive. Analysis of a typical segment of a SAS shows that even for moderate levels of traffic demand, investments in upgrading ordinary streets to SAS standards should be cost-effective.

The conceptual SAS is *not* a freeway although, as conceived, it does have some of the attributes of a freeway. The primary differences are lower design speed, only partial control of access, and some concessions for infrequently-spaced signalized non-grade-separated intersections. The estimated cost is from $5.1 to $6.1 million per mile, which is about one-half or less of the cost of a new freeway. It is also estimated that the traffic service productivity of a SAS is about one-half to two-thirds of that of a freeway exhibiting the same number of traffic lanes.

Right-of-way requirements for the SAS are less than half those generally required for new freeways. This can be of predominant importance in planning for future street systems, considering the perpetual difficulties in reserving adequate amounts of rights in rapidly growing urban areas. The SAS concept is also adaptable to stage construction, thereby deferring large initial investments until traffic demands justify additional improvements.

The most important action to be taken with respect to improving mobility and providing high-quality traffic services for future growth is *reserving or acquiring adequate rights-of-way.*

TABLE OF CONTENTS

V. COST AND COST-EFFECTIVENESS

I. INTRODUCTION

THE PROBLEM

Declining traffic mobility is a serious problem in Houston and Harris County. Within Harris County, the freeway system is the critical element in delivering mobility, providing traffic service for over 40 percent of the vehicle miles traveled in the county. Many segments of this freeway system, which comprises only about 2 *percent* of the total road and street mileage in the county, have become overloaded with traffic. Freeway traffic service is being further diminished by the rehabilitation construction work becoming increasingly necessary as some parts of the freeway system are approaching the end of—and some have transcended—their physical design lives.

For various reasons, freeway planning and construction have not kept up with the demand for freeway services. The interactions of population growth, land use, political constraints, increases in energy costs, environmental constraints, increased construction costs, and declining funds for highway improvements have coalesced to restrain the planning and construction of new freeway facilities and the expansion of existing facilities. The historical result is a geographically limited network of freeways incorporating many overloaded segments offering limited scope for capacity improvement which must continue to serve a growing urban population. Furthermore, it may not be feasible to increase the capacity of many segments of the freeway system in Harris County sufficiently to provide a desirable level of traffic movement during peak traffic periods or to extend freeway service within a convenient distance of much of the population within many of the new growth areas of Harris County.

A POSSIBLE SOLUTION?

A plausible approach to restoring and improving mobility would be to increase the supply of high-quality traffic service along *other* roads and streets as a means of supplementing the area-wide service furnished by the freeway system and to accommodate the unfulfilled demand for high-quality traffic service in those areas not conveniently accessible to the freeway system. It is recognized that in Harris County, as compared to other U.S. urban areas of similar size and population density, the arterial streets are accommodating a smaller proportion of the vehicle trip demands. It is probable that because of deficiencies in the arterial street system, some freeway congestion is caused by too many motorists using the freeway system for shorter trips which should be attracted by and diverted to arterial streets.

The supply of area-wide high-quality traffic service can be increased by constructing and otherwise improving a *selected* system of long uninterrupted arterial thoroughfares. These can be planned and designed to intercept potential freeway users and provide acceptable alternate travel routes for vehicle trips of about 10 miles or less and to improve traffic service in those areas not readily serviced by the freeway system. These arterial thoroughfares, in order to be effective, need to be constructed to design standards and operated in a manner that would produce trip times that make the arterials as desirable to use as the freeway system, at least during peak traffic periods. Desirable standards postulate such characteristics as the proximity of the arterials to aggregated origins and destinations of trip demands; adequate traffic capacity; good geometric design; progressive signalization; uniform quality of design along each route; route continuity with lengths of perhaps 4 miles or more; management of access control; consideration for public transit; and grade separations at railroad crossings and critical cross-street intersections. The recognition of the enormous economic benefits derived from the operations of the freeway system as well as those derived from other isolated highway and street improvements in Houston and Harris County strongly counsels that investing in the construction of a *system* of selected arterial thoroughfares would be cost-effective.

OBJECTIVES OF STUDY

The objectives of this study were to:

(1) estimate the effect on traffic mobility and the cost-effectiveness of increasing
    (a) the traffic capacity,
    (b) the scope, and
    (c) the range of selected arterial thoroughfares;
(2) recommend certain thoroughfares for improvements;
(3) recommend the level of physical improvements for the selected thoroughfares; and
(4) furnish an estimate of the construction costs of recommended improvements.

SCOPE OF STUDY

In pursuing the objectives of this study it should be recognized that the resources allocated to the study were limited and that the quality, scope, and depth of the findings were dependent largely on the *availability and convenient access* to *existing* highway planning data and suitable computer tools to perform the operational and economic analysis. The types of information necessary to this study were traffic flow characteristics, trip origins and destinations, land use, demographics, cadastral details, utilities, road and street geometrics, pavement physical condition, drainage quality, construction costs, etc. This study does not propose to collect any additional field data or to develop new computer models.

Digital computers can, with suitable programs, be used to manage and process the large quantities of data needed to characterize and analyze the operations of a large road and street network. Developing such a computer program, customized for Harris County, would be expensive and was beyond the scope of this study. The findings of the subject study may also be limited because of the lack of credible trip origin and destination (O & D) data. The last comprehensive area-wide O & D study performed in Harris County was in 1953, with an update in 1960. A new O & D study would be very expensive and was also beyond the scope of this project, which had to rely on other sources of data in order to estimate trip demands on thoroughfares.

Resources limited the subject study to using planning data compiled by other agencies as a consequence of their transportation planning responsibilities. There appears to be sufficient planning information available concerning the existing road and street facilities to satisfy the limited objectives of this study.

The engineers and planners contributing and participating in this study are capable and experienced and have broad knowledge of the physical and operational assets and deficiencies in the Harris County road and street network. This knowledge and experience was used as a resource in examining and recommending thoroughfare alternatives and planning input data. The counsel, suggestions, and knowledge acquired from the participants and contributors, coupled with the judicious use of relatively simple computer tools, produced useful and convincing guidance in planning and scoping a selected system of arterial thoroughfares and otherwise assessing the feasibility and desirability of constructing a selected system of thoroughfares as envisioned herein.

DEFINITIONS

This study focused on a class and network of urban arterial streets whose intended function is to serve high volumes of traffic and longer trip demands while carrying a high proportion of the total urban travel on a minimum of street mileage. These arterials are also intended to accommodate a significant proportion of intra-regional travel, such as commuter trips between suburban residential areas and suburban business-shopping centers, and to provide bypass routes around the central city and other high-activity centers. For the purposes of this study the conceptual class of streets so addressed, as a network, is called the STRATEGIC ARTERIAL STREET SYSTEM (SASS), and individually or severally as STRATEGIC ARTERIAL STREET(S) (SAS). This description has been coined, upon the advice and consent of the steering committee of this study, in order to distinguish facilities *addressed by this study* from those arterial streets included within the SDHPT's PRINCIPAL ARTERIAL STREET SYSTEM (PASS), of which particular segments may be included in the SASS network. The word *strategic*, as used in this study, conforms to one of Webster's definitions as: "of great importance within an integrated whole or to a planned effect." The strategic arterial street system addressed by this study is intended to be a part of the *principal arterial system* in Harris County.

The American Association of State Highway and Transportation Officials (AASHTO) in their 1984 edition of *"A Policy on Geometric Design of Highways and Streets"* classifies highways in urban areas by *functional* systems, as a hierarchy, from those providing the highest-quality traffic service to those providing the least-quality: principal arterials, minor arterials, collector roads, and local roads. Components of the principal arterial system are further sub-stratified as (1) interstates, (2) other freeways and expressways, and (3) *other principal arterials (with partial or no control of access)*. The arterial street system envisioned in this study would for the most part be considered as subset (3).

The term "superstreet" is commonly used in describing the higher types of street improvements which provide not only increased traffic capacity, but increased travel speeds, reliability of operations, and range of service. Obviously, whether a street is truly "super" is in the eye of the beholder and is intended to convey the idea of a street delivering traffic service of a quality significantly higher than the prevailing community standard but less than that expected from a freeway of adequate capacity. If it were otherwise, such streets would be called *freeways* for the purposes of soliciting political and public endorsement, with which the public is intimately familiar. The term "superstreet," which succinctly promises much and evokes a vision of some higher form of urban street travel, may have been first coined by the Orange County, California, Transportation Commission in the mid-1970's in order to call attention to, and promote improvements to, some principal arterial thoroughfares. More specifically, the Orange County concept is to upgrade some principal arterials by widening intersections and re-striping, improving traffic signal coordination, closing median openings, consolidating driveways, controlling access, installing grade separations at critical intersections, and adding lanes along some segments.

Other terms that have been used are "principal arterials," "high-flow arterials," "continuous-flow boulevards," "regional arterials," and "regional thoroughfares." In any case the idea is to designate and set apart this particular quality of street for purposes of identification and discussion, although physically and functionally these alternate designations are intended to convey the idea of a road facility conforming to subset (3) in the above paragraph: *other principal arterials (with partial or no control of access).*

The SDHPT has adopted the term Principal Arterial Street System (PASS) in describing one of its funding programs designed to improve traffic operations along arterial streets in urban areas. As mentioned previously, the term Strategic Arterial Street System (SASS) has been adopted for the purposes of this study to distinguish the facilities and network addressed by this study from other similar facilities on the SDHPT's Principal Arterial Street System and any other designated arterial network.

II. GENERAL CONCEPT

STRATEGIC ARTERIAL STREET SYSTEM

The concept of a strategic arterial *street* system for Houston-Harris County is, in this study, considered as a *selected* network of roads and streets which are planned and designed to supplement the regional and sub-regional traffic services furnished by the freeway system and to accommodate the demand for long trip services in those areas of the county not conveniently served by the freeway system. The strategic arterial *street* system is also considered as a component of the *principal arterial street system*, which, according to the AASHTO definition given in Part II of this study, comprises both freeways and *other principal arterials (with partial or no control of access).*

NEED

It was postulated in Chapter I that a plausible solution to the problem of diminishing mobility in Harris County would be to increase the supply of traffic service and otherwise supplement the service furnished by the freeway system by improving both the quality and quantity of traffic service along other roads and streets. The regional transportation system is short of *high-quality* road and street facilities. There are about 16,000 centerline miles of freeways, arterial streets, collector roads, and local streets in Harris County, and of these about 2 percent (300 miles) of the total mileage are freeways. About 12 percent (1,900 miles) are a collection of minor and principal arterials, and about 4 percent (700 miles, included in the 1,900 miles) are roads and streets having contiguous lengths of 4 miles or longer which may function as principal arterials even though the quality of traffic service provided may not be uniformly adequate. The freeways carry over 40 percent of the vehicle miles traveled in the county and the 4-miles-plus arterials carry about 20 percent. It is apparent that a small part of the total road and street network serves most of the traffic. Increasing the supply of traffic services along the arterial routes means incrementing and increasing the efficiency of a relatively small part of the total road and street system.

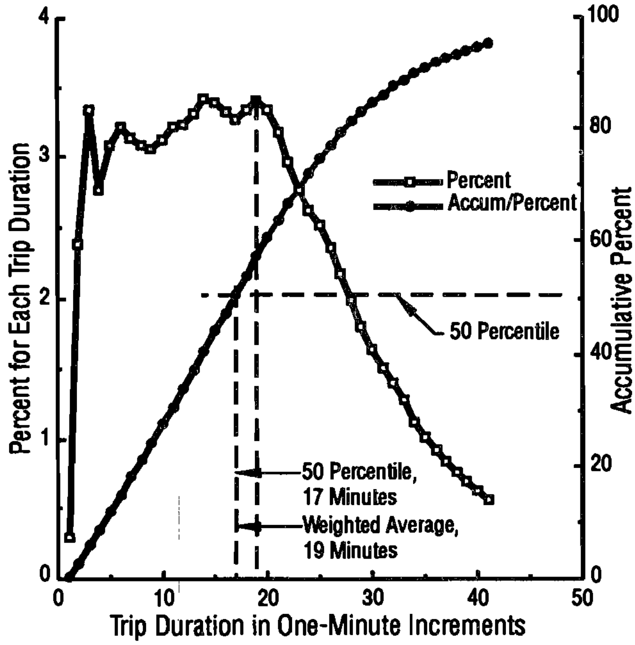
Studies of vehicular travel in the Houston area and other large urban areas indicate that the freeways in Houston and Harris County carry a larger share of the total areal traffic and the arterial streets carry a smaller share than in the other urban areas. The implication is that Houston and Harris County are more dependent on the freeway system than other cities and that the present network of roads and streets is not attracting a sufficient share of the total vehicle miles traveled within the county. It is further postulated in this study that it may be cost-effective to so improve a selected portion of the numerous road and street routes within the county that the selected routes will *attract* more traffic.

FUNCTION OF A PRINCIPAL ARTERIAL STREET

The function of a principal arterial street is to provide high-quality traffic service. For transportation planning purposes, according to AASHTO policy, highways should be functionally classified, or grouped, according to the quality of service they provide. Consequently, freeways, which are a part of the principal arterial system and provide the highest-quality service, are at the top of the rating hierarchy and local streets are at the bottom. Within a functional classification system, standards and levels of service vary according to the function of the highway facility. The strategic arterial street *system* proposed in this study, which is composed of selected streets designated as *principal arterials*, is assumed to provide a quality of service less than that provided by the freeway system but better than that provided by other arterials.

Functional classification is also related to trip length. Freeways handle the longest trips, principal arterials the next longest, and so on. In 1984 the Houston-Galveston Regional Area Council (HGAC) conducted a regional telephone survey and found that within the Houston urbanized area the average vehicular (personal cars or pickups) trip length was about 7 miles and the average work or commute trip was about 11 miles. Consequently, the 55 to 60 million vehicle miles traveled each day in 1988 in Harris County represent about 8 or 9 million discrete trips. Planners for the HGAC also derived trip duration (travel time) frequencies, for various categories of trip purposes, from the 1980 census data. These travel data were compiled from telephone poll samples and from travel logs maintained by selected participants. The results for the home-to-work trip are displayed in Figure 2.1 (page 5).

The 11-mile average for a home-to-work trip agrees closely with the average 19-minute trip duration and produces an average speed of 35 mph. The 19-minute trip represents the average during the entire work day. Work-trip durations during the morning and afternoon peak traffic periods would be substantially longer and the average speeds substantially less. It is apparent that if a strategic arterial is to be effective it should be of sufficient length to attract a significant portion of the demand for trips of 7 miles or longer.



Frequency Distribution

Trip Lengths - Harris County

(From HGAC study; derived from 1980 census data)

Figure 2.1

TRIP DEMAND

Vehicle trips are generated because the highway user perceives the value of the trip to be greater than the cost. Excluding trips which are generated for the sheer pleasure of traveling, if such is possible nowadays, an economic transaction takes place where the value of the trip is presumed to be greater than the cost. The demand for a trip may exist without the consequent event because the user perceives the trip not to be worth the time, the cost, and the risk. The demand for a 10-mile trip *might be* fulfilled if all or part of the trip could be accomplished using a principal arterial and *might not be* if a principal arterial were not available. On the other hand, a street of a lower quality would be sufficient to satisfy the demand for a 1 or 2-mile trip. Consequently, higher quality road and street facilities such as principal arterials may, in addition to diverting traffic from other arterials, also generate trips that otherwise would not be made.

To the economist, a highway user perceives a trip to have both a value and a cost. The probability of a trip being taken is proportional to the ratio of the value to the cost, and is usually referred to as the *demand elasticity.* The demand for a trip increases if the cost of the trip decreases or if the value of the trip increases. Perceptions change, however, which is a human characteristic, and consequently the likelihood that any particular trip will be taken for a given purpose should be viewed as a probability. As an example, this probability can be high in the case of the home-to-work trip. In this case, the value of the trip is considered high, and in the short term is almost *inelastic* with respect to cost. Another way of describing the inelasticity of the work trip is to say that it will be taken, in the short run, almost without regard to cost. Those making such trips may be able to modify their trip starting times to avoid congestion but, in general, work trips cannot be cancelled and can be modified only with respect to times of departure, which in turn will "stretch out" the period of peak traffic flow. The provision of improved arterial streets can be expected to ease peak flows of existing traffic and generate new trips in the off-peak hours. Therefore trip demand will have both existing and generated traffic components.

QUALITY OF SERVICE

Quality of service is attributed to (1) range of service, (2) travel time, (3) reliability of operations, and (4) safety. The first of these attributes, range of service, is a result of street length and geographical location. An arterial should be sufficiently long to attract average (say 7-mile) and longer trip demands and should be located so that it is convenient to trip origins and destinations. Determining the location of arterial streets for existing and future mobility needs is a function of areal and regional planning. Arterial streets have a strong potential for attracting high-activity commercial developments. These developments can lead to expensive improvements that may conflict with the ensuing plans to upgrade and widen an existing street to improved arterial standards. Of particular importance is the establishment of building lines such that subsequent arterial street right-of-way needs will not result in extraordinary costly damages to abutting property. Orderly and efficient land use development and mobility improvements mandate the establishment of arterial design standards so that future land developments can accommodate the high-quality arterial street design standards.

The last three attributes (travel time, reliability of operations, and safety) are closely related and mutually supporting in that improving one attribute generally results in improving the others. These attributes are in turn a result of geometric design, traffic operations control, access control or management, drainage design, and structural design factors. The question is, how difficult will it be to install a principal arterial street having all the desired attributes? Answers to this question require insight into the factors influencing the desired attributes and are discussed in the following paragraphs.

GEOMETRIC DESIGN

Travel time is influenced by intrinsic design features such as street alignment, traffic signalization, number of lanes, median design, provisions for one-way street pairs where existing street patterns and land use permit, provisions for grade separations, bus transit facilities, pedestrian facilities, and intersection design. Intersection design is a critical feature in the design of urban arterial streets because of the significant influence such design has on the quality and efficiency of traffic operations. Intersection design is a function of roadway configuration and delineation, traffic signal arrangements and operations, and signing. Good intersection design enhances left and right-turn movements, bus transit operations, and pedestrian movements.

The key to improving the quality of traffic service along most urban roads or streets is to improve the vehicular throughput of the intersections. Such improvement might entail providing a grade separation, closing a crossing street, channelizing traffic, providing turning lanes, providing U-turns, or denying street access near the intersection. Unfortunately, property near or abutting street intersections is often considered prime commercial property, and some types of intersection improvements may divert traffic from corner properties and/or require the taking of additional corner property. These actions to improve the quality of traffic flow in the public interest may be regarded as a threat by the owners and tenants of such property. Contrarily, increases in traffic due to intersection improvements may affect mid-block residential areas *un*favorably.

The installation of a principal arterial street requires very few if any innovations in design and construction. What it does require is the *application* of those design standards and features consistent with AASHTO policy and with the large reservoir of local experience known to be effective. Innovation in design and construction will usually result as a consequence of adapting the appropriate policies and experiences to the local environment.

TRAFFIC OPERATIONS CONTROLS

Arterial street operations can be significantly improved by the proper design and operation of a supporting traffic signal system. The traffic *capacity* of a signalized arterial street is primarily proportional to the number of traffic lanes and the *amount of green signal time* allocated to those lanes and is affected to some degree by other traffic operations which might interfere with traffic flow along the arterial. The average traffic *speed* along an arterial is primarily a function of the *frequency* and duration of stops. The duration of stops are in turn influenced by intersection geometric design and traffic signal operations.

This is illustrated by the set of curves in Figure 2.2 (page 7), which shows the trajectory of a single vehicle traveling along a 4-mile stretch of arterial highway and the effect of introducing one or more stops. Assuming the desirable maximum driving speed along this street is 45 mph, one stop of 20 seconds' duration, plus the time lost due to deceleration from and acceleration to 45 mph, reduces the average driving speed to 40 mph. Three stops reduce the average driving speed to 32.7 mph. Assuming that the 20-second stop time represents about 25 percent of a signal cycle length of 90 seconds (which includes the "change interval," or yellow time between the green and red phases) at each of the signalized intersections along the arterial represented in Figure 2.2, then the productivity of the street or its traffic capacity is also reduced by about 25 percent. Actually a stream of vehicles would behave similarly to the single vehicle assumed in Figure 2.2, except that the average speed of all the vehicles in the stream would be somewhat less because of the interference of the competing vehicles. A further reduction in the speed of a stream of traffic would occur if the intersection capacity or amount of green time along the arterial is not sufficient to accommodate the traffic demand. If there is insufficient green time at a signalized intersection to clear queueing traffic, additional delays would occur due to the vehicles forced to wait for the next green signal, which in turn would reduce the average speed along the arterial.

Freeways represent the ideal arterial wherein all crossing traffic is eliminated and the freeway in effect is allocated 100 percent of the green time. Other freeway operational friction is reduced by channeling ingress and egress through entrance and exit ramps. It follows that the closer the operations of an arterial can be made to approach those of a freeway, the higher the quality of service that can be furnished.

AASHTO policy suggests that principal arterials should provide peak-period operating speeds of 35 to 40 mph and off-peak speeds of 45 to 55 mph. Operating speed, as differentiated from the legal speed limit, is a function of geometric design and access control. Operating standards should require that the traffic using arterials be allocated a higher priority than that on crossing streets.

There is a limit to what may be accomplished by even the most sophisticated traffic control devices and systems. Where principal arterials and other heavily trafficked streets intersect at grade, traffic operations along the crossing streets may become intolerable if the principal arterial is given favored treatment. In this case, provisions for installing a grade-separated interchange should be considered.

ACCESS CONTROL OR MANAGEMENT

Travel time and reliability of service are also influenced by the degree of access control. Freeways operate reliably and efficiently because ingress and egress is relatively infrequent and rigorously controlled. It is axiomatic that the quality of freeway operations is proportional to the spacing of the entrance and exit ramps. However, freeways would be of little utility to the user if they were totally inaccessible, and consequently good freeway design is a result of trade-offs between the convenience and utility to the highway users and the quality of traffic operations. Similarly, traffic operations along other road and street facilities not

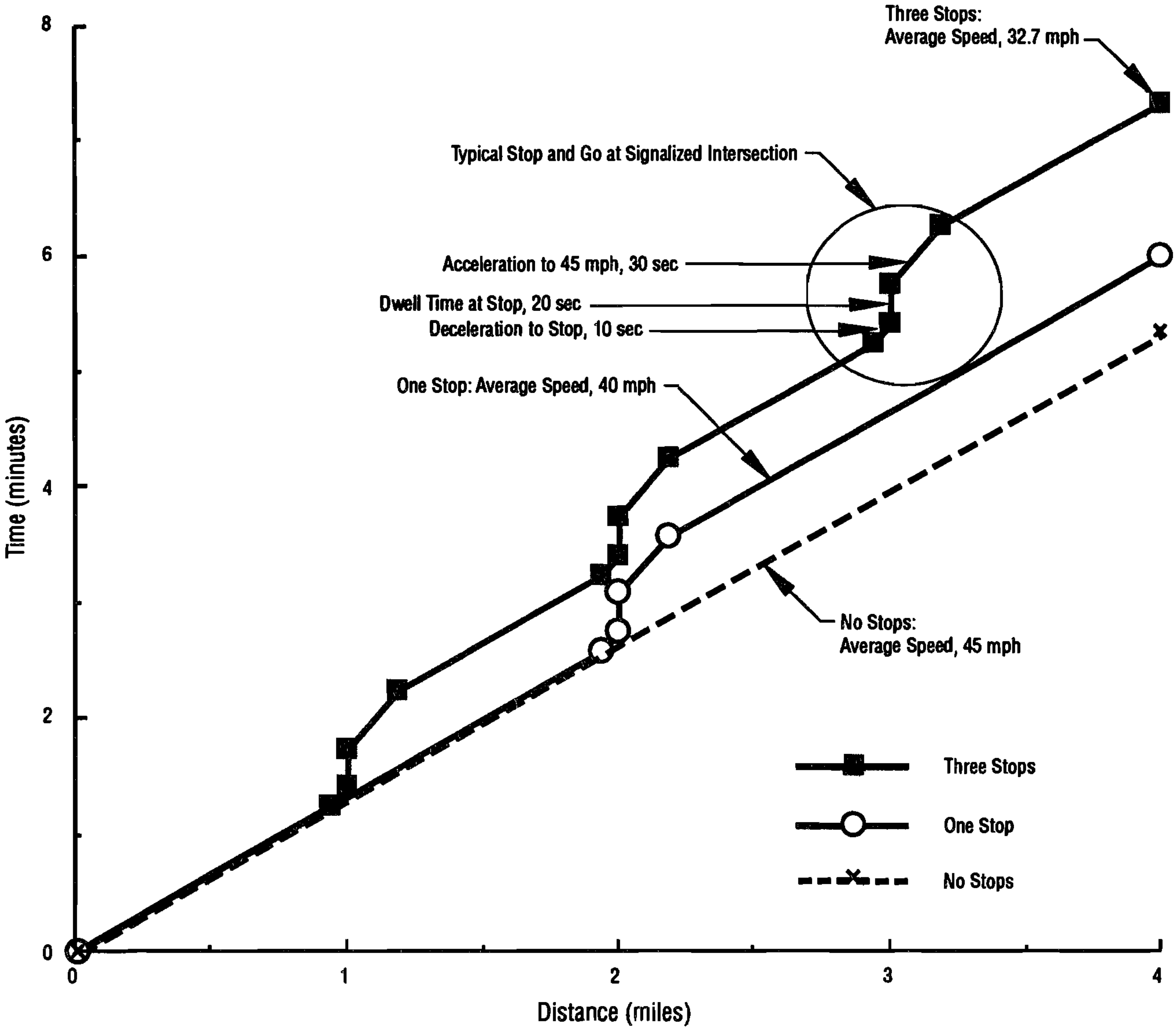


Figure 2.2

having the same degree of access control as freeways can still be improved by controlling the access to abutting property and to the traffic stream. The relationship between traffic movement (operations) and property access is illustrated by Figure 2.3 (page 8).

Management of access control is probably the most important factor influencing the quality of traffic operations in urban areas. It is also a difficult issue to cope with because of the perpetual conflict between the public interest on one hand (traffic movement) and intense private interests (property access, access to the traffic stream and/or relief from traffic) on the other hand. Access is a property right which may be valuable and is usually difficult to negotiate other than on a *quid pro quo* basis. A property owner usually expects to be compensated if this right is taken away, although access rights may be abridged to a certain extent by the exercise of governmental police powers. Any uncompensated abridgement of access rights hinges on the legal question of *reasonable* access. Reasonable access has been interpreted to mean that a *property owner* must have reasonable access to the general street system rather than being guaranteed that *potential patrons* should have convenient access from the general street system to the owner's property. Abridgements would encompass such actions as regulations covering the location and width of driveways, parking, direction of travel, and land use. Access may also be controlled by geometric design, as in the case where a frontage road is constructed along a freeway in order to provide property access, and freeway access is restricted to entrance and exit ramps.

Private property values and commercial activities are strongly influenced by the quantity of traffic and the accessibility to property. Owners of and tenants using

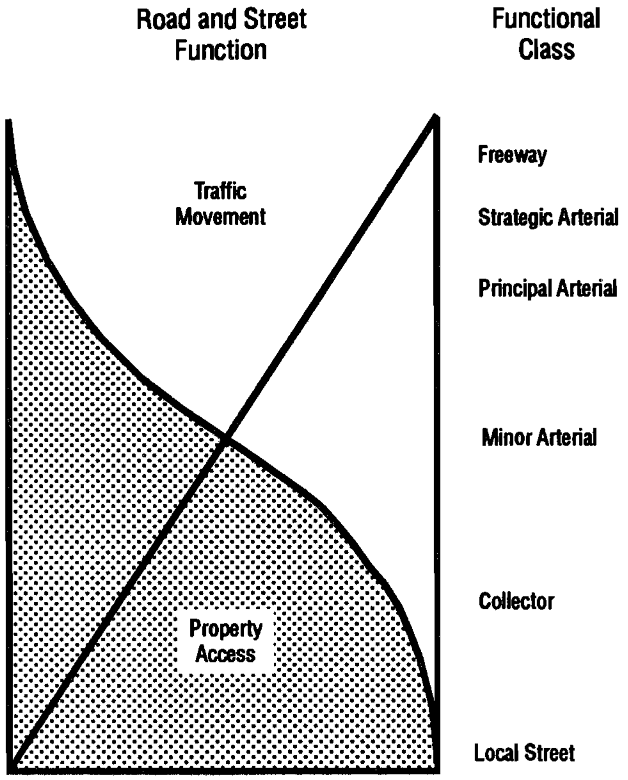


Figure 2.3

properties who are financially dependent upon the near presence of traffic will feel deprived if such traffic is diverted or otherwise interfered with. There are persuasive, even if not always successful, arguments that it is in a property owner's interest to relinquish immediate or convenient access rights for the purpose of improving traffic operations along an adjacent arterial. Arterial street improvements can in turn make property more accessible to a larger market area in addition to increasing the total amount of traffic having access even though such access may become more indirect. Conversely, increasing traffic along a route may have a detrimental effect on residential property. Consequently, upgrading an existing street route for any significant length through mature urban areas increases the probability of passing through both commercial and residential property, and may bring about a political dilemma difficult to resolve (which goes a long way toward explaining why there are no easy answers and why urban congestion persists).

DRAINAGE DESIGN

Reliability of traffic service is affected by the adequacy of the drainage facilities which are provided. The degree of toleration of impaired traffic service due to flooding is ordained by local standards. A principal arterial street system should provide a standard of protection from flooding much higher than the local street system. From the standpoint of appearance, safety, and minimum right-of-way requirements, it is assumed that the principal arterial street system will be constructed as a curb and gutter facility at abutting property lines.

STRUCTURAL DESIGN

Reliability of traffic service may also be affected by the structural standards adopted. This is primarily a function of the quality of pavement design selected. In recent years bridge and other structural design and construction standards have evolved such that the durability of structures can be considered almost eternal provided an adequate inspection and maintenance program is administered by the owner.

Such is not the case with pavement. Pavement is a consumable product. Higher-quality pavement is more durable and requires less maintenance. Principal arterial streets are expected to accommodate large volumes of traffic, and therefore the resulting congestion caused by excessive maintenance and early replacement can generate substantial user's costs. The pavement structure for a principal arterial street should reflect the importance of the street and the consequences of not being sufficiently durable, and should be designed to accommodate thirty or more years of projected traffic use. Future repair and maintenance of pavement in the presence of intense traffic along important streets is an important consideration when designing pavement. There will be a large regret factor associated with pavement repair and maintenance operations, especially in the presence of traffic, at some future time. The public is severely inconvenienced during these operations, and the costs of repair and maintenance are greatly increased. Consequently, the pavement structure should be of the highest standards.

USER'S COST AND OPERATIONAL QUALITY

In order to attract trips that would otherwise be carried by the freeway system, a principal arterial should be perceived by the user as providing service which is as good as or better than that available on the freeway system. User's costs are generally considered to be the expense of travel time, safety, and vehicle operations. These costs have been quantified and consequently can be used to estimate aggregate user's costs for various types of highway facilities. Some planners assign an additional cost to the user's aggravation. Aggravation is difficult to quantify, although not difficult to detect, and is usually not included in determining user's costs. Generally speaking, time costs have the most significant impact on a user's decision as to which route to take.

Many studies concerning the socio-economics of trip generation and travel confirm that travelers are rational animals and sooner or later will find travel routes which minimize their trip costs. There is no reason to fear that the services offered by an arterial street facility which has been significantly improved will go unused because potential users remain unaware of its existence for very long.

PUBLIC TRANSPORTATION

The most significant benefit to public transportation of a wide-ranging network of arterials is the ability afforded to furnish enhanced crosstown bus routes to connect the various and diversely located trip generators (residential areas) and trip attractors (high-activity centers) in Harris County. Along with the possibility of increasing the scope of the bus system, well-designed arterials will also permit more efficient use of the bus fleet because of increased travel speeds. Long continuous arterials permit many direct travel paths for local bus service. The existing street system requires bus routes to meander along a combination of local and arterial streets in order to effect a continuous route.

Any strategic arterial street should incorporate geometric design features which can facilitate transit bus operations and reduce interference between bus operations and general vehicular traffic. Such features might include adequate turning radii at corners, stopping bays (near-side and far-side) for discharging and picking up passengers, pedestrian access, and passenger shelters. The schematic representation of the special design features conceptualized for a strategic arterial is shown in Chapter IV in Figures 4.3a, b, and c. Among the features shown included are provisions for a transit bus turnout. In this case the turnout is shown as located along the arterial, but it could also be located along one of the ramps serving the arterial. Consideration for transit bus operations along the SASS should be incorporated in the earliest stages of planning; it is not something to be appended when planning is complete. Transit considerations should be a factor in route selection, geometric design, and access controls.

ENVIRONMENTAL CONSIDERATIONS

The rapid and incrementally large growth in population and economic activity in Harris County has given rise to fears about the degradation of the environment and the effect on the quality of life. Within the county, which is recognized as the home of one of the world's largest petrochemical industrial complexes, some of the culpability for these anxieties is attributed to the intense use of the automobile as the primary means of transportation. If growth is to be sustained and if more traffic services are provided, what will be the environmental effect? More particularly, what will be the effect on air quality?

Air quality in an urban area is to a certain extent affected by traffic congestion. Slow traffic, stop-and-go traffic, recurrent stop delays, incidental stop delays, and searches for alternate (longer?) routes define congestion. The consequences of congestion are prolonged trip times and reduced vehicle operating efficiency, which increase fuel consumption which in turn increases the load of atmospheric pollutants thrown off by vehicle engines. Reduction in congestion and improvements in air quality can be achieved by furnishing more and better-quality traffic service and/or reducing the traffic demand. Considerations concerning the latter reality, which is generally associated with reduced economic activity or no-growth planning, are beyond the scope of this study, which is to suggest means of improving both the quality and quantity of traffic services. Vehicle pollutants can also be reduced by more efficient and different types of engines and fuels. Deliberations concerning these matters are also beyond the scope of this study.

Traffic diversions to improved arterials from overloaded freeways and less efficient arterial streets will reduce the vehicle miles traveled in congestion. These diversions, in turn, will reduce the amount of vehicle emissions. If the county continues to grow, vehicle emissions will grow or decline at a rate affected by the efficiency of the road system, combined with the effectiveness of future technology in reducing the rate and virulence of vehicle emissions.

Installing a SASS would certainly enhance the effectiveness of public transit. METRO's public transportation services will, in the foreseeable future, be delivered predominantly by transit buses. Bus routes will be greatly advantaged by operating over a countywide system of improved arterials, increasing the scope of service in addition to the quality. Improvements in public transit service will enhance the possibility of reducing the dependency on private automobility and should lower vehicle emissions proportionally.

AESTHETICAL CONSIDERATIONS

There will always be opportunities, when building from scratch or upgrading existing streets, to improve the general appearance of the roadside by plantings and landscaping and by careful attention to structural details so that the many elements of the streets blend together. Any investment in appearance will have to be supplemented by timely and effective maintenance operations. With respect to public works projects, it is difficult by ordinary engineering analysis to make credible benefit-to-cost estimates in order to justify investments in improving highway aesthetics. What generally happens is that designers take advantage of any opportunity to use the space made available for other purposes to embellish the roadside. There is no conflict between good street design and good appearances. An aesthetically appealing roadway design is more a tribute to the capability, perseverance, and experience of the designer than to the cost of the project. In this study, allowances were not made for additional rights-of-way or other features specifically intended for roadway beautification. The cost estimates presented in this study do include some provisions for landscaping, which in any case is usually considered a small part of the cost of an arterial street.

It was assumed in this study that obtaining even the least amounts of rights-of-way would be a slow and arduous undertaking and that acquiring a *minimum* of rights-of-way would be an expedient policy. Consequently, only those right-of-way requirements commensurate with efficient traffic and roadway maintenance operations are recommended. Should the opportunity arise to acquire rights-of-way beyond those needed for functional requirements, then it would be desirable to use this extra room to enhance the general appearance. From an aesthetic viewpoint it would also be desirable to eliminate some outdoor advertising and all overhead utility lines, but such considerations are not properly a part of this study, and these matters must be left to others to resolve.

III. CONCEPTUAL SYSTEM

DESCRIPTION OF SYSTEM

Figure 3.1 (page 12) shows a conceptual Strategic Arterial Street System (SASS) for Harris County. It is a 490-mile system plus 120 miles outside of the county to provide route continuity along and outside the county's perimeter. This system is laid out to meet the present and future demands for high-quality traffic service in those areas of the county not conveniently accessible to the freeway system, provide better access to the freeway system, and offer alternative travel routes in lieu of the freeway system. Table 3.1 (pages 13-21) briefly defines the alignment of the various routes in the system. It is apparent from examining Figure 3.1 that there are large areas of the county in which freeway service neither is nor will be convenient. The routes selected were spatially arranged to fill in the spaces between the various elements of the existing and future freeway system. This system postulates the needs for additional high-quality traffic service in Harris County during the next twenty years.

SELECTION OF THE NETWORK

The routes comprising the subject system were compiled from suggestions originally developed by planners from the City of Houston and augmented by the State Department of Highways and Public Transportation and the Harris County Metropolitan Transit Authority, and are intended as conceptual only. The resources allocated to this study did not permit detailed review or examination of each route as to its feasibility or desirability as a candidate strategic arterial street.

All the routes included in the system are situated along existing and projected city and county street rights-of-way. Some routes and some segments of the routes are also currently included as part of the SDHPT Principal Arterial Street System (PASS), the Federal Aid Urban System (FAUS), and the Federal Aid Secondary (FAS) system. The pattern of a SASS was adapted to distribute high-quality traffic service to the county as a whole. The actuality that a given route was or was not included on another designated system was not a consideration in including the route in the SASS system. The lateral locations of particular routes selected are not necessarily space-critical in that they were selected to provide service to a given area without regard to existing or future land use. Other route locations in the vicinity of those selected might prove equally, or more, desirable.

NETWORK OPTIMIZATION

The 490-mile conceptual system presented is not necessarily the optimum size in that more or fewer miles might be more cost-effective when transportation needs are forecast for the next twenty or thirty years. The predetermined length and scope of the system is important only to the extent of evoking the political commitment necessary to reserve and acquire, in a timely manner, sufficient rights-of-way to construct the system to the standards necessary to provide high-quality service. In any event, it is expected that if a SASS were adopted, it would be constructed in increments of such lengths and at such locations as to follow the growth and traffic demands of various parts of the county.

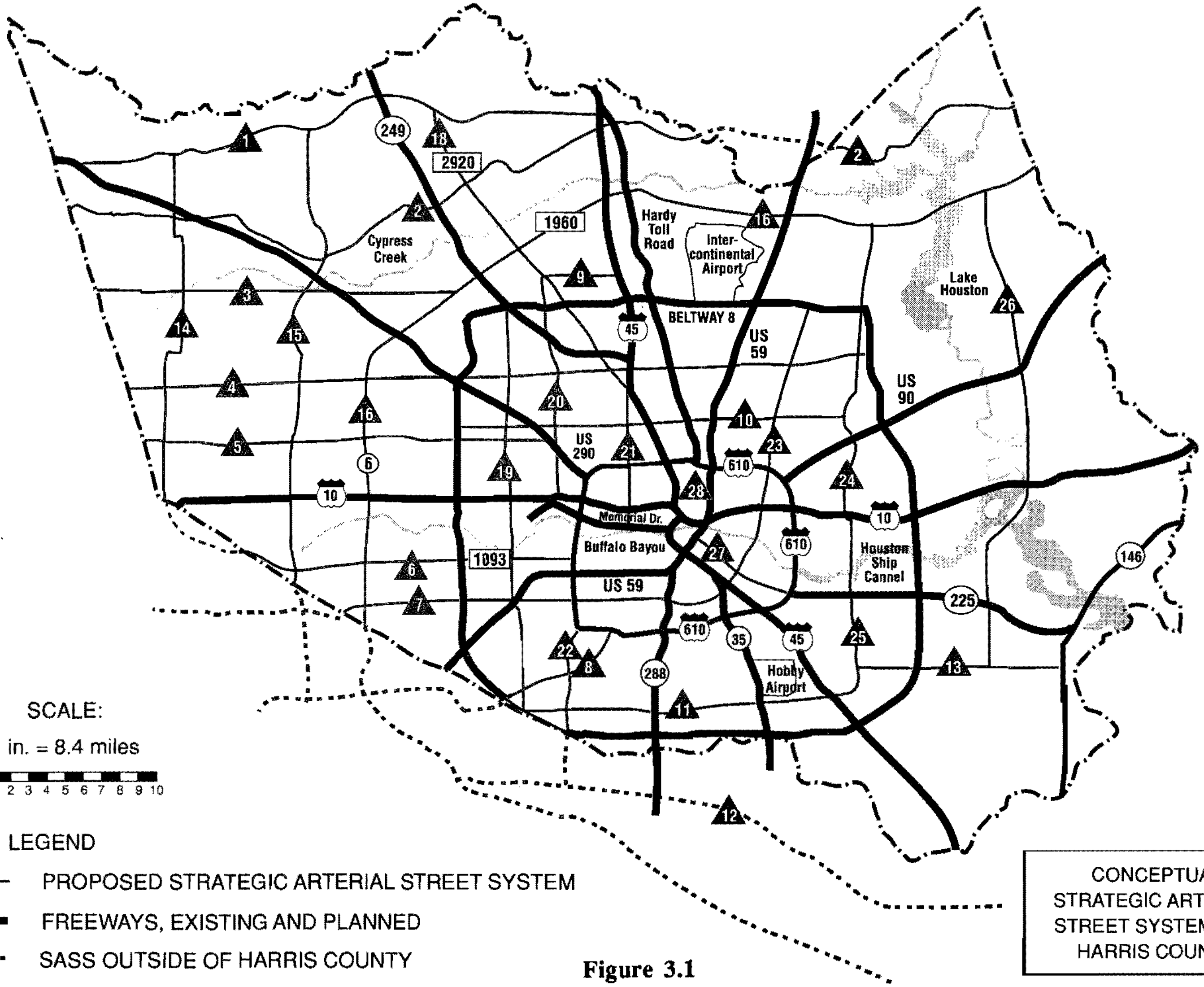
INFLUENCE ON LAND USE

There is a strong interaction between the supply of street facilities and land use, as is evidenced by the intense growth along the freeway corridors in Harris County. A similar interaction may be expected with the type of improved arterials conceived in this study, and land use can be directed to a large extent by the selection and prioritization of the routes to be included in the system. The influence on land use and growth is greatest when the *assurance* of adequate rights-of-way for strategic arterials is less speculative. Accordingly, the more rights-of-way reserved in advance of development, the greater the prospect of directing land use.

EXISTING ARTERIAL STREET SYSTEM

It is useful to look at the productivity (traffic services furnished and traffic demand, or supply and demand) of the existing freeway and arterial street systems as a basis for speculating on the desirable scope and service quality of a conceptual system. Tables 3.2 (pages 22-26) and 3.3 (pages 27-29), along with Figures 3.2 through 3.9 (pages 30-34), present an overview of the traffic services provided by the freeway and the arterial street system. The data from which the tables and graphs were compiled were furnished by the office of the Houston-Galveston Regional Transportation Study.

It is to be noted that all traffic volumes in these tables are stated as ADT (average daily traffic). Traffic congestion is usually perceived by the average motorist as being associated with *weekday* traffic—particularly with the congestion experienced during the morning and afternoon commuting periods. Average *weekday traffic* in the Harris County urban areas has been found to be about 10 percent greater than the average *daily traffic* (ADT). Consequently, the ADT per lane parameters used to estimate the deficiencies shown in Tables 3.2 and 3.3 should be increased by about 10 percent in order to reflect weekday driving conditions. On the other hand, the ADT per lane for *weekend* traffic would be less than that shown in the tables. The data are current as of 1988.



SCALE:

1 in. = 8.4 miles

0 1 2 3 4 5 6 7 8 9 10

LEGEND

- ▲# PROPOSED STRATEGIC ARTERIAL STREET SYSTEM
- ▬ FREEWAYS, EXISTING AND PLANNED
- ······ SASS OUTSIDE OF HARRIS COUNTY

Figure 3.1

CONCEPTUAL
STRATEGIC ARTERIAL
STREET SYSTEM FOR
HARRIS COUNTY

06/28/89

TABLE 3.1. STRATEGIC ARTERIAL STREET SYSTEM INDEX

	A	B	C	D	E	F	G	H	I	J	K
1						Existing	Existing				
2					Length	Length	No. of	Lane-			
3	Reference	Subsection	Street Name	Limits	(Miles)	(Miles)	Lanes	Miles	PASS	FAUS	FAS
4											
5	**S.A. No. 1**		**FM 2920**	**US 290 to IH 45**	**27.8**	**19.9**		**43.2**			
6											
7		A	FM 2920	US 290 to FM 149	16.3		2	32.6			√
8		B	√	FM 149 to N. Howard	1.7		4	6.8			√
9		C	√	N. Howard to Stubner-Huffsmith	1.9		2	3.8			√
10		D	(New Road)	FM 2920 to IH 45	7.9		0	0.0			
11											
12	**S.A. No. 2**		**Cypresswood-**	**C.L. (West) to C.L. (East)**	**53.0**	**15.6**		**57.2**			
13			**Kingwood Dr.**								
14		A	Cypresswood	C.L. (West) to Cutter Rd.	22.2		0	0.0			
15		B	√	Cutter Rd. to Stubner Airline	2.5		4	10.0			
16		C	√	Stubner Airline to Cranwood Dr.	1.0		2	2.0			
17		D	√	Cranwood Dr. to Cypress Dr.	1.3		0	0.0			
18		E	√	Cypress Dr. to Mirror Lake	1.8		4	7.2			
19		F	√	Mirror Lake to Echtd Stream	1.1		0	0.0			
20		G	√	Echtd Stream to IH 45	1.2		4	4.8			
21		H	√	IH 45 to Hardy Rd.	1.6		2	3.2			
22		I	√	Hardy Rd. to Aldine Westfield	0.7		0	0.0			
23		J	√	Aldine Westfield to Birnamwood	1.5		4	6.0			
24	i	K	√	Birnamwood to Sorters-McClellan Rd.	6.2		0	0.0			
25	ii	L	Kingwood Dr.	Sorters-McClellan Rd. to Hamblen Rd.	6.0		4	24.0			
26		M	√	Hamblen Rd. to C.L. (East)	5.9		0	0.0			
27											
28	**S.A. No. 3**		**Cypress-.**	**C.L. (West) to FM 1960**	**19.0**	**6.2**		**24.8**			
29			**N. Houston Rd**								
30		A	Cypress-N. Houston Rd.	C.L.(West) to US 290	12.8		0	0.0			
31		B	√	US 290 to Jones Rd.	4.4		4	17.6	√		
32		C	√	Jones Rd. to FM 1960	1.8		4	7.2	√		

(continued)

TABLE 3.1. STRATEGIC ARTERIAL STREET SYSTEM INDEX (CONTINUED)

	A	B	C	D	E	F	G	H	I	J	K
1						Existing	Existing				
2					Length	Length	No. of	Lane-			
3	Reference	Subsection	Street Name	Limits	(Miles)	(Miles)	Lanes	Miles	PASS	FAUS	FAS
33											
34	**S.A. No. 4**		**FM 529-**	**C.L. (West) to Beltway 8(E)**	**39.0**	**32**		**74.6**			
35			**Mt. Houston Rd.**								
36		A	FM 529	C.L. (West) to US 290	17.0		2	34.0		√	√
37		B	(New Road)	US 290 to Regal Row	1.0		0	0.0	√		
38		C	W. Gulf Bank Rd.	Regal Row to Windfern	1.0		4	4.0	√		
39		D	(New Road)	Windfern to Wood Bluff	1.2		0	0.0	√		
40		E	W. Gulf Bank Rd.	Wood Bluff to Shadyvale	0.3		4	1.2	√		
41		F	(New Road)	Shadyvale to Hollister	0.4		0	0.0	√		
42		G	W. Gulf Bank Rd.	Hollister to N. Houston-Rosslyn Rd.	0.7		4	2.8	√		
43		H	(New Road)	N. Houston-Rosslyn Rd. to Alabonson	0.8		0	0.0	√		
44		I	W. Gulf Bank Rd.	Alabonson to W. Montgomery	2.2		4	8.8	√		
45		J	(New Road)	W. Montgomery to Ella Blvd.	1.2		0	0.0	√		
46		K	W. Gulf Bank Rd.	Ella Blvd. to IH 45 (N)	1.1		4	4.4	√		
47		L	√	IH 45 (N) to Hardy Toll Rd.	2.3		2	4.6	√		
48		M	(New Road)	Hardy Toll Rd. to US 59	2.4		0	0.0	√		
49		N	Mount Houston Rd.	US 59 to Beltway 8 (E)	7.4		2	14.8	√		
50											
51	**S.A. No. 5**		**Clay Rd.-W. 43rd**	**C.L. (West) to US 290**	**21.1**	**21.1**		**46.0**			
52											
53		A	Clay Rd.	C.L. (West) to Kinloch	10.9		2	21.8			
54		B	√	Kinloch to SH 6	0.7		4	2.8			
55		C	√	SH 6 to Hempstead	8.3		2	16.6	√	√	
56		D	W. 43rd	Hempstead to US 290	1.2		4	4.8	√	√	
57											
58	**S.A. No. 6**		**Beeler Rd.-FM 1093**	**I-10(W) to I-610(W)**	**23.1**	**15.1**		**92.4**			
59											
60	iii	A	(New Road)	I-10(W) to Buffalo Bayou	8.0		0	0.0			
61		B	Beeler Rd.	Buffalo Bayou to SH 6	4.4		2	8.8		√	

(continued)

TABLE 3.1. STRATEGIC ARTERIAL STREET SYSTEM INDEX (CONTINUED)

	A	B	C	D	E	F	G	H	I	J	K
1						Existing	Existing				
2					Length	Length	No. of	Lane-			
3	Reference	Subsection	Street Name	Limits	(Miles)	(Miles)	Lanes	Miles	PASS	FAUS	FAS
62		C	FM 1093	SSH 6 to Alabama	9.7		8	77.6		√	
63		D	√	Alabama to I-610(W)	1.0		6	6.0		√	
64											
65	S.A. No. 7		**Bellaire Blvd.-**	**Grand Pkwy to IH 45**	**27.75**	**22.2**		**104.70**			
66			**S. Wayside**								
67	iv	A	(New Road)	Grand Pkwy to San Pablo	5.6		0	0.0			
68	iv	B	Bellaire Blvd.	San Pablo to Sugarland-Howell	3.1		4	12.4			
69		C	√	Sugarland-Howell to Wilcrest	3.8		2	7.6		√	
70		D	√	Wilcrest to Fondren	2.2		4	8.8		√	
71		E	√	Fondren to US 59	0.5		7	3.5		√	
72		F	Bellaire-Holcombe	US 59 to OST	8.6		6	51.6	√	√	
73		G	OST	Holcombe to MLK	2.5		6	15.0	√	√	
74		H	√	MLK to Telephone Rd.	1.3		4	5.2	√	√	
75		I	S. Wayside	Telephone Rd. to IH 45	0.2		4	0.6	√	√	
76											
77	S.A. No. 8		**US 90 A**	**FM 359 to I-610(S)**	**20.9**	**20.9**		**83.6**			F.A.P.
78											
79	v	A	US 90 A	FM 359 to I-610 (S)	20.9		4	83.6			√
80											
81	S.A No. 9		**Spears-W. Rankin**	**Veterans-Memorial Dr. to IH 45**	**3.3**	**3.3**		**6.6**			
82											
83		A	Spears-W. Rankin	Veterans-Memorial Dr. to IH 45	3.3		2	6.6			
84											
85	S.A. No. 10		**Tanner-Tidwell Rd.**	**Beltway 8(W) to Beltway 8(E)**	**22.2**	**21.5**		**68.6**			
86											
87		A	Tanner Rd.	Beltway 8(W) to Hempstead Hwy	2.0		2	4.0			
88		B	Tidwell	Hempstead Hwy to Hirsch Rd.	12.2		4	48.8		√	
89		C	√	Hirsch Rd. to C.E. King Pkwy	6.7		2	13.4		√	
90		D	√	C.E. King Pkwy to Pearl St.	0.6		4	2.4			

(continued)

TABLE 3.1. STRATEGIC ARTERIAL STREET SYSTEM INDEX (CONTINUED)

	A	B	C	D	E	F	G	H	I	J	K
1						Existing	Existing				
2					Length	Length	No. of	Lane-			
3	Reference	Subsection	Street Name	Limits	(Miles)	(Miles)	Lanes	Miles	PASS	FAUS	FAS
91		E	(New Road)	Pearl St. to Beltway 8(E)	0.7		0	0.0			
92											
93	**S.A. No. 11**		**W. Orem-Almeda-**	**Fondren Rd. to IH 45(S)**	**17.0**	**9.1**		**31.2**			
94			**Genoa Road**								
95		A	(New Road)	Fondren Rd. to Hillcroft	0.7		0	0.0			
96		B	W. Orem	Hillcroft to Chimney Rock	1.0		4	4.0			
97		C	(New Road)	Chimney Rock to S. Post Oak	1.0		0	0.0			
98		D	W. Orem	S. Post Oak to Hiram Clarke	1.2		4	4.8			
99		E	√	Hiram Clarke to Almeda Rd.	2.0		2	4.0			
100		F	(New Road)	Almeda Rd. to Southview	2.9		0	0.0			
101		G	E. Orem	Southview to Cullen	0.6		2	1.2			
102		H	√	Cullen to Redfern	0.8		4	3.2			
103		I	(New Road)	Redfern to Telephone Rd.	3.3		0	0.0			
104		J	Almeda-Genoa	Telephone Rd. to IH 45(S)	3.5		4	14.0			
105											
106	**S.A. No. 12**		**Senior-FM 518**	**SH 6 to SH 146**	**34.7**	**30.4**		**85.6**			
107											
108	iv	A	Senior Rd.	SH 6 to Farrell Rd.	3.0		2	6.0			
109	iv	B	(New Road)	Farrell Rd. to Almeda School Rd.	4.3		0	0.0			
110	iv	C	Smith Miller Rd.	Almeda School Rd. to SH 288	1.8		2	3.6			
111	iv	D	FM 518	SH 288 to Westminister	7.4		4	29.6			
112	iv	E	√	Westminister to FM 2351	4.2		2	8.4			
113	iv	F	√	FM 2351 to Castlewood	1.0		4	4.0			
114	iv	G	√	Castlewood to Algoa-Friendswood Rd.	3.0		2	6.0			
115	iv	H	√	Algoa-Friendswood Rd. to Bay Area Ave.	0.8		4	3.2			
116	iv	I	√	Bay Area Ave. to Williamsport Dr.	2.2		2	4.4			
117	iv	J	√	Williamsport Dr. to FM 2094	3.2		4	12.8			
118	iv	K	√	FM 2094 to SH 146	3.8		2	7.6			
119											

(continued)

TABLE 3.1. STRATEGIC ARTERIAL STREET SYSTEM INDEX (CONTINUED)

	A	B	C	D	E	F	G	H	I	J	K
1						Existing	Existing				
2					Length	Length	No. of	Lane-			
3	Reference	Subsection	Street Name	Limits	(Miles)	(Miles)	Lanes	Miles	PASS	FAUS	FAS
120	**S.A. No. 13**		**Fairmont Parkway**	**S. Shaver to SH 146**	**10.8**	**10.8**		**46.2**			
121											
122		A	Fairmont Parkway	S. Shaver to E. Belt	3.3		4	13.2		√	
123		B	√	E. Belt to Armand Bayou	1.5		6	9.0		√	
124		C	√	Armand Bayou to SH 146	6.0		4	24.0		√	
125											
126	**S.A. No. 14**		**Katy-Hockley Rd.-**	**I-10(W) to FM 2920**	**20.0**	**19.4**		**38.8**			
127			**Roberts Road**								
128	vi	A	(New Road)	I-10(W) to US 90	0.6		0	0.0			
129		B	Katy-Hockley Rd.	US 90 to Mound Rd.	14.6		2	29.2			
130		C	Roberts Rd.	Mound Rd. to FM 2920	4.8		2	9.6			
131											
132	**S.A. No. 15**		**FM 1464-Barker-**	**US 90 A to FM 2920**	**33.8**	**19.2**		**43.0**			
133			**Cypress Road**								
134	iv	A	FM 1464	US 90 A to FM 1093	7.6		2	15.2			
135		B	(New Road)	FM 1093 to I-10(W)	5.2		0	0.0			
136		C	Barker-Cypress Rd.	I-10(W) to Park Row	0.4		2	0.8			
137		D	√	Park Row to Saums	0.8		4	3.2			
138		E	√	Saums to US 290	10.9		2	21.8			
139		F	(New Road)	US 290 to Spring-Cypress Rd.	1.7		0	0.0			
140		G	Barker-Cypress Rd.	Spring-Cypress Rd. to Indian Cypress St.	0.5		4	2.0			
141		H	(New Road)	Indian Cypress St. to FM 2920	6.7		0	0.0			
142											
143	**S.A. No. 16**		**SH 6-FM 1960**	**Galveston Co. to Liberty Co.**	**90.5**	**90.5**		**326.0**			
144											F.A.P.
145	vi	A	SH 6	Galveston Co. to County Rd.	5.9		4	23.6			√
146	vi	B	√	County Rd. to Ft. Bend Co.	10.5		2	21.0			√
147	iv	C	√	Brazoria Co. to US 90 A	15.0		2	30.0			√
148	iv	D	√	US 90 A to Harris Co.	5.1		4	20.4			√

(continued)

TABLE 3.1. STRATEGIC ARTERIAL STREET SYSTEM INDEX (CONTINUED)

	A	B	C	D	E	F	G	H	I	J	K
1						Existing	Existing				
2					Length	Length	No. of	Lane-			
3	Reference	Subsection	Street Name	Limits	(Miles)	(Miles)	Lanes	Miles	PASS	FAUS	FAS
149		E	√	Harris Co. to Hempstead Hwy	16.4		4	65.6			√
150		F	FM 1960	Hempstead Hwy to North Fwy	13.7		6	82.2			√
151		G	√	North Fwy to Atascocita Shores	17.7		4	70.8			√
152		H	√	Atascocita Shores to Liberty Co.	6.2		2	12.4			√
153											
154	S.A. No. 17		**Omit**								
155											
156	S.A. No. 18		**Veterans Memorial**	**I-45(N) to FM 2920**	**18.4**	**18.4**		**55.4**			
157											
158		A	Veterans Memorial	Beltway 8(N) to FM 1960	4.3		4	17.2			
159		B	√	FM 1960 to Boudreaux	6.7		2	13.4			
160		C	√	Boudreaux to Stubner-Huffsmith	2.4		2	4.8			
161		D	√	I-45(N) to Beltway 8(N)	5.0		4	20.0			
162											
163	S.A. No. 19		**Fondren-Fairbanks-**	**W. Orem to Beltway 8(N)**	**21.3**	**19.6**		**62.0**			
164			**N. Houston**								
165		A	Fondren Rd.	W. Orem to US 90 A	0.3		4	1.2		√	
166		B	√	US 90 A to W. Airport	1.0		6	6.0		√	
167		C	√	W. Airport to Piney Point C.L.	7.2		4	28.8		√	
168		D	Piney Point	Piney Point C.L. to Memorial	0.7		2	1.4			
169		E	Blalock	Memorial to Long Point	3.2		2	6.4		√	
170		F	√	Long Point to Hempstead	1.9		4	7.6		√	
171		G	Fairbanks-N. Houston	Hempstead to New Road	5.3		2	10.6		√	
172		H	(New Road)	Fairbanks-N. Houston to Beltway 8(N)	1.7		0	0.0			
173											
174	S.A. No. 20		**Antoine Dr.**	**I-10(W) to Veterans Memorial**	**12.9**	**8.5**		**34.0**			
175											
176		A	Antoine Dr.	I-10(W) to W. Mt. Houston	8.5		4	34.0			
177		B	(New Road)	W. Mt. Houston to Veterans Memorial	4.4		0	0.0			

(continued)

TABLE 3.1. STRATEGIC ARTERIAL STREET SYSTEM INDEX (CONTINUED)

	A	B	C	D	E	F	G	H	I	J	K
1						Existing	Existing				
2					Length	Length	No. of	Lane-			
3	Reference	Subsection	Street Name	Limits	(Miles)	(Miles)	Lanes	Miles	PASS	FAUS	FAS
178											
179	S.A. No. 21		N. Shepherd	I-10(W) to IH 45(N)	7.7	7.7	4	30.8		√	
180		A	N. Shepherd	I-10(W) to IH-610(N)	3.3		4	13.2			
181		B	√	IH-610(N) to I-45(N)	4.4		4	17.6			
182											
183											
184											
185	S.A. No. 22		South Post Oak	I-610(S) to SH 6	11.7	7.1		31.2			
186		A	South Post Oak	I-610(S) to W. Bellfort	0.7		8	5.6		√	
187		B	√	W. Bellfort to Beltway 8(S)	5.0		4	20.0		√	
188	iv	C	√	Beltway 8(S) to McHard Rd.	1.4		4	5.6		√	
189	iv	D	(New Road)	McHard Rd. to SH 6	4.6		0	0.0			
190											
191	S.A. No. 23		S. Wayside-N. Wayside	IH 45(S) to Beltway 8(N)	12.0	6.4		23.2			
192											
193		A	S. Wayside Dr.	IH 45(S) to Ave. W	2.1		4	8.4	√	√	
194		B	N. Wayside Dr.	Ave. W to Ley	3.1		4	12.4	√	√	
195		C	√	Ley to Tidwell	1.2		2	2.4			
196		D	(New Road)	Tidwell to Beltway 8(N)	5.6		0	0.0			
197											
198	S.A. No. 24		S. Lake Houston Pkwy-	Prop. US 90 to FM 1960	12.8	8.7		18.6			
199			Woodland Hills								
200		A	S. Lake Houston Pkwy	Prop. US 90 to Beaumont Hwy	0.9		2	1.8		√	
201		B	C.E. King Pkwy	Beaumont Hwy to Garrett Rd.	3.8		2	7.6		√	
202		C	Lockwood	Garrett Rd. to Beltway 8(N)	3.4		2	6.8		√	
203		D	(New Road)	Beltway 8(N) to Rankin Rd.	2.5		0	0.0			
204		E	Woodland Hills	Rankin Rd. to Will Clayton Pkwy	0.6		4	2.4			
205		F	(New Road)	Will Clayton Pkwy to FM 1960	1.6		0	0.0			
206											

(continued)

TABLE 3.1. STRATEGIC ARTERIAL STREET SYSTEM INDEX (CONTINUED)

	A	B	C	D	E	F	G	H	I	J	K
1						Existing	Existing				
2					Length	Length	No. of	Lane-			
3	Reference	Subsection	Street Name	Limits	(Miles)	(Miles)	Lanes	Miles	PASS	FAUS	FAS
207	S.A. No. 25		**Shaver-Maxey Rd.**	**IH 45(S) to Prop. US 90**	**13.0**	**13**		**50.0**			
208											
209		A	Shaver	IH 45(S) to Red Bluff Rd.	7.0		4	28.0		√	
210		B	Washburn Tunnel	Red Bluff Rd. to Clinton	1.0		2	2.0		√	
211		C	Federal Rd.	Clinton to Maxey Rd.	3.1		4	12.4		√	
212		D	Maxey Rd.	Federal Rd. to Prop. US 90	1.9		4	7.6		√	
213											
214	S.A. No. 26		**Underwood-**	**Fairmont Pkwy to FM 1960**	**26.9**	**21.6**		**50.0**			
215			**Miller Wilson Rd.**								
216		A	Underwood Rd.	Fairmont Pkwy to SH 225	3.6		2	7.2			
217		B	Battleground Rd.	SH 225 to S. Park Rd.	2.0		4	8.0			
218		C	√	S. Park Rd. to Ferry Landing	2.1		2	4.2			
219		D	Channel Crossing	Ferry Landing to Ferry Landing	1.0		0	0.0			
220		E	Crosby-Lynchburg Rd.	Ferry Landing to Beaumont Rd.	8.1		2	16.2			
221		F	√	Beaumont Rd. to First St.	1.4		4	5.6			
222		G	Miller Wilson Rd.	First St. to Stroker Rd.	4.4		2	8.8			√
223		H	(New Road)	Stroker Rd. to FM 1960	4.3		0	0.0			√
224											
225	S.A. No. 27		**Harrisburg-Texas**	**Broadway to US 59**	**5.1**	**5.1**		**20.8**			
226											
227		A	Harrisburg	Broadway to Dowling	4.7		4	18.8			
228		B	Texas	Dowling to US 59	0.4		5	2.0			
229											
230	S.A. No. 28		**Elysian**	**I-610(N) to C.B.D.**	**3.8**	**3.8**	**4**	**15.2**	√		
231											
232				**Total**	**609.6**	**477.1**		**1563.7**			
233				**Outside County Total (see below)**	**119.4**			**273.0**			
234				**Harris County Total**	**490.2**			**1290.7**			
235	**Arterial Segments Located Outside Harris County**										

(continued)

TABLE 3.1. STRATEGIC ARTERIAL STREET SYSTEM INDEX (CONTINUED)

	A	B	C	D	E	F	G	H	I	J	K
1						Existing	Existing				
2					Length	Length	No. of	Lane-			
3	Reference	Subsection	Street Name	Limits	(Miles)	(Miles)	Lanes	Miles	PASS	FAUS	FAS
236	i	Montgomery County			3.8			–			
237	ii	Montgonery County			1.3			–			
238	iii	Ft. Bend County			7.2			–			
239	iv	Ft. Bend County			77.7			–			
240	v	Ft. Bend County			13.5			–			
241	vi	Brazoria County			16.4			–			
242				Outside County Total	119.9			273.0			
243	NOTE:	Distances shown are scale distances from the SDHPT Harris County Map, revised to January 1,1982.									

TABLE 3.2. HARRIS COUNTY ARTERIAL STREET INVENTORY

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Max			(SDHPT, Dist. 12, H-GRTS - Harris County Arterial Street Inventory, Dated, 10/12/88)											
2	Vehicles	2L	2L	2L	2L	Acc Mi	Acc	Acc VMT	3L	3L	3L	3L	Acc Mi	Acc	Acc Mi
3	Per Lane	Miles	VMT	ADT	Acc Mi	% of Tot	VMT	% of Tot	Miles	VMT	ADT	Acc Mi	% of Tot	VMT	% of Tot
4															
5	**500**	12.56	6,387	500	12.56	0.64	6,387	0.02	0.50	720	–	0.50	0.03	720	0.00
6	**1,000**	22.31	36,185	1,600	34.87	1.77	42,572	0.16	0.50	1,262	2,500	1.00	0.05	1,982	0.01
7	**1,500**	57.63	140,841	2,400	92.50	4.70	183,413	0.71	0.95	3,492	3,700	1.95	0.10	5,474	0.02
8	**2,000**	85.63	301,873	3,500	178.13	9.05	485,286	1.87	4.00	20,680	5,200	5.95	0.30	26,154	0.10
9	**2,500**	71.24	322,858	4,500	249.37	12.67	808,144	3.11	5.60	38,882	6,900	11.55	0.59	65,036	0.25
10	**3,000**	61.61	339,827	5,500	310.98	15.80	1,147,971	4.42	2.75	23,597	8,600	14.30	0.73	88,633	0.34
11	**3,500**	64.90	428,103	6,600	375.88	19.10	1,576,074	6.06	1.80	16,857	9,400	16.10	0.82	105,490	0.41
12	**4,000**	67.51	513,671	7,600	443.39	22.53	2,089,745	8.04	4.35	48,556	11,200	20.45	1.04	154,046	0.59
13	**4,500**	61.63	521,015	8,500	505.02	25.66	2,610,760	10.04	2.70	34,199	12,700	23.15	1.18	188,245	0.72
14	**5,000**	79.16	752,750	9,500	584.18	29.68	3,363,510	12.94	0.60	8,700	14,500	23.75	1.21	196,945	0.76
15	**5,500**	44.22	462,083	10,400	628.40	31.93	3,825,593	14.72	0.80	12,482	15,600	24.55	1.25	209,427	0.81
16	**6,000**	51.20	585,499	11,400	679.60	34.53	4,411,092	16.97	0.40	7,022	17,600	24.95	1.27	216,449	0.83
17	**6,500**	29.98	375,578	12,500	709.58	36.05	4,786,670	18.41	0.00	0	-	24.95	1.27	216,449	0.83
18	**7,000**	24.01	325,114	13,500	733.59	37.27	5,111,784	19.66	0.00	0	-	24.95	1.27	216,449	0.83
19	**7,500**	24.03	347,732	14,500	757.62	38.50	5,459,516	21.00	0.00	0	-	24.95	1.27	216,449	0.83
20	**8,000**	15.95	246,421	15,400	773.57	39.31	5,705,937	21.95	0.00	0	-	24.95	1.27	216,449	0.83
21	**8,500**	12.71	208,028	16,400	786.28	39.95	5,913,965	22.75	0.00	0	-	24.95	1.27	216,449	0.83
22	**9,000**	15.60	277,111	17,800	801.88	40.74	6,191,076	23.82	0.00	0	-	24.95	1.27	216,449	0.83
23	**9,500**	5.90	107,422	18,200	807.78	41.04	6,298,498	24.23	0.00	0	-	24.95	1.27	216,449	0.83
24	**10,000**	7.60	149,489	19,700	815.38	41.43	6,447,987	24.80	0.00	0	-	24.95	1.27	216,449	0.83
25	**10,500**	1.25	25,204	20,200	816.63	41.49	6,473,191	24.90	0.00	0	-	24.95	1.27	216,449	0.83
26	**11,000**	2.50	54,689	21,900	819.13	41.62	6,527,880	25.11	0.00	0	-	24.95	1.27	216,449	0.83
27	**11,500**	1.00	22,183	22,200	820.13	41.67	6,550,063	25.20	0.00	0	-	24.95	1.27	216,449	0.83
28	**12,000**	1.30	30,148	23,200	821.43	41.74	6,580,211	25.31	0.00	0	-	24.95	1.27	216,449	0.83
29	**12,500**	1.00	24,709	24,700	822.43	41.79	6,604,920	25.41	0.00	0	-	24.95	1.27	216,449	0.83
30	**13,000**	0.78	20,280	26,000	823.21	41.83	6,625,200	25.49	0.00	0	-	24.95	1.27	216,449	0.83
31	**13,500**	1.05	27,614	26,300	824.26	41.88	6,652,814	25.59	0.00	0	-	24.95	1.27	216,449	0.83
32															
33															
34															
35	TOTAL - By Lane Group				824.26	41.88	6,652,814	25.59				24.95	1.27	216,449	0.83
36	TOTAL - Accumulative				824.26	41.88	6,652,814	25.59				849.21	43.15	6,869,263	26.42

Page 1 of 5

(continued)

TABLE 3.2. HARRIS COUNTY ARTERIAL STREET INVENTORY (CONTINUED)

	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
1	Max			(SDHPT, Dist. 12, H-GRTS - Harris County Arterial Street Inventory, Dated, 10/12/88)											
2	Vehicles	4L	4L	4L	4L	Acc Mi	Acc	Acc VMT	5L	5L	5L	5L	Acc Mi	Acc	Acc VMT
3	Per Lane	Miles	VMT	ADT	Acc Mi	% of Tot	VMT	% of Tot	Miles	VMT	ADT	Acc Mi	% of Tot	VMT	% of Tot
4															
5	**500**	10.05	14,761	1,500	10.05	0.51	14,761	0.06	0.00	0	–	0.00	0.00	0	0.00
6	**1,000**	17.00	54,496	3,200	27.05	1.37	69,257	0.27	0.00	0	–	0.00	0.00	0	0.00
7	**1,500**	66.72	334,827	5,000	93.77	4.76	404,084	1.55	1.00	6,962	7,000	1.00	0.05	6,962	0.03
8	**2,000**	63.60	448,076	7,000	157.37	8.00	852,160	3.28	1.25	11,049	8,800	2.25	0.11	18,011	0.07
9	**2,500**	86.59	781,555	9,000	243.96	12.40	1,633,715	6.28	2.10	23,650	11,300	4.35	0.22	41,661	0.16
10	**3,000**	119.23	1,301,320	10,900	363.19	18.45	2,935,035	11.29	0.00	0	-	4.35	0.22	41,661	0.16
11	**3,500**	99.37	1,297,055	13,100	462.56	23.50	4,232,090	16.28	0.00	0	-	4.35	0.22	41,661	0.16
12	**4,000**	104.86	1,574,419	15,000	567.42	28.83	5,806,509	22.34	0.00	0	-	4.35	0.22	41,661	0.16
13	**4,500**	78.86	1,346,559	17,100	646.28	32.84	7,153,068	27.52	0.00	0	-	4.35	0.22	41,661	0.16
14	**5,000**	73.49	1,395,889	19,000	719.77	36.57	8,548,957	32.89	0.95	21,899	23,100	5.30	0.27	63,560	0.24
15	**5,500**	41.32	873,419	21,100	761.09	38.67	9,422,376	36.25	1.00	27,437	27,400	6.30	0.32	90,997	0.35
16	**6,000**	60.76	1,407,145	23,200	821.85	41.76	10,829,521	41.66	0.00	0	-	6.30	0.32	90,997	0.35
17	**6,500**	48.97	1,237,541	25,300	870.82	44.25	12,067,062	46.42	0.00	0	-	6.30	0.32	90,997	0.35
18	**7,000**	25.50	688,498	27,000	896.32	45.54	12,755,560	49.07	0.40	13,390	33,500	6.70	0.34	104,387	0.40
19	**7,500**	14.40	417,517	29,000	910.72	46.27	13,173,077	50.67	0.70	25,647	36,600	7.40	0.38	130,034	0.50
20	**8,000**	19.43	605,975	31,200	930.15	47.26	13,779,052	53.01	0.00	0	-	7.40	0.38	130,034	0.50
21	**8,500**	14.15	473,341	33,500	944.30	47.98	14,252,393	54.83	0.00	0	-	7.40	0.38	130,034	0.50
22	**9,000**	17.85	628,030	35,200	962.15	48.89	14,880,423	57.24	0.00	0	-	7.40	0.38	130,034	0.50
23	**9,500**	10.35	387,383	37,400	972.50	49.41	15,267,806	58.73	0.00	0	-	7.40	0.38	130,034	0.50
24	**10,000**	2.70	105,043	38,900	975.20	49.55	15,372,849	59.14	0.00	0	-	7.40	0.38	130,034	0.50
25	**10,500**	1.70	69,096	40,600	976.90	49.64	15,441,945	59.40	0.00	0	-	7.40	0.38	130,034	0.50
26	**11,000**	1.14	49,883	43,800	978.04	49.70	15,491,828	59.59	0.00	0	-	7.40	0.38	130,034	0.50
27	**11,500**	0.55	24,454	44,500	978.59	49.72	15,516,282	59.69	0.00	0	-	7.40	0.38	130,034	0.50
28	**12,000**	3.40	163,200	48,000	981.99	49.90	15,679,482	60.32	0.00	0	-	7.40	0.38	130,034	0.50
29	**12,500**	0.00	0	-	981.99	49.90	15,679,482	60.32	0.00	0	-	7.40	0.38	130,034	0.50
30	**13,000**	0.00	0	-	981.99	49.90	15,679,482	60.32	0.00	0	-	7.40	0.38	130,034	0.50
31	**13,500**	0.00	0	-	981.99	49.90	15,679,482	60.32	0.00	0	-	7.40	0.38	130,034	0.50
32															
33															
34															
35	TOTAL - By Lane Group				981.99	49.90	15,679,482	60.32				7.4	0.38	130,034	0.50
36	TOTAL - Accumulative				1831.20	93.05	22,548,745	86.74				1838.6	93.42	22,678,779	87.24

Page 2 of 5

(continued)

TABLE 3.2. HARRIS COUNTY ARTERIAL STREET INVENTORY (CONTINUED)

	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS
1	Max		(SDHPT, Dist. 12, H-GRTS - Harris County Arterial Street Inventory, Dated, 10/12/88)												
2	Vehicles	6L	6L	6L	6L	Acc Mi	Acc	Acc VMT	7/8L	7/8L	7/8L	7/8L	Acc Mi	Acc	Acc VMT
3	Per Lane	Miles	VMT	ADT	Acc. Mi.	% of Tot	VMT	% of Tot	Miles	VMT	ADT	Acc Mi	% of Tot	VMT	% of Tot
4															
5	**500**	0.00	0	-	0.00	0.00	0	0.00	0.00	0	–	0.00	0.00	0	0.00
6	**1,000**	3.80	20,914	5,500	3.80	0.19	20,914	0.08	0.00	0	–	0.00	0.00	0	0.00
7	**1,500**	4.48	34,763	7,800	8.28	0.42	55,677	0.21	0.00	0	–	0.00	0.00	0	0.00
8	**2,000**	9.70	100,129	10,300	17.98	0.91	155,806	0.60	0.00	0	–	0.00	0.00	0	0.00
9	**2,500**	14.47	197,105	13,600	32.45	1.65	352,911	1.36	2.30	44,390	19,300	2.30	0.12	44,390	0.17
10	**3,000**	13.60	225,675	16,600	46.05	2.34	578,586	2.23	0.00	0	–	2.30	0.12	44,390	0.17
11	**3,500**	15.37	305,777	19,900	61.42	3.12	884,363	3.40	0.00	0	–	2.30	0.12	44,390	0.17
12	**4,000**	9.35	209,958	22,500	70.77	3.60	1,094,321	4.21	0.00	0	–	2.30	0.12	44,390	0.17
13	**4,500**	8.30	215,542	26,000	79.07	4.02	1,309,863	5.04	0.00	0	–	2.30	0.12	44,390	0.17
14	**5,000**	11.60	334,799	28,900	90.67	4.61	1,644,662	6.33	0.70	24,291	34,700	3.00	0.15	68,681	0.26
15	**5,500**	8.45	264,443	31,300	99.12	5.04	1,909,105	7.34	0.00	0	–	3.00	0.15	68,681	0.26
16	**6,000**	4.30	145,573	33,900	103.42	5.25	2,054,678	7.90	2.00	90,000	45,000	5.00	0.25	158,681	0.61
17	**6,500**	7.90	295,197	37,400	111.32	5.66	2,349,875	9.04	0.50	21,029	42,100	5.50	0.28	179,710	0.69
18	**7,000**	1.80	72,142	40,100	113.12	5.75	2,422,017	9.32	0.00	0	-	5.50	0.28	179,710	0.69
19	**7,500**	0.30	12,946	43,200	113.42	5.76	2,434,963	9.37	0.00	0	-	5.50	0.28	179,710	0.69
20	**8,000**	1.10	51,858	47,100	114.52	5.82	2,486,821	9.57	0.00	0	-	5.50	0.28	179,710	0.69
21	**8,500**	0.00	0	–	114.52	5.82	2,486,821	9.57	4.25	289,000	68,000	9.75	0.50	468,710	1.80
22	**9,000**	0.00	0	-	114.52	5.82	2,486,821	9.57	1.45	102,950	71,000	11.20	0.57	571,660	2.20
23	**9,500**	0.00	0	-	114.52	5.82	2,486,821	9.57	0.00	0	-	11.20	0.57	571,660	2.20
24	**10,000**	0.00	0	–	114.52	5.82	2,486,821	9.57	0.00	0	-	11.20	0.57	571,660	2.20
25	**10,500**	0.00	0	-	114.52	5.82	2,486,821	9.57	0.60	42,600	71,000	11.80	0.60	614,260	2.36
26	**11,000**	1.05	68,250	65,000	115.57	5.87	2,555,071	9.83	0.00	0	-	11.80	0.60	614,260	2.36
27	**11,500**	0.00	0	-	115.57	5.87	2,555,071	9.83	0.00	0	-	11.80	0.60	614,260	2.36
28	**12,000**	2.10	147,500	70,200	117.67	5.98	2,702,571	10.40	0.00	0	-	11.80	0.60	614,260	2.36
29	**12,500**	0.00	0	-	117.67	5.98	2,702,571	10.40	0.00	0	-	11.80	0.60	614,260	2.36
30	**13,000**	0.00	0	-	117.67	5.98	2,702,571	10.40	0.00	0	-	11.80	0.60	614,260	2.36
31	**13,500**	0.00	0	–	117.67	5.98	2,702,571	10.40	0.00	0	-	11.80	0.60	614,260	2.36
32															
33															
34															
35	TOTAL - By Lane Group				117.67	5.98	2,702,571	10.40				11.8	0.60	614,260	2.36
36	TOTAL - Accumulative				1956.27	99.40	25,381,350	97.64				1968.07	100.00	25,995,610	100.00

(continued)

TABLE 3.2. HARRIS COUNTY ARTERIAL STREET INVENTORY (CONTINUED)

	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD
1			(SDHPT, Dist. 12, H-GRTS - Harris County Arterial Street Inventory, Dated, 10/12/88)								
2			SUMMARY OF DEFICIENT ARTERIALS BY LANE GROUPS								
3	**Miles of upgrade assuming maximum of 5,000 ADT/Lane.- Level of Service C**										
4		Total Mi	% Miles	4L	6L	*8L	Deficient	Deficient			
5	Number	Lane	Per Lane	10-20K	20-30K	30-40K+	Mileage	Mileage			
6	Lanes	Group	Group	ADT	ADT	ADT	Total	% Total			
7	2L	824.26	41.88	231.20	8.88	0.00	**240.08**	12.20			
8	3L	24.95	1.27	1.20	0.00	0.00	**1.20**	0.06			
9	4L	981.99	49.90	0.00	190.95	71.27	**262.22**	13.32			
10	5L	7.40	0.38	0.00	1.00	1.10	**2.10**	0.11			
11	6L	117.67	5.98	0.00	0.00	27.00	**27.00**	1.37			
12	7/8L	11.80	0.60	0.00	0.00	9.50	**9.50**	0.48			
13	Total	1968.07	100.00	232.40	200.83	108.87	**542.10**	27.54			
14											
15	**Miles of upgrade assuming maximum of 7,500 ADT/Lane.-Level of Service E**										
16		Total Mi	% Miles	4L	6L	*8L	Deficient	Deficient	* For cost estimation purposes of this		
17	Number	Lane	Per Lane	15-30K	30-45K	45-60K+	Mileage	Mileage	study, eight lanes considered the		
18	Lanes	Group	Group	ADT	ADT	ADT	Total	% Total	maximum expandable improvement.		
19	2L	824.26	41.88	66.64	0.00	0.00	**66.64**	3.39	For traffic demands in excess of 8 lane		
20	3L	24.95	1.27	0.00	0.00	0.00	**0.00**	0.00	capacity, lower level of service may		
21	4L	981.99	49.90	0.00	67.87	3.40	**71.27**	3.62	be considered acceptable or additional		
22	5L	7.40	0.38	0.00	1.1	0.00	**1.10**	0.06	geometric improvements warranted.		
23	6L	117.67	5.98	0.00	0.00	4.25	**4.25**	0.22			
24	7/8L	11.80	0.60	0.00	0.00	6.30	**6.30**	0.32			
25	Total	1968.07	100.00	66.64	68.97	13.95	**149.56**	7.60			
26				ESTIMATED COST OF ELIMINATING DEFICIENCIES							
27	**Upgrade to eliminate ADT/Lane >5,000**						**Upgrade to eliminate ADT/Lane >7,500**				
28		Upgrade to	Upgrade to	Upgrade to				Upgrade to	Upgrade to	Upgrade to	
29		4L	6L	8L	Total			4L	6L	8L	Total
30	Miles	232.40	200.83	108.87	542.1		Miles	66.64	68.97	13.95	149.56
31	**Est Const						**Est Const				
32	Cost/Mile				Avg. Cost/Mi.		Cost/Mile				Avg. Cost/Mi.
33	X $1,000	2,000	3,000	4,000	2,772		X $1,000	2,000	3,000	4,000	2,648
34	Total	**464,800**	**602,490**	**435,480**	**$1,502,770**		Total	**133,280**	**206,910**	**55,800**	**$395,990**
35		**Re-construction cost, assuming no salvage value in existing facility									
36											

(continued)

TABLE 3.2. HARRIS COUNTY ARTERIAL STREET INVENTORY (CONTINUED)

	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO
1			DEMAND DEFICIENCIES FOR THE ARTERIAL STREET SYSTEM								
2											
3		ESTIMATED DEFICIENCIES FOR 1988					ESTIMATED 20-YEAR DEFICIENCY				
4	Assuming maximum of 5,000 ADT/Lane land LOS C										
5			Deficient	VMT Congest			Total Mi.	Art. St. Capty.	1988	Arterial St	(1988 VMT
6		Number	Mileage	in excess of			Lane	@ 5,000 ADT	VMT	Utilization	Demand) +
7		Lanes	Total	5,000 ADT/Ln			Group	Per Lane	Demand	Factor % =	(Capacity for
8		2L	240.08	3289304			824.26	8242600	6652814	81	5000 ADT/L)
9		3L	1.20	19504	Lane Miles		24.95	374250	216449	58	20 Year
10		4L	262.22	7130525	Congestion >		981.99	19639800	15679482	80	Deficiency
11		5L	2.10	66474	5000ADT/L=		7.40	185000	130034	70	sssuming
12		6L	27.00	1057909	(VMT Cong.)		117.67	3530100	2702571	77	VMT doubles
13		7/8L	9.50	545579	+ (5000)		11.80	472000	614260	130	@ 3.5% growth
14		Total	542.10	**12,109,295**	**2422**		1968.07	32,443,750	25,995,610	**80**	**19,547,470**
15											
16											
17											
18	Assuming maximum of 7,500 ADT/Lane and LOS E										
19			Deficient	VMT Congest			Total Mi.	Art St Capty	1988	Arterial St	(1988 VMT
20		Number	Mileage	in excess of			Lane	@ 7,500 ADT	VMT	Utilization	Demand) +
21		Lanes	Total	7,500 ADT/Ln			Group	Per Lane	Demand	Factor % =	(Capacity for
22		2L	66.64	1193298			824.26	12363900	6652814	54	π
23		3L	0.00	0	Lane Miles		24.95	561375	216449	39	20 Year
24		4L	71.27	2506405	Congestion >		981.99	29459700	15679482	53	Deficiency
25		5L	1.10	0	7500ADT/L=		7.40	277500	130034	47	sssuming
26		6L	4.25	267608	(VMT Cong.)		117.67	5295150	2702571	51	VMT doubles
27		7/8L	6.30	434550	+ (7500)		11.80	619500	614260	99	@ 3.5% growth
28		Total	149.56	**4,401,861**	**587**		1968.07	48,577,125	25,995,610	**54**	**3,414,095**
29											
30											
31											
32											
33											
34											
35											
36											

TABLE 3.3. HARRIS COUNTY FREEWAY INVENTORY

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1																					
2	Maximum																				
3	Vehicles	4L	4L	5L	5L	6L	6L	7L	7L	8L	8L	9L	9L	10L	10L	TOTAL	TOTAL	ACCUMULATION			
4	Per Lane	Miles	VMT	Miles	VMT	Miles	VMT	Miles	VMT	Miles	VMT	Miles	VMT	Miles	VMT	MILES	VMT	MILES	%	VMT	%
5	2,000	6.45	36409													6.45	36,409	6.45	2.57	36,409	0.14
6	2,500	6.85	63705			1.85	23,405									8.70	87,110	15.15	6.03	123,519	0.48
7	3,000															0.00	0	15.15	6.03	123,519	0.48
8	3,500	5.00	64200			0.70	13,650									5.70	77,850	20.85	8.30	201,369	0.79
9	4,000	1.20	17160													1.20	17,160	22.05	8.78	218,529	0.86
10	4,500	3.44	56760													3.44	56,760	25.49	10.15	275,289	1.08
11	5,000	0.35	6438			2.95	82,600									3.30	89,038	28.79	11.46	364,327	1.43
12	5,500					2.45	77,366									2.45	77,366	31.24	12.44	441,693	1.73
13	6,000	0.60	13800			2.15	75,250									2.75	89,050	33.99	13.53	530,743	2.08
14	6,500					1.55	60,450									1.55	60,450	35.54	14.15	591,193	2.32
15	7,000	3.75	103350			0.65	25,777			0.60	33,000					5.00	162,127	40.54	16.14	753,320	2.96
16	7,500					5.00	225,000									5.00	225,000	45.54	18.13	978,320	3.84
17	8,000			0.85	33150	0.45	20,305									1.30	53,455	46.84	18.65	1,031,775	4.05
18	8,500	2.55	86700													2.55	86,700	49.39	19.66	1,118,475	4.39
19	9,000			1.50	64500	3.30	171,600									4.80	236,100	54.19	21.57	1,354,575	5.32
20	9,500					3.15	173,250							0.60	55,200	3.75	228,450	57.94	23.07	1,583,025	6.21
21	10,000	2.20	85800			1.50	88,203							4.00	389,200	7.70	563,203	65.64	26.13	2,146,228	8.42
22	10,500	4.70	192700							2.55	206,550					7.25	399,250	72.89	29.02	2,545,478	9.99
23	11,000					4.65	297,600			1.65	145,200					6.30	442,800	79.19	31.53	2,988,278	11.73
24	11,500					2.65	177,550							1.45	163,850	4.10	341,400	83.29	33.16	3,329,678	13.07
25	12,000					1.70	119,000			6.45	605,350					8.15	724,350	91.44	36.40	4,054,028	15.91
26	12,500									3.35	329,750					3.35	329,750	94.79	37.74	4,383,778	17.20
27	13,000									4.85	494,700					4.85	494,700	99.64	39.67	4,878,478	19.14
28	13,500					2.20	176,000									2.20	176,000	101.84	40.54	5,054,478	19.83
29	14,000					4.50	374,200			1.45	159,500					5.95	533,700	107.79	42.91	5,588,178	21.93
30	14,500					4.44	386,280			3.35	381,900			4.20	592,200	11.99	1,360,380	119.78	47.69	6,948,558	27.27
31	15,000					1.90	167,200			3.35	391,950					5.25	559,150	125.03	49.78	7,507,708	29.46
32	15,500					1.70	154,700									1.70	154,700	126.73	50.45	7,662,408	30.07
33	16,000					1.75	168,000			3.10	395,600			1.20	192,000	6.05	755,600	132.78	52.86	8,418,008	33.03
34	16,500									1.65	214,500					1.65	214,500	134.43	53.52	8,632,508	33.87
35	17,000					9.40	953,900									9.40	953,900	143.83	57.26	9,586,408	37.62
36	17,500					4.55	472,150			3.80	526,900					8.35	999,050	152.18	60.58	10,585,458	41.54
37	18,000	0.95	67450			2.30	246,100			1.90	273,600			1.10	194,700	6.25	781,850	158.43	63.07	11,367,308	44.61
38	18,500									2.95	430,700					2.95	430,700	161.38	64.25	11,798,008	46.30
39	19,000									5.15	771,900			0.50	93,500	5.65	865,400	167.03	66.50	12,663,408	49.69

Page 1 of 3

(continued)

TABLE 3.3. HARRIS COUNTY FREEWAY INVENTORY (CONTINUED)

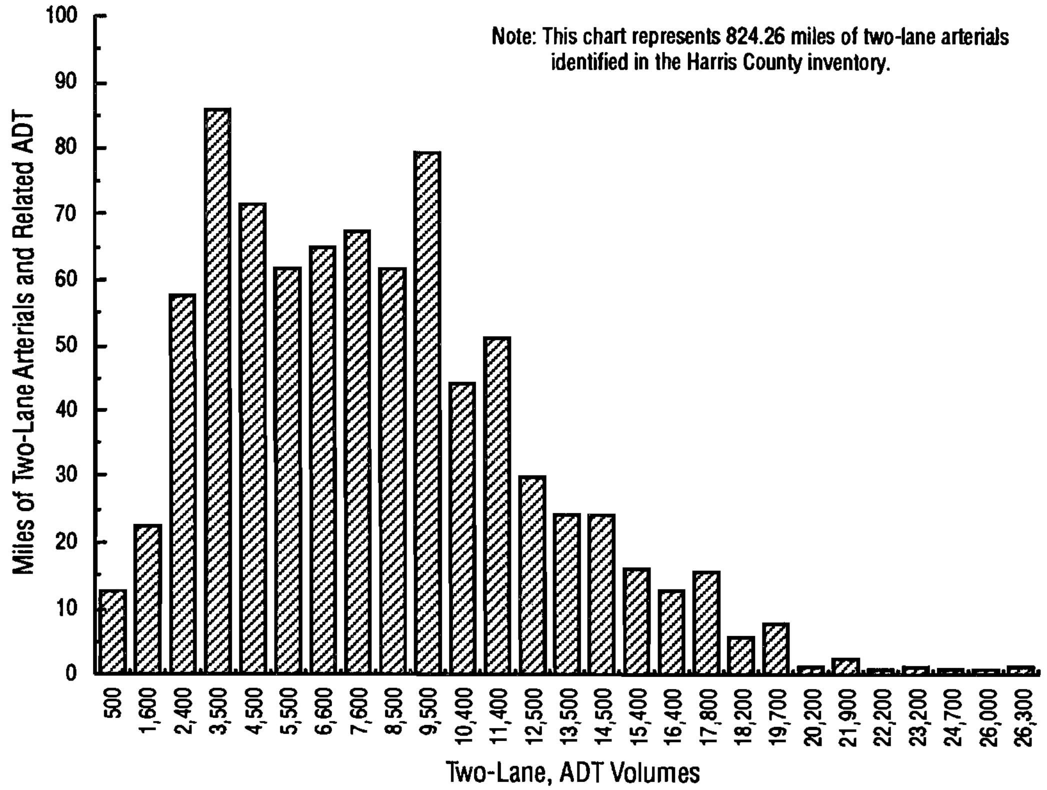
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
40	Maximum																				
41	Vehicles	4L	4L	5L	5L	6L	6L	7L	7L	8L	8L	9L	9L	10L	10L	TOTAL	TOTAL	ACCUMULATION			
42	Per Lane	Miles	VMT	Miles	VMT	Miles	VMT	Miles	VMT	Miles	VMT	Miles	VMT	Miles	VMT	MILES	VMT	MILES	%	VMT	%
43	19500	2.40	187,200											4.00	774,600	6.40	961,800	173.43	69.04	13,625,208	53.47
44	20000					2.30	276,000			3.15	499,650					5.45	775,650	178.88	71.21	14,400,858	56.51
45	20500									4.80	784,500					4.80	784,500	183.68	73.12	15,185,358	59.59
46	21000					1.50	186,000			2.10	350,700					3.60	536,700	187.28	74.56	15,722,058	61.69
47	21500									0.50	85,500			1.15	246,100	1.65	331,600	188.93	75.21	16,053,658	63.00
48	22000					2.55	335,600			3.25	565,500					5.80	901,100	194.73	77.52	16,954,758	66.53
49	22500	3.10	279,000			6.80	913,900			0.45	79,650			1.50	337,500	11.85	1,610,050	206.58	82.24	18,564,808	72.85
50	23000	3.30	303,600			2.00	274,800									5.30	578,400	211.88	84.35	19,143,208	75.12
51	23500	3.70	347,800							1.10	205,700			0.85	196,350	5.65	749,850	217.53	86.60	19,893,058	78.06
52	24000	0.75	72,000							1.05	200,550	0.95	202,350			2.75	474,900	220.28	87.69	20,367,958	79.92
53	24500					3.78	548,100			2.72	530,400					6.50	1,078,500	226.78	90.28	21,446,458	84.16
54	25000					0.95	142,500									0.95	142,500	227.73	90.66	21,588,958	84.72
55	25500															0.00	0	227.73	90.66	21,588,958	84.72
56	26000											1.90	438,900			1.90	438,900	229.63	91.42	22,027,858	86.44
57	26500	0.80	84,000			2.30	361,100									3.10	445,100	232.73	92.65	22,472,958	88.19
58	27000									1.80	384,200					1.80	384,200	234.53	93.37	22,857,158	89.69
59	27500					2.90	472,700									2.90	472,700	237.43	94.52	23,329,858	91.55
60	28000	4.90	543,900													4.90	543,900	242.33	96.47	23,873,758	93.68
61	28500															0.00	0	242.33	96.47	23,873,758	93.68
62	29000					5.09	882,120			0.90	207,900					5.99	1,090,020	248.32	98.86	24,963,778	97.96
63	29500					0.45	79,650									0.45	79,650	248.77	99.04	25,043,428	98.27
64	30000					1.85	329,300									1.85	329,300	250.62	99.77	25,372,728	99.56
65	30500															0.00	0	250.62	99.77	25,372,728	99.56
66	31000															0.00	0	250.62	99.77	25,372,728	99.56
67	31500															0.00	0	250.62	99.77	25,372,728	99.56
68	32000															0.00	0	250.62	99.77	25,372,728	99.56
69	32500					0.57	111,150									0.57	111,150	251.19	100.00	25,483,878	100.00
70																					
71	TOTALS	56.99	2,611,972	2.35	97,650	100.48	9,642,456	0.00	0	67.97	9,255,350	2.85	641,250	20.55	3,235,200	251.19	25,483,878				
72	TOTAL																				
73	Lane Mi.	227.96		7.05		602.88				543.76		25.65		205.50		1612.80					

(continued)

TABLE 3.3. HARRIS COUNTY FREEWAY INVENTORY (CONTINUED)

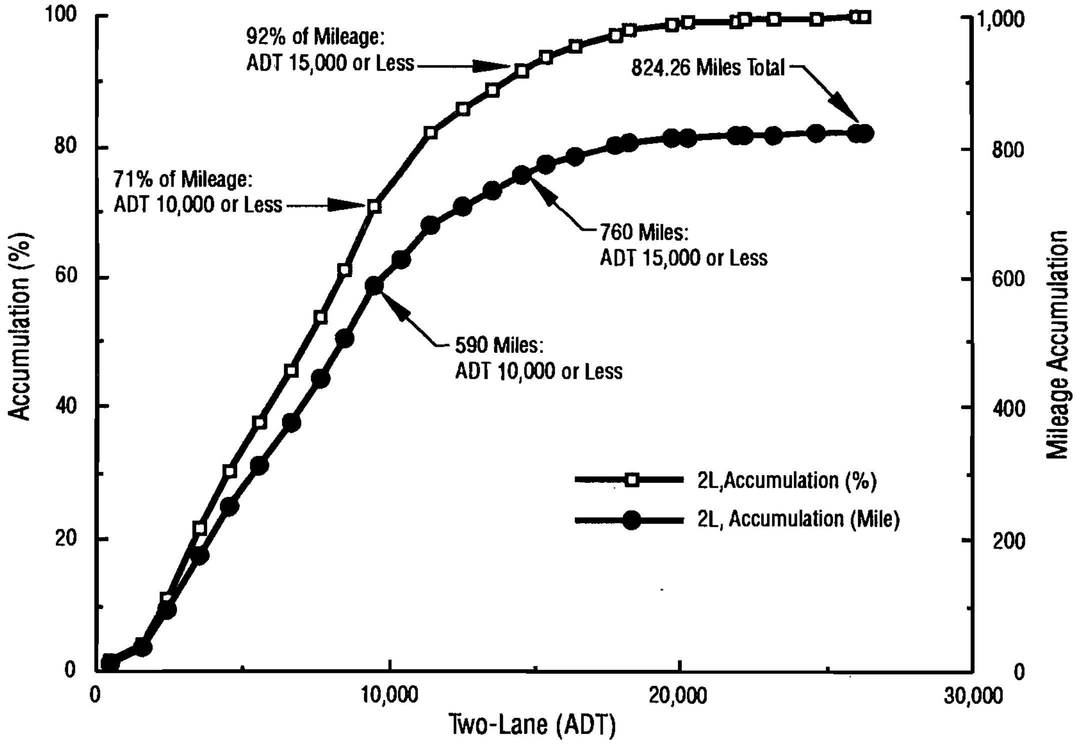
	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF
1				DEMAND DEFICIENCIES FOR THE FREEWAY SYSTEM							
2											
3			ESTIMATED DEFICIENCIES FOR 1988					ESTIMATED 20-YEAR DEFICIENCY			
4						Assuming maximum of 15,000 ADT/Lane and LOS C					
5		Lane		VMT >	Fwy VMT Cap.	VMT Congest.		Miles of Fwy	Fwy VMT Cap.		20 Year
6		Group	Miles	15000 ADT/L	@15,000/Lane	>15,000/Lane		by Lane Group	@15,000/Lane		Deficiency
7		4L	19.9	1884950	1194000	690950		56.99	3419400	Freeway System	assuming
8		5L	0	0	0	0	*Equivalent*	2.35	176250	Utilization	VMT grows @
9		6L	52.74	6907770	4746600	2161170	Lane miles of	100.48	9043200	Factor UF, % =	3.0% = (1.81*
10		7L	0	0	0	0	congestion >	0.00	0	(VMT 1988	1988 VMT) -
11		8L	40.37	6507450	4844400	1663050	15000 ADT/L =	67.97	8156400	Demand) +	(VMT Capacity
12		9L	2.85	641250	384750	256500	(VMT Cong.)	2.85	384750	(Capacity @	for 15000 ADT/L
13		10L	10.3	2034750	1545000	489750	+ (15000)	20.55	3082500	15000 ADT/L)	& 100% UF)
14		Total	126.16	17,976,170	7,569,600	**10,406,570**	**694**	251.19	24,262,500	**105**	**21,764,218**
15											
16						Assuming maximum of 18,000 ADT/Lane and LOS D					
17		Lane		VMT >	Fwy VMT Cap.	VMT Congest.		Miles of Fwy	Fwy VMT Cap.		20 Year
18		Group	Miles	18000 ADT/L	@18,000/Lane	>18,000/Lane		by Lane Group.	@18,000/Lane		Deficiency
19		4L	18.95	1817500	1364400	453100		56.99	4103280	Freeway System	assuming
20		5L	0	0	0	0	*Equivalent*	2.35	211500	Utilization	VMT grows @
21		6L	33.04	4912920	3568320	1344600	Lane miles of	100.48	10851840	Factor UF, % =	3.0% = (1.81*
22		7L	0	0	0	0	congestion >	0.00	0	(VMT 1988	1988 VMT) -
23		8L	29.92	5096850	4308480	788370	18000 ADT/L =	67.97	9787680	Demand) +	(VMT Capacity
24		9L	2.85	641250	461700	179550	(VMT Cong.)	2.85	461700	(Capacity @	for 18000 ADT/L
25		10L	8	1648050	1440000	208050	+ (18000)	20.55	3699000	18000 ADT/L)	& 90% UF)
26		Total	92.76	14,116,570	11,142,900	**2,973,670**	**165**	251.19	29,115,000	**88**	**19,823,218**
27											
28						Assuming maximum of 20,000 ADT/Lane and LOS E					
29		Lane		VMT >	Fwy VMT Cap.	VMT Congest.		Miles of Fwy	Fwy VMT Cap.		20 Year
30		Grouping	Miles	20000 ADT/L	@20,000/Lane	>20,000/Lane		by Lane Grpng	@20,000/Lane		Deficiency
31		4L	16.55	1630300	1324000	306300		56.99	4559200	Freeway System	assuming
32		5L	0	0	0	0		2.35	235000	Utilization	VMT grows @
33		6L	30.74	4636920	3688800	948120	Lane miles of	100.48	12057600	Factor UF, % =	3.0% = (1.81*
34		7L	0	0	0	0	congestion >	0.00	0	(VMT 1988	1988 VMT) -
35		8L	18.67	3394600	2987200	407400	20000 ADT/L =	67.97	10875200	Demand) +	(VMT Capacity
36		9L	2.85	641250	513000	128250	(VMT Cong.)	2.85	513000	(Capacity @	for 20000 ADT/L
37		10L	3.5	779950	700000	79950	+ (18000)	20.55	4110000	20000 ADT/L)	& 85% UF)
38		Total	72.31	11,083,020	9,213,000	**1,870,020**	**94**	251.19	32,350,000	**79**	**18,529,218**
39											

HARRIS COUNTY TWO-LANE ARTERIAL STREET INVENTORY—FREQUENCY DISTRIBUTION OF ADT BY MILEAGE



Note: This chart represents 824.26 miles of two-lane arterials identified in the Harris County inventory.

Figure 3.2



92% of Mileage: ADT 15,000 or Less

824.26 Miles Total

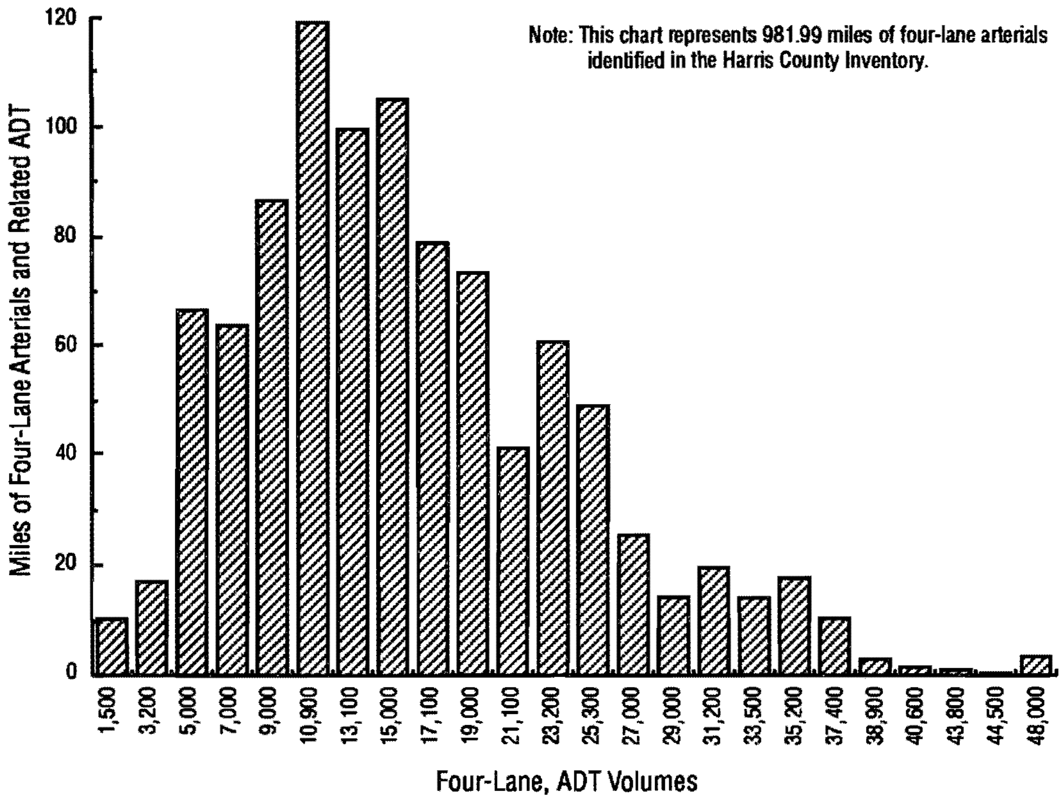
71% of Mileage: ADT 10,000 or Less

760 Miles: ADT 15,000 or Less

590 Miles: ADT 10,000 or Less

Figure 3.3

HARRIS COUNTY FOUR-LANE ARTERIAL STREET INVENTORY—FREQUENCY DISTRIBUTION OF ADT BY MILEAGE



Note: This chart represents 981.99 miles of four-lane arterials identified in the Harris County Inventory.

Figure 3.4

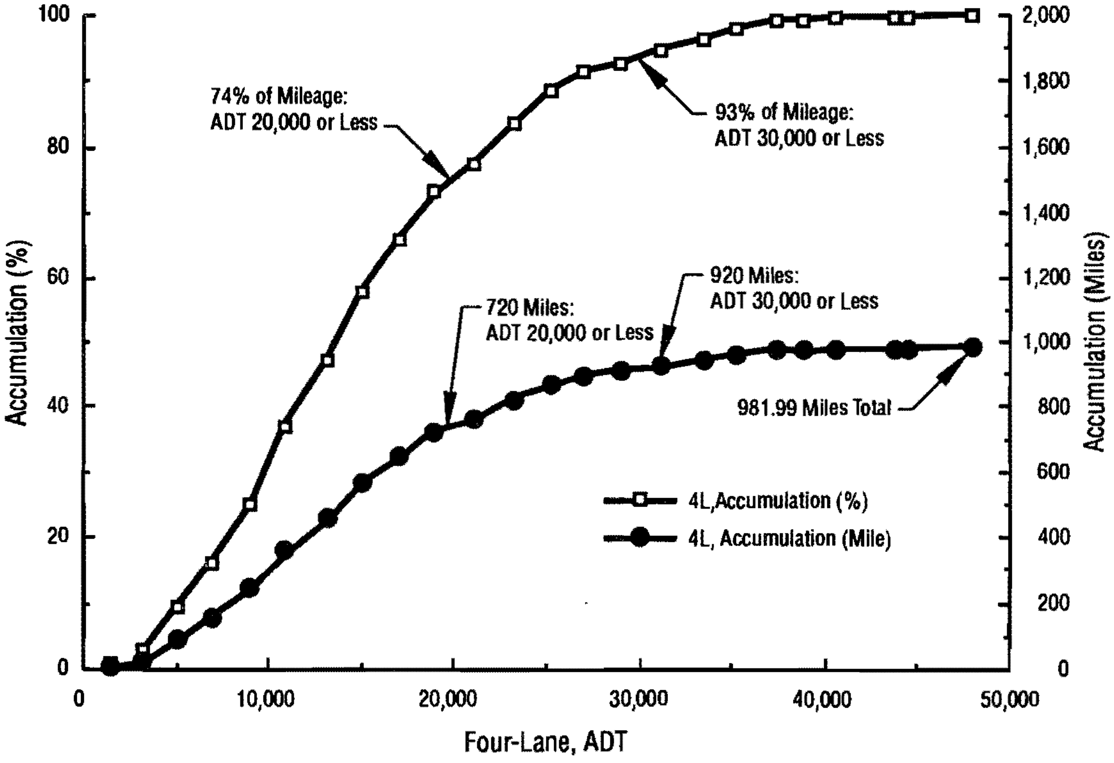
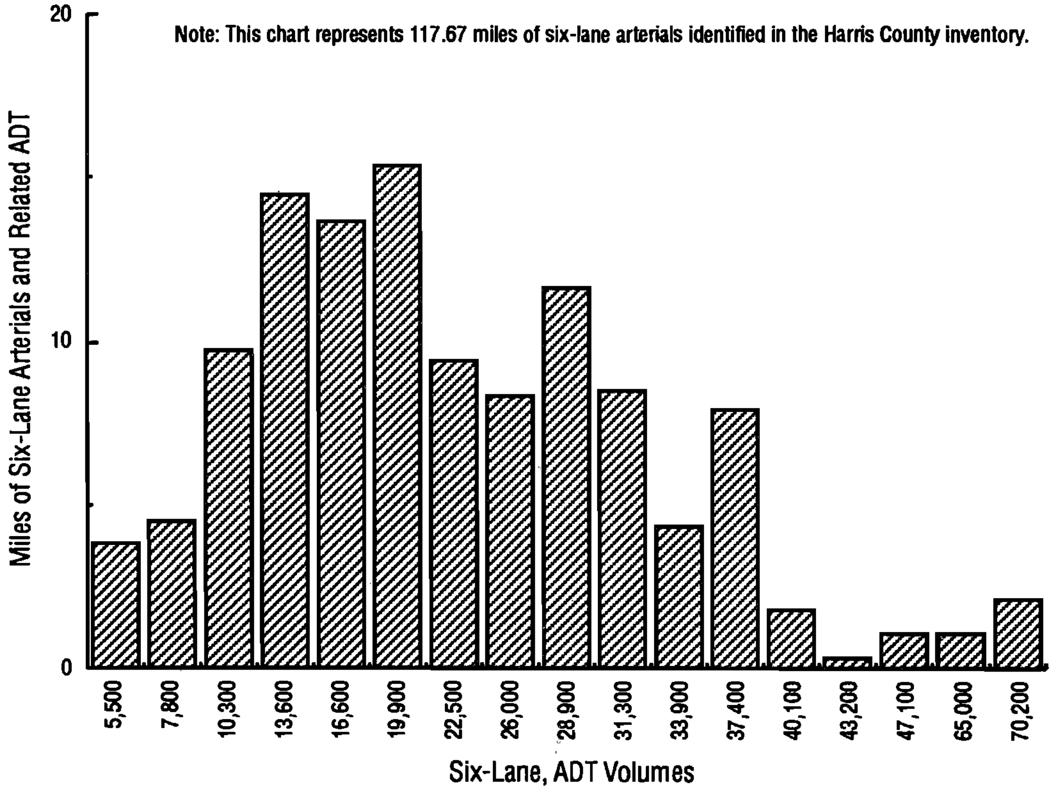


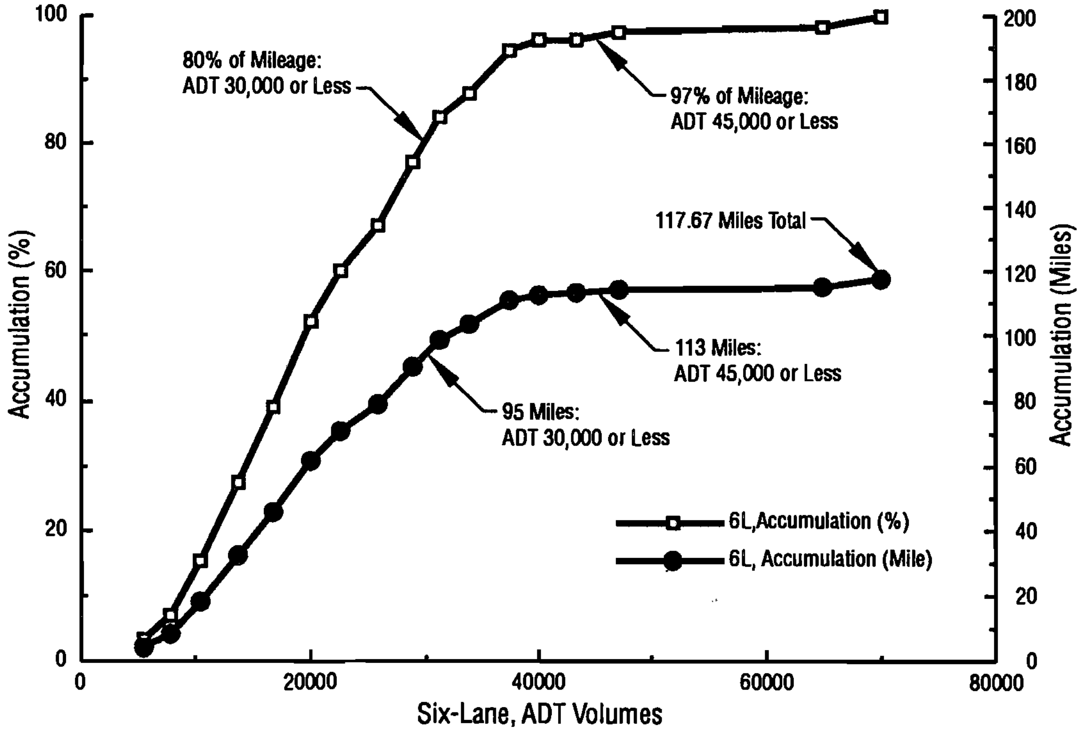
Figure 3.5

HARRIS COUNTY SIX-LANE ARTERIAL STREET INVENTORY—FREQUENCY DISTRIBUTION OF ADT BY MILEAGE



Note: This chart represents 117.67 miles of six-lane arterials identified in the Harris County inventory.

Figure 3.6



80% of Mileage:
ADT 30,000 or Less

97% of Mileage:
ADT 45,000 or Less

117.67 Miles Total

113 Miles:
ADT 45,000 or Less

95 Miles:
ADT 30,000 or Less

Figure 3.7

HARRIS COUNTY, TRAFFIC COUNT FREQUENCY CHART
ARTERIAL STREET ADT

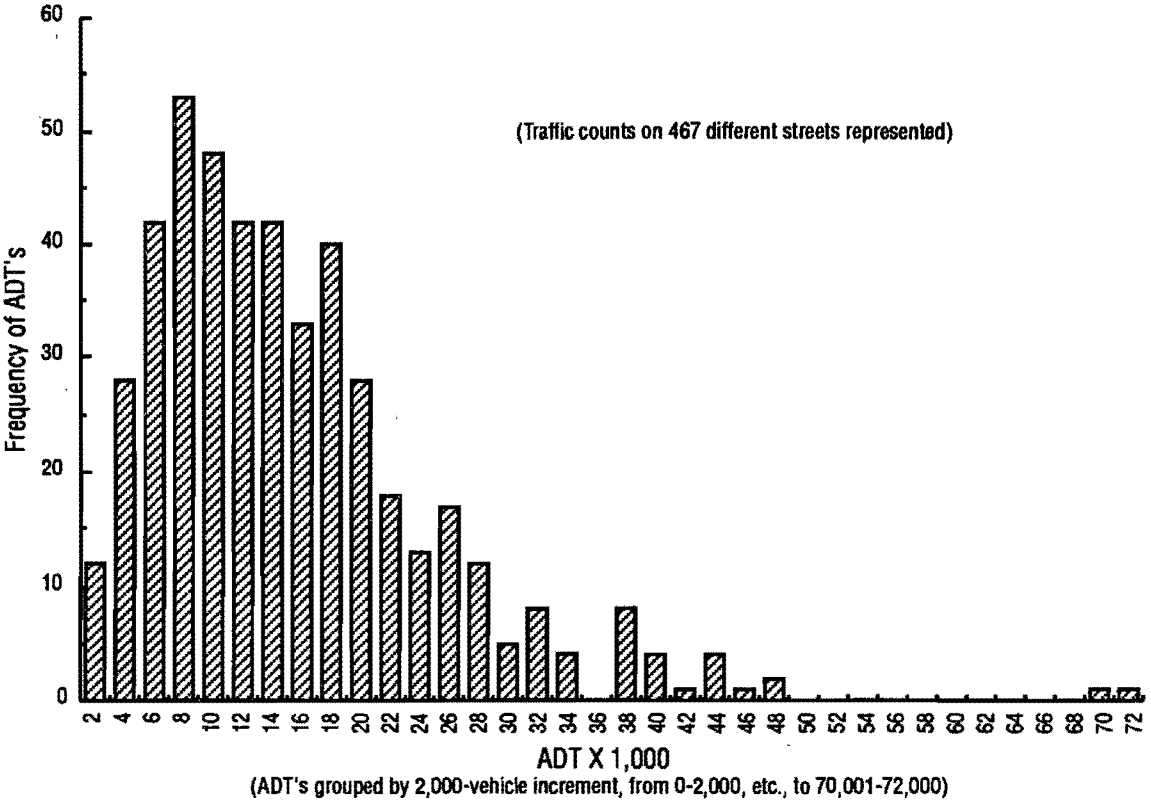


Figure 3.8

HARRIS COUNTY, ADT COUNTS FREQUENCY ACCUMULATION

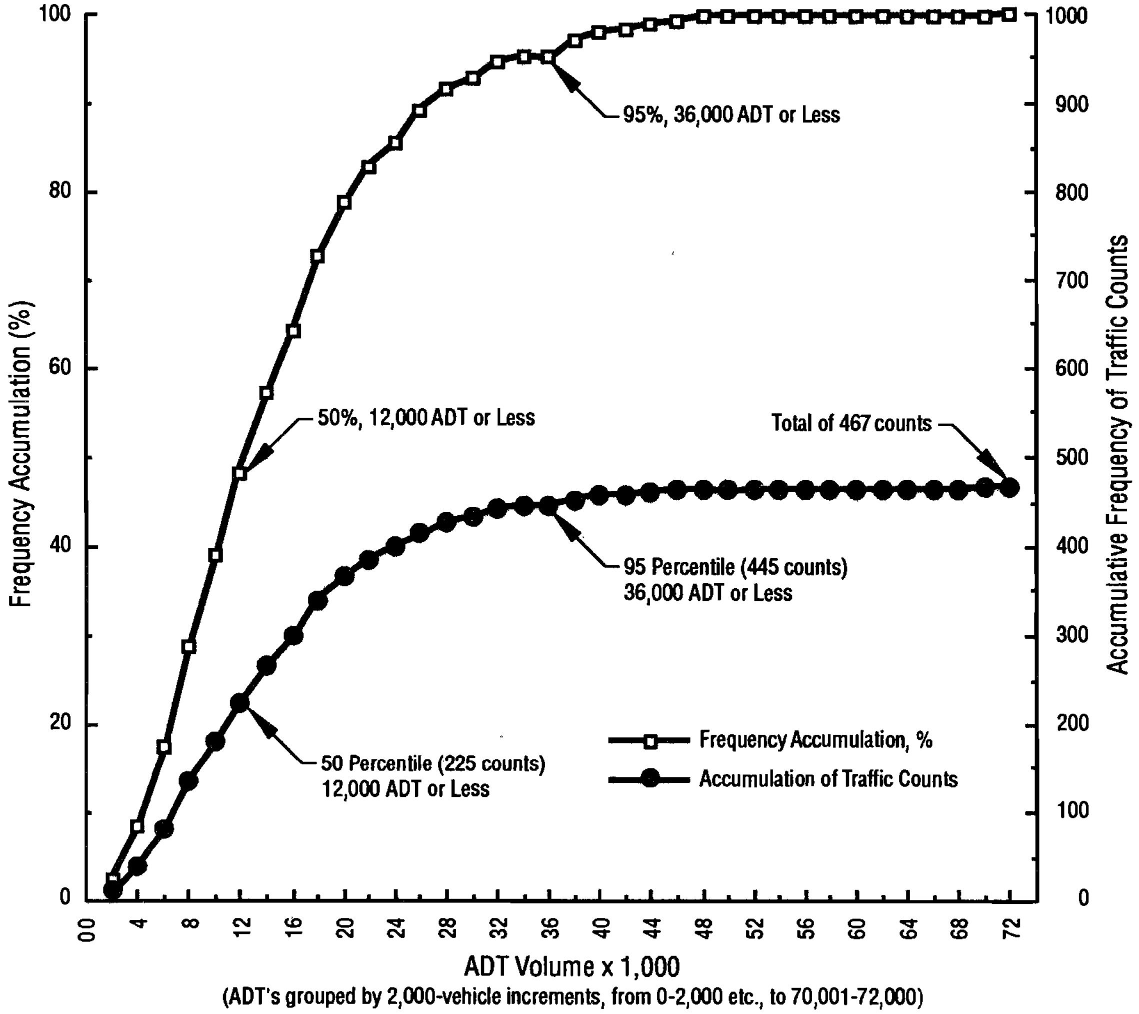


Figure 3.9

The Tables and Figures are briefly described and discussed as follows:

Table 3.2. An inventory of the streets functionally classified as *other principal arterials (with partial or no control of access) and minor arterials.* The table shows the miles of arterials classified by the number of lanes for each arterial inventoried and the ADT (average daily traffic) volume for each lane (this may also be considered as traffic density). Also shown are the ADT and the VMT (vehicle miles traveled) for each density group. Within the arterial system the two-lane and four-lane streets account for most of the mileage and traffic services. The two-lane arterials account for 42 percent of the mileage and 26 percent of the VMT, and the four-lane arterials account for 50 percent of the mileage and 60 percent of the VMT. On page 5 of Table 3.2 are summaries of the traffic service deficiencies in the arterial system. The deficiencies were considered on two levels. The first was 5,000 ADT per lane per day and the second was 7,500. A per-lane volume of up to 5,000 is considered to generate *peak-hour* level of service C. Level of service C is defined as stable flow. Although travel speeds are about 50 percent of those during off-peak-hours (free-flow conditions are generally associated with off-peak travel hours), longer queues will build up at traffic signals, and motorists will experience tension in driving. A volume of 7,500 is considered to generate peak-hour level of service E. Level of service E is defined as unstable flow, significant delays at traffic signals, and travel speeds of one-third or less of those during off-peak-hours. About 542 miles (or 28 percent) of the arterial system are considered deficient if the 5,000 maximum ADT per lane is used as a measure. About 150 miles (or 8 percent) are deficient for the ADT per-lane standard of 7,500.

Table 3.3. Inventory of the freeways in Harris County. The freeways are classified in incremental mileage by the number of lanes in the freeway and ADT per lane. Page 3 of Table 3.3 shows the supply deficiencies in the freeway system. The VMT on the freeway system is considered as the driving public's *demand* for *high-quality* traffic service. The argument for the SASS is the need to *supply* a high-quality service for future growth which otherwise might never be available from the freeway system unless it substantially increased in size. The degree of deficiency in freeway service is a function of the congestion levels the community will tolerate. Consequently, the freeway supply deficiencies have been set out separately from the supply deficiencies estimated for the arterial street system. However, it may also be that that there are trips (particularly short trips) taken on the freeway system which might be taken on the arterial system if the existing arterial system supplied a competitive alternate route.

Figures 3.2 through 3.7. The charts and graphs in these figures were plotted from the data in Table 3.2 and show the frequency of occurrence of various levels of ADTs and the distribution of these frequencies throughout the system. The charts and graphs were prepared for only the two, four, and six-lane arterials. The amount of mileage for the three, five, and seven/eight-lane arterials was considered too small to be statistically significant and was not plotted. The interesting feature of these plots is the similarity in the shapes. The fact that *each* of these lane groups shows about the same lane-volume density suggests that the quality of arterial street service is nearly uniform and reflects a certain level of public tolerance to congestion. It also suggests that each of the two, four, and six-lane groups is proportionately utilized. This is confirmed by the utilization factors shown in Table 3.2, page 5 of 5, which show that the utilization factors for the two, four, and six-lane facilities, at an ADT capacity of 5,000/lane, are 81, 80, and 77 percent. Whatever the powers are that respond to the public's demand for street facilities, they appear to propagate a uniform level of congestion among the various streets regardless of the number of lanes provided by each street.

Figures 3.8 and 3.9. These plots show the frequency distribution of *maximum* ADT for each of the 467 different streets (regardless of the number of lanes) included in the inventory.

The preceding data are useful in contemplating the magnitude of the supply and demand for traffic services in Harris County. The *premise* of the study *is* that in the future the county will need additional high-quality traffic services and the future supply of freeway traffic service is not likely to meet this additional demand. On page 5 of Table 3.2 and page 3 of Table 3.3, estimates are shown of the utilization of the respective arterial street and freeway systems. It is evident that the freeway system is more nearly saturated than the arterial system for all levels of service. One reason for this difference may be the matching of the assets of the arterial system to the market areas. In other words, there may be streets classified as arterials that do not have contributing market areas. It is highly unlikely, however, that any highway street system could ever be planned so efficiently that all segments would be utilized to the same degree of traffic usage.

EXTENT OF CONCEPTUAL SYSTEM

The critical issue in determining the size of the system is anticipating, at any one time, the most likely location and direction of growth and economic development and designating sufficient system mileage to accommodate the future mobility needs of these areas. Necessary rights-of-way should be reserved and/or acquired and provisions for utilities should be made sufficiently in advance of construction to assure a minimum of conflict with the prevailing and future land use. The ultimate size of the system is a function of the growth and economic development of the county and the rate at which the system should be expanded is a function of the rate of growth. It is not envisioned that a SASS be designated in its entirety or augmented every twenty years or so. The system should be incremented beginning with current needs and augmented every year or more to track and satisfy the direction and magnitude of growth. It is important in all aspects of planning to acknowledge the right-of-way requirements for elements in the SASS, and every attempt should be made to reserve, as far in advance as possible, the special right-of-way requirements for the SASS.

In 1988 the arterial system appeared to suffer a demand deficiency of about 4.4 million to 12.1 million VMT, according to the data presented on page 5 of Table 3.2. The estimate for the twenty-year deficiency in Table 3.2 suggests a shortfall of arterial capacity of between 8.1 million and 17.8 million VMT. The freeway system, from the data shown in Table 3.3, is estimated to have a 1988 demand deficiency of between 1.9 million and 10.4 million VMT and a twenty-year deficiency of between 18.5 and 21.8 million VMT.

These estimates do not take into account the construction of additional arterial and freeway facilities. The range of estimates is presented because there are no precise measures of tolerance to congestion and of the market price a community is willing to pay to improve mobility. As long as the population and economy of the county grow, additional arterial and freeway facilities will be needed. If history is any guide, the arterial street system should be augmented about as it has been in the past if it is to provide about the same degree of mobility and quality of service within the arterial system; it will then continue to have about the same range of VMT deficiency over the next twenty years. The freeway system, however, is not expected to double in scope in the existing urban areas during the next twenty years, which is about what it would take to continue to provide even the present-day marginal levels of service. Consequently, it appears that the demand for freeway-quality traffic service will exceed the supply unless sufficient additional facilities are installed which will furnish these services. Additionally, it is inferred that, if about one-third of the unfulfilled demand (21 million VMT) for freeway service is added to the 8 to 18 million VMT deficiency in the arterial street system, a total VMT deficiency range of about 15 to 25 million could be expected. From this it can be conjectured that a conceptual SASS of about 490 miles could, in twenty years, attract ADT's of 36,000 to 60,000 (VMT deficiency ÷ 490*UF) assuming a utilization factor (UF) of 85 percent (see Tables 3.2 and 3.3). The UF is the *traffic demand* on the system divided by the assumed (5,000 or 7,500 or ? ADT/lane) *capacity* of the *system*. The UF is, however, only an *average* value and may not tell much about the intensity of congestion on certain segments of the system, but should be useful in comparing different systems. No system serving the needs and desires of a varied, changing, and diverse traveling public should be expected to continually distribute traffic services uniformly throughout the system.

The adequacy of the SASS system to attract a share of the VMT will depend on the productivity (speed, capacity and demand, and reliability), continuity, length, and proximity (location with respect to the market area) of various routes in the system. Consequently, there will be a strong interaction between the geometric and traffic operation standards set for the SASS and the amount of traffic attracted to the system. The higher the quality of service provided by the SASS, the more traffic it will attract.

EFFECT OF CONCEPTUAL SYSTEM ON TOTAL NETWORK

The H-GRTS office has made several studies forecasting the traffic service demands and the effect of these demands on the highway and street systems in Harris County. These studies assume a scope and intensity of future land use, population growth, and productivity of the various elements making up the county road system. The principal functional elements considered in these studies are freeways, arterial streets, and collectors. Freeways are further grouped as interstate, non-interstate, and tollroads. Arterials may be further classified as other principal arterials, superstreets, arterials, and expressways. Collectors may be classified as freeway connectors and frontage roads and those streets connecting local streets to the arterial system. These various classifications are generally used to sort out, for various interests, the effect and contribution of the different roadway elements. The important consequence is in assigning travel speeds and capacities to these various elements regardless of their functional classifications.

In one study the H-GRTS office modeled two county highway and street networks, one simulation designating 492 miles of *improved* arterials (considered in this study to represent the SASS), and the other none. In the modeling simulation process the distinction between improved arterials and the other arterials is that faster average travel speeds and higher capacities are assigned to the improved arterials. In this study the improved arterials were assigned a travel speed 5 to 10 mph faster than the other arterials within urban areas. A summary of the results of this study is shown in Table 3.4 (page 37). The 492-mile improved arterial network modeled in the simulation is substantially the same as the 490-mile conceptual SASS system.

The significant result of the study is the diversion of 21 million VMT to the improved arterial system. The freeway system shows a reduction of 8 percent VMT and the other arterials show a reduction of 36 percent. It is to be noted that the total mileage for the Case 2 simulation is only 81 miles (3137.6 – 3056.4 = 81.2) longer than the Case 1 mileage, even though 492 miles of improved arterial have been added to Case 2. The difference is accounted for by the 373.5 miles of arterials and 37.4 miles (373.5 + 37.4+81 = 492) of collectors which were upgraded (within the simulation) to improved arterials.

The average design speeds assumed for conceptual SASS are about 5 to 10 mph faster that the speeds used in the above simulation study. Consequently, it should be expected that VMT diversions from the freeway system to the SASS should be somewhat larger than those derived from the simulation study.

TABLE 3.4. ARTERIAL NETWORK SIMULATION SUMMARY

	A	B	C	D	E	F	G
1							
2							
3							
4							
5							
6							
7							
8							
9							
10			CASE 1. WITHOUT IMPROVED ARTERIALS				
11	Case		Freeways	Arterials	Improved	Collectors	Total
12		Units			Arterials		
13	1	Miles	465.6	2094.3	0	496.5	3056.4
14	1	VMT	48992289	47903795	0	5505634	102401718
15	1	% Miles	15.23	68.52		16.24	100.00
16	1	% VMT	47.84	46.78		5.38	100.00
17							
18			CASE 2. WITH IMPROVED ARTERIALS				
19	2	Miles	465.6	1720.8	492.1	459.1	3137.6
20	2	VMT	45047780	30791511	21454546	4396655	101690492
21	2	% Miles	14.84	54.84	15.68	14.63	100.00
22	2	% VMT	44.30	30.28	21.10	4.32	100.00
23							
24		**Reduction in**					
25		**VMT**	**3,944,509**	**17,112,284**	**-21,454,546**	**1,108,979**	**711,226**
26		**% Reduction**					
27		**in VMT**	**8.1**	**35.7**		**20.1**	**0.7**
28							
29							
30							

IV. DESIGN CONCEPTS

GENERAL

The primary distinction between the strategic arterial streets proposed in this study and other arterials is that the strategic arterial streets will provide a higher quality of service and be more attractive to a motorist than otherwise. Higher-quality service is related to such characteristics as (1) travel speed, (2) capacity, (3) reliability of operations, and (4) proximity to trip origin and destination (route location). Speed, capacity, and reliability are primarily related to geometric design and access control. Proximity is a function of route location, land use, and availability of rights-of-way.

There are a wide variety of geometric designs and design standards that have been used by various public agencies for arterial streets which could be adopted for the SASS. A discussion of these variations is considered beyond the scope of this study. It is intended that the geometric design features associated with the SASS be distinctive and be easily perceived by the motorist as being different from ordinary arterials. Consequently, the roadway design features proposed in this study are a combination of the features associated with freeways and other arterials. These features result in a street that will have some of the operating characteristics of both the freeway and the arterial street.

CONCEPTUAL DESIGN FEATURES

These are the features proposed:

(1) Median-barrier-separated roadways.
(2) No left turns; all turning movements from the right-hand lane.
(3) Auxiliary lane, functioning as an emergency parking and speed-change lane on the driver's right.
(4) Provisions for U-turns.
(5) Signalized, at grade, intersections spaced at intervals of about one to two miles. Non-grade-separated signalized intersections should allocate a major portion of the green time in the signal cycle to the strategic arterial. In the examples presented in this study, the allocation is about 70 percent to the arterial and 30 percent to the crossing street.
(6) Grade separations where necessary to accommodate crossing traffic that cannot be accommodated by the allocated green time.
(7) Grade separations at all railroads.

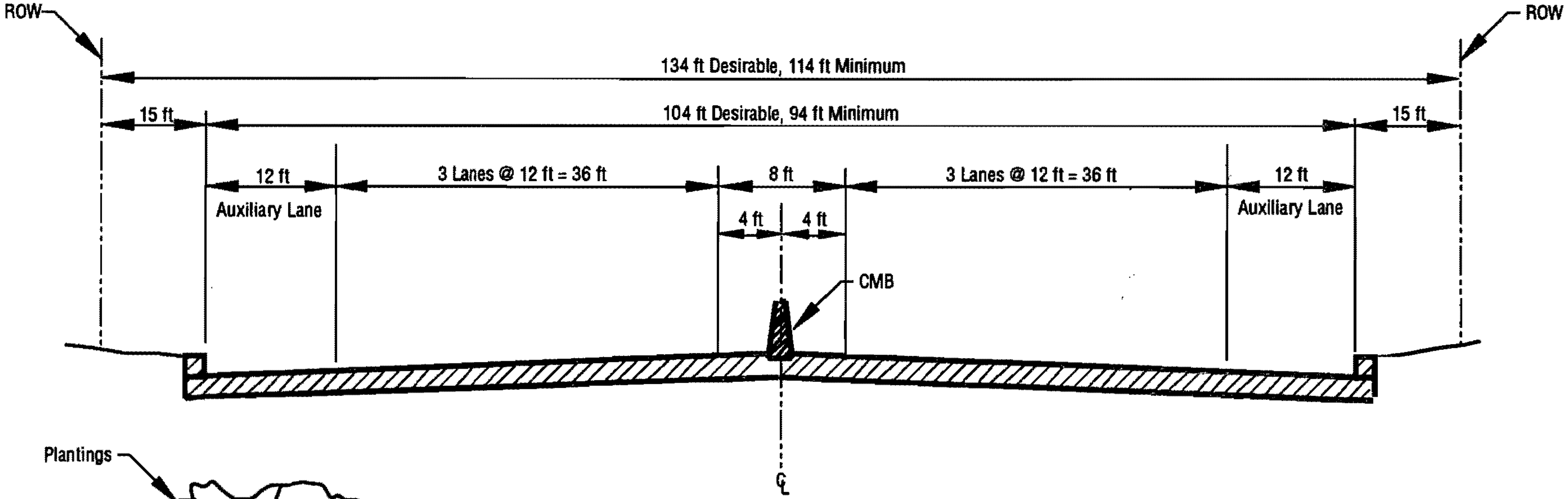
A *means* of achieving higher-quality service by utilizing the features described above is shown in Figures 4.1 through 4.10 (pages 39-53).

Figure 4.1 (page 39) illustrates the proposed basic cross-section of a six-lane divided strategic arterial street (SAS). This cross-section proposes the addition of an auiliary lane (AL) to serve as an emergency-parking shoulder (EPS) and a speed-change lane (SCL). The AL is not usually included on arterial streets. Traffic capacity is a function of the number of lanes and the operational characteristics of intervening intersections. Additionally, capacity *and* reliability of operations can also be enhanced by provisions for an AL on the driver's right. The AL is particularly effective where property access is permitted to the arterial, as this lane will accommodate speed changes during turning movements and during access to and from the arterial. It also provides space for channeling storm water which can reduce the capacity of a curb lane. The AL is also useful during maintenance operations for detours and working space. Ordinarily an EPS is considered an integral part of freeway design, but a similar addition to arterial streets should be very effective in improving traffic capacity, operational reliability, and safety.

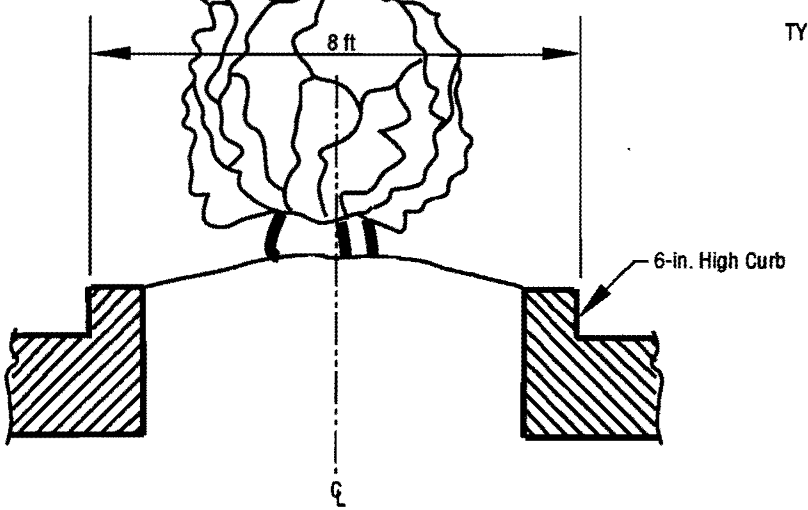
Figure 4.2 (page 40) shows the configuration for stage construction. It also suggests that stage development could forego the other features recommended as necessary for a strategic arterial such as no left turns, median barriers, grade separations, etc., until such time as traffic conditions and land use make the conversion to Stage II desirable. It is to be noted that the minimum right-of-way recommended is not the minimum considered adequate for the entire SASS but is only for segments within the system where acquiring or reserving rights-of-way is particularly difficult.

Figures 4.3a, b, and c (pages 41, 42, and 43) are diagrammatic drawings showing all the operational movements to be expected along a strategic arterial. With the exception of intersections that are signalized to accommodate some of the crossing traffic and U-turns, the traffic flow is the same as for the average freeway. Eliminating left turns along the arterial improves operations and enhances safety because the left-hand lane does not have to slow for left-turning traffic or be inconvenienced by the queueing for left turns.

Figure 4.4 (page 44) is a diagrammatic drawing showing how the various traffic movements can be spread out into separate movements along an arterial. These separate movements provide the same traffic service as a diamond interchange but with more indirection and the need for a traffic signal to handle U-turns. In order for this to operate satisfactorily, the *adjoining and crossing streets must be interconnected.* The advantage of this layout is that by separating some of the traffic movements, the areas and configurations of rights-of-way needed can be modified to adapt to abutting property. This is contrasted with the conventional right-of-way configurations needed at a



TYPICAL CROSS SECTION
(Not to Scale)



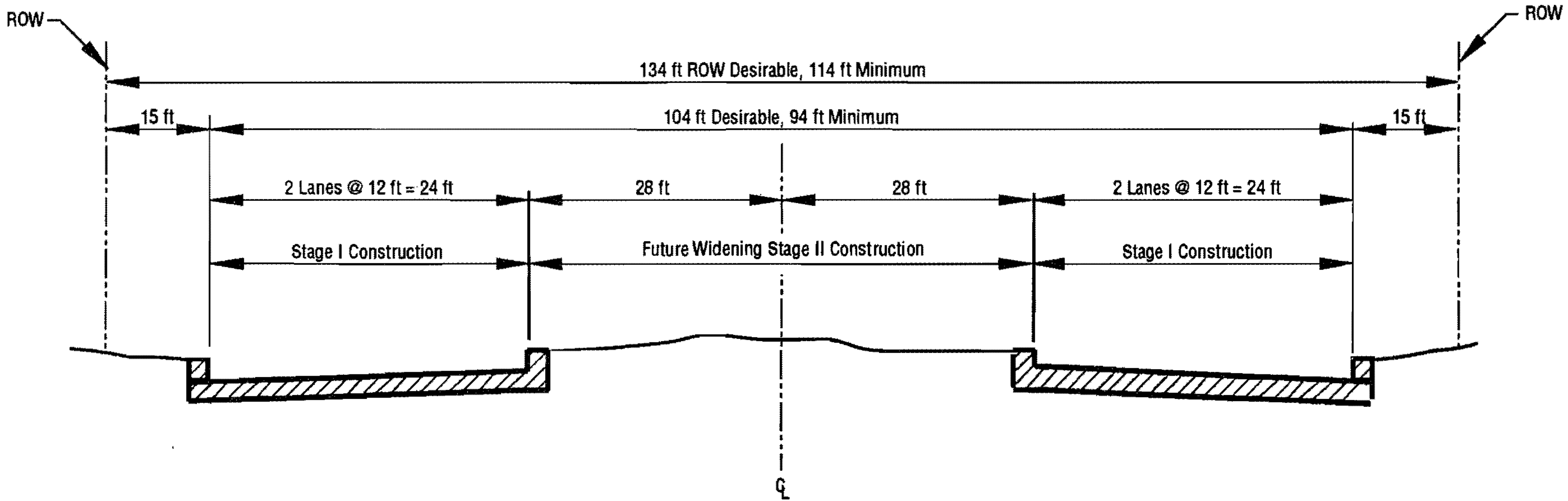
Alternate Median Design

NOTES

1. Auxiliary Lane to Function as Emergency Parking Shoulder and Speed-Change Lane
2. 8-ft Median Desirable; 6-ft Min
3. 12-ft Lane Widths Desirable; 11-ft Min
4. 15-ft ROW Clearance Desirable; 10-ft Min

STRATEGIC ARTERIAL STREET
(Left Turns Prohibited)
PROPOSED TYPICAL CROSS SECTION

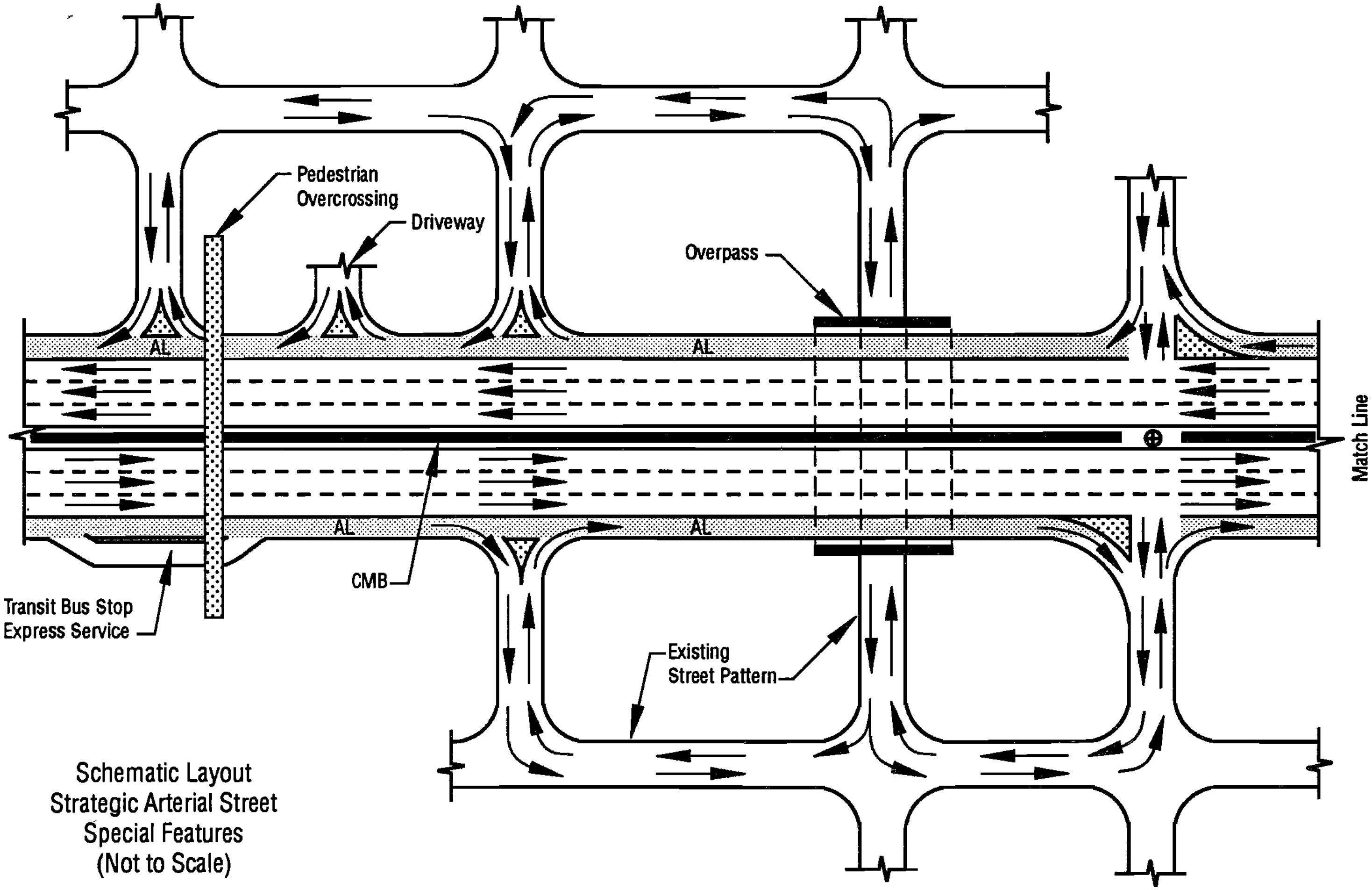
Figure 4.1



TYPICAL CROSS SECTION
(Not to Scale)

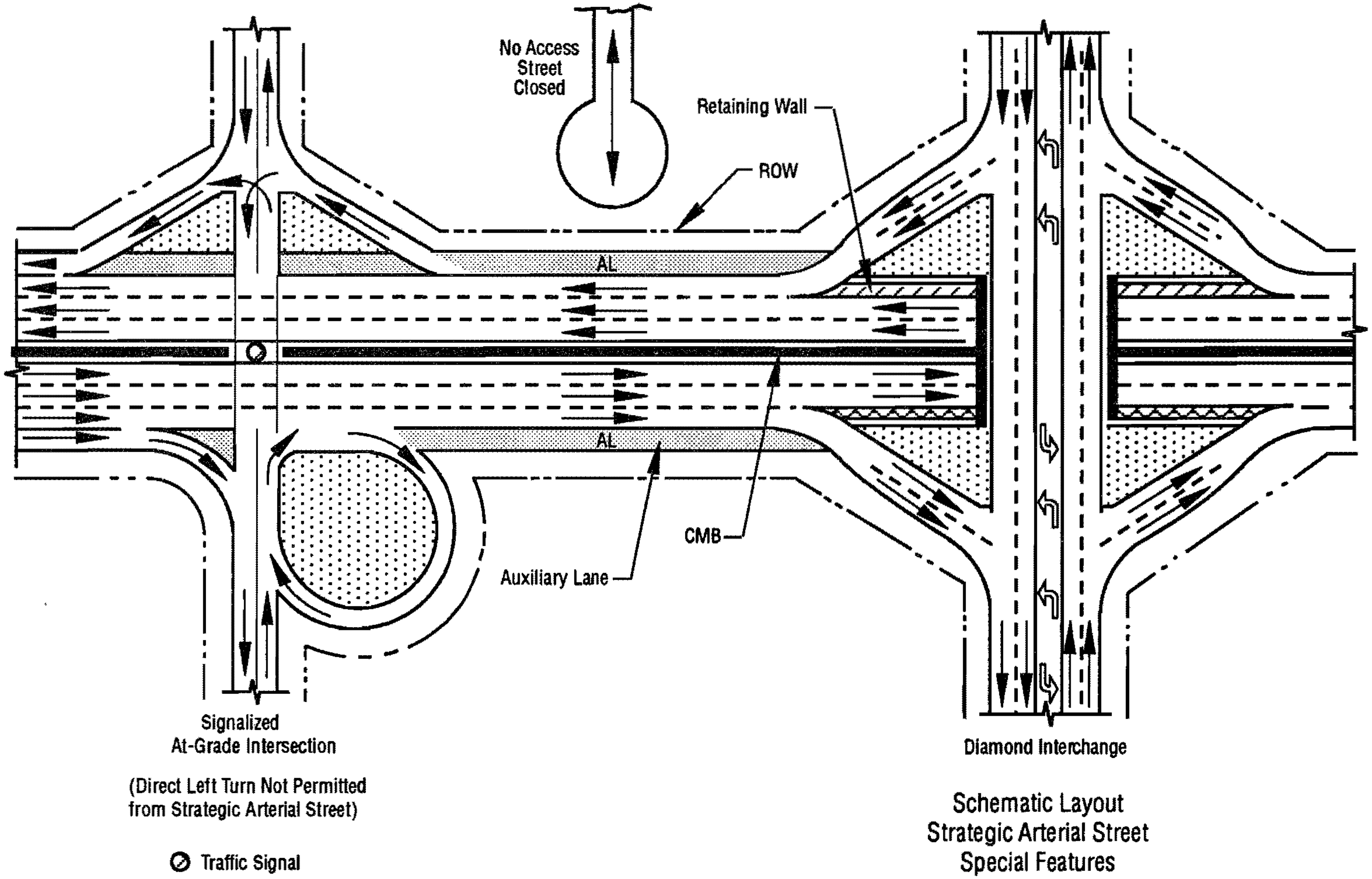
STRATEGIC ARTERIAL STREET
(Left Turns Prohibited)
PROPOSED TYPICAL CROSS SECTION
STAGE CONSTRUCTION

Figure 4.2



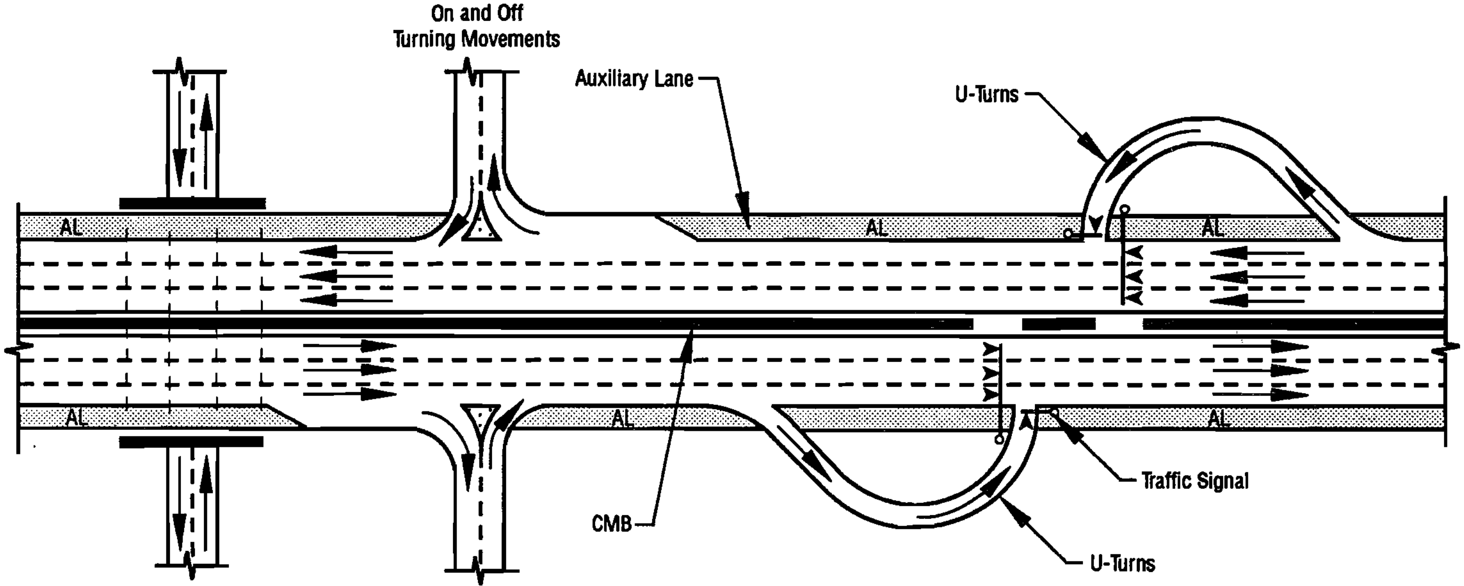
Schematic Layout
Strategic Arterial Street
Special Features
(Not to Scale)

Figure 4.3a



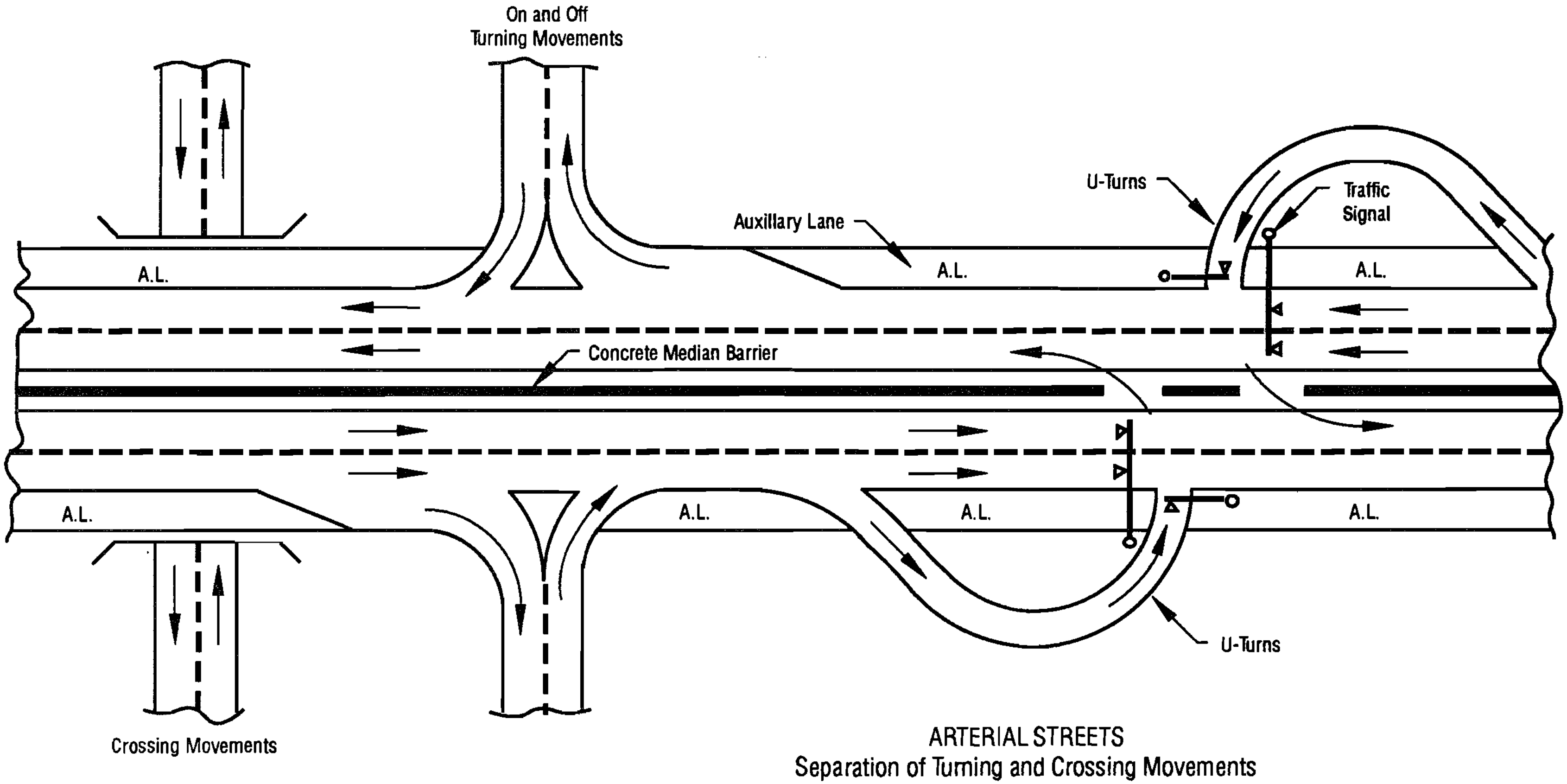
Schematic Layout
Strategic Arterial Street
Special Features
(Not to Scale)

Figure 4.3b



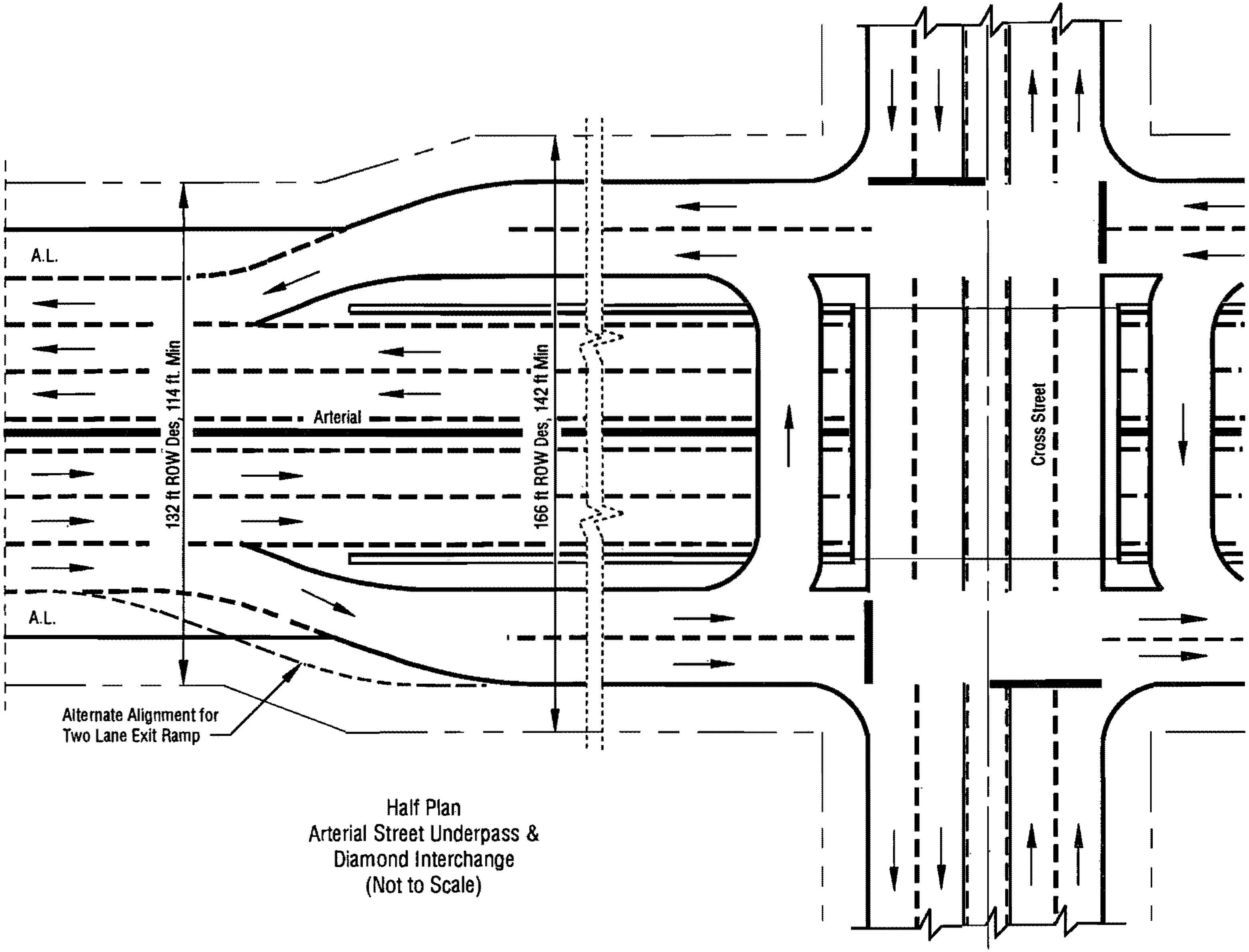
Schematic Layout
Strategic Arterial Street
Special Features
(Not to Scale)

Figure 4.3c



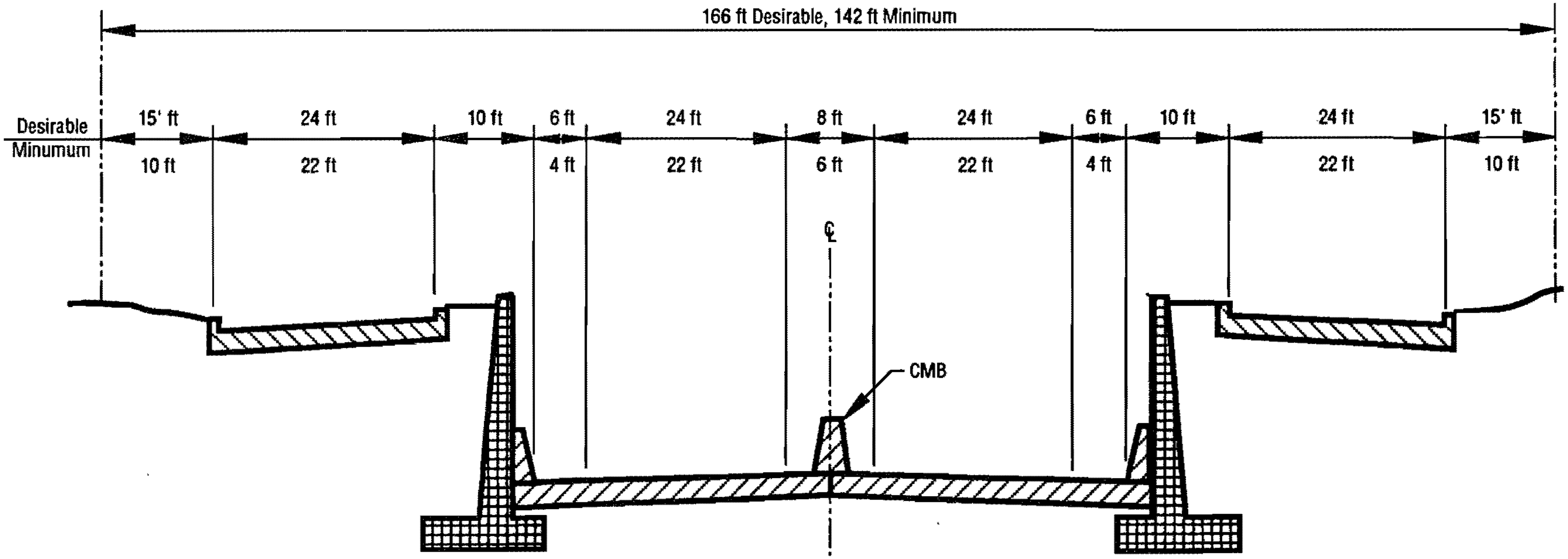
ARTERIAL STREETS
Separation of Turning and Crossing Movements

Figure 4.4



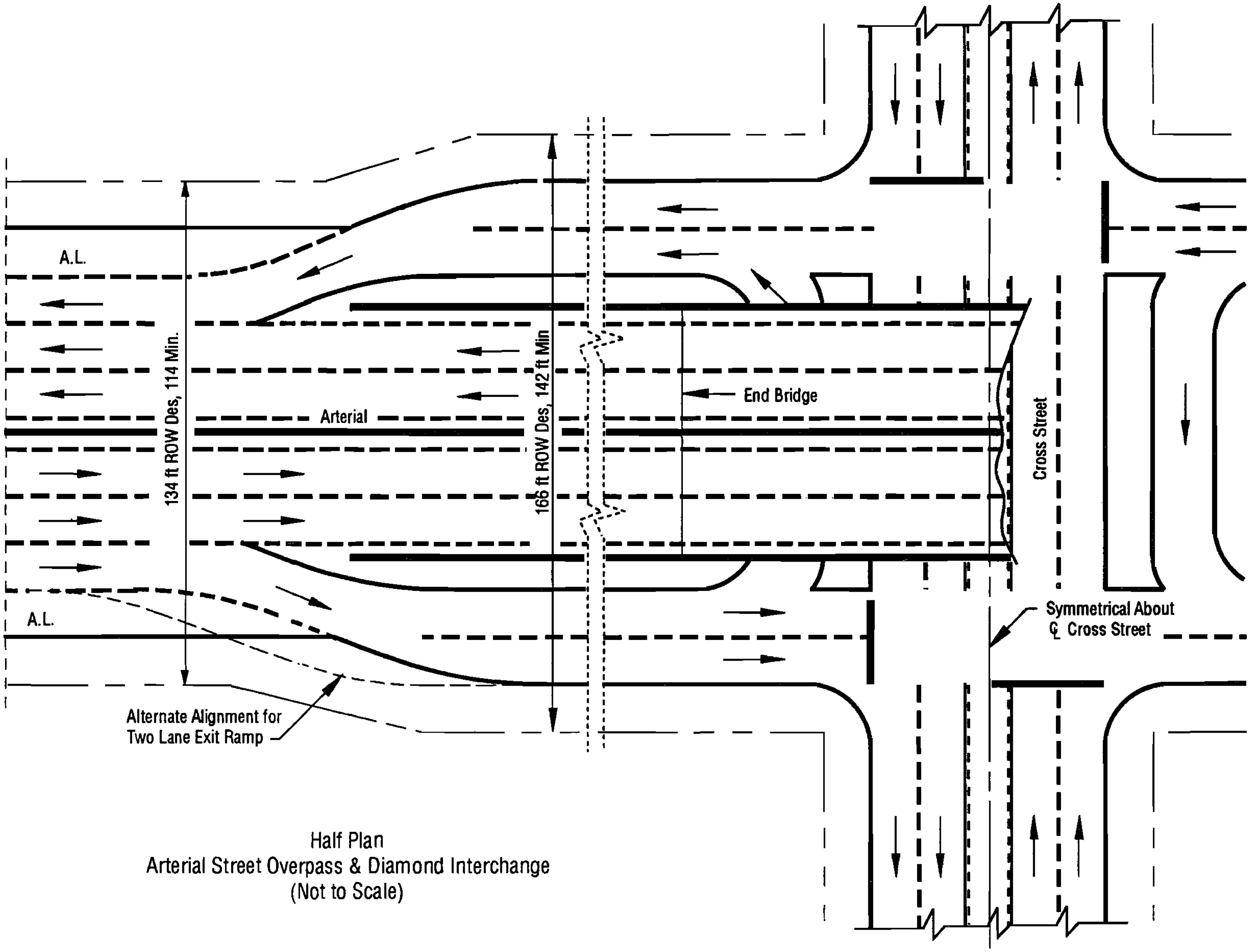
Half Plan
Arterial Street Underpass &
Diamond Interchange
(Not to Scale)

Figure 4.5a



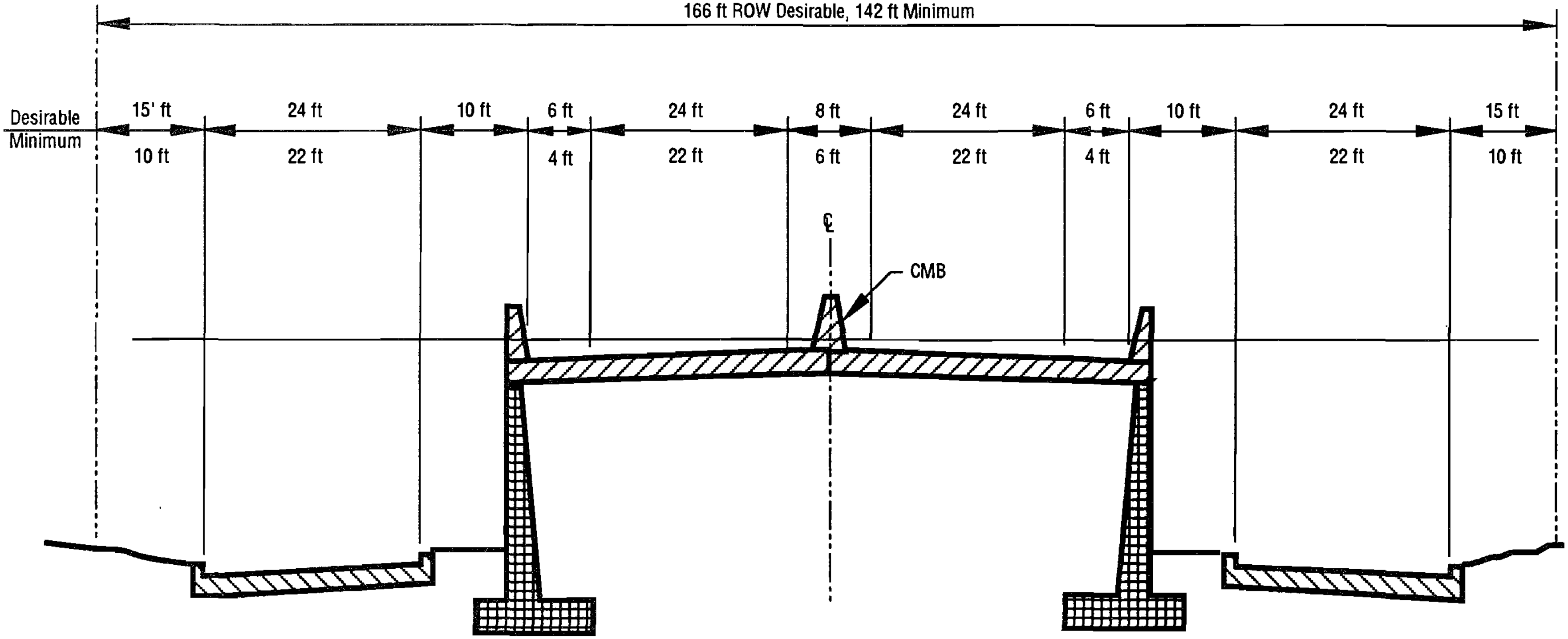
Typical Cross Section of Arterial Street Underpass
Approaches to Diamond Interchange
(Not to Scale)

Figure 4.5b



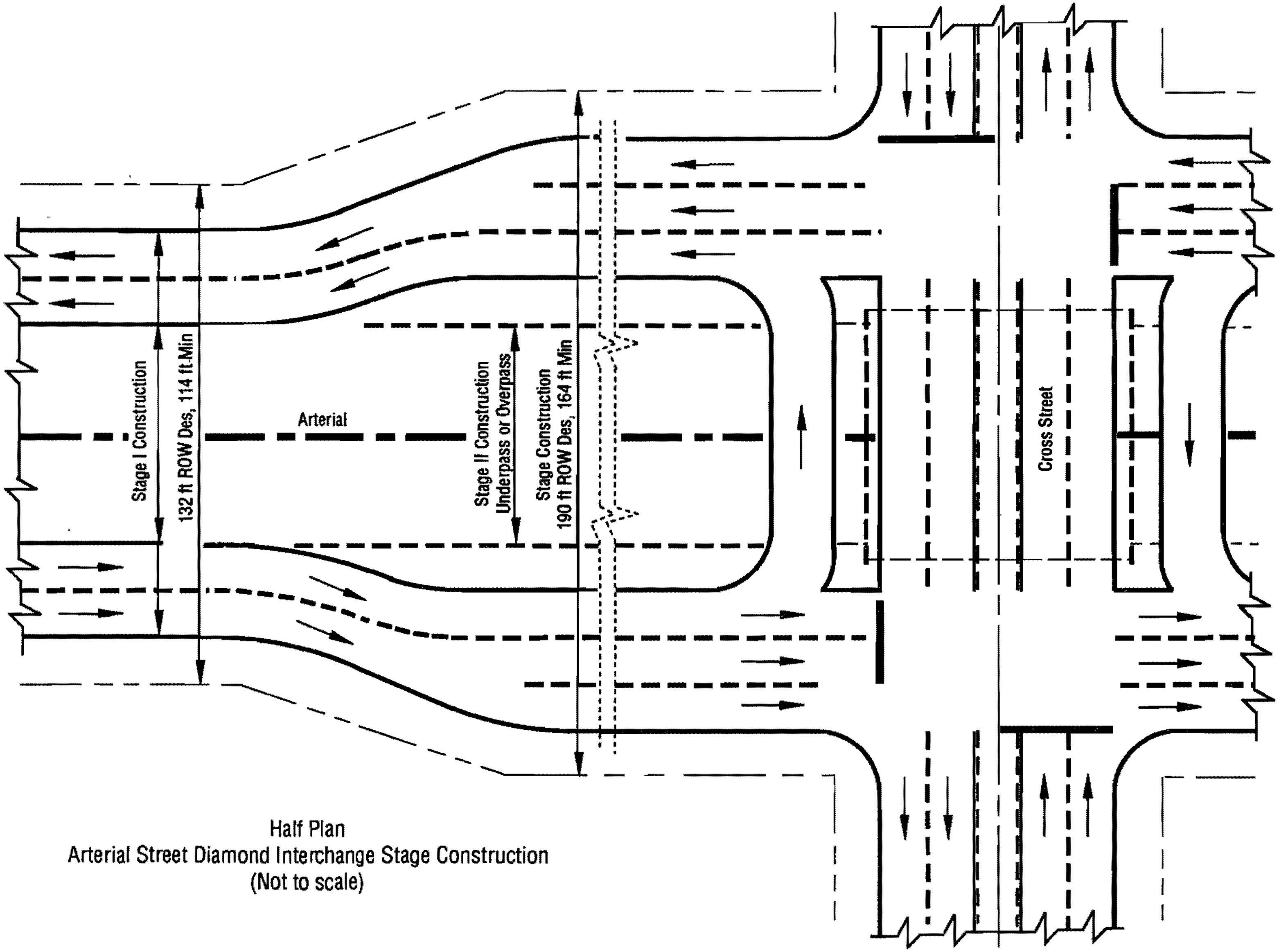
Half Plan
Arterial Street Overpass & Diamond Interchange
(Not to Scale)

Figure 4.6a



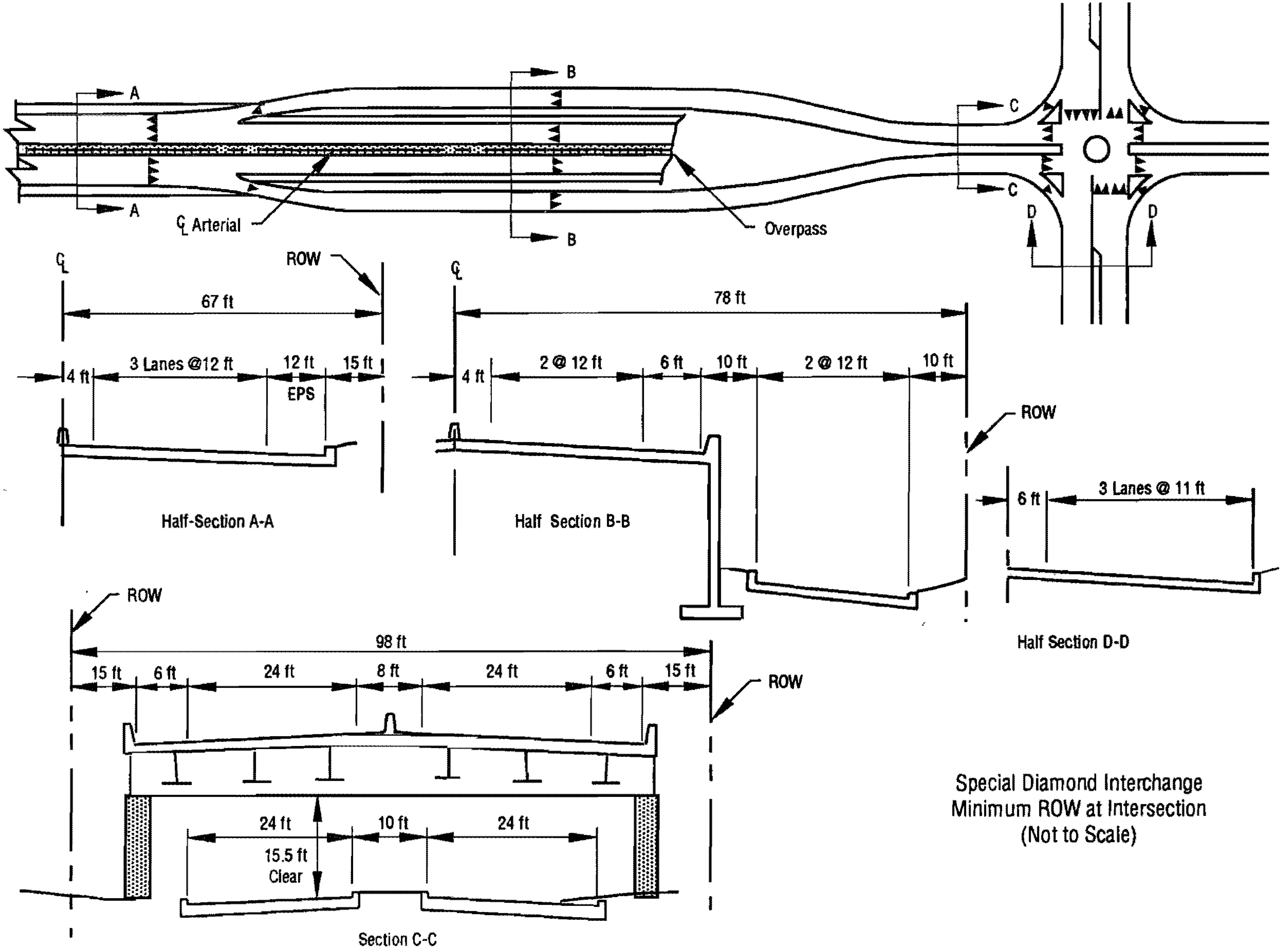
Typical Cross Section of Arterial Street Overpass
Approaches to Diamond Interchange
(Not to Scale)

Figure 4.6b



Half Plan
Arterial Street Diamond Interchange Stage Construction
(Not to scale)

Figure 4.7



Special Diamond Interchange
Minimum ROW at Intersection
(Not to Scale)

Figure 4.8

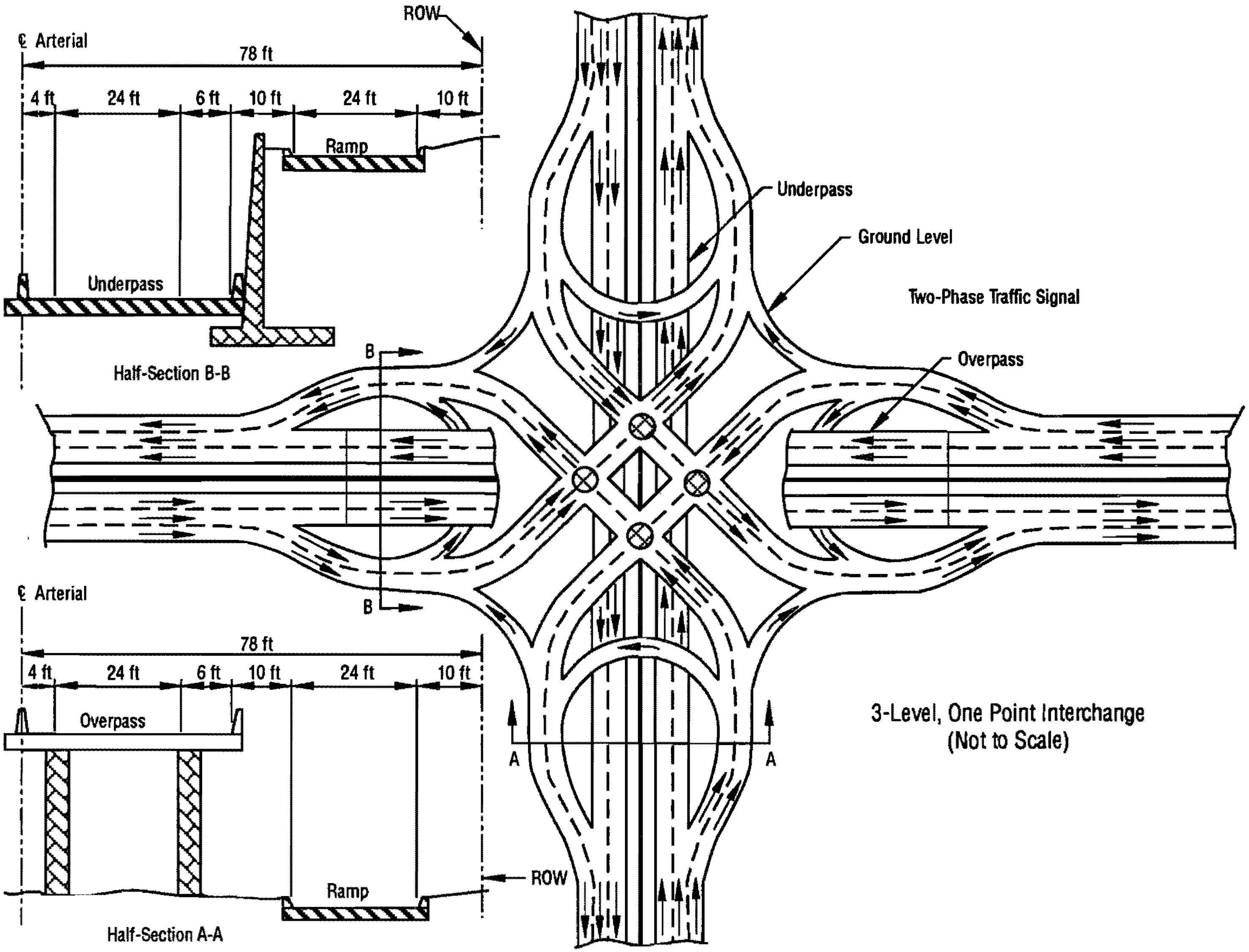
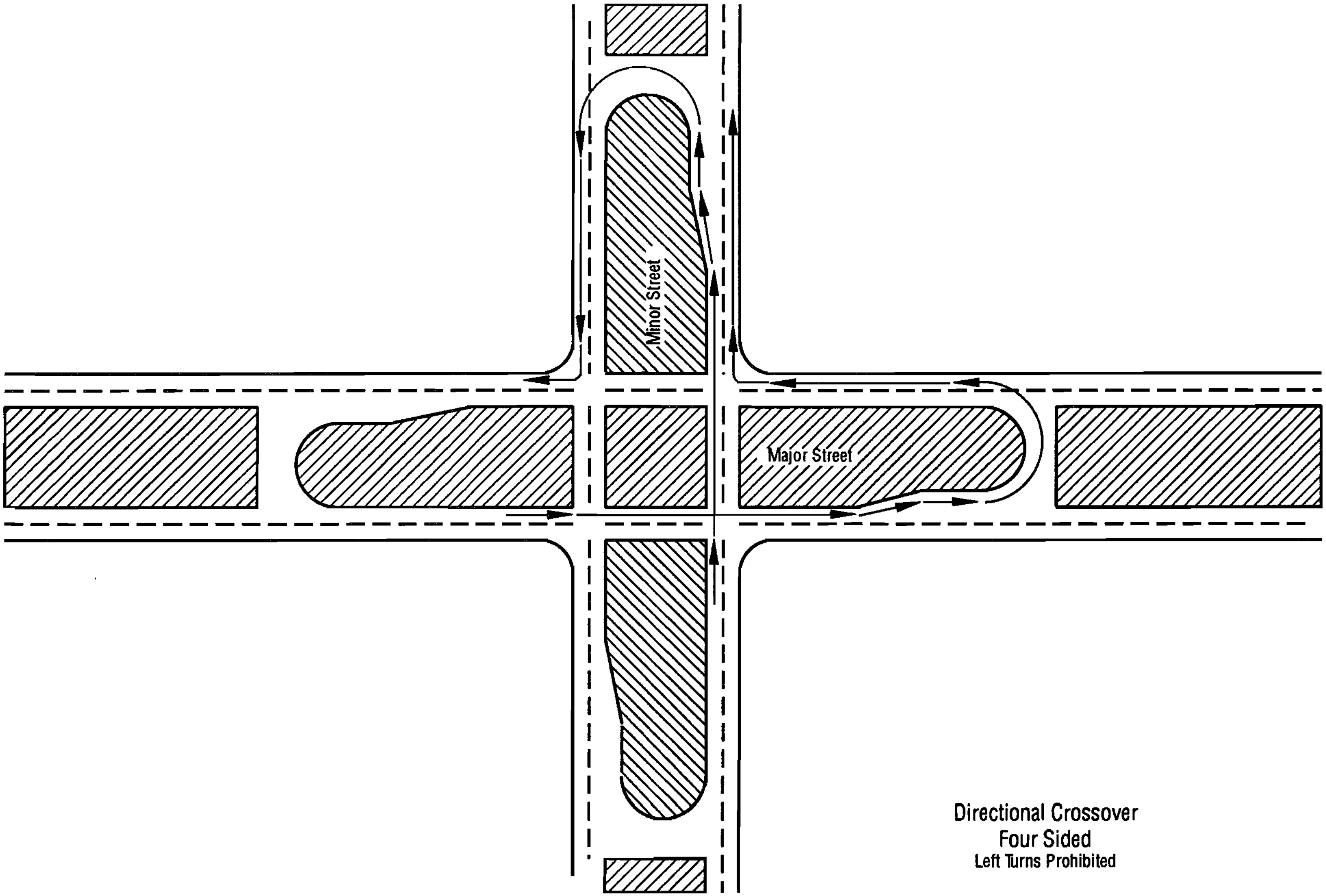
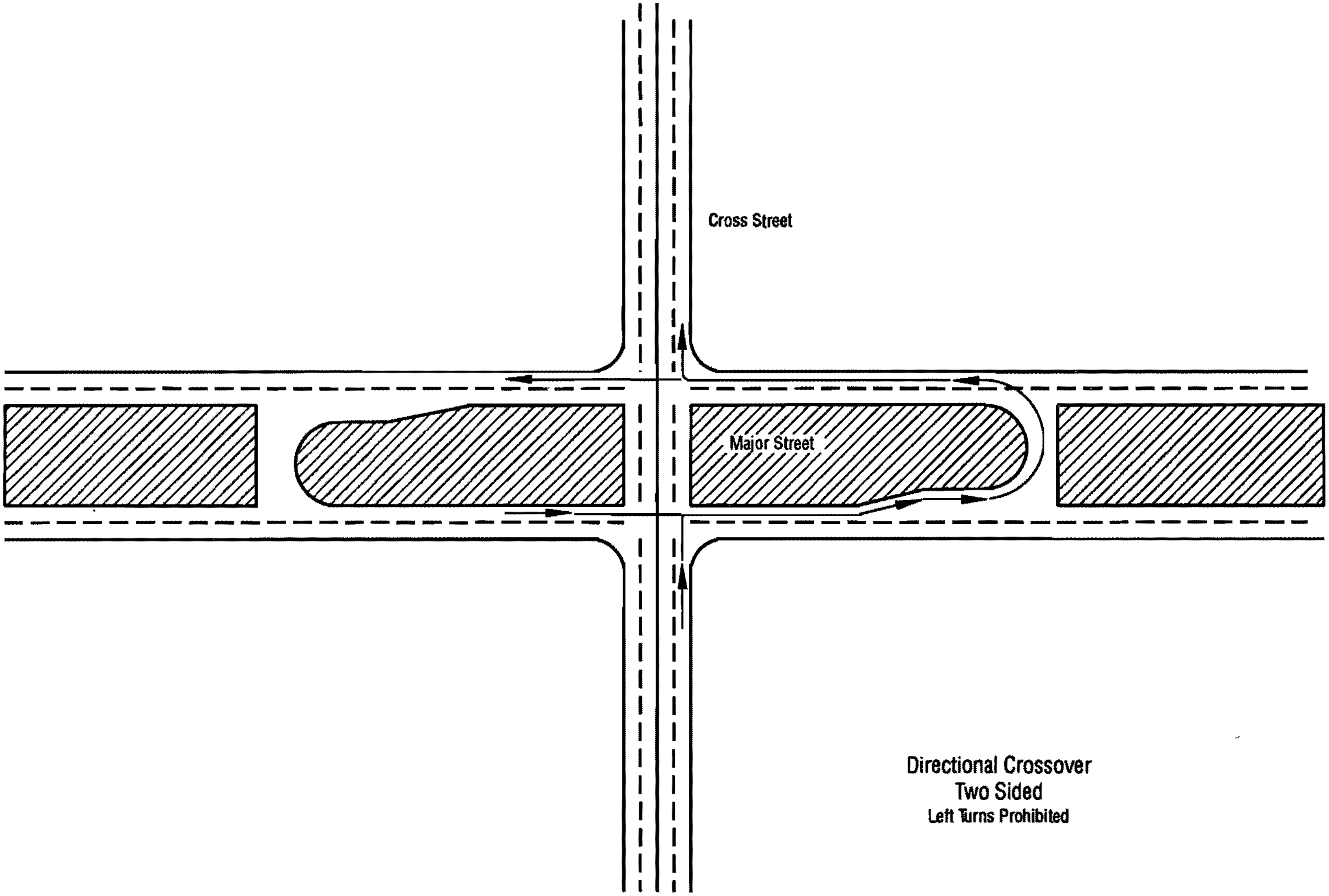

ROW
℄ Arterial
78 ft
4 ft
24 ft
6 ft
10 ft
24 ft
10 ft
Ramp
Underpass
Half-Section B-B
B
B
℄ Arterial
78 ft
4 ft
24 ft
6 ft
10 ft
24 ft
10 ft
Overpass
Ramp
ROW
Half-Section A-A
Underpass
Ground Level
Two-Phase Traffic Signal
Overpass
A
A
3-Level, One Point Interchange
(Not to Scale)

Figure 4.9



Directional Crossover
Four Sided
Left Turns Prohibited

Figure 4.10a



Directional Crossover
Two Sided
Left Turns Prohibited

Figure 4.10b

particular intersection, which can often be difficult and expensive to acquire because of the attractiveness of intersections for valuable commercial developments. The environmental impact at an intersection may be mitigated by separating the various traffic movements.

Figures 4.5a through 4.6b (pages 45 through 48) show layouts and approach cross-sections, with right-of-way requirements, for urban diamond-type interchanges constructed on minimum rights-of-way. Both the underpass and the overpass types are illustrated to show that the right-of-way requirements are the same. A number of interchanges similar to those shown here have been constructed and operated by the City of Houston and the SDHPT. The configuration of these layouts assumes that there will be a *lane drop* at the interchange. This is somewhat consistent with the notion of needing lane-balance at an interchange. Lane-balance is achieved if one-third of the six-lane roadway traffic exits or if the four through lanes are sufficient for the traffic demand at a particular interchange. If analysis shows that four through lanes are insufficient, then additional rights-of-way will be needed to accommodate the extra lanes. Experience generally has shown that if an interchange is warranted, there will be sufficient exiting traffic to reduce the through traffic demand to four lanes.

Figure 4.7 (page 49) is a layout similar to those shown in 4.5a and 4.6a except that provision has been made for staging construction. In this case additional rights-of-way may be required at the intersection to make room for the additional lane needed for the through-traffic movement. This additional lane may not be needed if the complete interchange is constructed initially.

Figure 4.8 (page 50) shows how a diamond interchange can be constructed at an intersection with a minimum of rights-of-way *at the intersection.* This interchange functions the same as the ordinary diamond interchange. This configuration requires more rights-of-way at the approaches, and the grade separation overpass structure may have to be 400 to 600 feet longer than that for a more conventional layout. Rights-of-way at or near intersections are often difficult to acquire or are excessively expensive because of damages to property remainders. The same configuration could be used with an underpass. This figure is included to indicate some of the means that might be necessary to maintain design and route integrity within the SASS.

Figure 4.9 (page 51) shows a three-level interchange, which may be necessary between intersecting strategic arterials if the turning-traffic demand between the arterials is sufficiently large. Ordinarily, a diamond interchange has sufficient signal capacity to handle the non-grade-separated through movement on strategic arterials. However, if the turning movements require too much of the traffic signal green time, to the detriment of the through traffic at an ordinary diamond interchange, then a three-level may be needed. These also can be planned and constructed in stages provided adequate rights-of-way are reserved along one of the arterials.

Figures 4.10a and 4.10b (pages 52 and 53) are diagrammatic layouts that illustrate a type of directional crossover intersection design. It is speculated that these could be used effectively for stage construction of the SASS. Whether the four-sided design, shown in Figure 4.10a, or the two-sided, as shown in Figure 4.10b, is to be used, depends upon the amount of rights-of-way available. The main feature of these designs is the advantage resulting from the prohibition of left turns. Left turns are provided for by sequential right and U-turns. The primary disadvantage of this type intersection is the indirectness of the left-turn movements and the difficulty in conveying signing messages to infrequent users. This type of design requires a median width of about 60 feet for U-turns if large trucks are to be accommodated and about 40 feet for passenger cars only. The median widths provided in the Stage I arterial shown in Figure 4.2 should adapt well to this design.

Figures 4.11, 4.12, 4.13, and 4.14 (pages 55 and 56) are pictures of a typical use of concrete median barriers (CMB) by the New Jersey Department of Transportation to separate traffic movements along non-controlled-access highways. New Jersey has installed about 290 miles of CMB along their highway routes. Many miles of these CMB-separated roads are located within densely populated urban environments. Figures 4.11, 4.12, and 4.13 show the use of the CMB within a typical urban setting. Normally, if sufficient rights-of-way are available, an auxiliary lane is included for emergency use and for speed-change maneuvers. Some routes of this type are signed for 55 mph. The New Jersey DOT does not believe that the use of the CMB has had any detrimental effect on property values or land use. Figure 4.14 shows the use of CMB at a typical signalized intersection. Where CMB is used to separate roadways, the frequency of at-grade intersections is decreased. Left turns are not permitted where the CMB is present. All left turns originate as right turns. Button-hook ramps are installed at intervals to permit U-turn movements. The elimination of left turns has greatly improved both safety and traffic operations. Two-phase signal timing is used at most intersections, and *all* at-grade intersections are signalized.

RIGHT-OF-WAY REQUIREMENTS

Traffic projections suggest the need for a six-lane arterial system. Consequently, the requisite amount of right-of-way is that needed to accommodate six lanes plus the additional amount needed to accommodate the geometric design requirements at intersections and at-grade separations.

In Chapter III in the section *EXTENT OF CONCEPTUAL SYSTEM*, the estimated twenty-year

Figure 4.11

Figure 4.12

Figure 4.13

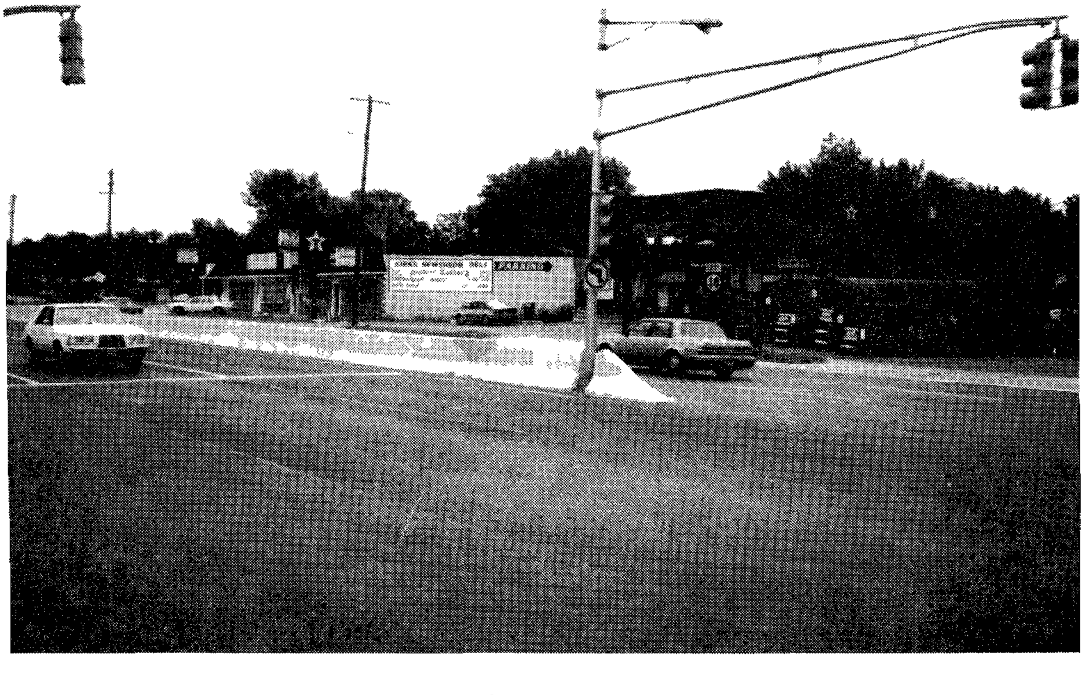


Figure 4.14

VMT deficiency is compatible with a need for route capacities of 36,000 to 60,000 ADT. The simulation modeling results presented in Table 3.4 indicate the conceptual system would attract about 21 million ADT, which also suggests an ADT of about 50,000 (VMT attracted + 490*UF), assuming again a utilization factor of 85 percent. Obviously the travel on any roadway network is not going to be evenly utilized, but a six-lane facility has the capacity to accommodate ADT's of 60,000 at a tolerable level of service, which should be ample capacity for all but a small part of the system. The capacity of the proposed arterials is discussed later.

The basic roadway cross section recommended for the conceptual SASS should have provisions for six traffic lanes. The implication of this recommendation is to be reasonably sure that the various links in the SASS will have adequate traffic capacity. Experience has shown that the providers of rights-of-way are not always inclined to look too far into the future and that regret, rather than anticipation, is more often the emotion experienced in contemplating the need for additional rights-of-way.

There will be segments of the system which may not require six-lane capacity, or at least not for a number of years. In this case these segments could be developed in stages. Even though the planning horizon is usually twenty years, right-of-way needs during the ensuing twenty years may not necessarily be adequate for the twenty years after that. The risk of securing too much right-of-way against too little is very small considering the importance of improved mobility. On the other hand, securing sufficient rights-of-way to permit construction of an *eight-lane-minimum* facility would insure against having *any* of the system under capacity. In this case, though, the cost of the insurance might be so high as to jeopardize the acquisition of rights-of-way for a system of enlarged scope. It is the case of building an eight-lane bridge halfway across the river or building a four-lane bridge all the way across. In any public works program there is always a scarcity of resources and not all eventualities can be reconciled. The primary objective in establishing a SASS is to acquire or preserve adequate rights-of-way almost irrespective of the type of roadway geometric design features that may be considered desirable.

CAPACITY AND TRAVEL SPEED

The primary factor affecting the capacity of an arterial street is the intersection capacity of any intervening grade crossings. Travel speed is primarily a function of the frequency of stops or slowdowns due both to any intervening traffic signals and to the posted speed limit. Other factors affecting capacity and travel speed, which are not easily quantifiable or predictable, are traffic side friction (driveways, side streets, and parking, possibly) which is a function of access control; the amount of truck traffic in the traffic stream; weather conditions; "down time" due to traffic accidents, which in turn is a function of traffic law enforcement; "down time" due to maintenance operations; and daily traffic distributional characteristics, which are a function of lifestyle, working hours, and urban population density.

For this study an attempt has been made to "average" speed and capacity for a typical arterial and state the average daily driving speed as a function of ADT. An example of this is the normalized speed-capacity curves used in the Highway Economic Evaluation Model (HEEM), which is a computer simulation model used to evaluate the cost-effectiveness of highway and street improvements. The HEEM has been used for several years by the SDHPT in highway planning and programming. The HEEM was developed in 1975-76 by McKinsey and Company Inc. for the SDHPT. The model was later refined and improved by the Texas Transportation Institute (TTI) as HEEM-II. TTI Research Report 225-28F, issued in November 1983 by the SDHPT, serves as a user's guide to the model.

Figure 4.15 (page 58) is a graphical illustration of the speed-capacity relationship for various types of highway and street facilities. The dashed-line curves showing the speed-capacity for a six-lane freeway, a six-lane expressway, and a six-lane city street were taken from the HEEM-II. The average speed is the weighted average speed of all vehicles throughout a typical 24-hour weekday. This includes vehicles traveling in congestion during the morning and afternoon peak traffic periods and during the off-peak-hours. Truck traffic is accounted for by passenger-car-equivalents, whereby the assumed amount of truck traffic replaces an equivalent number of passenger cars (say two passenger cars for one truck).

Also shown in Figure 4.15 is a set of solid-line curves representing the productivity (speed-capacity) of a typical improved arterial street, such as is proposed for the SASS. The purpose of Figure 4.15 is to show the relationship in productivity between an ordinary six-lane city street, the proposed SAS, and a six-lane freeway. It is obvious that the travel speed of a strategic arterial depends upon the frequency of stops even though the *capacity* of these streets is not significantly affected. Capacity is a function of the *allocation of traffic signal green time* at any intervening intersection.

The set of curves shown in Figure 4.15 for the improved arterials was derived from intersection simulations using the TEXAS (Traffic EXperimental Analysis Simulation) computer model for simulating traffic operations at intersections. The TEXAS model was developed by the Center for Transportation Research (CTR) and can simulate intersection operations for variable geometric configurations, traffic input volumes, traffic characteristics, and traffic signal settings. Among the output data of the model are stopped delay and total delay for all the vehicles passing through the intersection. The intersection

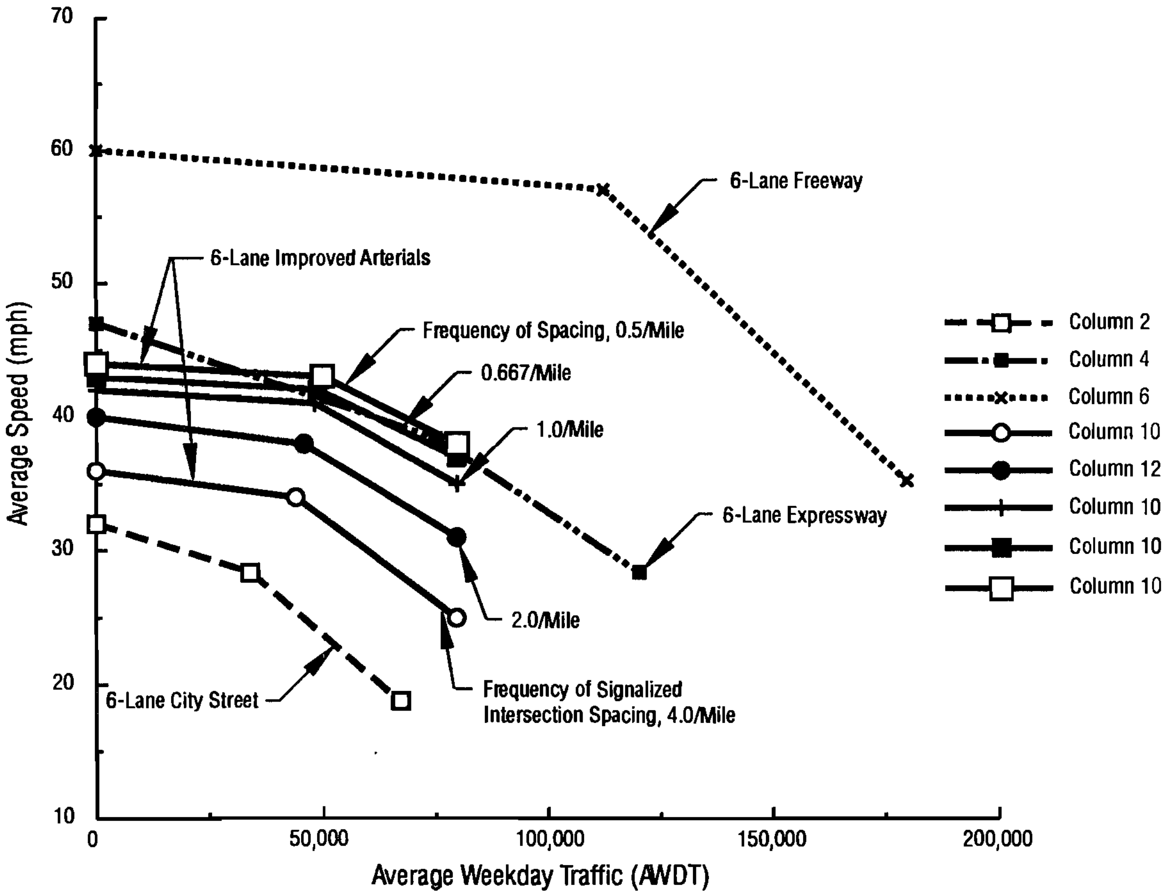


Figure 4.15

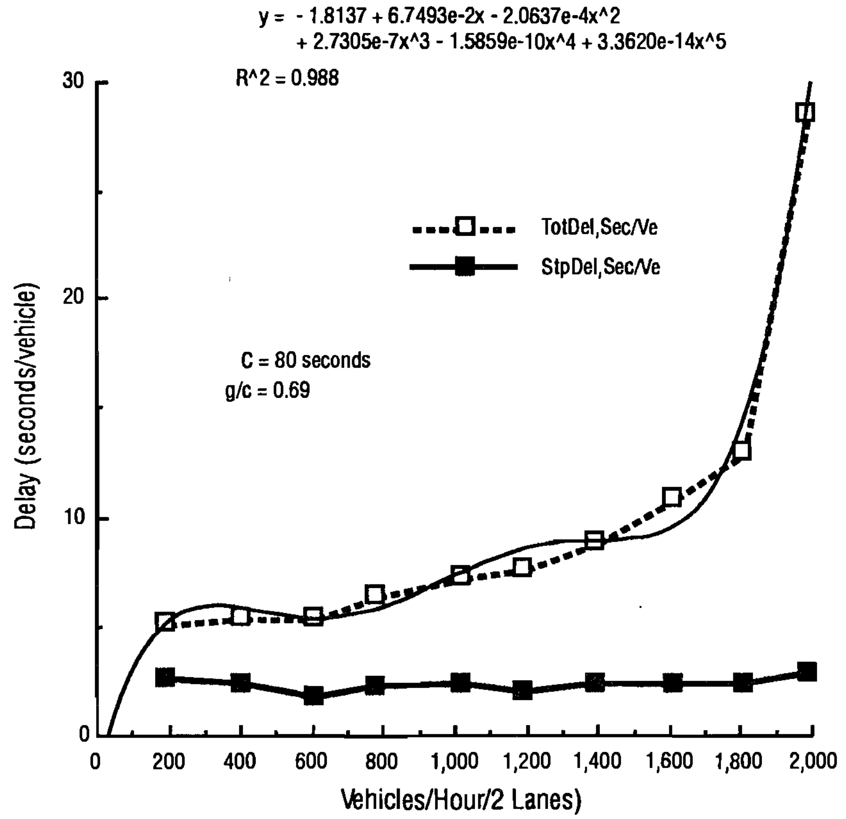


Figure 4.16

model used for this study simulated a two-lane approach to an intersection along an improved arterial assuming no left turns, a 45-mph designated speed limit, 25 percent right turns, an 80-second signal cycle, traffic volumes from 200 to 2000 per hour in 200-vehicle-per-hour increments, and that 70 percent of the green time was allocated to the arterial approach. This simulation was designed to produce a traffic stream time-distance trajectory through a signalized intersection for various intensities of average weekday traffic (AWDT).

Figure 4.16 (page 58) shows the results of the simulation modeling, which represents delay per vehicle as a function of the traffic volumes along the approach. Also shown is the stopped delay, which represents the average time of each vehicle forced to stop because of a red light. From the graph it is apparent that the arterial approach is reaching saturation at 900 to 1,000 vehicles per lane per hour. The graph also shows a "fitted" curve representing the relationship between approach volume and average vehicle delay. The fitted curve is used for convenience in calculations.

Figure 4.17 (below) shows the average daily speed versus ADT, assuming a frequency of signalized intersection spacings. The average speed was calculated from the delay approach volume curves generated from the TEXAS model and an assumed intersection spacing frequency. In running the TEXAS model, a *random* arrival rate input was used for the vehicles approaching the intersection. In other words, no assumptions were made as to progressive signal timing, where vehicles arrive at the intersection at the ***beginning*** of the green phase, nor was the worst case assumed for arrivals, where vehicles arrived at the intersection at the ***end*** of the green phase or beginning of the red cycle.

The intersection approach volume per hour was calculated using actual 24-hour traffic distribution data furnished by the City of Houston Traffic and Transportation Department (see Figure 4.18, page 60). Twenty-four-hour traffic distribution data can vary widely within a city, and the sample selected was taken from traffic counts recorded along a major arterial which was handling substantial traffic but was not considered to be saturated. The peak-hour factor (k) for the street chosen was close to 0.10 for both the morning and the afternoon peaks. A peak-hour factor of 0.10 or more generally indicates that a street has not exceeded its peak-hour capacity.

The approach volume per hour is some fraction of the 24-hour volume; it is used to calculate the delay from the fitted delay curve, which in turn is used to calculate the weighted average speed, assuming a 45-mph speed as reduced by the frequency of stops and the delay per stop. These calculations are:

(1) average delay per vehicle, in seconds = $y = f(x)$ where $x = \text{AWDT}*k$ (see Figure 4.16; refer to Figure 4.18 for values of k for each hour) and

(2) average speed (miles per hour) = $3600\,V / (3600 + f\,d\,V)$

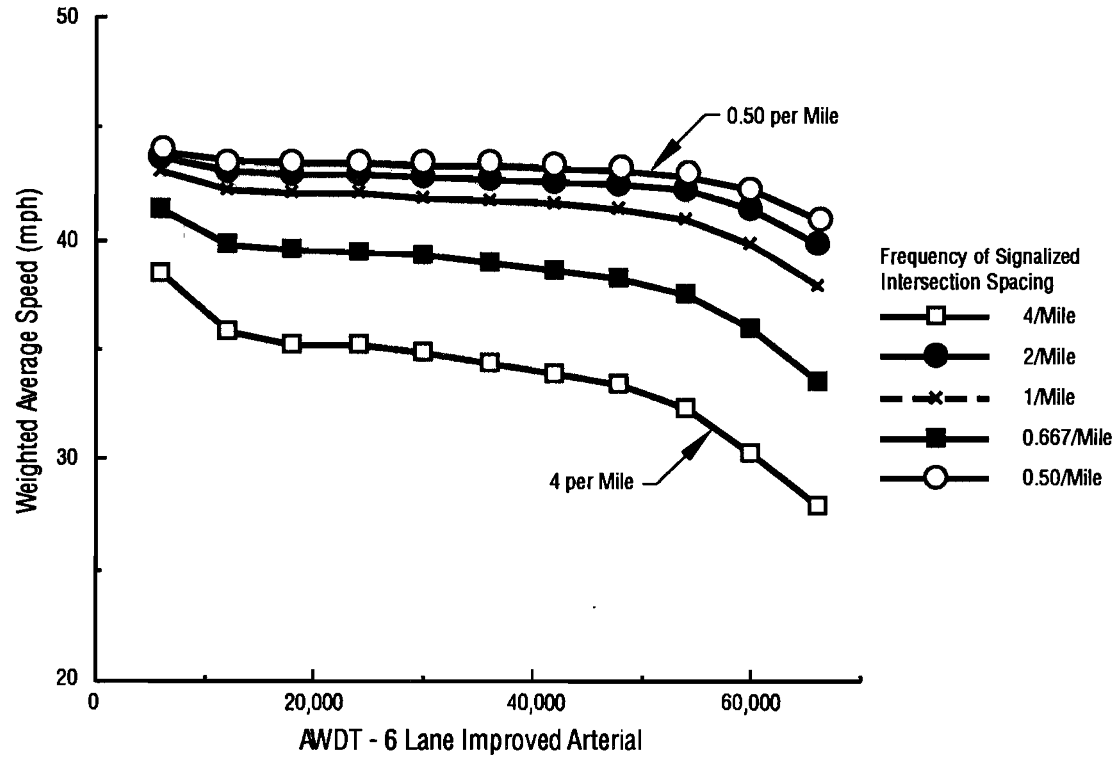


Figure 4.17

where f = frequency of signalized intersections, per mile;

d = delay per vehicle, in seconds, at each intersection; and

V = designated speed limit, or design speed, in miles per hour.

The curves shown in Figure 4.17 were derived as follows:

Delays were calculated (using Eq 1 on page 59) for each hour of the day for AWDT's ranging from 6,000 to 66,000 in increments of 6,000. The average speed (Eq 2 on page 59) was calculated using the hourly delay for each assumed intersection spacing frequency. The weighted average daily speed was calculated from the hourly average speeds for each value of AWDT.

Figure 4.19 (page 61) is included to show the relationship between AWDT and the *peak-hour* speed, which is how most drivers relate to level of service. The *delays* for these curves *reflect* the afternoon peak period (Figure 4.18) traffic condition and show much larger speed reductions at large values of AWDT than do the average daily speeds. The *peak-hour* speed curves in Figure 4.19 were derived from the delay equations in a manner similar to that described for the *average* daily speed. In this case the maximum hourly delay is related to the maximum k factor (0.099) occurring between 5 and 6 p.m. Equation 1 (page 59) was used to calculate the delay, only during the peak hour, for various assumed AWDT values. Equation 2 (page 59) was used to calculate the peak-hour speed for each AWDT value and for the various frequency values.

The speed-capacity curves derived herein for estimating the productivity of arterial streets are intended to provide a guide to be used in making tradeoffs between desirable capacity and a desirable level of service. It is apparent from Figure 4.19 that, if facilities are to be planned to cope with an AWDT demand of 60,000 and to maintain peak-hour speeds of 35 mph or greater, the planning will have to include a means for reducing the frequency of intersection spacings to 0.67/mile or less, or devise some means for operating a traffic signal system to keep intersection delay at an acceptable minimum. If

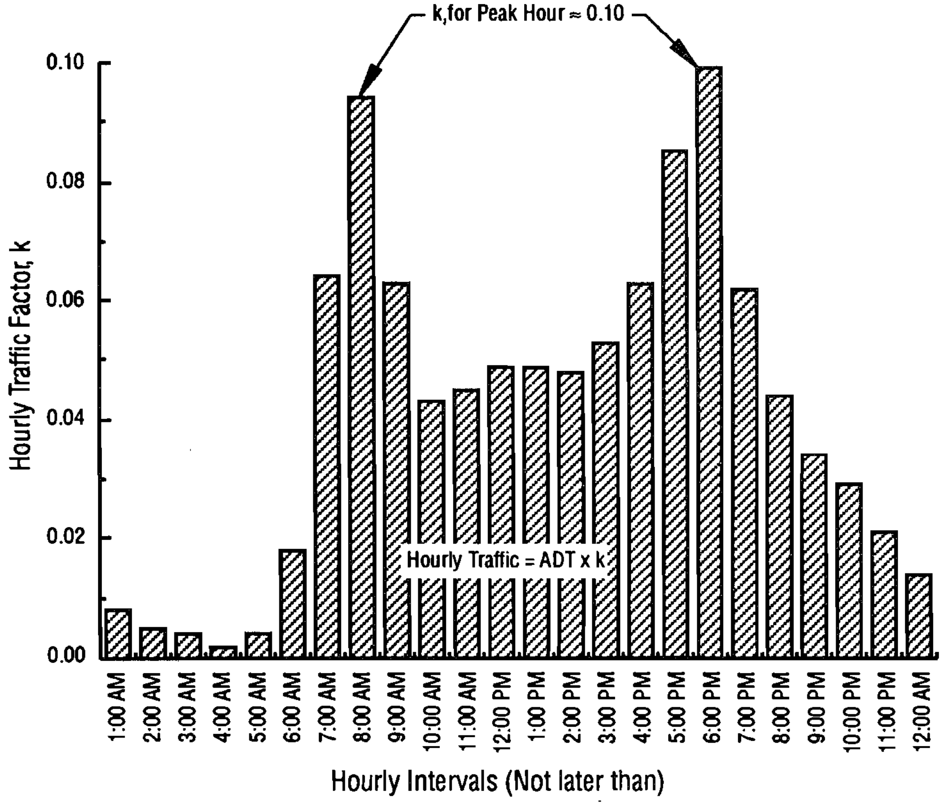


Figure 4.18

the criterion is to maintain average daily speed of 40 mph or greater or to keep the minimum peak-hour speeds at 35 mph or greater, then the intersection frequency will have to be about 1.0 mile or less. In general, the quality of service to be provided by an arterial is a function of the frequency of intersection spacing, or its equivalent in intersection delay.

CONTROL OF ACCESS

The design concepts herein are proposed in an attempt to devise a street facility that will permit reliable high-quality service *without complete control of access.* Comparing freeway-quality service with the service to be provided by improved arterials without complete control of access is inevitable, but the actuality remains that, if a SASS of any significant scope is to be implemented, the existing road and street rights-of-way will have to be incorporated into the system. In comparing the functional qualities of freeways and improved arterials, it should be recognized that the average trip lengths assumed to be accommodated by arterials are shorter than those using the freeway system. The *differences* in *scope* of service in effect argue that the *relative* quality of service proposed to be provided by the SASS is approximately equal to that provided by the freeway system.

Barring some providential changes in the manner in which rights-of-way are acquired, purchasing access rights will be an expensive and lengthy process, particularly in areas in where land has been developed. Consequently, it appears that in order to maintain—or, hopefully, improve—current mobility, it will be necessary for future road and street improvements to utilize existing rights-of-way. Furthermore, improvements in traffic operations and service quality will have to come about by improvements in arterial street design and traffic controls.

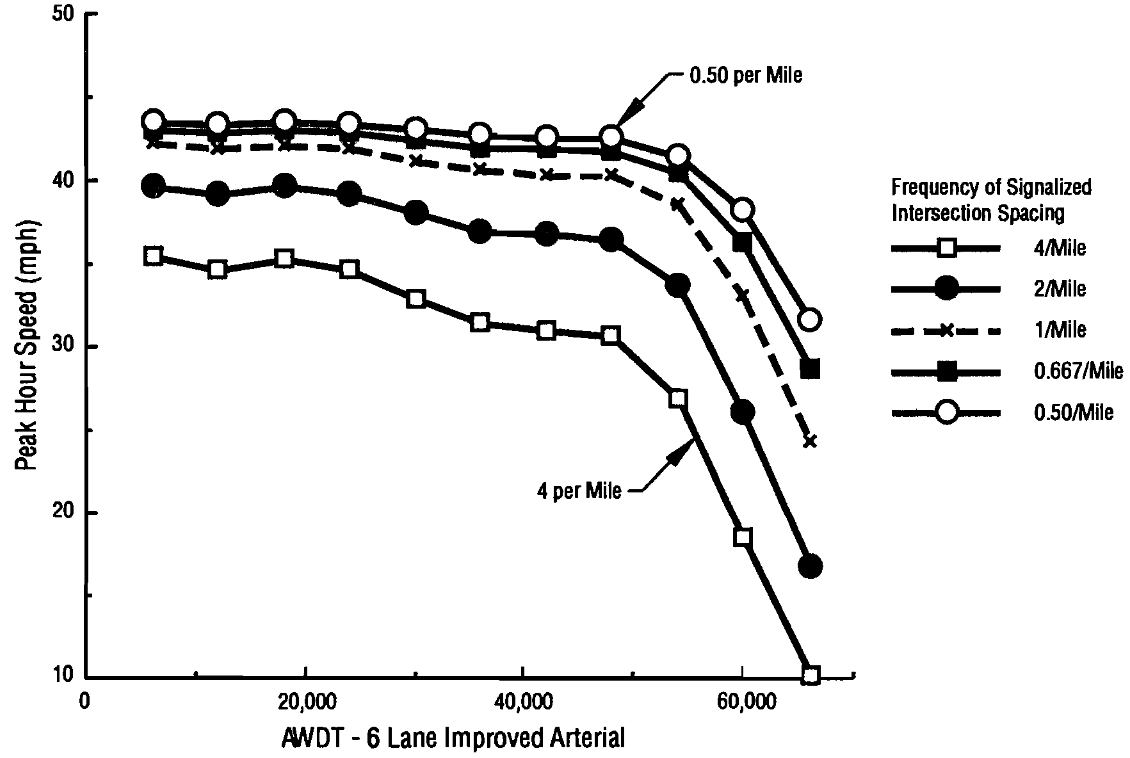


Figure 4.19

V. COST AND COST-EFFECTIVENESS

ESTIMATED COST OF CONCEPTUAL SYSTEM

Table 5.1 (page 64) is a compilation of the costs of the principal elements which comprise the conceptual SASS. The costs in Table 5.1 represent the average elemental costs derived, with two exceptions, from a large number of urban projects completed by the State Department of Highways and Public Transportation since 1979. The elemental cost for the railroad overpass was derived from City of Houston records and the elemental cost for a roadway underpass was derived from Harris County Toll Road records. There is considerable variation in some of the costs which might not be applicable in estimating the cost of a particular project. Since these costs were taken from a variety of projects planned and constructed in differing environments, the *average cost* should produce credible results when applied to estimating the cost of the conceptual SASS.

The resources of this study did not permit a ground survey of the potential routes in the conceptual system, and it is not known how much of the existing street facilities can be incorporated into the SASS or what proportion is salvageable. This problem can cause some large errors in estimating, since the cost of rehabilitation (which includes salvageable items such as storm sewers, utilities, traffic signal system, some pavement, etc.) is about one-half the cost of reconstruction (nothing salvageable). The same problem presents itself when trying to estimate right-of-way costs. Right-of-way needs can vary substantially across the county and it is difficult to "average" these costs. For this study, the right-of-way cost is estimated as 15 percent of the construction cost. The right-of-way costs reported by the Greater Houston Chamber of Commerce in their 1989 Regional Mobility Plan, as expended jointly by the SDHPT District 12, Harris County, and the City of Houston, for the seven years 1982 through 1988, were about 16 percent of their respective highway and street construction expenditures.

Some of the construction costs that are used as references would have been considerably less had the projects which generated these costs been constructed amid a less intensive urban environment or in a rural environment. However, past experience shows that roads are rarely constructed very far in advance of need, and it is to be expected that if a SASS is implemented, the environment surrounding individual projects at the time of construction will be urbanized and adjacent to vehicular traffic.

The estimated cost of the conceptual SASS is shown in Table 5.2 (page 65). Estimates were prepared for two cases. The first is for a minimum number of grade separations. The second case provided twice as many additional grade separations. The minimum number included those considered essential if the system is to provide a minimum level of higher-quality service and reliability. The grade separations considered essential were those where strategic arterials crossed each other and where strategic arterials crossed freeways. In the second case the total number of grade separations was increased by 175. This increment supplies one street/freeway grade separation at an average system spacing of 2 miles. The contrast in cost between the first and second case is used in the following section to illustrate the relationship between the quality of traffic service (average travel speed) and the cost of providing the better service.

The 2-mile grade separation spacing should simulate signalized intersections of 1 to 2 miles. Both cases provide for grade separations at all railroad crossings. The estimated ratio of overpass to underpass grade separations is more or less arbitrary and is stressed to indicate the differences in cost and the necessity in some instances to provide undercrossings rather than overcrossings because of environmental considerations.

COST-EFFECTIVENESS

The HEEM-II (described in Chapter IV) was used to estimate the cost-effectiveness of a typical 10-mile segment of the conceptual SASS. Values representing the speed-capacity curves described in Chapter IV (Figure 4.15) were used in the HEEM-II to calculate the benefits/costs of a segment.

The user's costs calculated by the HEEM are time costs, operating or vehicular costs, and safety (accident) costs. Cost-related input factors are percentage of trucks, car value of time ($0.17/minute), truck value of time ($0.32/minute), discount rate (4 percent assumed), inflation rate (0 percent assumed), urban diversion speed (14 mph), current and future daily traffic, construction costs and year of construction, maintenance costs, and accident costs. The output of typical HEEM problem typically shows that the reduction in time costs account for about 75 or 80 percent of the benefits, followed by operational and safety benefits. The HEEM compares the total of a stream of discounted costs generated by one alternative with those of another alternative. The difference between the costs represents the user's benefits. The benefits are then divided by the net cost (investment and maintenance cost of one alternative less that of the other) to give the benefits/costs ratio.

It should be understood that the HEEM traffic projections are *given* and the model calculates the user's costs based on these projections. The model does have a default diversion of traffic if an alternative is subjected to too much traffic. If a facility is overloaded, then present-day user's costs can rise very rapidly, subject to the discount. In the real world such a facility would probably not attract this additional traffic because of the ensuing congestion. However, if the latent *demand* exists for a traffic service and the service is not available, then the extra user's costs inferred from using inferior street facilities may be considered an economic cost of the deficiency. It is not unusual for the rate of traffic growth along a route to increase very rapidly when the facilities along the route are improved. This was particularly evident when the various freeways in Harris County were first opened to traffic. The very rapid rise in traffic flow was due to the latent demand for a higher-quality service. To state it another way, the latent demand represents trips not made because they were not considered worthwhile under the perceived traffic conditions. The latent demand is the increase in *rate* of traffic growth.

Table 5.3 (page 66) shows the results of several HEEM trials in which it was assumed that a 10-mile segment of a four-lane city street (coded U4C in Table 5.3) would be upgraded to a higher-type facility. Several ranges of traffic were assumed over a planning horizon of twenty years, between 1990 and 2110. Benefits/costs and average travel speed are the outputs of the trials. The time, operating, and safety costs used in the HEEM-II are 1982 costs which are lower than current costs. The result of this is to understate the benefits/cost estimates given in Table 5.3. It is estimated that current user's costs are 15 to 20 percent higher than the 1982 costs. The unrefined nature of the benefits/costs estimates is such that quantitative comparisons between the various categories of arterial upgrades, shown in Table 5.3, are not significantly affected by differences between the 1982 and current user's costs.

Data Set A shows the result of upgrading to a six-lane city street (U6C). In all cases the cost of upgrading was assumed to be $3 million per mile. The purpose of modeling the U6C alternative is to show the *increase* in benefits/costs, due to the SAS upgrades, when the U6C upgrades are compared to the SAS upgrades.

Data Set B shows the results of a number of trials of upgrading to various quality standards of six-lane strategic arterials by assuming various traffic projections. The quality standard of the arterial is defined by the assumed frequency of signalized intersections along the arterials. The higher the quality, the less frequent the intersections per mile. The estimated construction cost for each quality street was considered to vary uniformly between $51 million ($5.1 million/mile) for the 6LSA(4) (six-lane strategic arterial; frequency, 4/mile) to $61 million ($6.1 million/mile) for the 6LSA(0.5) (frequency, 0.5/mile). Table 5.2 shows the estimated minimum and maximum costs/mile. It was assumed that the costs would vary proportionally to the number of grade separations provided or inversely with the frequency occurrence of at-grade intersections.

The traffic projections shown on lines 8, 11, and 12 in Data Set A are respectively the same as those shown in Data Set B, Subsets B2, B4, and B5. In all cases the benefits/costs ratio for the strategic arterials are substantially higher than those for the U6C. The benefits/costs ratio associated with the 6LSA(1.0) facility for all traffic projections is slightly higher than those for the other grades. However, considering some of the gross assumptions concerning construction costs, operational characteristics, and traffic projections, it would be too much of a refinement in conjecture to make any final judgments in this study as to most desirable trade-offs between costs and service. The point here is that higher-quality facilities, even though more expensive, can be a better investment.

TABLE 5.1. CONSTRUCTION COST ESTIMATE

Principal Elements of Conceptual Strategic Arterial Street System

(Includes 15% for planning,
construction engineering,
and contingencies)

		Avg. Proj. Length
1. RECONSTRUCTION PROJECTS		
Cost per Lane Mile	$500,000	—
Variance Between Projects	32%	
2. REHABILITATION PROJECTS		
Cost per lane Mile	$250,000	—
Variance Between Projects	18%	
3. DRAINAGE STRUCTURES		
Cost per Square Foot	$42	—
Variance Between Projects	23%	
4. ROADWAY OVERPASS		
Average Unit Cost	$4,000,000	0.50 Mi.
5. ROADWAY UNDERPASS		
Average Unit Cost	$5,000,000	0.30 Mi.
Sump Drainage	$400,000	
6. RAILROAD OVERPASS		
Average Unit Cost	$6,000,000	0.60 Mi.
Variance Between Projects	9%	
7. RAILROAD UNDERPASS		
Average Unit Cost	$5,200,000	0.30 Mi.
8. CITY UTILITY COSTS		
Average Cost per Mile	$220,000	—
Variance Between projects	54%	

TABLE 5.2. COST ESTIMATE OF CONCEPTUAL SASS

	A	B	C	D	E	F
1						
2		**ESTIMATE OF ROADWAY LENGTH**				
3		Route miles (Refer to Table 3.1, Page 8 of 8)				**490**
4		Deductions for project length of grade separations				
5		with interchanges and bridges				
6				Est. Project	Total	
7		Item	Est. No.	Length (Mile, Ea)	Length (Mile)	
8		RR Overpass	50	0.6	30	
9		RR Underpass	23	0.3	6.9	
10		Street Overpass	50	0.5	25	
11		Street Underpass	15	0.3	4.5	
12		*Lake Houston Br.	1	1.5	1.5	
13		*Ship Channel				
14		Bridge	2	1.3	2.6	
15			Deduction, Sub-Total (Rounded)		71	71
16			Net length, Roadway (Mile)			420
17		*Special, identifiable, high-cost facilities				
18		**SYSTEM COST, MINIMUM GRADE SEPARATIONS**				
19					Unit Cost	Total
20		Item	Unit	Quantity	$1,000,000	$1,000,000
21		Roadway, 6-lane	Lane-Miles	2517	0.5	1,259
22		Utility Costs	Miles	420	0.22	92
23		RR Overpass	Each	50	6	300
24		RR Underpass	Each	23	5.2	120
25		Street Overpass	Each	50	4	200
26		Street Underpass	Each	15	5.4	81
27		Lake Houston Br.	Each	1	10	10
28		Ship Channel	–	–	–	–
29		Bridge	Each	2	50	100
30			Sub-Total			2,161
31			ROW @ 15% of Estimated Construction Cost			324
32			**Total**			**2,486**
33			**Average cost per mile**			**5.1**
34		**SYSTEM COST, ADDITIONAL GRADE SEPARATIONS**				
35		**Deductions for Project Length of Additional Grade Separations**				
36		Street Overpass	135	0.5	67.5	–
37		Street Underpass	40	0.3	12	–
38			Deduction, Sub-total (Rounded)		80	–
39		Roadway, Deduction	Lane-Miles	477	0.5	–238.5
40		**Additional Grade Separations and Interchanges**				
41		Street Overpass	Each	135	4	540
42		Street Underpass	Each	40	5.4	216
43			Sub-Total, Additional Grade Separations and Interchanges			756
44			**Total**			**#VALUE!**
45			**Average Cost per Mile**			**#VALUE!**

TABLE 5.3. COST-EFFECTIVENESS ANALYSIS, CONCEPTUAL SASS

	A	B	C	D	E	F	G	H	I	J
1										
2			Data Set A			Discount Rate - 4%				
3						Const.	Present Value		Year 2010	
4		Upgrade	ADT (1000's) by Year			Cost	of Benefits	Benefits	Average Speed (mph)	
5	From	To	1990	2000	2010	$10^6	$10^6	to Costs	Do Nothing	Construct
6	U4C	U6C	15	20	25	30	20	**0.7**	**27.6**	**29.4**
7	U4C	U6C	20	25	30	30	40.8	**1.4**	**25.4**	**28.9**
8	U4C	U6C	25	30	35	30	86.1	**2.9**	**23.3**	**28.3**
9	U4C	U6C	30	35	40	30	152.7	**5.1**	**21.2**	**26.9**
10	U4C	U6C	15	35	50	30	151.7	**5.1**	**18.8**	**24.0**
11	U4C	U6C	20	40	50	30	209.6	**7.0**	**18.8**	**24.0**
12	U4C	U6C	25	45	55	30	274.4	**9.2**	**18.8**	**22.6**
13	U4C	U6C	30	45	60	30	275.5	**9.2**	**18.8**	**21.2**
14										
15	Sub-		Data Set B			Discount Rate - 4%				
16	Set					Const.	Present Value		Year 2010	
17	B1	Upgrade	ADT (1000's) by Year			Cost	of Benefits	Benefits	Average Speed (mph)	
18	From	To	1990	2000	2010	$10^6	$10^6	to Costs	Do Nothing	Construct
19	U4C	6LSA(4.0)	15	25	30	51.0	145.6	**2.9**	**25.4**	**34.7**
20	U4C	6LSA(2.0)	15	25	30	53.5	181.3	**3.4**	**25.4**	**38.7**
21	U4C	6LSA(1.0)	15	25	30	56.0	199.8	**3.6**	**25.4**	**41.4**
22	U4C	6LSA(0.67)	15	25	30	58.5	206.4	**3.5**	**25.4**	**42.4**
23	U4C	6LSA(0.5)	15	25	30	61.0	212.7	**3.5**	**25.4**	**43.4**
24	B2									
25	U4C	6LSA(4.0)	25	30	35	51.0	227.7	**4.5**	**23.3**	**34.4**
26	U4C	6LSA(2.0)	25	30	35	53.5	273.0	**5.1**	**23.3**	**38.5**
27	U4C	6LSA(1.0)	25	30	35	56.0	297.5	**5.3**	**23.3**	**41.3**
28	U4C	6LSA(0.67)	25	30	35	58.5	305.9	**5.2**	**23.3**	**42.3**
29	U4C	6LSA(0.5)	25	30	35	61.0	313.8	**5.1**	**23.3**	**43.3**
30	B3									
31	U4C	6LSA(4.0)	25	35	40	51.0	318.1	**6.2**	**21.2**	**34.2**
32	U4C	6LSA(2.0)	25	35	40	53.5	370.6	**6.9**	**21.2**	**38.3**
33	U4C	6LSA(1.0)	25	35	40	56.0	399.7	**7.1**	**21.2**	**41.2**
34	U4C	6LSA(0.67)	25	35	40	58.5	409.3	**7.0**	**21.2**	**42.2**
35	U4C	6LSA(0.5)	25	35	40	61.0	418.4	**6.9**	**21.2**	**43.2**
36	B4									
37	U4C	6LSA(4.0)	20	40	50	51.0	436.0	**8.5**	**18.8**	**32.7**
38	U4C	6LSA(2.0)	20	40	50	53.5	496.7	**9.3**	**18.8**	**37.3**
39	U4C	6LSA(1.0)	20	40	50	56.0	530.9	**9.5**	**18.8**	**40.8**
40	U4C	6LSA(0.67)	20	40	50	58.5	541.6	**9.3**	**18.8**	**42.0**
41	U4C	6LSA(0.5)	20	40	50	61.0	551.7	**9.0**	**18.8**	**43.0**
42	B5									
43	U4C	6LSA(4.0)	30	45	60	51.0	579.8	**11.4**	**18.8**	**40.2**
44	U4C	6LSA(2.0)	30	45	60	53.5	658.7	**12.3**	**18.8**	**35.3**
45	U4C	6LSA(1.0)	30	45	60	56.0	703.0	**12.6**	**18.8**	**38.9**
46	U4C	6LSA(0.67)	30	45	60	58.5	717.2	**12.3**	**18.8**	**40.4**
47	U4C	6LSA(0.5)	30	45	60	61.0	729.6	**12.0**	**18.8**	**41.5**

VI. CONCLUSIONS

The general thrust of this study is to demonstrate, subject to the resources allocated, the *feasibility* and *cost-effectiveness* of improving the supply and quality of traffic services within Harris County by enhancing the efficiency of arterial streets. That there is or will be a shortfall in the supply of high-quality traffic service appears to be obvious to those interested and concerned about the population growth and future quality of life in the county. It is problematical that the planned additional increments to the freeway system, which is the backbone of the surface transportation system, will not keep up with the demand for high-quality service if the population increases as predicted for the next twenty or more years.

Arterial streets can be designed to accommodate the demand for better traffic service. A *system* of arterial streets can be planned such that it will supplement and reduce the traffic demands on the freeway system. It is also likely that improving the efficiency of the arterials will attract trips from the reservoir of latent demand which is not now, and may never be, within convenient range of the freeway system. Improving the arterials will also divert substantial traffic from the other arterials, collectors, and local streets. The effects can be wide in scope if the system is wide in scope. Traditional planning to increment the road and street system to track the direction of and keep up with growth can provide street *capacity*. The accent in designing the system should be on improving the *quality* of traffic services. The HEEM-II analysis in Chapter V, unsophisticated as it may be, was made to demonstrate, even at relatively low traffic volumes, the cost-effectiveness of increasing the efficiency of a facility.

The arterial street design *features* conceptualized in this study *represent* a compromise between those of a freeway and an ordinary arterial street. The significant difference between the conceptual design and the freeway design are provisions for signalized grade crossings and reduced access control. This compromise reduces the capacity of the strategic arterial to about two-thirds that of a freeway assuming that at least 70 percent green time at intervening signalized intersections is allocated to the arterials.

The efficiency of the conceptual arterials is a function of travel speed and capacity. The travel speed along arterials can be improved by reducing the number of at-grade intersections at an increase in cost, although the degree of access control also has an effect on travel speed. By providing auxiliary lanes and regulating driveway access design, some of the ill effects of reduced access control can be mitigated. The reduced access control may limit the design speed to 50 mph in an urban area.

By staging construction it will be possible to adapt the arterials to traffic demand and land use provided provisions are made for reserving adequate rights-of-way. As traffic demand increases and land use intensifies, some grade crossings should be eliminated and replaced by grade separations. The adaptability of arterial street construction to urban development reduces the risk of providing facilities before they are needed or cost-effective. As sub-segments of the system are upgraded to the final design stages and joined together to provide longer segments, and then further joined with other routes and finally integrated into a *system*, *then* the streets will function as designed, which is to provide high-quality service for median-length trips. Hopefully then, diverse arterial routes will gradually evolve to constitute a countywide system of distinctive and superior street facilities.

Adequate rights-of-way can accommodate a variety of design features, to be decided later if necessary. The conceptual system proposed in this study presumed that rights-of-way would always be difficult to acquire, and consequently the design features recommended are those believed to be the minimum necessary to provide a design delivering high-quality service. *In all cases*, more (wider) rights-of-way are desirable. Construction costs can be reduced with more working room. Landscaping and better environmental enhancement become options with more rights-of-way.

The political considerations for planning and implementing a SASS are varied but have a common interest in providing for their constituents travel patterns that are not circumscribed by political boundaries. The state, county, and cities within the county all have an interest in improving mobility, but it is difficult to assign to each of these agencies a fair share of the responsibility and burden for supplying the resources for planning, securing rights-of-way, and constructing the system.

The state's interest is related to its responsibility for maintaining the state highway network within Harris County. The maintenance of this network is equivalent to supplying a good part of the traffic services available, or at least marketable, within the county. As the county grows and land use becomes more intense, the cost of supplying the same proportion of services is going to be more expensive. Due to the superior quality of traffic services provided by the freeway system, and the lack of an adequate functional arterial system, the freeway system is carrying traffic which could be diverted to the arterial system if it were more comprehensive and of better quality. The state's interest should lie therefore in supplementing the freeway system with an improved arterial system. The conceptual SASS is postulated to furnish these supplemental services at less cost than the marginal costs of adding to the freeway system. To what degree the state is responsible or will be benefited will require further insight into the productivity and scope of the arterial system. The final questions are: how much and when will the state's network be affected by a SASS?

The other governmental agencies also have a general and a specific interest in implementing a SASS. This degree of responsibility, and sharing of the financial burden too, will also require further insight into the intensity and distribution of the traffic within the system. The most important step in instituting a SASS will be to reach agreement on some of the routes as soon as possible so that adequate rights-of-way can be reserved for the system. This is particularly desirable where land use is more advanced.