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16. Abstract

This report documents the first-year effort of a research project that provides recommendations for the use of access management techniques on state roadways in Texas. In the first year of the project, the research team focused on developing a matrix of guidelines for the application of different access management techniques for various roadway access classifications. The access management treatments for which recommended guidelines are presented include minimum access spacing, minimum corner clearance, median treatments, auxiliary lanes, alternate left-turn treatments, access separation at interchanges, frontage roads, and the use of traffic impact analyses for site development. The matrix allows the user to identify critical threshold criteria for the application of each access management technique, given the projected roadway access classification.

The guidelines presented in this report will be valuable for state transportation professionals for use on new and retrofit projects as a toolbox of techniques for managing access to all state roadways—thus preserving the intended use of these facilities.

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DEVELOPING ACCESS MANAGEMENT GUIDELINES FOR TEXAS

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DISCLAIMER

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CHAPTER 1.0
INTRODUCTION

Traffic volumes and congestion have increased in recent years, particularly on arterial streets. The primary purpose of arterial streets is the movement of vehicles, while providing necessary access to residential and commercial developments. If unlimited access is provided directly from businesses and/or homes to the arterial streets, average speeds decrease and the capacity of the arterials diminishes. Frequent access also presents safety concerns by providing more locations for potential conflicts of vehicles' paths. Some solutions in the past have been to build relief routes to the arterial. It is very common, however, for the same problems to eventually occur on the relief route. In some cases, tertiary relief routes have been built.

A better, more cost efficient solution than building relief routes is to incorporate access management techniques into the design of the arterials. This practice is most successful when originally designing the arterial, but it can also be applied through retrofit projects on existing roads. By using access management techniques such as raised medians, turn lanes, auxiliary lanes, median opening spacing, and driveway spacing, the public investment in the arterial is protected by preserving its function of moving vehicles. Such design methods also provide a safer street for the motoring public by decreasing the potential number of conflict points that result from intersections.

In a recent Texas Transportation Institute (TTI) research project, Department of Transportation (DOT) officials from several states were surveyed about access management. The findings of this research project indicate that consistent guidelines are necessary for an agency to provide fair implementation and enforcement of an access management program (*1*). Several Texas Department of Transportation (TxDOT) district staff members have also expressed a desire in having access management guidelines in place to help them with the design of arterial facilities and to help manage access locations.

1.1 PROJECT OBJECTIVES

The primary objectives of this research effort are threefold:

1. Provide recommendations for the use of access management techniques on state roadways. TxDOT may adopt any or all of these recommendations into the TxDOT *Roadway Design Manual*.

2. Provide recommendations for improvement to the current *Regulations for Access Driveways to State Highways* (*Driveway Manual*) that governs driveway permitting for TxDOT.

3. Develop an *Access Management Guidebook*, corresponding training materials, and pilot training courses to assist TxDOT districts in implementing access management techniques throughout the state.

In the first year of the project, the research team has focused on developing a matrix of access management techniques by different roadway access classifications. This matrix allows the user to identify critical threshold criteria for the application of each access management technique, given the projected roadway access classification. The research performed in the first year satisfied objective number one listed above. In the second year of the project, the focus will be to satisfy the second and third objectives of providing recommendations to improve the *Driveway Manual* and developing the *Access Management Guidebook* and pilot training course materials.

1.2 RESEARCH PROCEDURE

Throughout the first year of the project, researchers have completed several work tasks to satisfy the first objective of the project. This section will briefly describe these work tasks.

1.2.1 Conduct State-of-the-Practice Literature Review

Numerous research studies, case studies, and design manuals describe empirical findings of various access management treatments and under what criteria they operate optimally. The first task performed in this research effort identified these references and sources. Design manuals from states with highly evolved access management programs provided significant insight. Many of the details of these programs had been identified from a legal and content perspective in recent research (*1*). As part of this research project, the research team followed up with these states, and other access management professionals throughout the country, with specific questions related to the development of an access management program from a design perspective.

1.2.2 Document Threshold Values for Access Management Treatments

In the second work task, the research team documented threshold values for different access management treatments. Threshold values were often identified from successful design practices of different states for each access management technique. This task yielded a matrix of access management techniques and threshold criteria for use on different roadway access classifications. Researchers used discussions with access management personnel from select states operating successful access management programs to supplement experiences for the matrix developed in this task. Supporting information and guidelines for the proper use and application of each access management technique based upon the experiences of successful states were also developed as part of this task.

1.2.3 Develop Recommendations for TxDOT Design Practices

The draft recommendations for TxDOT design practices were made in this task based upon the results obtained in the previous task. Researchers developed these recommendations and presented them to the project advisors and internal stakeholders for comment. Internal stakeholders included individuals from different districts and divisions within the TxDOT organization. The stakeholders and advisors provided comments and recommendations that the research team incorporated into the matrix.

1.2.4 Future Research Activities

The focus of the first year of the project has been developing the matrix of access management techniques and threshold conditions for their use by roadway access classification. The research team will perform several tasks during the second year of the project, including further investigation of driveway permitting methods throughout the state. This effort will yield recommendations for the permitting process. In addition, the research team will develop the

Access Management Guidebook, and TxDOT will provide review and comment. The *Guidebook* is anticipated to be of use to planners and engineers in understanding the importance of various access management treatments and further identifying criteria for their recommended use. The *Guidebook* will also be used in providing policy support for access management decision-making and as a tool for consistent access control by design for affected communities.

Future tasks also include developing training materials and a pilot course on these materials. Researchers anticipate conducting one or two pilot training courses that allow interested personnel from TxDOT districts to attend. A key component of the training will be an evaluation of the course and *Guidebook*. This evaluation will offer the opportunity for course participants to identify areas that may need further clarification to address access management concerns in a given TxDOT district. Finally, the research team will revise the *Guidebook* and training course materials based upon feedback from the pilot courses.

1.3 ORGANIZATION OF REPORT

This report is organized into seven chapters, as described below:

- **Chapter 1.0, Introduction**: This chapter provides an introduction to the research topic, presents the research objectives, and presents the work plan of the research project.

- **Chapter 2.0, State-of-the-Practice**: This chapter provides a discussion of the primary references used in the research project related to access management techniques and their application. This chapter also describes the advantages of select state access management programs whose experiences were valuable in the development of recommendations for Texas.

- **Chapter 3.0, Research Results**: This chapter presents the matrix and supporting information that describes the proposed access management techniques and their use by roadway access classification.

- **Chapter 4.0, Site Development Traffic Impact Analysis Guidelines**: A recommended traffic impact analysis (TIA) guideline is provided in this chapter. These guidelines are meant to supplement the matrix in Chapter 3.0.

- **Chapter 5.0, Recommendations and Discussion**: This chapter describes the recommendations and discussion related to the implementation of the matrix presented in Chapter 3.0.

- **Chapter 6.0, References**: This chapter provides a listing of the references used in the report.

- **Chapter 7.0, Bibliography**: This chapter includes a listing of additional references that may also be of interest to the reader for more information on access management.

CHAPTER 2.0
STATE-OF-THE-PRACTICE

2.1 INTRODUCTION

The first task of this research project was a state-of-the-practice literature review. Significant research in the area of access management over the past decade relates to this project. Previous studies include national research efforts, research within other states, and many research studies within the state of Texas. The literature review summarized this information and documented many areas related to access management including:

- access management plans and programs;
- design practices and criteria for various access management treatments in other states;
- impacts of other existing programs;
- legislative/legal issues; and
- Texas' current status with access management program considerations.

This chapter provides an overview of the state-of-the-practice including the results of the literature review, recent Texas access management research projects, experience from other states in terms of overall access management and specific access management programs, and application of the literature to the current project.

2.2 STATE-OF-THE-PRACTICE LITERATURE REVIEW

2.2.1 Background

Within the United States Department of Transportation (U.S. DOT) Federal Highway Administration (FHWA) several research projects have been conducted over the years to assess the impacts of access management on arterial streets. Azzeh, et al., and Glennon, et al. completed some of the first of these reports in the mid 1970s (*2*, *3*, *4*). This research was later followed up by work completed by Flora (*5*) in June 1982. Several additional studies were also completed during this time, including work by Stover, Koepke, Levinson, and others. The information presented in these early reports has been continually expanded upon as new concepts have unfolded and more data have been made available for access management. Although the guidelines have changed slightly, the benefits of access management on the transportation system have followed three basic themes. These themes include:

- the preservation of highway capacity;
- improved safety; and
- protecting infrastructure investment.

2.2.2 Access Management Guidelines for Activity Centers (*NCHRP Report 348*)

In the late 1980s and early 1990s, the National Cooperative Highway Research Program (NCHRP) began to look in depth at different access management techniques and their applications in different settings. These research projects built upon earlier research and publications to present the state-of-the-art for access management. One of the first of these projects was Koepke and Levinson's work in *NCHRP Report 348*, "Access Management Guidelines for Activity Centers," published in 1992. This project's objective was "to provide reasonable methods to coordinate transportation in relation to land development by (a) developing access management guidelines and procedures, (b) outlining design and operational techniques, and (c) recommending legislative options and enforcement techniques" (*6*). The findings of this report are based upon an extensive literature search and a survey of state and local traffic engineers and major private developers to obtain information on effective access management practices, policies, and enforcement techniques. Although this document tended to focus at times on large developments and activity centers, the guidelines provided have proven useful in nearly all access management situations.

The topics covered in *NCHRP Report 348* include:

- current access management practices;
- discussion on administration and planning;
- legal considerations;
- overview as well as steps and procedures for access permits;
- discussion on access classification systems;
- access spacing guidelines;

- access design concepts including access design principles, interchange concepts, frontage roads, intersection concepts, access driveways, site design, and retrofit actions; and
- access design criteria including design objectives, design parameters, driveway design separate turning lanes, median openings, and application of the criteria.

NCHRP Report 348 provides a comprehensive guideline to use for access management from both a design and application perspective and was used to a great extent in determining access classification, access management techniques, design criteria, and technique thresholds for use in the state of Texas.

2.2.3 Capacity and Operational Effects of Midblock Left-Turn Lanes (*NCHRP Report 395*)

One of the topics identified in *NCHRP Report 348* included medians and median openings. Median openings have always been a "hot topic" for traffic engineers due to the constraints that they place on accessibility, offset by the freedom that they provide for mobility along arterial corridors. In response to the need to provide better recommendations for median openings along arterial streets, and to help determine the type of median to apply for given conditions, a research project was undertaken. Bonneson and McCoy record the results of this research in *NCHRP Report 395*, "Capacity and Operational Effects of Midblock Left-Turn Lanes." The approach in this research was to "develop a comprehensive midblock left-turn treatment evaluation methodology, collect field data to calibrate this methodology, and use the calibrated methodology to develop treatment selection guidelines" (*7*). Three different models were developed as part of this project:

- Operations Model: predicts the delay to arterial left-turn and through movements;
- Safety Model: predicts the annual frequency of accidents along the mid-block street segment; and
- Access Impact Model: predicts an index value that represents the proportion of business owners who would perceive a given left-turn treatment as having a favorable effect on business.

The operations and safety models are used to develop "guidelines for selecting midblock left-turn treatments," while the performance measures are used to predict and compute road-user "benefit" associated with a change in left-turn treatment. This "benefit" is then compared with the construction costs associated with the treatment conversion. Arterial conditions that were found to be cost-effective were identified in the selection guidelines. The research in this report is beneficial in choosing the best alternative for median installation.

2.2.4 Access Management, Location, and Design (*NHI Course 15255*)

In June 1998, the National Highway Institute (NHI) compiled the research conducted on access management into a short course. *NHI Course No. 15255*, "Access Management, Location, and Design" provided reference material on the basics of access management, the benefits of access management, access design principles, access management techniques, information on retrofit projects, site planning, and access management policies and practices. In addition, *NHI Course No. 15255* included sections on implementation of access management principles and procedures, evaluation of potential improvements, and several problems and exercises to test users of the manual on access management practices and procedures (*8*).

The objectives of the course were to aid the participant in obtaining the following information:

- a basic understanding of the concept of access management;
- an understanding of the significance of the Transportation–Land Use Cycle and where state highway agencies and local governments can influence the cycle; and
- an understanding of the concept of functional roadway classification and the need to preserve the functional integrity of roadways.

NHI Course No. 15255 defines access management as the "process of balancing the competing needs of traffic movement and land access" (*8*). Access management provides access to land development while at the same time preserving the safe and efficient flow of traffic on the adjacent roadway network. Access management includes:

- classifying roadways based upon functional criteria which reflect the importance of each roadway to statewide, regional, and local mobility;
- defining allowable levels of access for each road class, including criteria for the spacing of signalized and unsignalized access points;

- applying appropriate geometric design criteria and traffic engineering analysis to the allowable access; and
- adopting appropriate regulations and administrative procedures.

The course demonstrates the need to manage access by quoting from Solomon (*9*) as follows:

> "When conventional highways are constructed on new rights-of-way, initially there are few commercial driveways and the safety record is good. As the highways get older, the traffic volume builds up, roadside businesses develop, more and more commercial driveways are cut, and the accident rate gradually increases.
>
> This demonstrates the importance of maintaining control of access when either two-lane or multilane highways are built on new locations. Increased numbers of either intersections or driveways alone will also increase the accident rate. Intersections should be restricted to those essential for the highway, and the right (direct) access from abutting businesses should be severely limited."

Some symptoms of poor access management are identified in the course as follows:

- high crash rates;
- poor traffic flow and congestion;
- numerous brake light activations by drivers in the through lanes;
- unsightly strip development;
- neighborhoods disrupted by through traffic;
- using a local street parallel to the overburdened "arterial" to make a one-way pair;
- pressures to widen an existing street or build a bypass;
- bypass routes as congested as the roadways they were built to relieve; and
- a decrease in property values.

Several benefits of access management are also outlined in this course. The major benefits include safety, efficiency, aesthetics, and more livable communities. A summary of each of these benefits is as follows:

- Safety: fewer and less severe crashes; and less auto-pedestrian conflict.
- Efficiency: less stop and go traffic, reduced delay, increased and preserved capacity, reduced fuel consumption, and preservation of investment in the roadway system.
- Aesthetics: more attractive corridors, and improved community appearance.
- Livable Communities: enhanced community character, preserved neighborhood integrity, preservation of private investment in abutting properties, and lower vehicular emissions.

According to the course materials, everyone benefits from access management: motorists experience fewer crashes, reduced travel time and delay, and lower fuel consumption; pedestrians and bicyclists benefit from fewer driveways and pedestrian refuges provided in medians; bus riders benefit through reduced travel time and improved schedule reliability; property owners benefit through preservation of their investment and limited through traffic in residential areas; and the general public benefits through stabilization of land use patterns, encouraged coordination of land use and transportation decisions, preserved investment in major thoroughfares, and fewer deaths and injuries resulting from crashes.

NHI Course No. 15255 has been updated over the years to incorporate new research in access management. The most recent version (2001) of the course material is published as *NHI Course No. 133078*, "Access Management, Location, and Design" (*10*).

2.2.5 Impacts of Access Management Techniques (*NCHRP Report 420*)

Although the early studies performed on access management contain information that is still applicable, many of the subsequent studies and reports have identified new access management techniques and offered guidance on their application. Transportation agencies and real estate developers have continued to seek better methods of analyzing, selecting, and predicting the impacts of access management techniques. Much of the information that was available up until the mid 1990s was either out of date or too limited to reflect the state-of-the-art in access management.

Under *NCHRP Project 3-52*, Urbitran Associates and their subcontractors listed and classified more than 100 access management techniques. A comprehensive literature search was performed and the results were synthesized. The techniques were evaluated on the basis of how widely they can be applied to the road network and the likelihood that their benefits could be expressed quantitatively. Twelve techniques were selected for further study and were consolidated into eight categories (traffic signal spacing, unsignalized access spacing, corner clearance criteria, median alternatives, left-turn lanes, U-turns as alternatives to direct left-turns, access separation at interchanges, and frontage roads). The results of this research effort have been compiled into *NCHRP Report 420*, "Impacts of Access Management Techniques," which describes the research approach used and then discusses each of the selected techniques. In most cases, the literature review and subsequent study supported methods for quantitatively estimating the safety and operational impacts of the access management techniques. When this was not possible, case studies were used to illustrate good practice (*11*). *NCHRP Report 420* has been used as the basis for access management techniques by the Transportation Research Board (TRB) Access Management Committee and currently includes the state-of-the-practice for access management in the United States.

NCHRP Report 420 "discusses methods for predicting and analyzing the safety and traffic operational effects of selected access management techniques. It classifies access management techniques; identifies the more significant techniques; and suggests safety, operations, and economic impact measures. It quantifies the effects and benefits of priority techniques and sets forth salient planning and policy implications" (*11*). A more detailed listing of the techniques outlined in this report is provided in **Section 3.5, Matrix of Techniques**, and are referenced throughout the matrix and definition of access management techniques in Chapter 3.0.

2.2.6 Additional Resources

Several additional resources are available and have been referred to in this report. One of the more useful resources is the Systems Planning Interactive Library compact disc (CD) prepared by the Florida Department of Transportation (*12*). This resource has been very helpful in pinpointing access management documentation including reports, conference proceedings, state guidelines, Internet references, and others sources that help aid traffic engineers in obtaining access management information. A second source includes the four national Access Management Conference proceedings, which contain a wide range of information on access management, practices, policies, and techniques. Additional sources also exist that provide the reader with a wide range of information on access management practices, policies, and techniques. A list of pertinent sources of information that have been used in preparing this document, but that are not specifically referenced within the document, can be found in **Chapter 7.0, Bibliography**. This listing should be reviewed to obtain more specific information on access management.

TxDOT has been involved in access management related projects for several years. Additionally, several other states have prepared comprehensive access management programs, some of which have been in place for over a decade. These comprehensive programs contain a wide range of information on policies, procedures, and recommended practices. Based on this available information, a short summary of the lessons that have been learned within the state of Texas to date is provided in the next section, followed by a section that outlines experiences of other states with access management. Several states are referenced in this section, with the information obtained from these states utilized in preparing guidelines and recommendations for Texas.

2.3 TEXAS EXPERIENCE

Two of the most recent projects completed by TTI that relate to access management are TxDOT Project 0-1847, "Identify the Legal Issues and Regulatory Requirements Needed to Establish an Access Management Plan for Texas," and TxDOT Project 7-3904, "A Methodology for Determining Economic Impacts of Raised Medians: Final Project Results." A summary of each of these projects is included in the following sections.

2.3.1 Identify the Legal Issues and Regulatory Requirements Needed to Establish an Access Management Plan for Texas (*TxDOT Project No. 0-1847*)

This project was conducted over a two-year timeframe. In the first year, researchers identified states that had successful access management programs in place, or those who were working on the development of their programs. Five states (Colorado, New Jersey, Wisconsin, Michigan, and Montana) were identified and chosen for in-person interviews with DOT staff and observations of techniques being used. Researchers asked representatives from each of these states questions from a survey instrument developed during the project. The intent of the survey was to collect information about access management programs and activities in the various states. In the second year of the project, a survey for TxDOT district staff was administered.

This survey asked 10 questions that were designed to determine knowledge levels among various employees in the TxDOT district offices. Seventy staff members from 22 of the 25 district offices responded to the survey, providing interesting and valuable insight to their perspectives and understandings of access management (*1*).

The results of the state DOT surveys identified several different methods for developing an access management program. Some specific variances were identified in these different programs including political, legislative, and prioritization of transportation needs. In general, the states that had the most success with access management were those that had a comprehensive program and legislation to support the program. The research team also identified physical treatments that state DOTs use to implement their access management programs and plans. Some of these treatments were considered somewhat traditional, such as left-turn lanes and access separation, while others were more unique, such as jughandles and a variety of U-turn configurations. Finally, the research team learned lessons from the experiences of state DOTs that had already developed and implemented access management programs, as well as those that were in the process of establishing programs. One such lesson was to involve as many internal and external stakeholders as possible early on in the process, while a second lesson was the importance of providing information such as crash data and related costs to the public to help support the need for a comprehensive access management program (*1*).

The research team developed the following recommendations for TxDOT consideration as it prepares to develop a comprehensive access management program (*1*).

- Identify internal and external stakeholders that will be involved.
- Involve all stakeholders from the earliest points in the process as possible.
- Form committees of TxDOT staff members to participate in program development.
- Gather statistical and other supporting information (i.e., crash records and related financial benefits, costs of building alternate facilities instead of implementing access management techniques).
- Develop a consistent theme throughout the program that includes issues such as safety, mobility, design, and right-of-way.
- Obtain as much administrative support for the program as possible.

- Inform/educate stakeholders about access management issues.
- Develop specific supporting legislation at some point in the process.
- Develop enforceable regulations.
- Enforce regulations consistently throughout the state, with minimal flexibility.

The results of this research effort and the importance of access management were summarized into a public information presentation for use with TxDOT, city, county and most importantly Metropolitan Planning Organizations (MPOs) throughout the state of Texas. The Appendix includes a copy of one of these presentations outlining some of the benefits of access management and summarizing the benefits and practices identified through this project.

2.3.2 A Methodology for Determining Economic Impacts of Raised Medians (*TxDOT Project No. 7-3904*)

The "Methodology for Determining Economic Impacts of Raised Medians" project was performed over a four-year period. The following reports were generated by this research effort:

Report 3904-1 *A Methodology for Determining Economic Impacts of Raised Medians: Initial Development*. October 1997.

Report 3904-2 *A Methodology for Determining Economic Impacts of Raised Medians: Data Collection for Additional Case Studies*. October 1998.

Report 3904-3 *A Methodology for Determining Economic Impacts of Raised Medians: Data Analysis on Additional Case Studies*. October 1999.

Report 3904-4 *A Methodology for Determining Economic Impacts of Raised Medians: Final Project Results*. October 2000.

Report 3904-5 *Assessment of Economic Impacts at Select Raised Median Installation Locations in Texas and Development of Recommended Methodology for Economic Impacts Estimation*. October 2000.

Report 3904-S *A Methodology for Determining Economic Impacts of Raised Medians: Final Project Results*. October 2000.

The objective of this four-year research effort was to develop and test a methodology to estimate the economic impacts of median design. This effort yielded the following key results (*13*).

- When asked to rank the factors that affect customers entering their businesses, business owners generally ranked "accessibility to store" fourth or lower below some combination of customer service, product quality, and product price. According to business owners, the most important elements used by customers when deciding where to shop or eat are factors controlled by the business owners themselves. In surveys of customers at five selected businesses along Texas Avenue in College Station, customers ranked "accessibility to store" in much the same way as the business owners.
- When combining all business types, it was found that 85.7 percent of business owners whose businesses were present before, during, and after the median installation felt that their regular customers would be more likely (15.7 percent) or stay about the same in likeliness (70.0 percent) to endorse their business. In contrast, those businesses that were interviewed prior to the installation of the raised median thought their customers would be less likely to continue to use their businesses. Therefore, for the case studies investigated in this project, the perceptions appear to be worse than reality. A similar question was posed to customers in College Station, and the customer survey responses seemed to match the business owners and/or managers opinions. Generally, customers indicated construction was a greater factor in deciding where to shop than the existence of the raised median.
- A majority of customers indicated that while the raised median made access more difficult, they indicated that customer satisfaction was better or that it remained about the same.
- There was almost always an increase in the number of total employees along several of the corridors. Those corridors that did experience a decrease in the number of employees only experienced a decrease for one year and not over consecutive years.
- Those business owners present before, during, and after the raised median installation indicated property values increased an average of 6.7 percent after the raised median installation, while business owners interviewed before construction expected they would decrease.
- The construction phase seemed to impact customers and businesses the most. Several suggestions to alleviate these impacts include:

    - ensuring adequate and highly visible access to businesses during construction;
    - reducing construction time; and
    - performing the construction in smaller roadway segments (phases) to the extent possible.
- Overall, public involvement participation of business owners was indicated as low for 61.5 percent of the business surveys. This response indicates that there is a majority of business owners and/or managers that are not attending the public meetings for raised median projects.

TxDOT staff will be able to use the results of this research to explain experiences on corridors with median projects. This information will also allow TxDOT staff to discuss these issues with the public using appropriate research data, instead of having to say that they are unsure of what to expect. These results will also assist other planners, engineers, and researchers investigating these issues, or involved in similar median projects (*13*). The results of this research will be useful as a comprehensive access management program is put in place in Texas, particularly with respect to median projects. The project director and the research team also determined that additional economic impact information should be compiled to expand the database.

2.4 STATE EXPERIENCE

Several state DOTs around the country have established comprehensive access management programs that provide legislation or policy governing access within their respective states. Other states have prepared access management plans that provide more general guidelines to "plan" for access management. The states of Colorado, Florida, New Jersey, and Oregon have become very well known for the success of their access management programs over the years. In addition, the states of Iowa, Michigan, South Dakota, South Carolina, Utah, Wisconsin, and others are in the process of, or have recently completed studies, establishing access management programs within their states. Each of the main states (Colorado, Florida, New Jersey, and Oregon) was included in the literature review to form the basis of a "successful" comprehensive access management program. Criteria from the other states with existing or emerging programs has also been included in summary format as this information was also used to form the basis of a comprehensive access management program. A summary of each of the state's experiences is included in the following sections.

2.4.1 Colorado

The Colorado *State Highway Access Code*, Volume 2, Code of Colorado Regulations 601-1 was adopted by the Transportation Commission of Colorado effective August 31, 1998 (*14*). Prior access regulations had been in place since the 1950s. The first comprehensive program designed to improve public safety and preserve the functional integrity of the system was established in 1981. The current 1998 Colorado Code is an update of the 1981 document that includes guidelines for administration and access standards as well as design standards and specifications. One of the main purposes of the *State Highway Access Code* is to "…provide procedures and standards to aid in the management of that [Colorado's state highway system] investment and to protect the public health, safety, and welfare to maintain smooth traffic flow, to maintain highway right-of-way drainage, and to protect the functional level of state highways while considering state, regional, and local transportation needs and interests" (*14*).

The Colorado Code includes eight basic access category classifications based on the functionality of the roadway, reality, and long-range plans. Under each of the access category classifications, guidelines have been established for sight distance criteria, access spacing, access width, access radii, access surfacing, speed change lanes (including auxiliary lanes and median design), and other design elements. One of the basic criteria for the access management guidelines is the sight distance requirement established by the America Association of State Highway and Transportation Officials (AASHTO). The desirable sight distance criteria established in the 1994 *A Policy on Geometric Design of Highways and Streets* (AASHTO Green Book) (*15*) are the primary source for guidance in the Colorado Code based on the relationship between AASHTO design criteria and basic human factors issues.

The Colorado Code has established very specific requirements for the design and construction of auxiliary lanes on state roadways. The Colorado Department of Transportation (CDOT) Safety and Traffic Engineering Branch has indicated that the specific nature of this design has allowed the state to require developers in most cases to improve access to their developments. This has resulted in fewer access locations on the state system due to the spacing requirements, and each access is also designed to operate more safely and efficiently because of the requirements.

Some of the strengths identified with the Colorado Code are the consistency that is provided in the access approval process as well as the ability of the Code to address the political will to reduce accidents and preserve the highway system. Some of the lessons to be learned from Colorado are the importance of enforcement of the bandwidth criteria as part of the signalized intersection spacing criteria and the need to train the DOT in access management so that they can help make access management successful statewide.

2.4.2 Florida

Florida was one of the first states to adopt a formal comprehensive access management program. The Florida *Rules of the Department of Transportation Chapter 14-97 State Highway System Access Management Classification System and Standards* was adopted in 1990 and has led the way for access management in the state since that time (*16*). The purpose of Chapter 14-97 is to adopt "…an access classification system and standards to implement the State Highway System Access Management Act of 1988 for the regulation and control of vehicular ingress to, and egress from, the State Highway System. The implementation of the classification system and standards is intended to protect public safety and general welfare, provide for the mobility of people and goods, and preserve the functional integrity of the State Highway System" (*16*). In addition to Chapter 14-97, the state of Florida recently (June 24, 1999) updated and adopted *Chapter 14-96 State Highway System Connection Permits, Administrative Process* (*17*). This document outlines the permitting process for access along the state's highways.

The basic outline of the Florida comprehensive program includes a seven level classification system (access class 1 through 7). The access classifications vary depending on the level of development for the area and the need to provide non-traversable or traversable medians. The program was originally set up with interim standards (based on posted speed) while the classification of the roadway network was completed. The classification was completed in 1993; however, the interim measures are still being utilized to provide standards where roadways are transferred to the state by local governments. Today Florida is in a "maintenance" mode and has been emphasizing the reclassification of transfers from counties, rather than "building" new roadways.

The spacing standards provided in the Florida access management program are based on research conducted by Stover and include interchange spacing requirements, intersection spacing requirements, driveway spacing requirements, corner clearance criteria, and median opening spacing (*16*). The main area of success for the Florida comprehensive program has been with respect to medians. The Access Management Coordinator for the Florida DOT has indicated that non-traversable median standards have been more effective than the driveway spacing standards. It was reported that, as of 1993, any new multilane design in the state of Florida is required to have a non-traversable median unless the design speed is less than 35 mph. This has been accomplished through policy only (no legislation), and has been very successful. The policies that have been followed include Chapter 14-97 and Chapter 14-96 as outlined previously as well as the *Median Opening and Access Management Decision Process* (Topic No.: 625-010-021-d) (*18*) and the Florida *Median Handbook* (*19*). In addition, Florida has established an Access Management Committee in each region of the DOT to oversee access management in the region. These committees ensure that the policies are being followed and have proven critical to the success of the program.

Some of the strengths identified in the Florida comprehensive program are the median opening criteria and its success statewide, the consistency that has been established through the access management committees in each region, and the ability of the DOT to spread the word about access management through their Systems Planning Interactive Library CD (*12*). The informational CD outlines not only the basics of access management and access management standards throughout the state of Florida, but also includes references and documentation from national sources and from other states. Some of the lessons to be learned from the Florida program include identification of the time necessary to implement an access classification system and the occasional inconsistency that occurs because of the decentralization of the program.

2.4.3 New Jersey

The New Jersey Chapter 47 *State Highway Access Management Code* has been in effect since 1992. The most recent version of the New Jersey Code is dated January 1998 and represents the current access management program in New Jersey. The New Jersey Code is a comprehensive document that contains definitions, access classifications, access standards, and permitting requirements (*20*).

Access classifications in New Jersey were based on the functional classification for federal funding purposes. A spokesperson for the New Jersey Department of Transportation (NJDOT) indicated that the access classifications were created with great sensitivity to the difference in purpose between access management and federal funding and differ greatly where appropriate. The New Jersey Code includes six basic classifications or "access level" (AL) designations. The descriptions include: AL 1, fully controlled access; AL 2, access via streets or interchanges only; AL 3, right-turn access with provisions for left-turn access via jughandles; AL 4, driveways with provisions for left-turn access via left-turn lane; AL 5, driveways with provisions for left-turn access (limited by spacing requirements and safety considerations); and AL 6, driveways limited by edge clearance and safety considerations.

One of the more unique concepts that is included in the New Jersey Code is a provision for providing access to "non-conforming" lots. Essentially, non-conforming lots do not have enough frontage to meet the driveway spacing requirements. In the case of a non-conforming lot, a conformance test is done using the frontages of the lot and the lots on either side of the parcel in question. The analysis results in several interesting relationships and incentives. First, non-conforming lots have limitations on the amount of traffic that they can generate. This leads to fewer traffic conflicts when driveways are provided close together. Second, one non-conforming lot cannot exist alone. At a minimum, there is a pair of non-conforming lots. There is an incentive in the New Jersey Code to allow two non-conforming lots that share a driveway to generate more traffic than the sum of the limited trips for the two individual lots. New Jersey has been very successful with this concept as it has allowed them to predictably and consistently work with property owners on access spacing issues. Enforcement of the non-conforming principle is handled through the permitting process and has resulted in a successful program.

Additionally, in 1987, New Jersey implemented traffic impact study requirements for development that were predicted to generate more than 200 peak hour trips. These studies have allowed the burden of performing the access studies to be shifted to the applicant with the DOT providing the review and approvals. The traffic study requirements have been an essential element of the New Jersey Code enabling the DOT to authorize safe and efficient access to the state highway system. Traffic studies have also been used in New Jersey to determine impact fees and to quantify the improvements that must be made by the applicant to the adjacent roadway network when developments are proposed.

There are several strengths that can be identified in the New Jersey Code. First of all, it is comprehensive. Additionally, the traffic impact study requirements have proven very successful, as have the permitting requirements for all applications, particularly non-conforming lots. Some of the lessons to be learned from the New Jersey Code are the importance of enforcing the spacing and bandwidth requirements for the traffic signal spacing criteria. However, driveway geometry standards that have limited the width of driveways and forced driveways to be divided to comply with the standards have been identified as an area that may require additional attention.

2.4.4 Oregon

Oregon completed their comprehensive access management program as part of the *1999 Oregon Highway Plan.* Goal 3: "Access Management" in the *Oregon Highway Plan* is to "…employ access management strategies to ensure safe and efficient highways consistent with their determined function, ensure the statewide movement of goods and services, enhance community livability, and support planned development patterns while recognizing the needs of motor vehicles, transit, pedestrians, and bicyclists" (*21*). The *1999 Oregon Highway Plan* was adopted by the Oregon Transportation Commission on March 18, 1999, and serves as the basis for access management within the state.

The Oregon access management program includes a very detailed breakdown of access management classifications based on the roadway classifications used in the *1999 Oregon Highway Plan*. Freeways—Interstate and Non-Interstate, Statewide Highways, Regional Highways, District Highways and Local Interest Roads—are outlined as the classifications for the program. In addition, each classification has been segmented according to the designations of Rural Expressways, Rural Other, Urban Expressways, Urban Other, Urban Business Areas, and Special Transportation Areas for a very complete and comprehensive classification system. By classifying the access management according to the overall highway program, consistency is maintained in the roadway system. The Oregon Department of Transportation (ODOT) has indicated the importance of managing access based on the function (or hierarchy) of the road system. Where mobility is the emphasis, the spacing of approaches should be further apart. In contrast, where mobility and accessibility are more evenly balanced, the spacing of approaches can be somewhat closer together. For this reason, the spacing of approaches on statewide highways are further apart based on the mobility emphasis for these highways and closer together on the district highways, since mobility and accessibility are more closely balanced.

The basic standards provided by the Oregon comprehensive access management program include:

- classification and spacing standards;
- medians;
- interchange access management areas;
- deviations; and
- appeals.

One of the themes throughout the comprehensive program is the importance of access rights. Oregon's program is designed such that approaches can only be approved where the property owner has the right of access. ODOT has indicated that, in most cases, property owners have a "common law right to access" to a highway if their property abuts the highway. However, there are cases where this is not true. By statute, if a highway is constructed on a new alignment after 1951, the abutting property owners do not have a right of access. Additionally, ODOT may acquire the rights of access (access control) by purchase, donation, condemnation, or by law. In some cases the property owner's common law right of access may be limited to a specific location through a "reservation of access" where ODOT has acquired access control along the highway frontage. In other cases, the access rights were acquired in total, and no right of access exists between the abutting property and the highway.

Some of the strengths identified in the Oregon comprehensive program include the focus on access rights and the documentation that is provided in the decision-making process for approach request approvals and denials. The program also provides more predictability in the application of access management standards and better clarity regarding how access management standards apply to projects. Of the different policies in the program, Policy 3C: "Interchange Access Management Areas" provides a good background and basis for interchange spacing criteria, while Policy 3D: "Deviations" and Policy 3E: "Appeals" both provide a basis for changes to the standards on a case-by-case basis. Some of the lessons that can be learned from the Oregon program are the importance of assigning an appropriate access classification system. The Oregon program is rather complex and somewhat redundant with its access classification system. Although this system follows the roadway classification, the segmentation of each of the main classifications appears to be redundant and could possibly be eliminated. Overall, the Oregon program appears to be effective in handling the access management issues of the state.

A summary of the Florida, Colorado, New Jersey, and Oregon comprehensive programs is provided in Table 2-1.

Table 2-1. Florida, Colorado, New Jersey, and Oregon Comprehensive Program Summary.

State	Date of Issue [1]	General Comments	Special Focus Area
Florida	November 1990	• 7 access classifications. • Comprehensive. • Now (10 years later) reaping the rewards of the program.	• Medians required on multilane roadways with design speed > 35 mph. • Access Management Director in each Region.
Colorado	August 1998	• 8 access classifications. • General guidelines are strong. • Standards based on AASHTO desirable criteria.	• Auxiliary Lanes (i.e., left-turn deceleration lanes, right-turn deceleration lanes and acceleration lanes).
New Jersey	January 1998	• 6 access level categories. • Comprehensive. • Traffic Impact Study requirements.	• Conformance and non-conformance of lots with detailed analysis of vehicular use limitations for non-conforming lots.
Oregon	May 1999	• Classifications include 3 major categories with 6 subcategories of each. • Comprehensive.	• Access rights. • "Deviations" to the standards. • Interchange spacing.

[1] The Date of Issue corresponds to a recent version of the comprehensive program.

2.4.5 Other State Comprehensive Access Management Programs

Several other states have also prepared comprehensive access management programs. Some of these include Iowa, Michigan, South Carolina, South Dakota, Utah, and Wisconsin. A brief summary of each of these programs is provided in this section with a summary in Table 2-2.

2.4.5.1 Iowa

The *Access Management Handbook* (*22*) was prepared by the Center for Transportation Research and Education (CTRE) at Iowa State University in October 2000 under the direction of the Access Management Task Force and through funding provided by the Iowa DOT. The Iowa *Access Management Handbook* provides a good background on the definition of access management while developing an effective access management program. In addition to outlining the access management program, the handbook includes several case studies from which information on the program has been developed as well as a complete section on public involvement and example access management ordinances for city and county consideration.

2.4.5.2 Michigan

The *Administrative Rules Regulating Driveways, Banners, and Parades on and Over Highways* is currently the policy being used for access management in the state of Michigan (*23*). The "*Blue Book*," as it is often referred to, provides guidance to the Michigan Department of Transportation (MDOT) for the permitting of driveways within the state and includes sections on general provisions, driveway permits, driveway design standards, banner permits, parade, celebration, festival highway closure permits, and hearings and appeals. The third reprint of the document was issued in April 1999. In addition to the *Blue Book*, MDOT in conjunction with the Tri-County Regional Planning Commission in Lansing, Michigan, and the Southeast Michigan Council of Governments located in Detroit, Michigan, has also published a manual entitled, *Evaluating Traffic Impact Studies* (*24*). This guide shows how to determine when to require traffic impact studies and how to evaluate and use traffic studies in the state of Michigan. This has been successful in applying the guidelines of the *Blue Book*.

2.4.5.3 South Carolina

In October 1996, the South Carolina Department of Transportation (SCDOT) published the *Access and Roadside Management Standards* to aid with the mission of the SCDOT "…to provide South Carolina the best possible intermodal transportation systems and services for the safety, efficient movement of people and goods, and stewardship of the State's environment and natural beauty" (*25*). The SCDOT standards include sections on the following:

- encroachment permits;
- points of access;
- roadside encroachments;
- drainage; and
- construction.

The SCDOT standards include a good foundation for access management, simple and concise guidelines, and no access classifications, with standards based on operating speed, frontage length, and lane configurations.

2.4.5.4 South Dakota

To determine the need for access management in South Dakota, the South Dakota Department of Transportation (SDDOT) and the U.S. DOT FHWA contracted with Dye Management Group, Inc. to complete a project entitled *Review of SDDOT's Highway Access Control Process* (*26*). The final report of this review was completed in February 2000 and includes a very comprehensive analysis of background and purpose of access management, access policy as it applies in South Dakota, access criteria and design, permit process recommendations, and access management authority in South Dakota. In addition, the project also outlines the benefits of improved access management in South Dakota, provides tools for local government, and outlines the implementation of the program. The objectives of this project were to develop "improved access policies, design guidelines, and procedures for applying them" (*26*). The South Dakota program provides a very comprehensive tool for access management within the state.

2.4.5.5 Utah

The *Utah State Highway Access Management Manual* is currently being used for interim operation based on the draft manual dated March 2001 (*27*). The manual was prepared for the Utah Department of Transportation (UDOT) by Fehr & Peers Associates, Inc. to provide the basis for access design standards and specifications in the state of Utah. The manual includes administration guidance, access category standards, and design standards and specifications for application within the state. The manual is currently undergoing internal review and the final document is expected to be published in the near future.

2.4.5.6 Wisconsin

Access management is addressed generally in the State of Wisconsin Department of Transportation (WisDOT) *Facilities Development Manual*, Chapter 7, Access Control (*28*). This document indicates that "Wisconsin has an Access Management System Plan which specifies a network of state highways on which access will be controlled through the purchase of access rights or the designation of 'controlled access highways.' Some of these routes are freeways, others are two-lane or multilane roadways where access is currently being controlled, and others are roadways where the department plans to obtain access controls during the next two decades" (*28*). In addition to the *Facilities Development Manual*, access control is also addressed through Wisconsin Administrative Code, Trans 233, which is WisDOT's administrative rule regarding land divisions, as well as through a series of statues that cover such topics as purchased control, driveway permits, freeway relocation, and other controlled-access projects. Several districts in Wisconsin have also adopted traffic impact analysis guidelines to aid in access management efforts.

Table 2-2. Access Management Comprehensive Programs.

State	Date of Issue [1]	General Comments	Special Focus Area
Iowa	October 2000	• Summary of basic guidelines for access management. • Guidance for retrofit of existing roadways. • Includes example city and county ordinances.	• Focuses on all aspects of access management, including the background behind access management.
Michigan	November 1998	• No access classification. • Driveway design standards for commercial and residential driveways. • No information on median spacing, driveway spacing, corner clearance, etc. in Administrative Rules.	• Focuses mainly on individual driveway design rather than access management measures.
South Carolina	October 1996	• Simple and concise. • No access classifications. • Standards based on operating speed, frontage length and number of lanes.	• Focuses on basic access management techniques.
South Dakota	February 2000	• 4 major classifications with sub-classifications for divided/undivided and urban/non-urban for each. • Comprehensive.	• Detailed analysis and guidelines for all major aspects of access management.
Utah	DRAFT	• Still in draft format. • 9 classifications. • Traffic Impact Study emphasis.	• Focuses around permitting process in the state.
Wisconsin	February 1999	• TRANS 233, administrative rule regarding land division. • Access management practices are controlled by a series of procedures and highway provisions tied to TRANS 233.	• Focuses primarily on permitting and provision of direct access to state trunk highway or connecting highways.

[1] In most instances the Date of Issue corresponds to a revision of the comprehensive program.

2.5 APPLICATION OF LITERATURE REVIEW

The state-of-the-practice literature review has provided the research team with information and resources used to develop the basis of the Texas comprehensive access management program. The details of the techniques to utilize and their sources will be provided in the following sections. In addition to the technical information that this process provided, practical knowledge and information has also been gained from the process. Some of the important factors that should be considered in preparing the Texas access management comprehensive program are included in the following sections.

2.5.1 Access Management Coordinator

The literature review, particularly the review of other state comprehensive access management programs, has indicated the need to provide a coordinator to oversee access management within the Department. The states that have demonstrated the most success with their access management programs are those states in which a DOT employee led the access management efforts and was on-hand during the implementation, organization, and initial set-up of the program. In most cases, this individual is still involved with the program and continues to ensure its success. In addition to this statewide access management coordinator, several states have also implemented district or region access management coordinators or committees as well. These local access management coordinators have taken the responsibility of ensuring that access management practices are followed within their jurisdictions and have been a key to the success of the program. In the case where local coordinators or committees are provided, the statewide coordinator still plays an important role in ensuring consistency throughout the state.

2.5.2 Implementation

Another common theme identified in the literature review, and particularly in speaking with DOT access management coordinators, is the importance of implementation consistency and the realization that success will not happen overnight. Access management requires a great deal of investment before the results of its implementation will begin to be noticed throughout the state. For instance, Florida has indicated that after 10 years of monitoring and enforcing their access management comprehensive program, they are just now beginning to reap the benefits of this program. These results did not come easily. Enforcement had to be consistent, and a great effort was made to train both DOT personnel and the public as well. Access management requires a commitment from the Department as an organization and from the staff members individually to reap the benefits that it can provide to the roadway network.

2.5.3 Consistency

The final necessary aspect of the access management program to ensure success is consistency. Consistency in policy and implementation statewide is needed for the program to be effective. One of the most important lessons to be learned, identified through contact with the statewide access management coordinators, was maintaining consistency throughout the state. Even with someone to oversee the program and to manage the system, consistency can still be a concern and is something that needs to be addressed early in the program.

CHAPTER 3.0
RESEARCH RESULTS

3.1 INTRODUCTION

This chapter will present and describe the first-year research results for managing access on arterials. The research has yielded guidelines for managing access through effective access management techniques and treatments. The sections that follow will provide information on the background and purpose of access management, define common terms related to access management, define the access classification system to be considered for implementation, and then unveil the proposed matrix of access management techniques by roadway access classification for the state of Texas. Once the matrix is unveiled, detailed sections will follow to provide recommended practices for each of the techniques outlined.

The discussion of techniques has been supplemented with the results of the state-of-the-practice literature review for each of the techniques to provide guidance and recommended practices for the state of Texas. Researchers recommend that TxDOT consider the results of this section for inclusion in the TxDOT *Roadway Design Manual* and *Driveway Manual*. This information will be included as approved in the development of an *Access Management Guidebook* in the second year of the project.

3.2 BACKGROUND AND PURPOSE

Traffic volumes and congestion in the state of Texas have increased in recent years, particularly on arterial streets. The primary purpose of arterial streets is the movement of vehicles while providing necessary access to residential and commercial developments. If unlimited access is provided directly from businesses and/or homes to the arterial streets, average speeds decrease and capacity of the arterial diminishes, thus compromising the functional integrity of the arterial street. Frequent access also presents safety issues by providing more locations for potential conflicts of vehicles' paths. Some solutions in the past have been to build relief routes parallel to arterial corridors. It has been very common, however, for the same problems to occur on the relief routes. In some cases tertiary relief routes have been built to try and alleviate the congestion problems on the secondary routes.

A better, more cost effective solution than building relief routes is to incorporate access management techniques into the design of arterial streets. Access management is the process that manages vehicular access to land development while simultaneously preserving the flow of traffic on the surrounding road network in terms of safety, capacity, and speed (*6*). There are four terms that must be addressed in considering access management techniques. These terms are access, accessibility, movement, and mobility. In addition to these four terms, functional classification must also be considered in addressing access management techniques.

3.2.1 Access

Access is the ability to obtain ingress and egress between a parcel of land and the highway system. In short, to get to and from your property via a public road.

3.2.2 Accessibility

Accessibility is an area-wide measure of the ease of travel between locations within a defined area such as a city, state, or region of the country. It is the ability to reach a given location from numerous other locations or areas. The accessibility to potential customers is of great importance to a retail establishment. Accessibility is also the ability to reach a variety of other locations from a given location. Accessibility can be measured and quantified.

3.2.3 Movement

Movement is the ability to traverse a segment of highway. As used in access management, it concerns the degree of ease, or difficulty, of vehicles passing by an access drive or through an intersection.

3.2.4 Mobility

Mobility is related to the ability of persons to make trips to satisfy their needs and desires by walking, auto, transit, bicycle, or any combination of modes.

3.2.5 Functional Classification

All roads provide some degree of both vehicular movement and property access, depending on the function that they are intended to serve. These roadway functions vary from primarily movement of vehicles attained through complete access control to primarily access to properties provided through unlimited driveway and street intersections. Freeways are at the highest functional classification level because they completely control access with on- and off-ramps and grade-separated intersections. Some functional classification systems (though local nomenclature may vary) include expressways, which limit access at on- and off-ramps, as well as some signalized intersections. Such a facility may include both grade-separated and at-grade intersections, as well as frontage roads.

The next functional classification is the principal arterial. A principal arterial's primary function is moving traffic through a city or an area, as well as receiving traffic from, and distributing traffic to, minor arterials and collectors. Urban principal arterials are typically four- or six-lane divided facilities and are several miles in length. It is impossible and unnecessary to completely prohibit direct access from other streets and driveways to principal arterials, but such access should be minimized through design controls in order to preserve the integrity of the primary arterial streets. Minor arterials should provide somewhat more access than principal arterials but should still be mainly intended for vehicular movement. These roads are typically four-lane divided facilities.

Collector streets are at the mid-point of providing movement and access. Such roads may range from two-lane, undivided to four-lane, divided facilities and are typically up to a few miles in length. Street and driveway intersections should be more frequent on collectors because they serve the purposes of collecting traffic from local streets and feeding the traffic to arterial streets, as well as receiving traffic from arterials and distributing the traffic to local streets.

Local streets in urban areas serve the purpose of providing virtually unlimited access to adjacent properties. Local streets range from one-block cul-de-sacs to loop streets with longer streets serving residential and other developments.

The relationship among functional classification, access and vehicle movement is shown in Figure 3-1. This figure illustrates the range of unrestricted access and no through traffic to that of complete access control. The management of both access and movement as illustrated in this graphic is the practice of "access management."

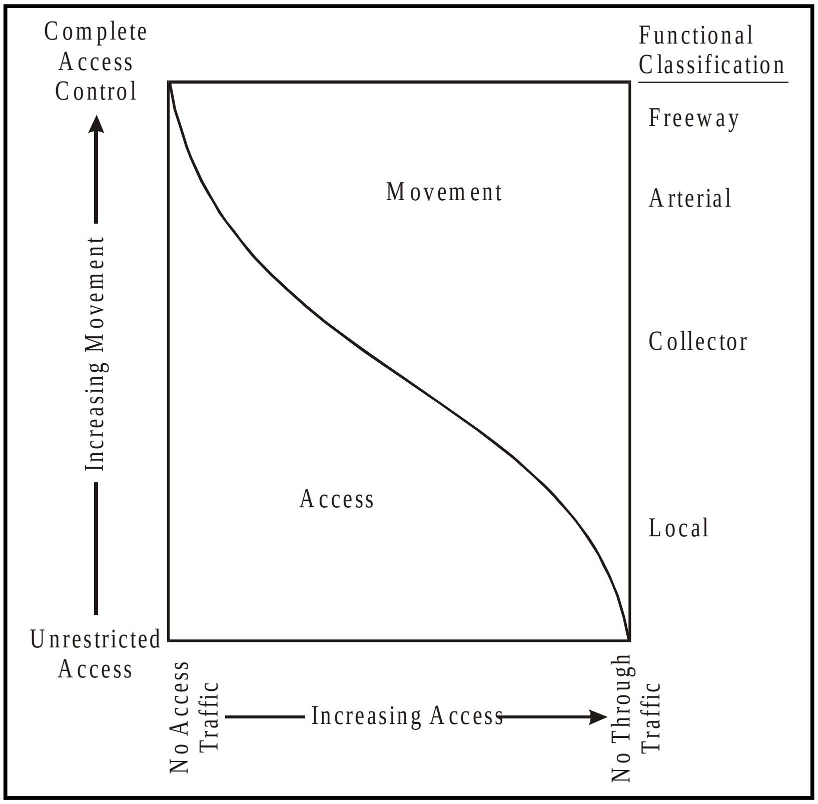


Figure 3-1. Relationship Among Functional Classification, Access, and Vehicle Movement (*6*).

The practice of access management is most successful when originally designing the arterial, but it can also be applied through retrofit projects on existing roadways. Using access management techniques, such as raised medians, turn lanes, acceleration/deceleration lanes, median opening spacing criteria, and driveway spacing criteria, the public investment in the arterial is protected by preserving its capacity, maintaining mobility, and improving safety. These benefits have been recognized at all levels of government and are being incorporated in several states throughout the nation. Streets and highways constitute a valuable resource as well as a major public investment. It is essential that they operate safely and efficiently through the management of access to and from abutting properties. Owners of the abutting properties have a right of reasonable access to the roadway system; roadway users also have the right for freedom of movement, safety, and efficiency. The need to balance these rights is one of the main goals of access management.

3.3 DEFINITIONS

The following definitions and abbreviations are provided to help explain certain technical words, phrases, or abbreviations used in this document. The definitions are based upon programs of other states as well as those specifically identified for Texas (*14*, *16*, *20*, *21*, *29*). If a word is not further defined herein, it may be assumed that it is the common and acceptable meaning of the word as found in any widely accepted English language dictionary.

AADT: the annual average daily traffic volume. It represents the total two-way traffic on a roadway for the year, divided by 365. It includes both weekday and weekend traffic. Usually, AADT is adjusted for day of the week, seasonal variations, and/or vehicle classification.

ADT: the average daily traffic volume. It represents the total two-way traffic on a roadway for some period less than a year, divided by the total number of days it represents and includes both weekday and weekend traffic. Usually, ADT is adjusted for day of the week, seasonal variations, and/or vehicle classification.

Acceleration lane: a speed-change lane, including tapered areas, for the purpose of enabling a vehicle entering a roadway to increase its speed to a rate at which it can more safely merge with through traffic.

Access: any driveway or other point of entry and/or exit such as a street, road, or highway that connects to the general roadway system.

Access classification: an identification system for regulating access, based on function, environment, and traffic characteristics. The access classification system is applicable to all streets and highways within the state. A change in the function, surrounding environment, traffic characteristics, posted speed, or desirable typical section may be a basis for changing the access classification and associated access level.

Access spacing: the allowable distance between conforming access points, measured from the closest edge of pavement of the first access to the closest edge of pavement of the second access along the edge of the traveled way.

Auxiliary lane: a lane striped for use, such as an acceleration lane or deceleration lane, right-turn lane or left-turn lane, but not for through traffic use.

Backage road: see "reverse frontage road."

Bandwidth: the time in seconds or the percent of traffic signal cycle between the passing of the first and last possible vehicle in a group of vehicles moving at the design speed through a progressive traffic signal system.

Capacity: the number of vehicles that can traverse a point or section of a lane or roadway during a set time period under prevailing roadway, traffic, and control conditions.

Corner clearance: the distance along the curbline between the edge of pavement of the corner radius at the intersection and the edge of pavement of the nearest curbline opening (driveway or intersection).

Corner lot: a lot with one frontage on a state highway and an adjacent frontage on a road that intersects the state highway.

Deceleration lane: a speed-change lane, including tapered areas, for the purpose of enabling a vehicle that is to make an exit to turn from the roadway and slow to a safe exit speed after it has left the mainstream of faster-moving traffic.

Department: the Texas Department of Transportation, or TxDOT.

Directional median opening: an opening in a non-traversable median that provides only U-turn movements, and/or left-turn movements only from the state highway.

Divided highway: a highway with medians to separate roadways for traffic moving in opposite directions.

Driveway: an access that is not a public street, road, or highway.

Frontage road: a local street or road along an arterial highway allowing control of access and service to adjacent areas and property. Also known as service road or access road.

Full median opening: an opening in a non-traversable median designed to allow all turning movements to take place from both the state highway and the adjacent connection.

Functional boundary: the area of an intersection necessary to provide all required storage lengths for separate turn lanes and for through traffic plus any maneuvering distance for separate turn lanes. The functional boundary of an intersection includes more than just the physical area of the intersection as identified in Figure 3-14 of this report.

Functional classification: the process by which streets and highways are grouped into classes, or systems, according to the character of service that they are intended to serve; a system that classifies roadways according to traffic flow from the movement function to the access function. At one extreme is the fully access controlled freeway that provides no local access function to the cul-de-sac that provides no through movement.

Intersection: the common area at the junction of two highways, other than the junction of an alley and a highway. The dimensions of an intersection include only the common area within the connection of the lateral curb lines, or in the absence of curb lines, the lateral boundary lines of the roadways of intersecting highways that join at approximate right angles or at the place where vehicles could collide if traveling on roadways of intersecting highways that join at any angle other than an approximate right angle.

Level of Service (LOS): a measure of traffic flow and congestion. As defined in the *2000 Highway Capacity Manual* (*30*), it is a qualitative measure describing operational conditions within a traffic stream; generally described in terms of such factors as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.

Limited access facility: a street or highway especially designed for through traffic and over, from, or to which owners or occupants of abutting land or other persons have no right or easement of access by reason of the fact that their property abuts such limited access facility or for any other reason. Interstate highways, parkways, and freeways are usually developed as limited access facilities.

Manual on Uniform Traffic Control Devices (MUTCD): a guide to provide uniformity in the placement of signs, pavement markings, and traffic signals.

Median: that portion of a divided highway separating the opposing traffic volumes. The median may be traversable or non-traversable.

Median barrier, concrete: a type of median providing a physical obstruction to crossing.

Median, depressed: a median that is lower in elevation than the traveled way and designed to carry a certain portion of the surface water.

Median, non-traversable: the portion of a divided highway or divided driveway physically separating vehicular traffic traveling in opposite directions. Non-traversable medians include physical barriers that prohibit movement of traffic across the median such as a concrete barrier, a raised concrete curb and/or island, and a grassed or a swale median.

Median opening, crossover: an opening in a median for crossing and turning traffic.

Median opening spacing: the spacing between openings in a non-traversable median to allow for crossing the opposing traffic lanes to access property or for crossing the median to travel in the opposite direction (U-turn). The distance is measured from centerline to centerline of the openings along the traveled way.

Median, raised: a median that is higher in elevation than the traveled way and usually outlined with a curb.

Median, traversable: a median, whether raised, depressed or flush, that consists of a visible separation without any physical obstruction that can be crossed with ease and comfort.

Metropolitan Planning Organization (MPO): an association established to coordinate transportation planning and development activities within a metropolitan region.

Reverse frontage road: frontage on an access road constructed at the rear of lots fronting on the state highway. Also referred to as a backage road.

Right-of-way: a general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to a highway for the construction of the roadway.

Service road: see “frontage road.”

Shared driveway/shared access: a single driveway serving two or more adjoining lots. A shared driveway may cross a lot line, enabling a lot without direct highway access an opportunity for access to the highway.

Sight distance: the distance visible to the driver of a passenger vehicle measured along the normal travel path of a roadway from a designated location and to a specified height above the roadway when the view is unobstructed by traffic.

Signal: a traffic control signal.

Signal progression: progressive movement of traffic, at a planned rate of speed without stopping, through adjacent signalized locations within a traffic control system.

Signal spacing: the distance between adjacent traffic signals on a controlled access facility measured from centerline to centerline of the signalized intersections along the traveled way.

State highway system (SHS): the system of highways in the state included in a comprehensive plan prepared by the Department’s executive director under the direction and with the approval of the commission.

Stopping sight distance (SSD): the distance required by a driver of a vehicle, traveling at a given speed, to bring the vehicle to a stop after an object on the roadway becomes visible. It includes the distance traveled during driver perception-reaction time and the vehicle braking distance.

Storage lane length: length of a portion of an auxiliary lane required to store the maximum number of vehicles likely to accumulate in the lane during a peak period.

Traffic impact analysis (TIA): a report analyzing anticipated roadway conditions with and without an applicant's development for the specified horizon years. The report includes an analysis of mitigation measures to offset the impacts with the development. Also referred to as a traffic impact study (TIS).

Traffic impact study (TIS): see traffic impact analysis (TIA).

Traveled way: a portion of the roadway for the movement of vehicles. It includes the actual travel lanes and not shoulder or auxiliary lanes.

Warrant(s): the criteria by which the need for a safety treatment or highway improvement can be determined.

In addition to the definitions outlined in this section, three key verbs are identified throughout the recommendations for access classification, access management techniques, and traffic impact analysis requirements. These verbs are "shall," "should," and "may". The 2000 Manual on Uniform Traffic Control Devices (MUTCD) breaks down each section of guidance into three main categories. These categories are standards, guidance, and options. Standards are defined as statements of "required, mandatory, or specifically prohibitive practice regarding a traffic control device" (*31*). Standards are typically identified by the verb "shall." Guidance is defined as "a statement of recommended, but not mandatory, practice in typical situations, with deviations allowed if engineering judgment or engineering study indicates the deviation to be appropriate" (*31*). Guidance statements are generally identified with the verb "should." Finally, options are defined as "a statement of practice that is a permissive condition and carries no requirement or recommendation. Options may contain allowable modifications to a Standard or a Guidance" (*31*). Options are typically identified with the verb "may."

The same basic guidelines identified in the MUTCD have been used throughout access management literature to ensure that proper action is taken when providing guidance on access management techniques and to ensure that the safety and general well being of the public can be met. The "shall," "should," and "may" verbiage is carried throughout this document to identify those recommendations that are critical in meeting the goals of Texas' access management program. The results of the research have shown that states with successful access management programs have included this verbiage in their programs to provide the emphasis that is necessary to meet the goals of the access management program, and it is recommended, therefore, that this be carried throughout the proposed access management program for the state of Texas.

3.4 ACCESS CLASSIFICATION

The access classification (AC) system forms the basis of access management implementation. It defines where and how often access can be allowed between proposed developments and public highways; where it should be denied or discouraged; where access should be limited by the use of non-traversable medians; where provisions should be made for auxiliary lanes for both acceleration and deceleration purposes; and where other access management techniques (i.e., U-turn movements, jughandles, frontage roads) should be considered for implementation.

Safe and efficient operation of streets and highways has always required that facilities be classified and designed to meet the purpose they are intended to perform. The entire road system is classified according to the functional classification system and is based on the function of the given roadway. Roadways must be ranked as to their importance in providing a logical and efficient movement of trips through the network. The existing roadway functional classifications mandated by FHWA include the following:

1. interstate (urban and rural);
2. other freeways and expressways (urban);
3. other principal arterials (urban and rural);
4. minor arterials (urban and rural);
5. major collectors (rural);
6. urban collectors;
7. minor collectors (rural);
8. local road (rural); and
9. local street (urban).

The FHWA functional classification categories are used throughout the country primarily to determine which roads are eligible for various categories of federal maintenance and construction funding. In some cases roads may have one FHWA functional classification but actually be serving the purpose of another functional classification as described in **Section 3.2.5, Functional Classification**. For example, there are some roads carrying in excess of 10,000 vehicles per day (vpd) that are classified as local streets. While traffic volume is not a basis for functional classification, local streets typically carry volumes of less than 2,500 vpd. Such misclassifications occur for a variety of reasons and begin to illustrate the need for a separate AC system so that the appropriate access management treatments may be considered.

To accurately control and manage access, the AC system is recommended to consider such factors as: roadway purpose (access versus vehicle movement), land use, system continuity, design features, location (urban/rural), and safety (crash rates and type). In contrast to functional classification, which considers existing roadway operations, access classification decisions should include discussion of future (20+ years) projected traffic volumes, future land use projections, projected roadway purpose (access versus vehicle movement), future right-of-way considerations, and existing crash rates. The access classification should be determined by future access needs along the roadway, while considering the primary purpose of the roadway and its ability to provide safe and efficient traffic movement. Most importantly, however, the AC system is designed to aid the Department in improving safety, increasing mobility, and protecting infrastructure investment now and in the future.

In reviewing alternatives for access classification, the research team concluded that a classification system similar to that used in the state of Florida was most applicable for application in Texas (*16*). In keeping with the goals of access management (improve safety, increase mobility, and protect infrastructure investment), the AC classifications are defined to preserve future access through land use planning and a vision of the future. The proposed access classification system provides an opportunity to determine the extent to which access should be "preserved" along a corridor, and therefore, the definitions are based on this vision of future access preservation.

It is recommended that the access classifications be determined by the district engineer and recorded through the proposed statewide access management coordinator or appropriate division to support planning and design activities. The district engineer may appoint an access management committee to assist in the evaluation of access management classification based on varying local operational conditions of roadway segments. If needed, the access management committee is recommended to include the following positions:

- local district staff members;
- local area engineer;
- local MPO representative (where applicable);
- local city/county representative (where applicable); and
- statewide access management coordinator (for review according to uniform state standards).

The district engineer and access management committee, if desired, will look at roadway segments as needed for new development, permit applications, reconstruction and/or highway maintenance projects and make a determination on the appropriate access classification. The district engineer may also consider classification of roadway segments at the request of the Transportation Commission. Once a classification determination has been made, this classification can be changed only through official petition to the district engineer.

The AC system proposed for Texas includes seven levels of access classified as AC 1 through AC 7. The following definitions and photographs of example corridors describe the access provided for each classification. A summary of the access classifications is provided in Table 3-1. The photographs provided for each classification are intended to provide examples of possible roadways to be considered for each classification. These examples do not necessarily meet all of the recommended design requirements for access management techniques as outlined in **Section 3.5, Matrix of Techniques**, and the detailed sections that follow, outlining the recommended standards. These examples are, however, representative of the types of roadways that would be considered for each access classification and would then be retrofitted as appropriate to the recommended standards. It should be noted that the unsignalized access spacing values indicated for the classifications below are based upon AASHTO stopping sight distance for the design speed of the roadway and shall not be lower than the values indicated in Table 3-4 which are presented later in this chapter for the design speed of the roadway.

Table 3-1. Access Classification (AC) Summary.

Access Classification (AC)	General Definition
AC 1	Multilane, Non-traversable Median. No Direct Property Access Allowed.
AC 2	Multilane, Non-traversable Median. Highly Controlled Property Access.
AC 3	Multilane or 2-Lane, Non-traversable Median. For use in undeveloped or partially developed areas to preserve access.
AC 4	Multilane or 2-Lane, Traversable Median. For use in undeveloped or partially developed areas to preserve access.
AC 5	Multilane or 2-Lane, Non-traversable Median. For use in developed areas in which AC 3 criteria cannot be satisfied.
AC 6	Multilane or 2-Lane, Traversable Median. For use in developed areas in which AC 4 criteria cannot be satisfied.
AC 7	2-Lane, Non-traversable or Traversable Median. For use on roadway segments where there is little intended purpose of providing for high-speed travel and where access will not compromise public health, welfare, or safety of the roadway users.

One of the main distinguishing features of the access classifications is the non-traversable median. Such medians can have the greatest impact on minimizing vehicle conflict points on arterial streets. Non-traversable medians are typically good replacements for two-way-left-turn-lanes when traffic volumes on the street exceed 20,000 ADT. These impacts are due to the decrease in the opportunities for vehicles to make left-turns at intersections with streets and driveways. Vehicles making left turns typically experience more conflict points than right turns, due to crossing more vehicle paths. There are several types of non-traversable medians, such as raised (usually similar to the curb and gutter along the outer sides of a street), depressed (usually grassy medians that provide drainage), and barrier (usually a narrow, concrete structure a few feet high). Some of the access classifications are established for streets and highways that already have non-traversable medians. Other access classifications include non-traversable medians as a future design element. Finally, local land use planning, zoning, and subdivision regulations should be written to the extent possible to support the restrictive spacing of these designations.

AC 1: Highways in this class are generally multilane with non-traversable medians and are designed to provide for safe and efficient high-speed and high-volume traffic movements. AC 1 roadways are generally categorized as interstate, interregional, and intercity roadways and include all interstate highways as well as most freeways and expressways. Roadways classified as AC 1 do not provide direct property access. An example AC 1 corridor is illustrated in Figure 3-2.

Figure 3-2. Example AC 1 Corridor.

AC 2: AC 2 roadways have the ability to serve high-speed and high-volume traffic over long distances safely and efficiently. This classification is designed according to a highly controlled and limited number of access connections, median openings, and infrequent traffic signals. Roadways classified as AC 2 are multilane highly controlled access facilities with non-traversable medians. An example AC 2 corridor is illustrated in Figure 3-3.

Figure 3-3. Example AC 2 Corridor.

AC 3: Roadways classified as AC 3 are facilities where the direct access to adjacent properties is controlled to maximize movement of traffic. This classification should be used where existing land use and roadway sections are undeveloped or partially undeveloped or where the probability of significant land use change in the near future is high in order to maximize efficiency through the control of access as development occurs. AC 3 highways include existing or planned non-traversable medians, as well as optimal signalized and unsignalized access spacing criteria. Local land use planning, zoning, and subdivision regulations should be written to the extent possible to support the restrictive spacing of this designation. An example AC 3 corridor is illustrated in Figure 3-4.

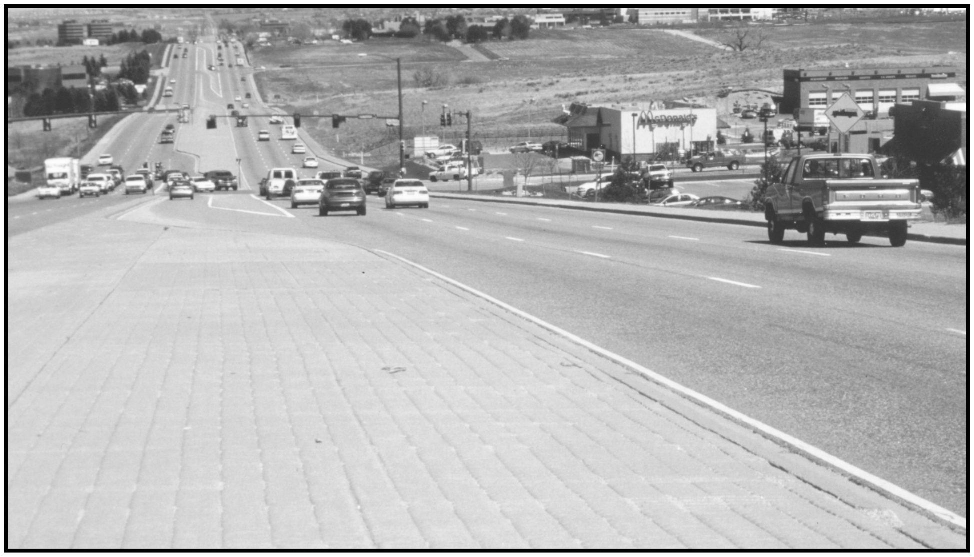


Figure 3-4. Example AC 3 Corridor.

AC 4: Roadways classified as AC 4 are facilities where the direct access to adjacent properties is controlled in order to maximize movement of traffic. This classification should be used where existing land use and roadway sections are undeveloped or partially undeveloped or where the probability of significant land use change in the near future is high in order to maximize efficiency through the control of access as development occurs. AC 4 highways will include existing or planned traversable medians while still providing optimal signalized and unsignalized access spacing criteria. An example AC 4 corridor is shown in Figure 3-5.

AC 5: This classification of access will be used where existing land use and roadway sections are more developed than those classified as AC 3; where the probability of major land use change is not as high as those classified AC 3; and where existing access management criteria and spacing does not currently meet, and is not expected to meet, the criteria outlined under AC 3. These highways will be distinguished by existing or planned non-traversable medians as illustrated in the example AC 5 corridor in Figure 3-6.

Figure 3-5. Example AC 4 Corridor.

Figure 3-6. Example AC 5 Corridor.

AC 6: This classification of access will be used where existing land use and roadway sections are more developed than those classified as AC 4; where the probability of major land use change is not as high as those classified AC 4; and where existing access management criteria and spacing does not currently meet, and is not expected to meet, the criteria outlined under AC 4. These highways will be distinguished by existing or planned traversable medians as illustrated in Figure 3-7.

Figure 3-7. Example AC 6 Corridor.

AC 7: AC 7 roadways are recommended in urbanized areas where existing land use and roadway sections are built out to the maximum feasible intensity and where significant land use or roadway widening will be limited. This class should be assigned only to roadway segments where there is little intended purpose of providing for high-speed travel. Access needs, though generally high in these roadway segments, will not compromise the public health, welfare, or safety of the roadway users. Exceptions to standards in this classification will be considered if the applicant's design changes substantially reduce the number of connections compared to existing conditions. These highways can have either non-traversable or traversable medians. Figure 3-8 shows an example of an AC 7 corridor.

Figure 3-8. Example AC 7 Corridor.

3.5 MATRIX OF TECHNIQUES

Access management techniques and classification systems have been evolving over the last 25 years. The early classification systems, developed by Stover and Glennon, were based on techniques relating to highways and driveways (*32*, *3*). This system was expanded in 1993 to include management elements. In contrast, a 1982 FHWA report on access management classified techniques by functional objective (*5*). *NCHRP Report 348* in 1992 described various policy and design approaches but did not develop a specific classification system (*6*).

The most recent compilation of access management techniques, *NCHRP Report 420*, has identified about 25 candidate techniques as important and promising in terms of access management. These techniques cover much of the roadway system, are effective in improving safety and/or reducing delay and emissions, and are generally amenable to analysis. These techniques are frequently encountered in key access management decisions (*11*).

The priority access management techniques outlined in *NCHRP Report 420* include the following (*11*):

- traffic signal spacing criteria;
- unsignalized access spacing criteria;
- corner clearance criteria;

- access separation at interchanges;
- install non-traversable median or undivided highway;
- replace two-way left-turn lane with non-traversable median;
- close existing median openings;
- replace full median with median designed for left-turn movement from major roadway;
- install left-turn deceleration lanes where none exist;
- install left-turn acceleration lanes;
- install continuous two-way left-turn lane on undivided highway;
- install U-turn movements as an alternate to direct left-turn movements;
- install jughandle to eliminate left-turn movements along highway;
- install right-turn acceleration/deceleration lanes;
- install continuous right-turn lane;
- consolidate driveways;
- channelize driveways to discourage or prohibit left-turn movements;
- install barrier to prevent uncontrolled access along property frontage;
- coordinate driveways on opposite sides of street;
- install frontage road to provide access to individual parcels; and
- locate/relocate the intersection of a parallel frontage road further from arterial.

Of the techniques outlined in *NCHRP Report 420*, not all were determined to be applicable at this time in Texas. Several of the techniques have also been grouped together to provide guidance on a wide range of access management techniques. The following techniques were determined to be applicable to Texas and have been evaluated in further detail as part of this research effort:

- signalized intersection access spacing;
- unsignalized intersection access spacing;
- signalized intersection corner clearance criteria;
- unsignalized intersection corner clearance criteria;
- directional median spacing criteria;
- full median spacing criteria;
- auxiliary lanes (including right-turn and left-turn lane criteria);

- alternatives for left-turn treatments (U-turn and jughandle);
- access separation at interchanges;
- arterial frontage roads;
- freeway frontage roads; and
- site development traffic impact analysis guidelines.

A summary of these techniques, as well as the minimum requirements for each, has been organized into a matrix of techniques in Tables 3-2a and 3-2b on the following pages. Each of the techniques identified on the matrix is discussed in more detail in the sections following the table as referenced in each section of the matrix. These sections contain the detail and guidance on the recommended practice for each technique.

Table 3-2a. TxDOT Access Management Standard Evaluation Matrix.

		General Information		Access Management Technique					
		Direct Property Access	General Design Features	Minimum Access Spacing		Minimum Corner Clearance		Minimum Median Spacing Criteria	
				Signalized	Unsignalized	Signalized	Unsignalized	Directional	Full
Documentation	**Example States**			Colorado, Florida, New Jersey	Colorado (AASHTO) Oregon, New Jersey	Florida	Florida	Florida	Florida
Documentation	**Other Sources**			NCHRP 348 NCHRP 420	NCHRP 348 NCHRP 420	NCHRP 348 NCHRP 420	NCHRP 348 NCHRP 420	NCHRP 348 NCHRP 420	NCHRP 348 NCHRP 420
Proposed TxDOT Access Classification (AC) and Standards	**AC 1**	No	Multilane Non-traversable Median	N/A	N/A	N/A	N/A	Full Median – No Opening	Full Median – No Opening
Proposed TxDOT Access Classification (AC) and Standards	**AC 2**	Restrict or Deny	Multilane Non-traversable Median	Urban – 2,640 feet. Rural – 2 miles *Where unattainable, refer to Section 3.6 for guidelines.*	1,320 feet. (≥ 45 mph) 645 feet. (< 45 mph) *Where unattainable, refer to Section 3.7 for guidelines.*	*Refer to Section 3.8 for guidelines.*	*Refer to Section 3.8 for guidelines.*	1320 feet. *Where unattainable, refer to Section 3.9 for guidelines.*	2,640 feet. *Where unattainable, refer to Section 3.9 for guidelines.*
Proposed TxDOT Access Classification (AC) and Standards	**AC 3**	Yes	Multilane or 2-Lane Non-traversable Median	2,640 feet. *Where unattainable, refer to Section 3.6 for guidelines.*	645 feet. (≥ 45 mph) 360 feet. (< 45 mph) *Where unattainable, refer to Section 3.7 for guidelines.*	*Refer to Section 3.8 for guidelines.*	*Refer to Section 3.8 for guidelines.*	1,320 feet. *Where unattainable, refer to Section 3.9 for guidelines.*	2,640 feet. *Where unattainable, refer to Section 3.9 for guidelines.*
Proposed TxDOT Access Classification (AC) and Standards	**AC 4**	Yes	Multilane or 2-Lane Traversable Median	2,640 feet. *Where unattainable, refer to Section 3.6 for guidelines.*	645 feet. (≥ 45 mph) 360 feet. (< 45 mph) *Where unattainable, refer to Section 3.7 for guidelines.*	*Refer to Section 3.8 for guidelines.*	*Refer to Section 3.8 for guidelines.*	N/A	N/A
Proposed TxDOT Access Classification (AC) and Standards	**AC 5**	Yes	2-Lane Non-traversable Median	2,640 feet. (≥ 45 mph) 1,320 feet. (< 45 mph) *Where unattainable, refer to Section 3.6 for guidelines.*	425 feet. (≥ 35 mph) 250 feet. (< 35 mph) *Where unattainable, refer to Section 3.7 for guidelines.*	*Refer to Section 3.8 for guidelines.*	*Refer to Section 3.8 for guidelines.*	660 feet. *Where unattainable, refer to Section 3.9 for guidelines.*	2,640 feet. (≥ 45 mph) 1,320 feet. (< 45 mph) *Where unattainable, refer to Section 3.9 for guidelines.*
Proposed TxDOT Access Classification (AC) and Standards	**AC 6**	Yes	2-Lane Traversable Median	2,640 feet. (≥ 45 mph) 1,320 feet. (< 45 mph) *Where unattainable, refer to Section 3.6 for guidelines.*	425 feet. (≥ 35 mph) 250 feet. (< 35 mph) *Where unattainable, refer to Section 3.7 for guidelines.*	*Refer to Section 3.8 for guidelines.*	*Refer to Section 3.8 for guidelines.*	N/A	N/A
Proposed TxDOT Access Classification (AC) and Standards	**AC 7**	Yes	2-Lane Non-traversable or Traversable Median	1,320 feet. *Where unattainable, refer to Section 3.6 for guidelines.*	155 feet. (≤ 25 mph) *Where unattainable, refer to Section 3.7 for guidelines.*	*Refer to Section 3.8 for guidelines.*	*Refer to Section 3.8 for guidelines.*	330 feet. (when required) *Where unattainable, refer to Section 3.9 for guidelines.*	660 feet. (when required) *Where unattainable, refer to Section 3.9 for guidelines.*

Table 3-2b. TxDOT Access Management Standard Evaluation Matrix.

		Access Management Technique						
		Auxiliary Lanes	**Alternate Left-Turn Treatments**		**Access Separation at Interchanges**	**Frontage Roads**		**Site Development Traffic Impact Analysis Guidelines**
			U-turn Movements	**Jughandles**		**Freeway**	**Arterial**	
Documentation	**Example States**	Colorado	Michigan Florida	New Jersey Florida	Oregon			New Jersey Michigan
	Other Sources	NCHRP 348 NCHRP 420	NCHRP 348 NCHRP 420	NCHRP 348 NCHRP 420	NCHRP 348 NCHRP 420	NCHRP 348 NCHRP 420	NCHRP 348 NCHRP 420	Institute of Transportation Engineers (ITE)
Proposed TxDOT Access Classification (AC) and Standards	**AC 1**	*Refer to criteria in Section 3.10 for guidelines.*	*Refer to criteria in Section 3.12 for guidelines.*	*Refer to criteria in Section 3.13 for guidelines.*	*Refer to criteria in Section 3.14 for guidelines.*	*Refer to criteria in Section 3.16 for guidelines.*	*Refer to criteria in Section 3.17 for guidelines.*	*Refer to basic guidelines in Section 3.18 and detailed requirements in Section 4.0: Site Development Traffic Impact Analysis Guidelines.*
	AC 2	*Refer to criteria in Section 3.10 for guidelines.*	*Refer to criteria in Section 3.12 for guidelines.*	*Refer to criteria in Section 3.13 for guidelines.*	*Refer to criteria in Section 3.14 for guidelines.*	*Refer to criteria in Section 3.16 for guidelines.*	*Refer to criteria in Section 3.17 for guidelines.*	*Refer to basic guidelines in Section 3.18 and detailed requirements in Section 4.0: Site Development Traffic Impact Analysis Guidelines.*
	AC 3	*Refer to criteria in Section 3.10 for guidelines.*	*Refer to criteria in Section 3.12 for guidelines.*	*Refer to criteria in Section 3.13 for guidelines.*	*Refer to criteria in Section 3.14 for guidelines.*	*Refer to criteria in Section 3.16 for guidelines.*	*Refer to criteria in Section 3.17 for guidelines.*	*Refer to basic guidelines in Section 3.18 and detailed requirements in Section 4.0: Site Development Traffic Impact Analysis Guidelines.*
	AC 4	*Refer to criteria in Section 3.10 for guidelines.*	*Refer to criteria in Section 3.12 for guidelines.*	*Refer to criteria in Section 3.13 for guidelines.*	*Refer to criteria in Section 3.14 for guidelines.*	*Refer to criteria in Section 3.16 for guidelines.*	*Refer to criteria in Section 3.17 for guidelines.*	*Refer to basic guidelines in Section 3.18 and detailed requirements in Section 4.0: Site Development Traffic Impact Analysis Guidelines.*
	AC 5	*Refer to criteria in Section 3.10 for guidelines.*	*Refer to criteria in Section 3.12 for guidelines.*	*Refer to criteria in Section 3.13 for guidelines.*	*Refer to criteria in Section 3.14 for guidelines.*	*Refer to criteria in Section 3.16 for guidelines.*	*Refer to criteria in Section 3.17 for guidelines.*	*Refer to basic guidelines in Section 3.18 and detailed requirements in Section 4.0: Site Development Traffic Impact Analysis Guidelines.*
	AC 6	*Refer to criteria in Section 3.10 for guidelines.*	*Refer to criteria in Section 3.12 for guidelines.*	*Refer to criteria in Section 3.13 for guidelines.*	*Refer to criteria in Section 3.14 for guidelines.*	*Refer to criteria in Section 3.16 for guidelines.*	*Refer to criteria in Section 3.17 for guidelines.*	*Refer to basic guidelines in Section 3.18 and detailed requirements in Section 4.0: Site Development Traffic Impact Analysis Guidelines.*
	AC 7	*Refer to criteria in Section 3.10 for guidelines.*	*Refer to criteria in Section 3.12 for guidelines.*	*Refer to criteria in Section 3.13 for guidelines.*	*Refer to criteria in Section 3.14 for guidelines.*	*Refer to criteria in Section 3.16 for guidelines.*	*Refer to criteria in Section 3.17 for guidelines.*	*Refer to basic guidelines in Section 3.18 and detailed requirements in Section 4.0: Site Development Traffic Impact Analysis Guidelines.*

3.6 SIGNALIZED ACCESS SPACING

Access spacing criteria are essential in maintaining the functional integrity of the roadway while providing the desired mix between access and mobility. The spacing of traffic signals is essential in governing the performance of both urban and suburban highways. Traffic signals account for the majority of delay that motorists experience as they traverse a network. Traffic signals constrain capacity during peak travel periods with queuing and spillback, while delaying vehicles during both peak and off-peak periods whenever they are randomly located, ineffectively coordinated, or improperly timed. Closely spaced and/or irregularly spaced signals can reduce arterial travel speeds, resulting in an excessive number of stops, even under moderate traffic volume conditions (*11*). Without proper spacing and design, signalized intersections can prove to be the weak link along both urban and suburban roadway networks. As a result, traffic signal spacing criteria is one of the most important and basic access management techniques.

In an attempt to ensure efficient traffic flow, signalized intersections should be limited to locations where the movement of traffic will not be impeded significantly. The recommended traffic signal spacing criteria outlined previously in Table 3-2a and Table 3-2b *TxDOT Access Management Standard Evaluation Matrix* indicate that the minimum signalized access spacing criteria ranges from two miles for rural AC 2 classification to between 1,320 feet and 2,640 feet for AC 2 through AC 7 classification, depending on the conditions of the roadway. In some cases, these minimum spacing requirements cannot be met. This section outlines the alternative signal spacing criteria and bandwidth criteria for these conditions.

In determining the optimal spacing for traffic signal installation outside of the minimum spacing outlined, several factors must be considered to maintain safety and efficiency on the roadway. The first, and most important, factor in determining an optimal spacing between intersections is the operating speed of the roadway network while the second most important factor is the cycle length necessary to efficiently pass traffic through the intersection. High operating speeds combined with long cycle lengths require greater distances between intersections while slow operating speeds and short cycle lengths can be accommodated in shorter intersection spacing. The basic relationship between cycle length and speed for 0.50-, 0.33-, and 0.25-mile signal spacing can be found in Figure 3-9.

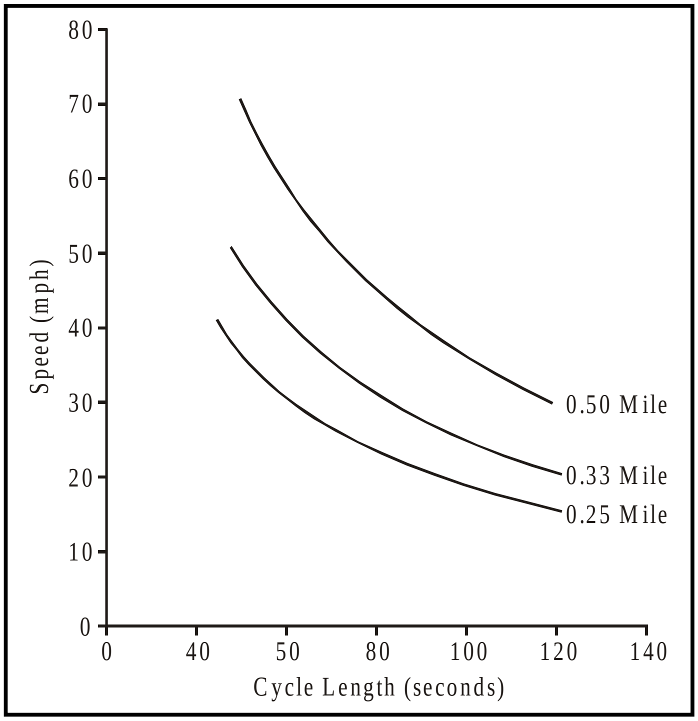


Figure 3-9. Signal Spacing as a Function of Speed and Cycle Length (*11*).

Table 3-3 provides a representation of the optimum signal spacing requirements as a function of operating speed and cycle length for single alternate signal timing. In a single alternate system, cycle lengths are equal, with red and green phases alternating with each progressive signal in the system for maximum bandwidth and progression. The bandwidth of a single alternate signal system is approximately equal to one half of the cycle length. The spacing requirements outlined in Table 3-3 are based on the relationship outlined in Figure 3-9 and the following equation:

$$Spacing(ft) = \frac{CycleLength(\sec) \times Speed(ft/s)}{2} \quad [3\text{-}1]$$

Equation 3-1 yields recommended signalized intersection spacing greater than 2,640 feet in high-speed, long-cycle length situations, the results of which should be incorporated as appropriate. Where this is not determined to be appropriate, however, a minimum signalized intersection spacing of 2,640 feet should be provided as outlined in Table 3-3.

Table 3-3. Signalized Intersection Spacing Criteria
(Single Alternate Signal Timing).

Cycle Length (sec.)	Operating Speed (mph)						
	25	30	35	40	45	50	55
	Spacing (feet)						
60	1,100	1,320	1,540	1,760	1,980	2,200	2,420
70	1,280	1,540	1,800	2,060	2,310	2,590	2,640
80	1,470	1,760	2,060	2,350	2,640	2,640	2,640
90	1,650	1,980	2,310	2,640	2,640	2,640	2,640
100	1,840	2,200	2,570	2,640	2,640	2,640	2,640
110	2,020	2,420	2,640	2,640	2,640	2,640	2,640
120	2,200	2,640	2,640	2,640	2,640	2,640	2,640

Source: Calculated from Equation 3-1 with 2,640 feet as a maximum requirement.

The choice of cycle length depends on the capacity needed to pass traffic through critical intersections as well as the time needed for pedestrians to safely cross wider streets and to achieve efficient signal coordination at desired speeds. Cycle lengths should always be as short as possible while still maintaining coordination and efficiency. Cycle lengths longer than 120 seconds should be avoided as they can result in higher intersection delay and potentially undesirable levels of service.

Access spacing criteria have been developed for signalized access locations to meet the needs of safety and mobility along arterial and collector streets. The following guidelines are recommended for implementation of signalized access spacing and include both spacing and bandwidth requirements for signalized intersections.

3.6.1 Traffic Signal Warrants

A traffic signal may be permitted within the segment at the designated optimal location (Table 3-3) after the applicant demonstrates that the intersection meets the criteria for warrants set forth in the most recent edition of the Texas MUTCD based on the posted speed limit for the roadway. The same conditions would apply to another location if the applicant demonstrates that:

- the intersection meets the criteria for warrants set forth in the most recent edition of the Texas MUTCD based on the posted speed limit for the roadway; and
- the minimum bandwidth percentages outlined in Table 3-4 are attained or exceeded on the state roadway.

Table 3-4. Signalized Intersection Bandwidth Criteria.

Access Level	Minimum Through Bandwidth
AC 2	45% – 50%
AC 3	40% – 45%
AC 4	35% – 40%
AC 5 – AC 7	30% – 35%

Source: Adapted from (*11*)

3.6.2 Designation of Segment for Bandwidth Determination

It is recommended that the Department designate the segment used in making the bandwidth determination after recommendation by the applicant. The limits for analyzing bandwidth should extend at least one traffic signal outside of the study area, unless the existing area of progression extends further. In that case, the limits should encompass the existing area of progression as determined by the Department.

In designating optimal locations for future traffic signals, the Department may apply standards for optimum spacing in whichever direction along the state highway is deemed appropriate and may exclude locations where specific circumstances, as determined by the Department, preclude future signalization.

Minimum bandwidth percentages (bandwidth/cycle length) on the state highways shall be calculated based upon posted speed limits and coordinated cycle lengths unless otherwise specified by the Department. The calculations should be conducted using computer software acceptable to the Department and should assume the operation of the existing traffic signals at the optimal locations designated by the Department.

3.6.3 Planning, Program, and Operation of Traffic Signals

The planning, design, and operation of traffic signals along arterial streets and roadways must achieve a balance between safety, capacity, and progression. The key variables, as outlined, include cycle length, signal spacing, travel speeds, and progression (bandwidth) efficiency. The key issues to consider in signalized access spacing are as follows (*11*):

- Long, uniform spacing of traffic signals are desirable to allow effective progression of traffic in both directions of travel. During off-peak periods, arterial roadways should operate at operating speeds of 25 to 35 mph in urban environments and 35 to 55 mph in suburban or rural settings. During peak conditions, roadways should operate at operating speeds of at least 20 mph. Throughput is maximized, and fuel consumption and emissions are minimized, at operating speeds of 35 to 45 mph.
- The green time per cycle for arterial roadway traffic should be maximized. This requires minimizing the time needed for left-turn movements by prohibiting and redirecting the turns or by providing single or multiple left-turn lanes. Where left-turn phases are provided, cycle lengths may have to be increased to ensure sufficient green time and traffic progression efficiency (through bandwidth divided by the cycle length).
- Major urban and suburban arterials experience high travel demands, especially during the morning and evening peak periods; therefore, capacity is critical. This may require longer cycle lengths to minimize the “lost” time that occurs each time the traffic signal indication is changed and to provide special phases for left-turn movements. Cycle lengths during peak periods normally range from 80 to 120 seconds as compared with 60 to 80 seconds at other times.
- Cycle lengths that preclude achieving desired speeds for any given block spacing should be avoided. For example, cycle lengths should not exceed 120 seconds for 0.5-mile spacing along a suburban roadway with 20 mph travel speeds.
- Where signals must be provided at locations that do not “fit” in the time-space pattern, additional arterial green is necessary to ensure adequate through bandwidth. This results in less green time for the intersecting street or driveway.

3.7 UNSIGNALIZED ACCESS SPACING

Unsignalized access points such as private driveways and public streets introduce conflicts and friction into the traffic stream. These access points serve a variety of traffic ranging from local and collector street traffic to large activity center access as illustrated in Figure 3-10. Vehicles entering and leaving the main roadway at these locations often slow the through traffic, and the difference in speeds between through and turning traffic increases crash potential. As stated in the 2001 *A Policy on Geometric Design of Highways and Streets* Fourth Edition (2001 AASHTO Green Book), "Driveways are, in effect, intersections and should be designed consistent with their intended use…The number of crashes is disproportionately higher at driveways than at other intersections; thus their design and location merit special consideration" (*33*).

Figure 3-10. Unsignalized Access in Dallas, Texas.

Recent studies show that driveway spacing is one of the key factors that influence crashes. As a result of these studies, unsignalized access spacing should be limited to locations where the movement of traffic will not be adversely affected and the potential for crashes is minimized. According to *NCHRP Report 348*, "Strict application of traffic engineering criteria may push spacing requirements to 500 ft or more. However, such spacings may be unacceptable for economic development in many suburban and urban environments, where development pressures opt for 100-ft to 200-ft spacing" (*6*). The increase in access density has a dramatic increase in crash rates. Accident indexes suggest that doubling the access frequency from 10 to 20 accesses per mile (approximately 528 to 264 foot spacing) would increase crash rates by 40 percent. A road with 60 access points per mile (approximately 88 foot spacing) would have triple the crash rate—200 percent increase—as compared with a spacing of 10 access points per mile (approximately 528 foot spacing) (*11*).

The unsignalized access spacing criteria recommended in Table 3-2a and Table 3-2b (*TxDOT Access Management Standard Evaluation Matrix*) indicates that the minimum criteria ranges from 1,320 feet for high speed AC 2 roadways to a minimum of 155 feet for AC 7 classification, depending on roadway conditions and design speed. These criteria are based on the minimum distances necessary to stop a vehicle according to current stopping sight distance criteria outlined in the 2001 AASHTO Green Book.

In some cases, the minimum spacing requirements cannot be met. However, safety cannot be compromised in any situation. Various conditions may be considered in making the final determination on an unsignalized access location, including sight distance, conflict overlap, and maneuvering or deceleration distance. Adequate stopping sight distance must be maintained in all situations, particularly for unsignalized access locations. The conflict of vehicles entering and exiting the major roadway should be limited to one conflict (driveway) at a time and should provide sufficient deceleration distance to limit speed differentials to 10 mph or less. These conditions, combined with the following criteria, should be considered in final unsignalized access location determination.

3.7.1 Stopping Sight Distance

The stopping sight distance requirements in Table 3-5 shall be used to determine the required horizontal and vertical sight distance necessary as measured from the vehicle traveling on the highway to the access as shown in Figure 3-11. Sight distance should be adjusted for grade as required (Table 3-6).

Access points should be separated at a minimum by a distance equal to the design sight distance shown in Table 3-5 and should not be permitted within an auxiliary lane, taper, or ramp (functional boundary).

Table 3-5. Unsignalized Access Spacing Criteria.

Design Speed (mph)	Driveway Spacing (Stopping Sight Distance) [1]	
	Calculated (feet) [2]	Design (feet) [2]
25	151.9	155
30	196.7	200
35	246.2	250
40	300.6	305
45	359.8	360
50	423.8	425
55	492.4	495
60	566.0	570
65	644.4	645
70	727.6	730

[1] Source: (*33*)
[2] Lengths shown should be adjusted for any grade of 3% or greater (see Table 3-6).

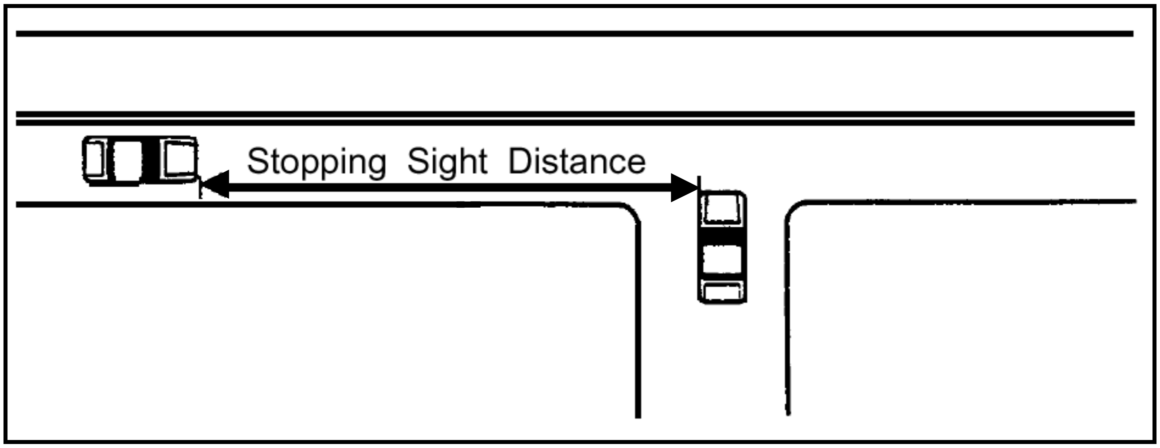


Figure 3-11. Stopping Sight Distance Criteria (*8*).

Table 3-6. Stopping Sight Distance on Grades.

Design Speed (mph)	Stopping Sight Distance (feet)					
	Downgrades			Upgrades		
	3%	**6%**	**9%**	**3%**	**6%**	**9%**
25	158	165	173	147	143	140
30	205	215	227	200	184	179
35	257	271	287	237	229	222
40	315	333	354	289	278	269
45	378	400	427	344	331	320
50	446	474	507	405	388	375
55	520	553	593	469	450	433
60	598	638	686	538	515	495
65	682	728	785	612	584	561
70	771	825	891	690	658	631

Source: (*33*)

3.7.2 Variation for Trucks

The stopping sight distance requirements in Table 3-5 are based on passenger car operation and do not explicitly consider the design of truck operations. The 2001 AASHTO Green Book states that "trucks as a whole, especially the larger and heavier units, need longer stopping distances from a given speed than passenger vehicles. However, there is one factor that tends to balance the additional braking lengths for trucks with those for passenger cars. The truck driver is able to see substantially farther beyond vertical sight obstructions because of the higher position of the seat in the vehicle. Separate stopping sight distances for trucks and passenger cars, therefore, are not generally used in highway design" (*31*).

There is one case in which the design values in Table 3-5 should be exceeded for stopping sight distance of trucks. "Where horizontal sight restrictions occur on downgrades, particularly at the ends of long downgrades where truck speeds closely approach or exceed those of passenger cars, the greater eye height of the truck driver is of little value, even when the horizontal sight obstruction is a cut slope" (*31*). It is desirable in these conditions to exceed the design values in Table 3-5.

3.7.3 Entering Sight Distance

Table 3-7 shall be used to establish the minimum sight distance necessary for a passenger car to safely turn left onto a two-lane highway with no median and grades 3 percent or less. For other conditions (design vehicle, multilane, grade), it is recommended that the design intersection sight distance necessary shall be calculated according to equation 3-2 and the adjustments provided in Table 3-8. The design intersection sight distance should be used only in determining acceptable sight distance for vehicles entering the highway in order to properly site proposed access locations. These criteria are not used in determining access spacing. A graphical representation of the entering sight distance criteria is provided in Figure 3-12. The sight distance requirements identified in Figure 3-12 are not anticipated to require right-of-way acquisition to maintain but require cooperation with landowners and maintenance easements as needed.

$$ISD = 1.47 V_{major} t_g$$ [3-2]

where:

ISD = intersection sight distance (feet)

V_{major} = design speed of major road (mph)

t_g = time gap for minor road vehicle to enter the major road(s)

Table 3-7. Design Intersection Sight Distance – Left-Turn Movement from Stop.

Design Speed (mph)	Stopping Sight Distance (feet)	Intersection Sight Distance for Passenger Cars	
		Calculated (feet)	Design (feet)
25	155	275.6	280
30	200	330.8	335
35	250	385.9	390
40	305	441.0	445
45	360	496.1	500
50	425	551.3	555
55	495	606.4	610
60	570	661.5	665
65	645	716.6	720
70	730	771.8	775

Note: Intersection sight distance shown is for a stopped passenger car to turn left onto a two-lane highway with no median and grades 3 percent or less. For other conditions, the time gap must be adjusted [Table 3-8], and required sight distance recalculated [Equation 3-2].

Source: (*33*)

Table 3-8. Design Intersection Sight Distance Criteria.

Design Vehicle	Time Gap(s) at Design Speed of Major Road (t_g)
Passenger Car	7.5
Single-unit Truck	9.5
Combination Truck	11.5

Note: Time gaps are for a stopped vehicle to turn right or left onto a two-lane highway with no median and grades 3 percent or less. The table values require adjustment as follows:

For multilane highways:

For left turn movements onto two-way highways with more than two lanes, add 0.5 seconds for passenger cars or 0.7 seconds for trucks for each additional lane, from the left, in excess of one, to be crossed by the turning vehicle.

For minor road approach grades:

If the approach grade is an upgrade that exceeds 3 percent, add 0.2 seconds for each percent grade for left-turn movements.

Source: Adapted from (*33*)

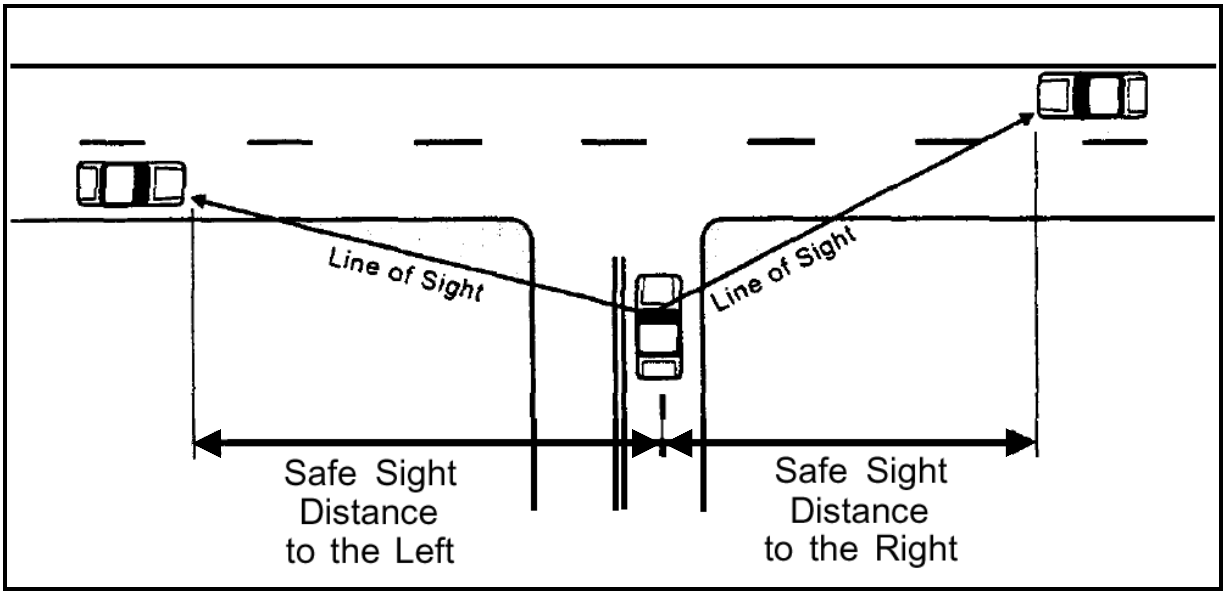


Figure 3-12. Entering Sight Distance Criteria (*8*).

3.8 CORNER CLEARANCE

Corner clearance represents the minimum distance that is required between intersections and the first driveway along a roadway. As stated in the 2001 AASHTO Green Book, "Ideally, driveways should not be located within the functional area of an intersection, or in the influence area of an adjacent driveway. The functional area extends both upstream and downstream from the physical intersection area and includes the longitudinal limits of auxiliary lanes" (*33*). Inadequate corner clearances can result in traffic-operation, safety, and capacity problems. These problems can be caused by blocked driveway ingress and egress movements, conflicting and confusing turns at intersections, insufficient weaving distances, and backups from far-side driveways into intersections. An example of insufficient corner clearance and the blockage that can occur at such locations is illustrated in Figure 3-13.

Specific operational and safety problems that could occur as a result of insufficient corner clearances include (*11*):

- through traffic is blocked by vehicles waiting to turn into a driveway;
- right- or left-turn movements into or out of a driveway (both on arterial and crossroad) are blocked;

- driveway traffic is unable to enter left-turn lanes;
- driveway exit movements are impacted by stopped vehicles in left-turn lanes;
- traffic entering an arterial road from the intersection street or road has insufficient distance;
- the weaving maneuvers for vehicles turning onto an arterial and then immediately turning left into a driveway are too short; and
- confusion and conflicts result from dual interpretation of right-turn signals.

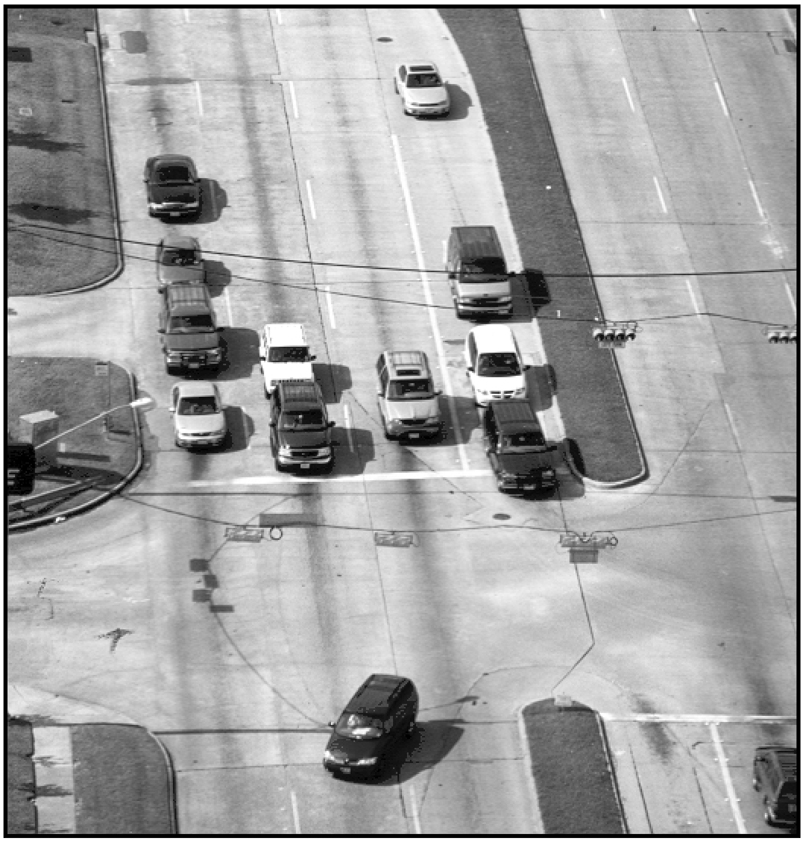


Figure 3-13. Insufficient Corner Clearance.

The functional boundary of an intersection should include all required storage lengths for separate turn lanes and for through traffic, plus any maneuvering distance for separate turn lanes. The minimum maneuvering distance assumes that the driver is in the proper lane and only needs to move laterally into an adjacent right- or left-turn lane. The functional boundary of an intersection includes more than just the physical area of the intersection as outlined in Figure 3-14. The functional boundary for a given direction is the distance upstream and downstream from the intersection in which access should be controlled.

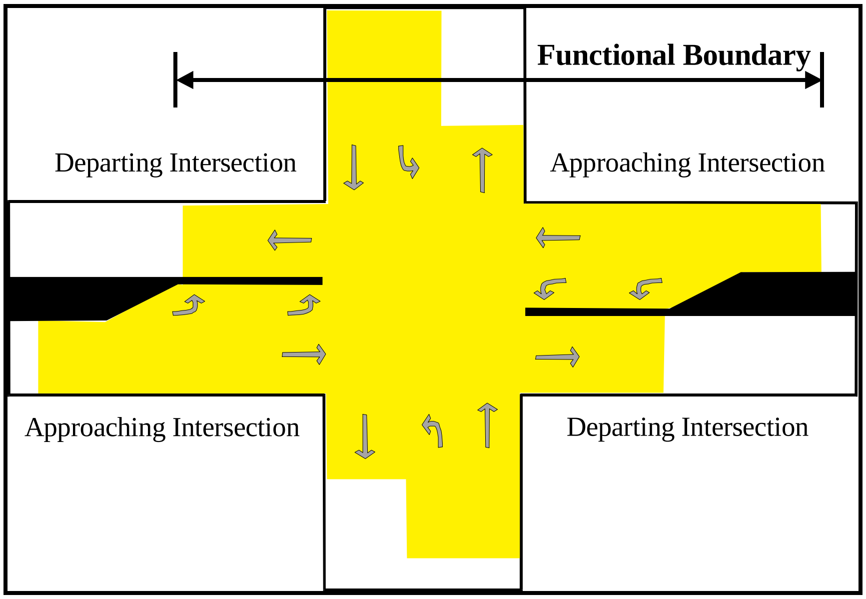


Figure 3-14. Functional Boundary of an Intersection (*34*).

3.8.1 Corner Clearance Criteria

Corner clearance for connections adjacent to signalized or unsignalized intersections shall meet or exceed intersection spacing criteria outlined previously in Table 3-5.

If, due to property size, corner clearance criteria cannot be met, and where joint access, which meets or exceeds the applicable minimum corner clearance criteria cannot be obtained with a neighboring property, it is recommended that the district engineer discuss alternatives for driveway location design. Access may be granted in situations where corner clearance criteria cannot be met if reasonable access cannot be provided in any other way. If access is granted at a location less than the recommended spacing, the following additional conditions must also be met:

- The proposed access should be located as far from the intersection as possible.
- There will be no more than one connection per state road frontage.
- When joint or alternate access that meets or exceeds the applicable minimum corner clearance criteria becomes available, the permittee will close the permitted connection, unless the permittee shows that such closure is not feasible because of conflicting land use or

conflicting traffic volumes/characteristics or existing structures that preclude a change in the existing connection.

3.9 MEDIAN SPACING ALTERNATIVES

The treatment of median alternatives plays an important role in the operation and safety of roadways. Medians are generally introduced to prevent crashes caused by crossover traffic, headlight glare distraction, and left-turning traffic (vehicular safety); to provide a refuge for pedestrians crossing the roadway (pedestrian safety); and to remove turning traffic from through lanes thereby improving roadway operations (vehicular efficiency). Non-traversable medians and well-designed median openings are proven to be some of the most important features in a safe and efficient roadway system. The design and placement of these medians and median openings are an integral part of the access management practice (*19*).

There are two basic types of median openings: directional and full median openings. Directional median openings provide access for one direction of travel only, as illustrated in Figure 3-15. Full median openings provide full access for main and cross-street traffic. Illustrative examples of full median openings are provided in Figure 3-16 for developed areas and in Figure 3-17 for more undeveloped locations.

Figure 3-15. Directional Median Opening in Houston, Texas.

Figure 3-16. Full Median Opening (developed area) in Houston, Texas.

Figure 3-17. Full Median Opening (undeveloped area) in Houston, Texas.

The recommended minimum median spacing alternatives for directional and full medians are outlined previously in Table 3-2a and Table 3-2b (*TxDOT Access Management Standard Evaluation Matrix*). This matrix indicates that minimum median spacing for directional median openings ranges from 1,320 feet for AC 2 and AC 3, to 660 feet for AC 5 and 330 feet for AC 7. Full median openings range from 2,640 feet for AC 2 and AC 3, to 2,640 feet/1,320 feet for AC 5 (≥45 mph/<45 mph), to 660 foot minimum spacing for AC 7. The specifics of these requirements as well as criteria to follow when the spacing is unattainable are provided in this section.

3.9.1 Median Opening Guidelines

The spacing of median openings for signalized driveways should reflect traffic signal coordination requirements and the storage space needed for left-turn movements.

The spacing of median openings for unsignalized roadways and driveways should be based on the values suggested in Table 3-9. Ideally, spacing should be conducive to signalization and is generally provided at unsignalized junctions of arterials and collector streets.

Full and directional median openings for left-turn entrances—where there is no left-turn exit—should be spaced to allow sufficient storage for left-turning vehicles.

Median openings at driveways can be subject to closure where volumes warrant signals, but signal spacing would be inappropriate.

Median openings should be set far enough back from nearby signalized intersections to avoid possible interference with intersection queues.

Median openings that allow traffic across left-turn lanes, as illustrated in Figure 3-18, should not be allowed.

Table 3-9. Median Spacing Criteria.

Access Classification	**Minimum Median Opening Spacing (feet)**	
	Directional	**Full**
AC 1	Full Median – No Opening [1]	Full Median – No Opening [1]
AC 2	1,320	2,640
AC 3	1,320	2,640
AC 4	Traversable Median	Traversable Median
AC 5	660	2, 640 (≥ 45 mph) 1, 320 (< 45 mph)
AC 6	Traversable Median	Traversable Median
AC 7	330	660

[1] Emergency vehicle median openings may be provided at the discretion of the local agency, but should be designed such that only emergency vehicles can access them.
Source: Adapted from (*18*)

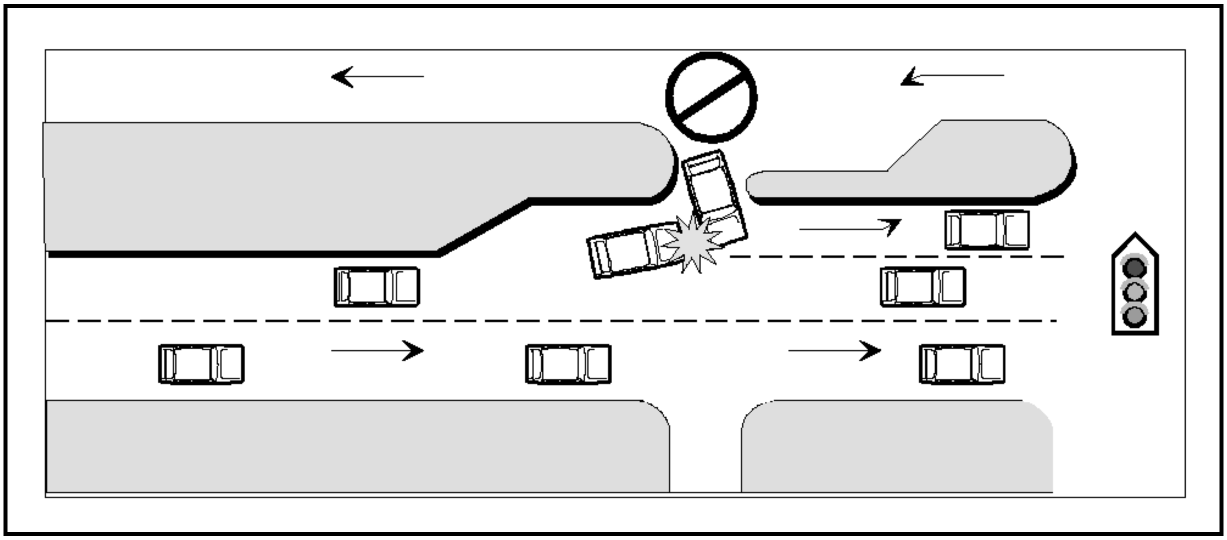


Figure 3-18. Left-Turn Median Opening Prohibition (*18*).

Median openings that allow the following movements should be avoided:

- across exclusive right-turn lanes, as shown in Figure 3-19; and
- across regularly forming queues from neighboring intersections.

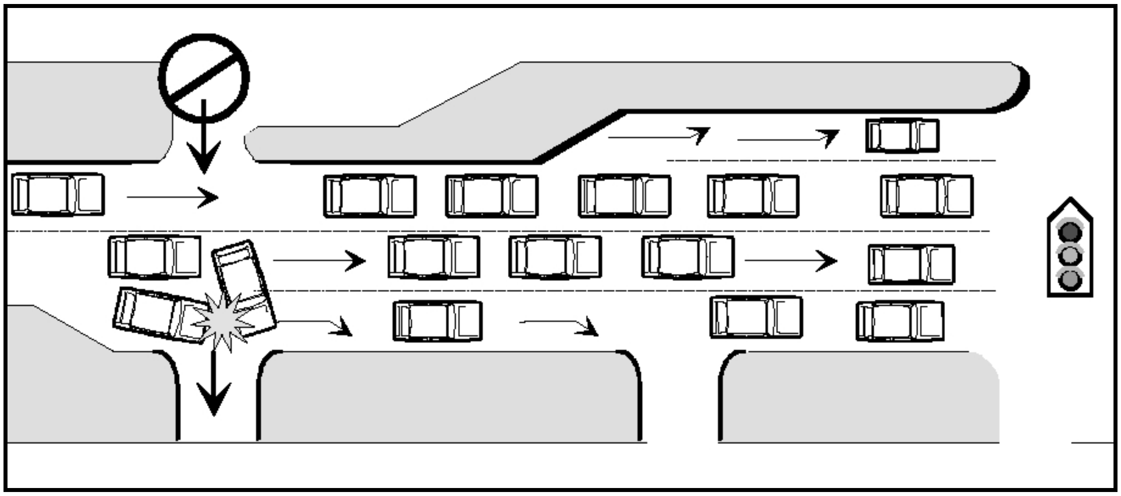


Figure 3-19. Right-Turn Median Opening Avoidance (*18*).

3.9.2 Deviations from Standard

It is recommended that deviations shall be coordinated through the district engineer in each district and recorded with the statewide access management coordinator to ensure consistency statewide.

Deviations from the standards should show an overriding benefit in safety or traffic operations or be shown not to degrade the following:

- traffic safety;
- traffic efficiency; and
- highway functional integrity.

The following items should be considered in the review of a possible deviation from the standards:

3.9.2.1 Deviation Approval

Approval of deviations should be in harmony with the purpose and intent of good access management practices and in protecting public safety, providing mobility, and preserving the functional integrity of the state highway system.

Deviations should not be considered until the feasible options for meeting access management standards are explored, or under any of the following conditions:

- the geometrics preclude design that meets or exceeds standards outlined in the current TxDOT *Roadway Design Manual*;
- where the provision of the median opening would cause any safety hazard, such as queuing on railroad tracks, school pedestrian crossings, freeway on- or off-ramps, or the functional area of the intersection; or
- the hardship is self-created by the landowner or business.

3.9.2.2 Requests for Deviation from Standards

Requests for deviation from median opening standards must:

- provide documentation of unique or special conditions based upon established engineering principles that make strict application of the spacing standards impractical or unsafe; and
- provide documentation as to how the deviation would affect the traffic efficiency and safety of the transportation facility; and
- be signed and sealed by a professional engineer, licensed to practice in the state of Texas, and knowledgeable in traffic engineering; and
- be clearly beneficial or justifiable to the district engineer or his/her designated representative.

3.9.3 Alternative Median Designs

In cases where a full or directional median is determined to be not feasible or impractical based on the request for deviation process outlined above, or in the case of classifications AC 4, AC 6, and AC 7, a two-way left-turn lane (TWLTL) should be considered as a traversable median alternative. A TWLTL removes left-turning vehicles from the through lanes and stores the left-turning vehicles in the roadway median until an acceptable gap in oncoming traffic allows the vehicles to turn. TWLTLs may also be considered in the following applications:

- where numerous, closely spaced, low-volume access connections already exist and cannot be consolidated under current or projected conditions, and
- where average daily traffic demands of less than 20,000 vpd are expected along the roadway.

3.10 AUXILIARY LANES

Auxiliary lanes consist of left-turn and right-turn lanes. Left-turn movements may pose problems at driveways and street intersections. They may increase conflicts, delays, and crashes and often complicate traffic signal timing. These problems are especially acute at major suburban highway intersections where heavy left-turn movements take place, but also occur where left-turn movements enter or leave driveways serving adjacent land development. As with left-turn movements, right-turn movements also pose problems at both driveways and street intersections. Right-turn movements increase conflicts, delays, and crashes, particularly where right turn vehicles are traveling at a difference in speed of 10 mph or more as compared to through traffic volumes.

The width of auxiliary lanes normally varies between 11 feet and 12 feet with a minimum width of 10 feet. In special circumstances, (i.e., low-speed urban settings with restricted right-of-way and passenger vehicles traffic only in the turn lane), a 9 foot lane may be used.

Auxiliary lanes should be of sufficient length to satisfy the longest of the following conditions:

- store turning vehicles during stop conditions; or
- provide sufficient length to permit turning vehicles to clear the queue of through vehicles and thereby enter the lane.

To help address the need for auxiliary lanes in Texas, the following practices are recommended:

3.10.1 Accommodating Left-turn Movements

Left-turn movements may be accommodated by permitting movements from shared lanes or by providing single or dual left-turn lanes.

Shared left-turn lanes should be allowed only along minor low-speed streets or where it is physically impossible to develop protected lanes.

Left-turn lanes should be provided at all signalized intersections where left-turn movements are permitted.

Basic guidelines for left-turn lanes include the following items:

- Permissive-protected movements may be desirable where left-turn volumes range from 150 to 250 vph, speeds are less than 40 mph, and there are no more than two opposing through lanes.
- Permissive movements are appropriate where left-turn volumes are under 150 vph, speeds are less than 40 mph, and there are no more than two opposing through lanes.
- Protected movements are necessary where left-turn volumes exceed 200 vph and speeds exceed 40 mph.

Dual left-turn lanes are desirable where peak turning movement volumes exceed 350 vph and include the following guidelines:

- Dual left-turn lanes require a protected traffic signal phase and will normally require a minimum of 26 to 30 feet with minimum lane widths of 11 feet.
- Intersections with dual left-turn lanes should provide 28 to 30 feet of roadway available to receive the turning vehicles after they pass through the intersection.
- Storage length should be at least 1.5 to 2.0 times the expected left-turn movements per cycle based on peak 15 minute volumes as a general guideline, with more specific calculations preferred based on the equations in this section.

Left-turn storage can be calculated using Equation 3-3. For design projects, it may be necessary to estimate input parameters to calculate storage length. When doing so, conservative estimates should be used to account for variability in future demand.

$$L = \frac{25VK(1+p)}{N_c} \qquad [3\text{-}3]$$

where:

	L	=	storage length (excluding taper)
	V	=	peak 15 minute flow (vph)
	K	=	constant to reflect random arrival of vehicles
			(K = 2.0 for normal flow and 1.5 for saturated flow)
	p	=	percent of trucks or buses
	N_c	=	Number of cycles per hour

3.10.2 Accommodating Right-turn Movements

Right-turn lanes should be considered when the right-turn volumes exceed 300 vph and the adjacent through-lane volumes also exceed 300 vph per lane.

Right-turn storage can be calculated using Equation 3-4. For design projects, it may be necessary to estimate input parameters to calculate storage length. When doing so, conservatives estimates should be used to account for variability in future demand.

$$L = \frac{25VK(1-G/C)(1+p)}{N_c l}$$ [3-4]

where:

L	=	storage length (excluding taper)
V	=	peak 15 minute flow (vph)
K	=	constant to reflect random arrival of vehicles (K = 2 for no right turn on red (RTOR) and 1.5 with RTOR)
G	=	green time
C	=	cycle length
p	=	percent of trucks or buses
N_c	=	number of cycles per hour
l	=	number of traffic lanes

3.10.3 Provision of Deceleration Lanes

Provision for deceleration clear of the through traffic lanes is desirable on arterial roads and streets, and should be incorporated into design whenever feasible. The total length required for deceleration lanes is that needed for a safe and comfortable stop from the design speed of the highway.

Table 3-10 shows minimum deceleration lengths for auxiliary lanes with grades of 3 percent or less, and with an accompanying stop condition.

The AASHTO Green Book, the Texas MUTCD, and the Highway Capacity Manual (HCM) should be used to supplement the above standards as applicable.

Table 3-10. Deceleration Standards.

Design Speed (mph)	Deceleration Length (feet) [1]
30	230
40	330
50	550

Source: (*33*)

3.11 ALTERNATIVE LEFT-TURN TREATMENTS

As indicated, left-turn movements may pose problems at driveways and street intersections. They may increase conflicts, delays, and crashes and can often complicate signal timing. The following points illustrate some of the more specific problems of left-turn movements:

- More than two-thirds of all driveway-related crashes involve left-turn movements from the arterial or from the driveway (*35*).
- Where there are five or more left-turn vehicles in a shared lane per traffic signal cycle, virtually all through vehicles in the shared lane may be blocked by the left-turning vehicles (*36*).
- Where left-turn lanes are provided along multilane highways, each opposing left-turning vehicle reduces the through vehicle capacity by the number of through lanes it crosses (e.g., 100 left-turn movements/hour across three traffic lanes reduces the through vehicle capacity by 300 vehicles) (*36*).

As a result of these conflicts, left-turn movements have become an important consideration in access management due to their disruption of through traffic movement and the increase in safety concerns that they provide. Due to the concerns associated with left-turn traffic, left-turn movements at driveways and street intersections may be accommodated, prohibited, diverted, or separated depending on specific circumstances. Table 3-11 shows criteria for how this is accomplished.

Table 3-11. Treatment of Left-Turn Movements at Intersections and Driveways (*6*).

Maneuver	Condition	Criteria
Provide	Shared Lane	Limit to minor roads or places where right-of-way is not available for left-turn lane
	Left-turn Lane	Protected or permissive phasing
	Dual Left-turn Lane	Protected phasing only
Prohibit	Full Time	Requires alternate routes
	Peak Periods Only	Requires alternate routes
Divert	Jug Handle	Divided highways at minor roads (signalized junctions only)
	Modified Jughandle	6-Lane divided highways
	Michigan U-turn	Divided highways with wide median – Allows two-phase signals
Separate	Directional Design	Very heavy turn movements in one direction
	Left-turn Flyover	Very heavy turn movements in one direction
	Through Lane Flyover	Major congestion points

Of the alternatives outlined, the most common applications for left-turn treatment include providing for left-turn movements through shared lanes, left-turn lanes, and dual left-turn lanes. The recommendations for accommodating these conditions were provided in **Section 3.10, Auxiliary Lanes**. Of the remaining options—Prohibit, Divert, and Separate—the diversion alternatives are considered the next best option for providing left-turn control on arterial streets. Prohibiting left-turn movements can be utilized in extreme conditions, while grade separation of left-turn movements is usually only considered for freeway and expressway situations (AC 1). Diversion, however, provides the best set of alternatives with a wide range of application. The following sections outline two of the most common diversion alternatives, **Section 3.12, U-turn Movements** and **Section 3.13, Jughandles**.

3.12 U-TURN MOVEMENTS

Increasingly, U-turn movements are being used as an alternative to direct left-turn movements to reduce conflicts and to improve safety along arterial roads. U-turn movements make it possible to prohibit left-turn movements from driveway connections onto multilane highways and to eliminate traffic signals that would not fit into time-space (progression) patterns along arterial roads. When incorporated into intersection designs, U-turn provisions enable direct left-turn movements to be rerouted and signal phasing to be simplified.

Where closely spaced, full median openings are provided along an arterial, the number of conflicts can increase to a level that may jeopardize safety. Replacing full median openings with "directional" openings that allow only left-turn ingress to abutting developments can substantially reduce the number of conflicts. The left-turn egress movements in this case are made by turning right onto the arterial road and then making U-turn movements downstream as shown in Figure 3-20. This U-turn alternative should be considered as an alternative to left-turn movements to increase safety and operational efficiency of the adjacent roadway network.

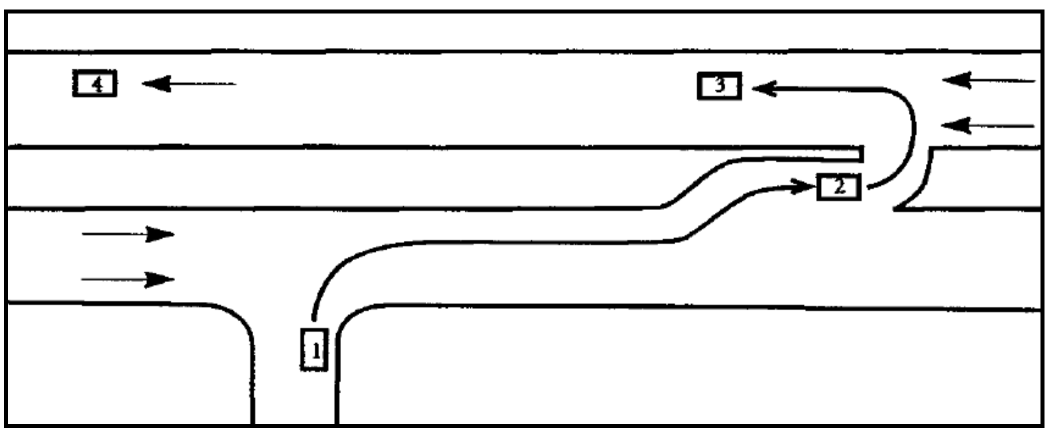


Figure 3-20. U-turn Alternative for Left-Turn Egress (*11*).

3.12.1 Alternative for U-turn Movements

Several approaches have evolved for accommodating the diverted left-turn volumes by providing U-turn lanes in advance of, at, or beyond intersections. The U-turn movements may be made from conventional left-turn lanes or via jughandles from the right (curb) lanes. Figure 3-21 shows illustrative treatments. These approaches include the following concepts (*11*).

3.12.1.1 U-turns in Advance of Intersection

Left-turn lanes can be provided for U-turning vehicles in advance (i.e., upstream) of signalized intersections. This avoids concentrating development-related turning traffic at signalized junctions of major crossroads.

3.12.1.2 U-turn at Signalized Intersection

Dual left-turn lanes can be provided at signalized intersections with the inner lane dedicated to U-turn movements. This application still requires multiphase traffic signal controls.

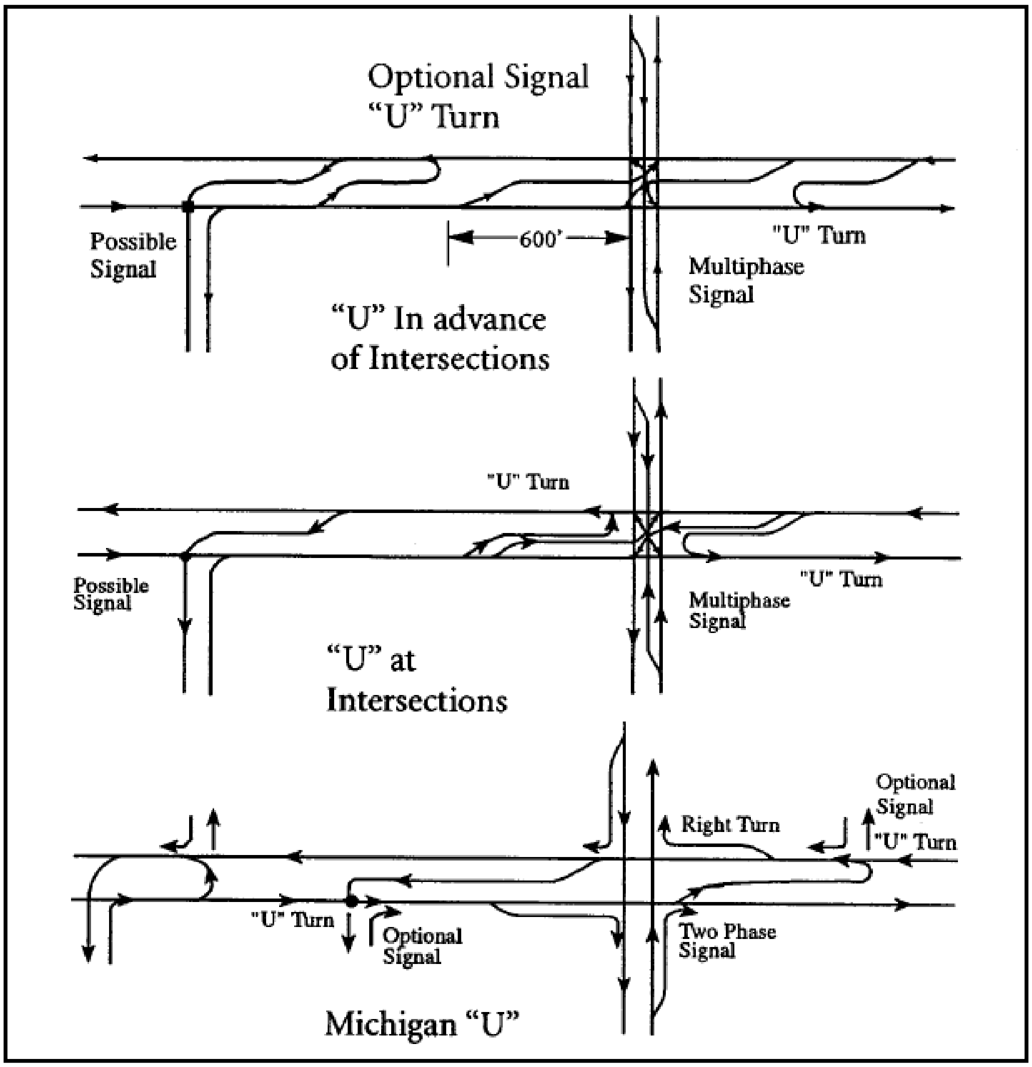


Figure 3-21. U-turn Alternative Approaches (*11*).

3.12.1.3 U-turn after Signalized Intersection

Left-turn and U-turn lanes can be provided downstream of signalized intersections, thereby allowing two-phase traffic signal controls ("Michigan U-turn").

3.12.2 Basic Guidelines for U-turn Movements

There are no set volume thresholds for determining when U-turn movements should be installed as an alternative to left-turn movements. Engineering judgment should be used in determining the circumstances in which safety and operations of providing left-turn movements could be a concern. To aid in making an informed decision on the use of indirect left-turn movements as an alternative to direct left-turn movements, the following basic guidelines and assumptions should apply (*11*).

3.12.2.1 U-turn Median Opening

A U-turn median opening can serve several access drives and eliminate the need for direct left-turn exit movements from driveways.

A left-turn lane at a median opening for directional left-turn/U-turn movements can be designed to store several vehicles because storage is parallel to the through traffic lanes.

3.12.2.2 Median Width

A median at least 25 feet wide is necessary to help ensure that a crossing or left-turning vehicle, stopped in the median perpendicular to the through traffic lane, will not extend beyond the median.

3.12.2.3 Median Opening Design

A vehicle turning left from an access drive and stopping in the median opening must yield to through traffic approaching from the right and vehicles turning left from the through lane. If there is even a moderate volume of left-turn movements from the through lane, the left-turn egress capacity is small. If it is a full median opening, the left-turn movement from an access drive also needs to yield to an opposing left-turning vehicle already stopped in the median opening. These conditions are alleviated when the direct left-turn exits are prohibited. A narrow median opening will allow only one left-turning vehicle at a time to advance into the median opening. A wide median opening allows multiple vehicles to stop in the opening. However, this may create a confusing and conflicting pattern of movements, angle stopping in the median opening, and some drivers' vision being obstructed by other vehicles.

Median storage for larger vehicles such as recreational vehicles, school buses, trucks, and a car pulling a trailer cannot be provided unless the median is exceptionally wide. It is usually more practical to provide for U-turn movements by such vehicles at selected locations using a jughandle design. Alternatively, added width can be provided in the opposing paved travel way at selected locations to accommodate these wide-radius turn movements (see **Section 3.13, Jughandles**).

In prohibiting direct left-turn movements from driveways, it is desirable to provide U-turn lanes in advance of downstream signalized intersections. Passenger cars can normally make U-turn movements along divided six-lane arterials. Along divided four-lane arterials, it may be desirable to add width or to use paved shoulders to accommodate U-turn movements.

When U-turn movements are provided as an alternative to left-turn movements, median width at signalized intersections should be adequate to accommodate the vehicles normally making the U-turn movements. Generally, a median width of at least 40 feet (preferably 60 feet) should be available. Midblock median openings may be made with less than 30 foot width. The minimum width of medians for U-turn movements on four-lane roads is provided in Figure 3-22. When designing for six-lane highways, 20 feet of median width will usually provide sufficient space for the U-turn movement for the passenger car (P) design vehicle (*19*).

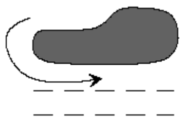
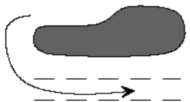
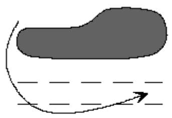
	Vehicle Classification		
	Passenger Car (P)	**Single Unit (SU)**	**Semi-Trailer (WB-50)**
 **Turn Lane to Inner Lane**	**42**	**75**	**83**
 **Turn Lane to Outer Lane**	**30**	**63**	**71**
 **Turn Lane to Shoulder**	**20**	**53**	**61**

Figure 3-22. Minimum Width of Median (feet) for U-turn Movements for Four-Lane Roads (*19*).

3.12.2.4 Median Design and Intensity of Land Development

As the intensity of land development increases, the traffic demand to access abutting properties also increases. Left-turn traffic at closely spaced full median openings can "interlock."

3.12.2.5 Consistency in Design

It is essential to provide a consistent treatment for left-turn movements along any highway. The differing left-turn options (direct left-turn, jughandle, and Michigan U-turn) should not be mixed. Driver expectancy must be respected.

3.12.3 Directional U-turn

The directional U-turn concept (often referred to as the "Michigan U-turn") for indirect left-turn movements (shown in Figure 3-23) places the U-turn channels about 660 feet downstream of intersections, eliminates all left-turn movements at the main intersection, and allows two-phase signal controls. The directional U-turn does, however, require a median width at intersections of 40 to 60 feet, depending on the type of vehicles involved. Narrower cross sections may be sufficient where there are few large trucks (*11*).

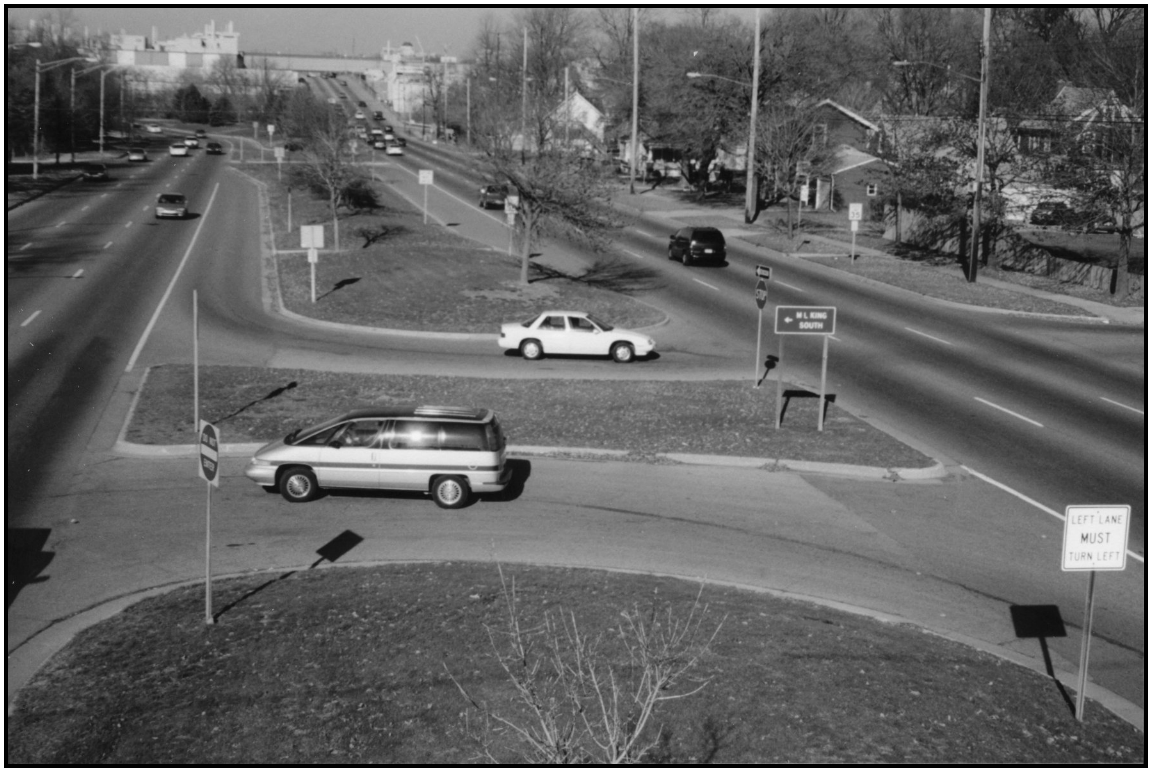


Figure 3-23. Michigan U-turn.

The directional U-turn design generally requires more median width than the conventional design. Its operational advantages include the following (*11*):

- It allows two-phase signal operations with a greater proportion of time allocated to arterial traffic flow. Shorter cycle lengths are possible, allowing more flexibility in signal progression.
- The wider median improves aesthetics and provides storage space for pedestrians.
- Through lane flyovers or flyunders can be incorporated within the right-of-way with relatively little or no widening as the need arises.

3.12.5 Safety and Operational Benefits of U-turn Movements

The safety and operational benefits of U-turn movements as an alternative to left-turn movements can be summarized as follows:

- Studies indicate that crash rates can be reduced by about 20 percent by eliminating direct left-turn movements from driveways (*11*). Roadways with wide medians and directional crossovers had half the crash rates of roads with TWLTLs (*37*). Additional studies in Michigan have shown mixed reports with results ranging from a 15 percent reduction in crash rates (*38*) to reports on highway sections without signals of 14 percent higher crash rates (*37*). However, as the density of traffic signals increased, divided highways with only directional crossovers had a decreasing relative crash rate.
- Operational benefits of U-turn movements as an alternative to left-turn movements include shorter travel times, less delay, and increased capacity. Right-turn movements followed by U-turn movements can provide comparable, if not shorter, travel times than direct left-turn movements from driveways under heavy volume conditions when the diversion distances are generally less than 0.5 miles (*11*).

3.13 JUGHANDLES

The second alternative to providing direct left-turn movements at intersections is to utilize the "jughandle" design. A "jughandle" is an at-grade ramp provided at or between intersections to permit the motorists to make indirect left-turn movements and/or U-turn movements. These ramps exit from the right lane of the highway in advance of the intersection (Figure 3-24), or past the intersection, and convey traffic across the main highway under traffic signal control (Figure 3-25). This movement eliminates all turn movements within active traffic lanes and, in addition to providing greater safety, reduces delays to the through traffic that left-turning vehicles usually create. Figure 3-26 provides the basic schematic design of a jughandle.

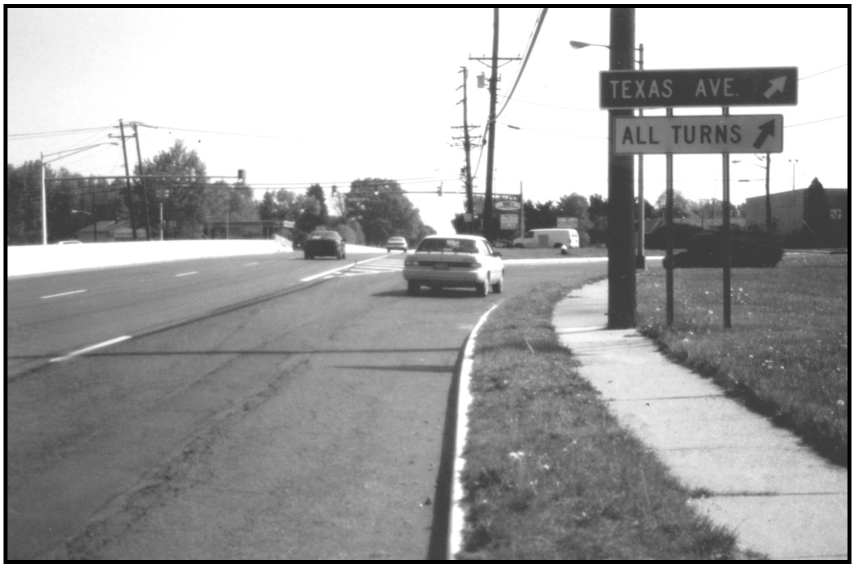


Figure 3-24. Upstream (Near Side) Jughandle Configuration.

Figure 3-25. Downstream (Far Side) Jughandle Configuration.

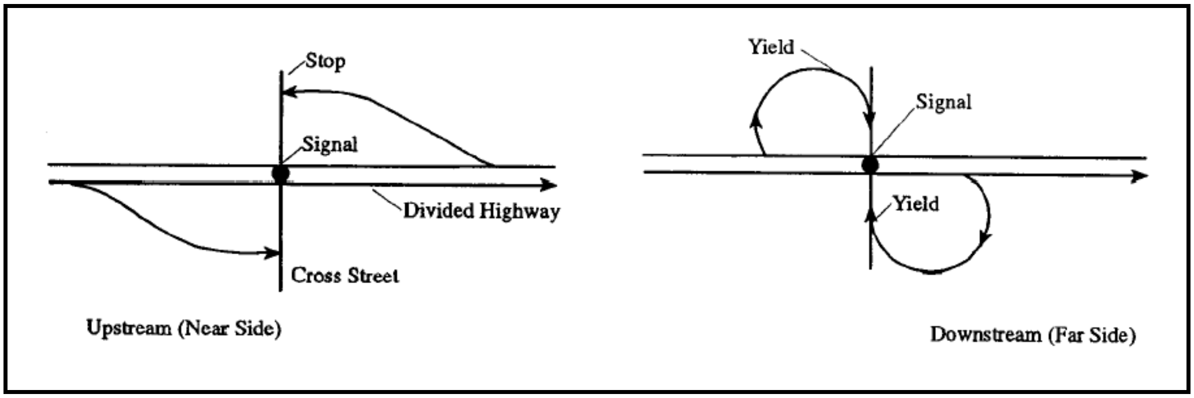


Figure 3-26. Basic Jughandle Design (*11*).

The design of jughandles should be performed to meet the following criteria:

- To provide safe and efficient traffic operations on land service highways, the interior of all jughandles should be acquired. In addition, no access is permitted on the outside of all jughandles including the entire length of acceleration and deceleration lanes, excluding the taper length. It is desirable that no access is permitted along the taper length of acceleration and deceleration lanes.

- When initially providing jughandles at locations where there are no existing cross streets or there is an intersecting street on only one side, the designer should evaluate the future development potential of the property adjacent to the jughandle. Consideration should be given to designing the jughandle for future expansion to accommodate the access needs of the adjacent property.

- In addition to the designs outlined, jughandles are also utilized in conjunction with U-turn designs to accommodate large vehicles or in situations when sufficient median width cannot be provided in order to facilitate design. In these situations, a flare-out or jughandle design can provide sufficient turning radius for design vehicles. Figures 3-27 and 3-28 provide three schematic designs for these alternatives. Figure 3-29 illustrates an application of the flare-out design.

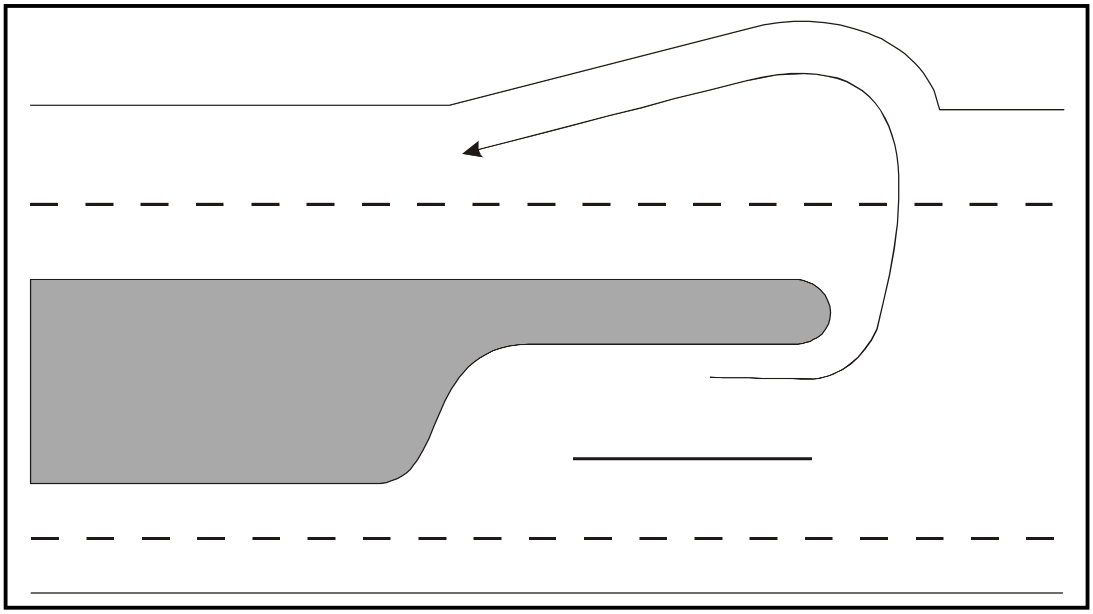


Figure 3-27. Flare-Out Jughandle Design (*19*).

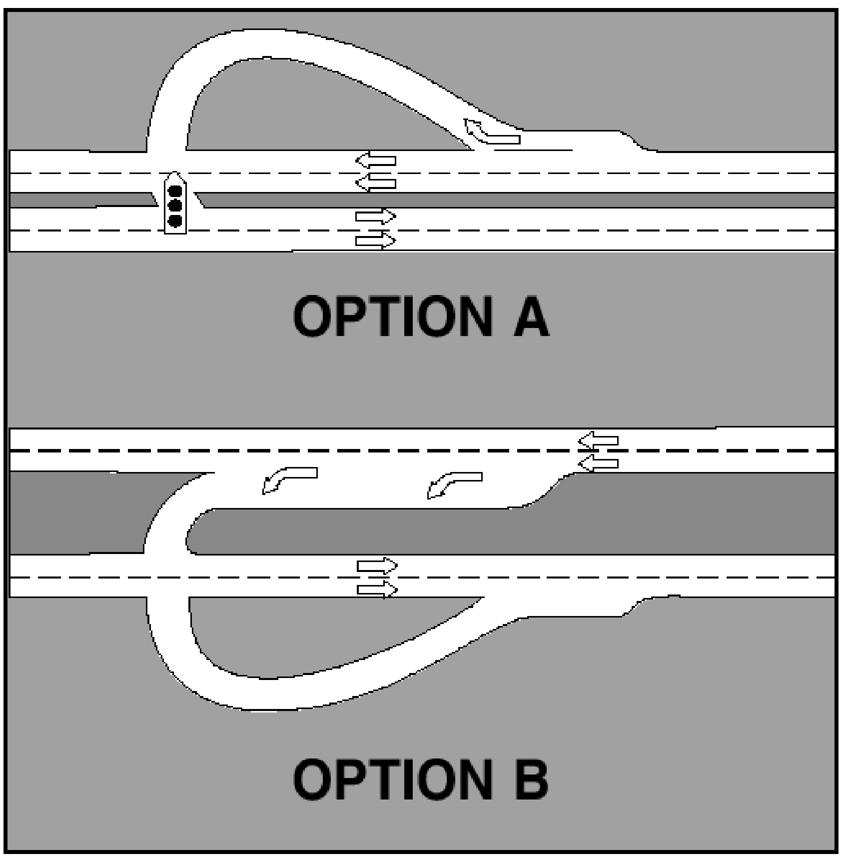


Figure 3-28. Jughandle U-turn Design for Large Vehicles (*19*).

Figure 3-29. Flare-out Jughandle Application.

3.14 ACCESS SEPARATION AT INTERCHANGES

Freeway interchanges provide the means of moving traffic between freeways and arterial streets and have become important focal points of activity in urban, suburban, and even some rural locations. Interchanges have become magnets for increased traffic and have stimulated much roadside development within their influence area. Where intersections are too close to the ramp termini of the arterial/freeway interchange, heavy weaving volumes, complex traffic signal operations, frequent crashes, and recurrent congestion have occurred. As a result, land development at interchanges should be sufficiently separated from ramp terminals.

Although access is strictly controlled on the freeway system itself, access control along the arterial roads adjacent to, and providing access to, the freeway is not often controlled. Existing street intersections and driveways along the arterial are often spaced too close to the interchange, reducing the capacity of the roadway and causing congestion along the arterial (*11*).

To ensure more efficient traffic flow at interchanges and to plan and manage grade-separated interchanges, the following guidelines are recommended. These guidelines have been adapted in part from *Policy 3C: Interchange Access Management Areas* from the *1999 Oregon Highway*

Plan (*21*). This document has been very successful at providing guidelines for management of interchange areas and as such has been utilized in these recommendations. The guidelines are as outlined in this section.

3.14.1 Interchange Area Management Plans

Develop interchange area management plans to protect the function of interchanges to provide safe and efficient operations between connecting roadways and to minimize the need for major improvement of existing interchanges.

3.14.2 Improving or Constructing an Interchange

To improve an existing interchange or construct a new interchange:

- The interchange access management spacing standards outlined in Tables 3-12 through 3-15 should apply. Interchange spacing dimensions are shown in Figure 3-30.
- These guidelines are not intended to retroactively apply to existing interchanges except or until any redevelopment, change of use, or highway construction, reconstruction, or modernization project affecting these existing interchanges occurs. It is recommended at that time, that the appropriate spacing standards be met if possible with improvements made in the direction of these guidelines at a minimum.
- Necessary supporting improvements, such as road networks, channelization, medians, and access control in the interchange management area, must be identified in the local comprehensive program and committed with an identified funding source, or must already be in place.
- Access to cross streets shall be consistent with established standards for a distance on either side of the ramp connections so as to reduce conflicts and manage ramp operations.
- Where possible, interchanges should connect to state highways and major or minor arterials.
- The design of urban interchanges must consider the need for transit and park-and-ride facilities, along with the interchange’s effect on pedestrian and bicycle traffic.
- When possible, access control should be purchased on crossroads for a minimum distance of 1,320 feet from a ramp intersection or the end of a free flow ramp terminal merge lane taper.
- When possible, no at-grade intersections should be permitted between interchanges less than five miles apart.

Table 3-12. Minimum Spacing for AC 1 Interchanges with Two-Lane Crossroads.

Type of Area	Spacing Dimension (feet)			
	A	X	Y	Z
Fully Developed Urban	1 mile	750	1,320	750
Urban	1 mile	1,320	1,320	990
Rural	2 miles	1,320	1,320	1,320

Source: Adapted from (*21*)

Table 3-13. Minimum Spacing for AC 1 Interchanges with Multilane Crossroads.

Type of Area	Spacing Dimension (feet)				
	A	X	Y	Z	M
Fully Developed Urban	1 mile	750	1,320	990	1,320
Urban	1 mile	1,320	1,320	1,320	1,320
Rural	2 miles	1,320	1,320	1,320	1,320

Source: Adapted from (*21*)

Table 3-14. Minimum Spacing for AC 2 Interchanges with Two-Lane Crossroads.

Type of Area	Spacing Dimension (feet)				
	B	C	X	Y	Z
Fully Developed Urban	2,640	1 mile	750	1,320	750
Urban	2,640	1 mile	1,320	1,320	990
Rural	1 mile	2 miles	1,320	1,320	1,320

Source: Adapted from (*21*)

Table 3-15. Minimum Spacing for AC 2 Interchanges with Multilane Crossroads.

Type of Area	Spacing Dimension (feet)					
	B	**C**	**X**	**Y**	**Z**	**M**
Fully Developed Urban	2,640	1 mile	750	1,320	990	1,320
Urban	2,640	1 mile	1,320	1,320	1,320	1,320
Rural	1 mile	2 miles	1,320	1,320	1,320	1,320

Source: Adapted from (*21*)

Notes for Tables 3-12, 3-13, 3-14, and 3-15:

1. If the crossroad is a state highway, these distances should be superseded by the Traffic Signal or Unsignalized Access Spacing Criteria, provided the distances are greater than the distances listed in the referenced tables.
2. No four-legged intersections may be placed between ramp terminals and the first major intersection.
3. Use four-lane crossroad standards for urban and suburban locations that are likely to be widened.
4. No at-grade intersections are permitted between interchanges less than 5 miles apart.
5. Refer to Figure 3-30 for graphical representation of the following spacing dimensions:
   - A = Distance between the start and end of tapers of adjacent interchanges.
   - B = Distance between the start and end of tapers of interchanges and at-grade intersections.
   - C = Distance between nearest at-grade and ramp terminal intersections or the end/start of the taper section.
   - X = Distance to first approach on the right; right-in/right-out only.
   - Y = Distance to first major intersection.
   - Z = Distance between the last approach road and the start of the taper for the on-ramp.
   - M = Distance to first directional median opening. No full median openings are allowed in non-traversable medians to the first major intersection.

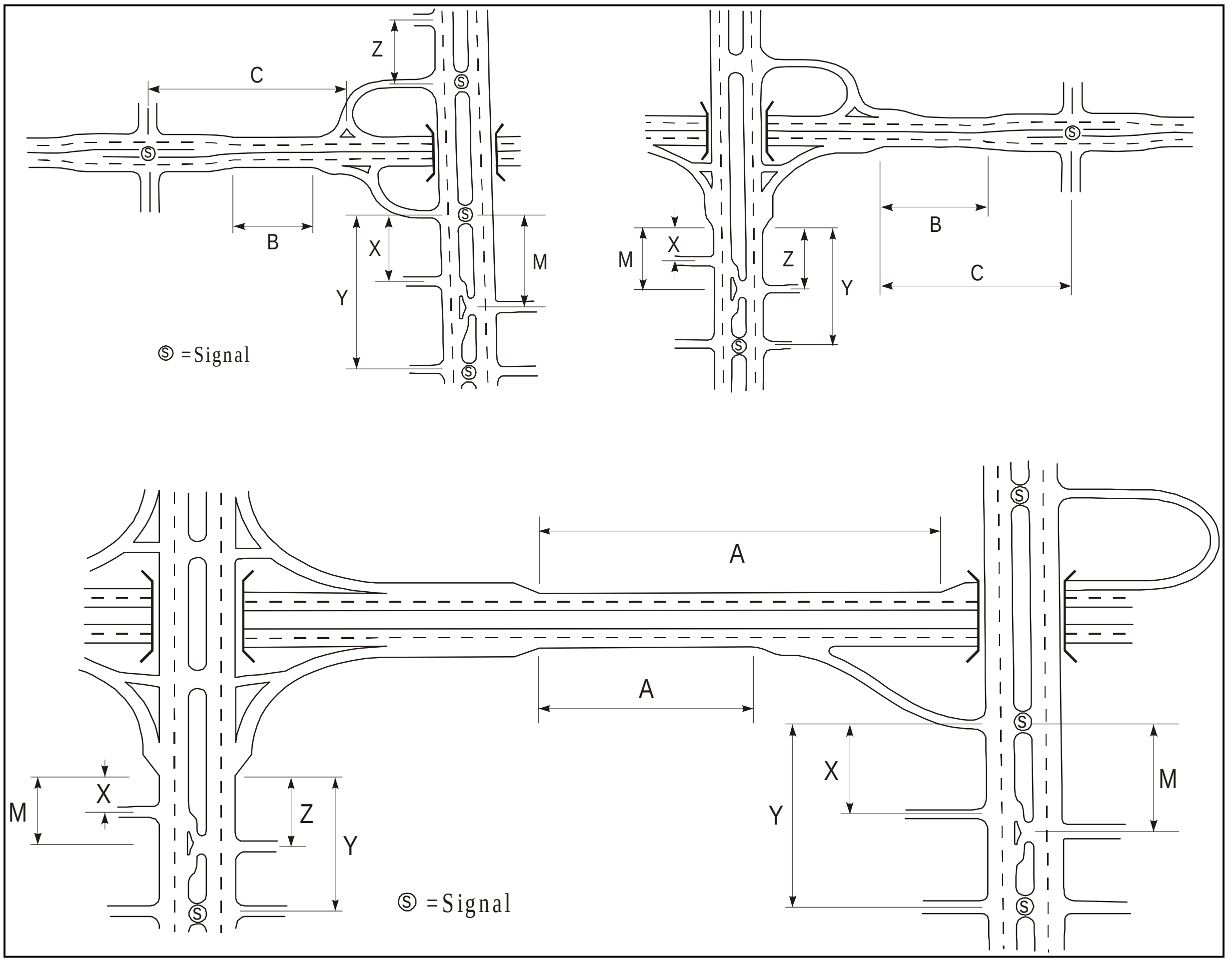


Figure 3-30. Interchange Spacing.

3.14.3 Deviations to Interchange Access Management Spacing

Criteria should be established to determine when deviations to the interchange access management spacing standards may be considered. The kinds of consideration likely to be included are:

- location of existing parallel roadways;
- use of traffic controls;
- potential queuing, increased delays, and safety impacts; and
- possible use of non-traversable medians for right-in/right-out movements.

3.14.4 Access Spacing and Operation of Interchanges

When new approach roads or intersections are planned or constructed near existing interchanges, property is redeveloped or there is a change of use. Wherever possible, the following access spacing and operation standards should be applied within the interchange access management area—measurements are from ramp intersection or the end of a free flow ramp terminal merge lane taper.

- Approach roads on the crossroads should be no closer than 750 feet, and those between 750 feet and 1,320 feet, should be limited to right-in/right-out. This may require construction of a non-traversable median or a median barrier.
- The first full intersection on a crossroad should be no closer than 1,320 feet.

3.14.5 Purchase of Access Rights

As opportunities arise, rights of access should be purchased on crossroads around existing interchanges. Whenever possible, this protective buying should be for a distance of 1,320 feet on the crossroads.

3.14.6 Grade-Separated Crossings

Grade-separated crossings should be used without connecting ramps to provide crossing corridors that relieve traffic crossing demands through interchanges.

3.15 FRONTAGE ROADS

The frontage road, as an access control technique, reduces the frequency and severity of conflicts along the main travel lanes of an arterial or freeway. Direct property access is provided from the frontage road and prohibited from the main travel lanes. The resulting spacing between the intersections along the main roadway facilitates the design of auxiliary lanes for deceleration and acceleration. Thus, frontage roads segregate through and local-land-service traffic, thereby protecting the through travel lanes from encroachment, conflicts, and delays.

Frontage roads, however, may require more circuitous access to adjacent land developments. They may also complicate the operations at signalized intersections thereby reducing some of the overall benefits achieved. How well they function depends on how well these considerations are reflected in the design and operations. Unless they are carefully designed and selectively applied, both in new and retrofit situations, frontage roads may not achieve the desired results.

Frontage roads are generally categorized as freeway frontage roads, or arterial frontage roads. Frontage roads generally are, but need not be, parallel to the roadway for through traffic. They may be provided on one or both sides of the main highway and may be continuous or extend for short sections only. Frontage roads may operate in either one-way or two-way configurations (*11*). Figure 3-31 illustrates the different types of freeway and arterial frontage roads typically used throughout the United States. The sections that follow provide detailed information on both freeway (**Section 3.16, Freeway Frontage Roads**) and arterial (**Section 3.17, Arterial Frontage Roads**) frontage roads as they relate to the state of Texas.

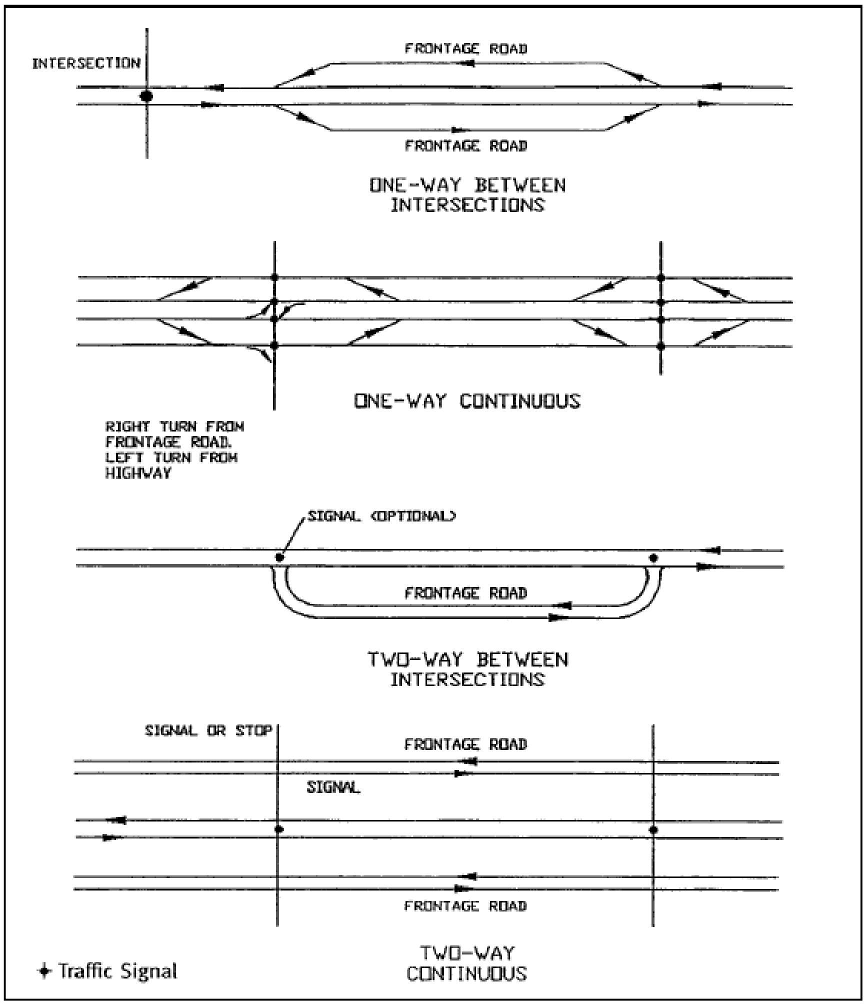


Figure 3-31. Types of Frontage Roads (*11*).

3.16 FREEWAY FRONTAGE ROADS

Freeway frontage roads are common throughout the state of Texas as illustrated in Figure 3-32. The freeway frontage road system is generally integrated with the interchange and ramping system to aid in alleviating congestion on interchanging arterials as well as freeway ramps. Freeway frontage roads generally operate one-way in developed areas and are integrated with the freeway ramping patterns. U-turn loops are often provided just short of the interchanges to permit reversal of direction before traffic signals.

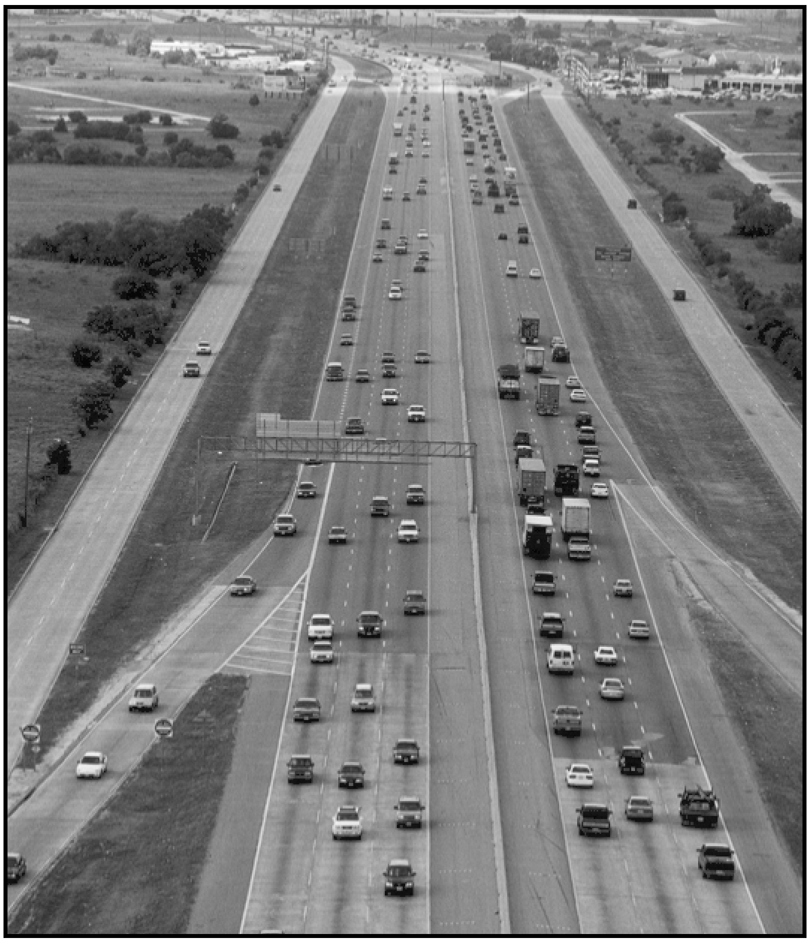


Figure 3-32. Freeway Frontage Road in Houston, Texas.

The vision of freeway frontage roads is that they will have an AC 3 classification, irrespective of the surrounding development. The design of freeway frontage roads should be consistent with the design guidelines outlined in the TxDOT *Roadway Design Manual* and should meet the criteria outlined therein, particularly the access guidelines illustrated in Figures 3-10 and 3-11 of the TxDOT *Roadway Design Manual*.

3.17 ARTERIAL FRONTAGE ROADS

Arterial frontage road design must address potential effects at major crossroad intersections, especially when the distances between the frontage road and arterial are short, the intersections are signalized, and the storage distances on the crossroad are inadequate. When commercial development occurs along frontage roads, the resulting traffic volumes may create congestion and increase crashes as a result of low-capacity overlapping maneuver areas, close conflict points, and complex movements needed to enter and exit the main travel lanes. Arterial frontage roads should only be used in extreme cases where other access management techniques will not provide acceptable results. The following general guidelines should be followed in the determination of arterial frontage road installation (*11*).

3.17.1 Arterial Frontage Road Function

The design of a frontage road is affected by the type of service it is intended to provide. Where a frontage road is continuous and passes through highly developed areas, its primary function is that of general service, and it assumes the character of an important street. At the other extreme, where a frontage road is only a few blocks long, follows an irregular pattern, borders the rear and side of buildings, or serves only scattered development, traffic will be light and operation will be local in character.

3.17.2 Arterial One-way Versus Two-way Frontage Roads

From an operational and safety standpoint, one-way frontage roads are preferable to two-way roads. The safety advantage in reducing vehicular and pedestrian conflicts on intersection streets often compensates for any inconvenience to local traffic. Where frontage roads parallel a freeway and accommodate traffic from slip ramps, the efficiency and safety associated with one-way frontage roads greatly surpasses those of two-way frontage roads.

Two-way frontage roads may be appropriate in sparsely developed areas where the adjoining street system is so irregular or so disconnected that one-way operation would introduce considerable added travel distance and cause undue inconvenience. Two-way frontage roads also may be necessary for suburban or rural areas where points of access to the through facility are infrequent, where only one frontage road is provided, where roads or streets connecting with the frontage roads are widely spaced, or where there is no parallel street within reasonable distance of the frontage roads.

3.17.3 Arterial Frontage Road Consideration

Fully developed frontage roads effectively control access to the through lanes on an arterial street, provide access to adjoining property, separate local from through traffic, and permit circulation of traffic on each side of the arterial. They may be used in conjunction with grade separation structures at major cross streets, in which case the arterial takes on many of the operating characteristics of a freeway.

Frontage roads along arterials must be carefully designed to avoid increasing conflicts at junctions and delays on intersecting roads. Arterial frontage roads must also be carefully designed to protect both arterial and crossroad operations.

The following planning and design guidelines should be considered in installing arterial frontage roads in both new developments and retrofit situations (*6*).

3.17.3.1 Frontage Road Operations

Frontage roads, especially for "retrofit" situations, should operate one-way and should enter or leave the mainlanes as merging or diverging movements. There should be no signalized junctions along the arterial or the frontage road in this area as shown in Figure 3-33.

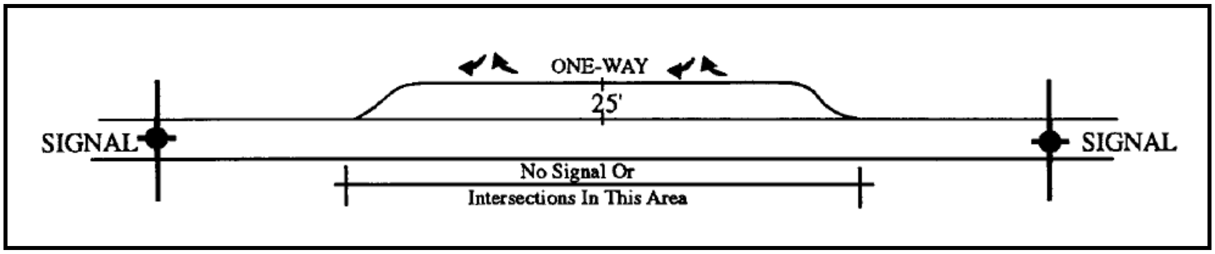


Figure 3-33. Arterial Frontage Road Concept for Retrofit Conditions (*6*).

3.17.3.2 Frontage Road Separation

The separation of arterial frontage roads at cross streets should be maximized to ensure sufficient storage for crossroad traffic between the frontage roads and the arterial. The absolute minimum separation (D2 in Figure 3-34) should be 150 feet where one-way or two-way frontage roads are provided. Greater distances are needed to provide adequate left-turn storage and to separate operation of the two intersections. Spacing of at least 400 feet (preferably more) enables turning movements to be made from the mainlanes onto the frontage roads without seriously disrupting arterial traffic and thereby minimizes the potential of wrong-way entry onto the through lanes of the predominant highway. The criteria outlined in **Section 3.6, Signalized Access Spacing** and **Section 3.7, Unsignalized Access Spacing** should be used in determining the desirable minimum spacing for these intersections. This minimum spacing should be used unless an acceptable engineering study determines that a shorter value will not compromise safety or efficiency; and it should reflect the following considerations:

- It is approximately the minimum acceptable length needed for placing signs and other traffic control devices to give proper direction to traffic on the cross street.
- It usually affords acceptable storage space on the cross street in advance of the main intersection to avoid blocking the frontage road. Under high traffic volume conditions, a queuing analysis should be made to ensure that the frontage road intersection is located beyond peak-hour traffic queues on the crossroad.
- It facilitates U-turn movements between the mainlanes and the two-way frontage road.
- It alleviates the problem of wrong-way entry onto the through lanes or the arterial.
- It separates points of conflict between the frontage traffic and the main highway.

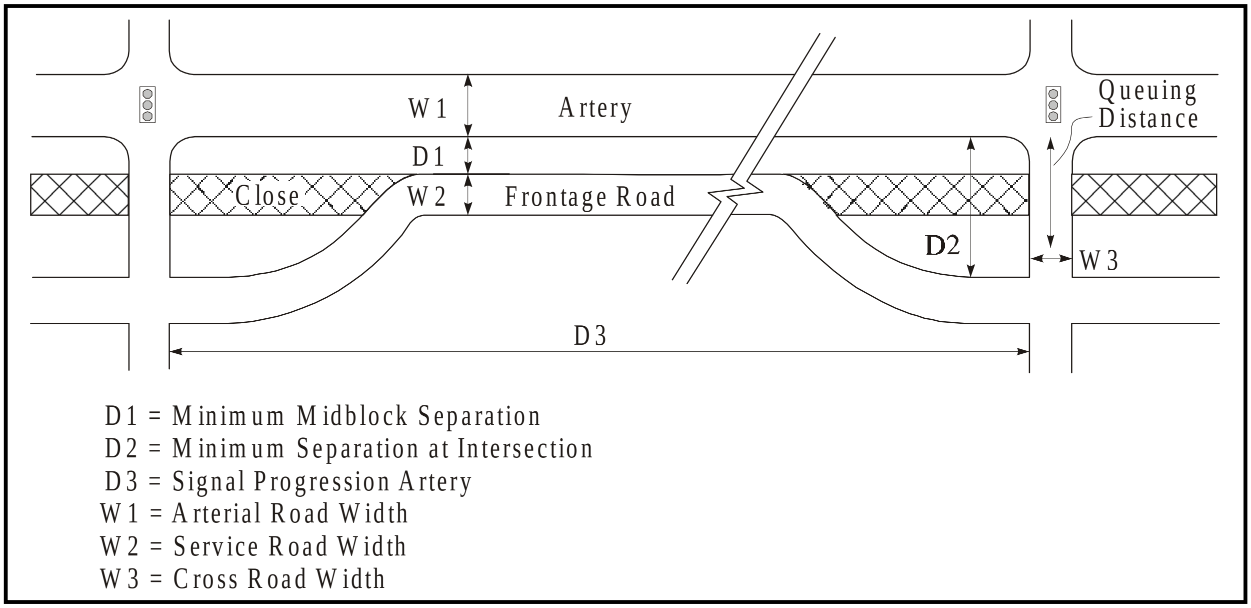


Figure 3-34. Arterial Frontage Road Design (*11*).

3.17.3.3 "Backage Roads"

"Reverse" frontage roads or "backage roads," with developments along each side, are desirable in developing urban areas. A desirable separation distance is 600 feet with a minimum distance of 400 feet. The frontage road may operate either one-way or two-way as shown in Figure 3-35.

3.17.3.4 Frontage Road Termination

Frontage roads that can be terminated at each block operate well with respect to the arterial roadway and the cross street. This type of design should be considered where continuity of the frontage road is not needed.

3.17.3.5 Pedestrian and Bridge Considerations

A minimum outer separation of 20 feet should be used to provide space for pedestrian refuge and safe placement of traffic control devices and landscaping.

Pedestrian and bicycle movements should use the frontage roads, and as such, the frontage road should be designed to accommodate this use. Parking may be permitted where the frontage roads traverse residential areas.

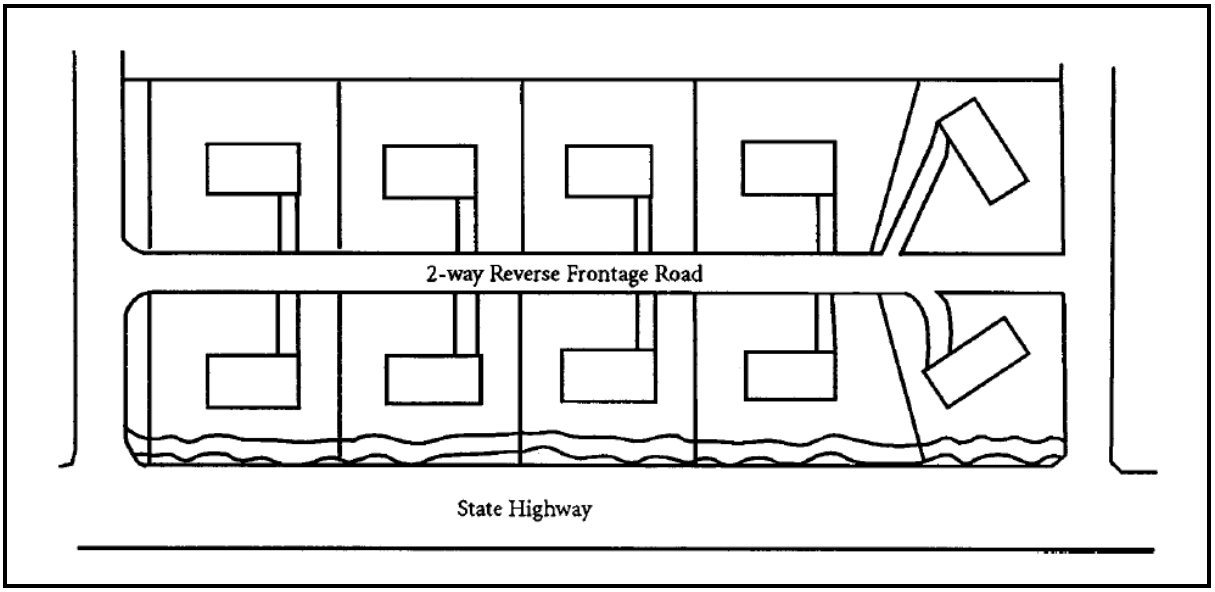


Figure 3-35. "Reverse" Frontage Road Concept (*11*).

3.18 SITE DEVELOPMENT TRAFFIC IMPACT ANALYSIS

To provide consistency in permitting and in making recommendations for access management decisions, a Site Development Traffic Impact Analysis (TIA) should be required for all new development that meets the criteria outlined in **Chapter 4.0, Site Development Traffic Impact Analysis Guidelines**. The purpose of the TIA will be to provide consistency among development and to provide an opportunity to analyze the impacts of development and the associated recommendations in order to help overcome these impacts. Roadway segments within the study area of the TIA shall be analyzed based on the access classification of these roadways, as determined by the district engineer. The recommended guidelines set forth in **Chapter 4.0, Site Development Traffic Impact Analysis Guidelines** shall be used in completing the TIA.

CHAPTER 4.0

SITE DEVELOPMENT TRAFFIC IMPACT ANALYSIS GUIDELINES

The purpose of this section of the report is to establish uniform guidelines when a TIA is required for site developments and to determine how the analysis is to be conducted, based on suggested guidelines established by the Institute of Transportation Engineers (ITE) (*39*).

A TIA is a specialized analysis of the impact that a development is projected to have on the surrounding transportation system. It is specifically concerned with the generation, distribution, mode split, and assignment of traffic to and from the "new development," where the term "new development" also includes properties that are being redeveloped.

4.1 WHEN REQUIRED

It is recommended that a TIA shall be required for all new developments or additions to and redevelopment of existing developments that generate 100 or more additional (new) peak direction (inbound or outbound) trips to or from the site during the adjacent roadway's peak hour or the development's peak hour. In some cases, a TIA may be required for a development that will generate fewer than 100 or more additional peak direction trips during the peak hour because of a localized safety or capacity deficiency. Such deficiencies may include:

- current traffic problems in the local area, such as a high-crash location, or an intersection in need of a traffic signal;
- current or projected level of service of the roadway system adjacent to the development is to be significantly affected (i.e., anticipated to drop by one or more LOS);
- sensitivity of adjacent neighborhoods or other areas that are perceived by the Department to be negatively impacted;
- existing or proposed site driveways that do not meet minimum spacing standards with other driveways or intersections;
- inability of the adjacent, existing, or planned roadway system to handle increased traffic, or the feasibility of improving the roadway system to handle increased traffic; and

- other specific problems or deficiencies, as determined by the Department, that may be affected by the proposed development or affect the ability of the development to be satisfactorily accommodated.

TIAs are divided into three categories. The scale of development will determine which category of analysis will be required. Each category differs by specific analysis requirements for the level of detail. Below is a description of each category. The district engineer, or his/her designated representative, shall make the final decision on requiring a TIA and determining whether the analysis falls within Category I, II, or III.

4.1.1 Category I

A Category I TIA should be required for all developments that generate 100 or more additional (new) peak direction (inbound or outbound) trips to or from the site, but less than 500 total trips, during the adjacent roadway's peak hour, or the development's peak hour, including morning, evening, and Saturday conditions. Peak hour trips should be determined by the latest edition of the ITE *Trip Generation* manual (*40*).

In addition to the above threshold requirements, a Category I TIA may also be required for a development that will generate fewer than 100 or more additional peak direction trips during the peak hour because of localized safety or capacity deficiencies as determined by the district engineer, or his/her designated representative. A listing of possible deficiencies can be found in **Section 4.1, When Required**.

For a Category I TIA, the analysis horizon should include the opening year of the development, assuming full build-out and occupancy.

The study analysis area should include all roads, ramps, and intersections through which peak-hour site traffic composes at least 5 percent of the existing capacity on an intersection approach or roadway sections on which crash potential or residential traffic character is expected to be significantly impacted. The minimum study area should include site access drives as well as affected signalized intersections and major unsignalized street intersections or driveways adjacent to the site.

4.1.2 Category II

A Category II TIA should be required for all developments that generate from 500 to 1,000 total trips during the adjacent roadway's peak hour, or the development's peak hour, including morning, evening, and Saturday conditions.

The analysis horizon should include the opening year of the development, year of completion for each phase of the development, if applicable, and five years after the development's full build-out and occupancy.

The study analysis area should include all roads, ramps, and intersections through which peak-hour site traffic composes at least 5 percent of the existing capacity on an intersection approach or roadway sections on which crash potential or residential traffic character is expected to be significantly impacted. The minimum study area should include the site access drives and all signalized intersections and major unsignalized street intersections and driveways within 0.50-mile of the development.

4.1.3 Category III

A Category III TIA should be required for all developments that generate above 1,000 total trips, during the adjacent roadway's peak hour, or the development's peak hour, including morning, evening, and Saturday conditions.

The analysis horizon should include the year of completion for each phase of the development, the year of its completion (assuming full build-out and occupancy), five years after the development's completion, and 10 years after the development's completion.

The study analysis area should include all roads, ramps, and intersections through which peak-hour site traffic composes at least 5 percent of the existing capacity on an intersection approach or roadway sections on which crash potential or residential traffic character is expected to be significantly impacted. The minimum study area should include the site access drives and all signalized intersections and major unsignalized street intersections and driveways within 0.50-mile of the development.

4.2 INITIAL WORK ACTIVITY

A developer, or his/her agent, should first estimate the number of vehicular trips to be generated by the proposed development to determine if a TIA may be required and, if so, to determine the applicable category. The developer must obtain concurrence from the district engineer, or his/her designated representative, on the number of trips to be generated by the proposed development. The developer may request that the district engineer, or his/her designated representative, assist in estimating the number of trips for the purpose of determining whether a TIA is required for the proposed development. The district engineer, or his/her designated representative, should make the final decision on requiring a TIA and determining whether the analysis falls within Category I, II, or III.

If a TIA is determined to be required by the district engineer, or his/her designated representative, the developer should prepare for submittal to TxDOT, for review and approval, a draft table of contents for the TIA. The table of contents will be sufficiently detailed to explain the proposed area of influence for the analysis, intersections and roadways to be analyzed, and level of detail for gathering of traffic volume information and preparation of level of service analyses. There should also be included in the draft a proposed trip distribution for site traffic. While preparing this information, it is recommended that the developer shall work with the district engineer, or his/her designated representative, to define the study area and to review any major land use or transportation system changes that have occurred, or are expected to occur, in the study area during the analysis period. Traffic generated by all approved and reasonably expected development ("on-line" development) in the study area should be obtained and included in the analysis. After approval of the draft table of contents and trip distribution by TxDOT, the actual TIA work activities may begin.

4.3 QUALIFICATIONS FOR PREPARING TIA DOCUMENTS

The TIA shall be conducted and prepared under the direction of a professional engineer (civil) licensed to practice in the state of Texas with special training and experience in traffic engineering. The final document shall be sealed, signed, and dated.

The traffic impact analysis scope of work agreement between the developer and his/her qualified traffic engineer should conform to the pre-approved draft table of contents. The findings, conclusions, and recommendations contained within the TIA document shall be prepared in accordance with appropriate professional civil engineering canons.

4.4 ANALYSIS APPROACH AND METHODS

The traffic analysis approach and methods are presented below.

4.4.1 Study Area

The minimum study area should be determined by project type and size in accordance with the criteria previously outlined. The extent of the study area may be either enlarged or decreased, depending on special conditions as determined by TxDOT.

4.4.2 Analysis Horizon Years

The analysis horizon years should be determined by project type and size, in accordance with the criteria outlined in **Section 4.1, When Required**.

4.4.3 Analysis Time Period

Both the morning and evening weekday peak hours should be analyzed, unless the proposed project is expected to generate no trips, or a very low number of trips, during either the morning or evening peak periods. If this is the case, TxDOT may waive the requirement to analyze one or both of these periods.

Where the peak traffic hour in the study area occurs during a different time period than the normal morning or evening peak travel periods (for example mid-day), or occurs on a weekend, or if the proposed project has unusual peaking characteristics, these additional peak hours should also be analyzed.

4.4.4 Seasonal Adjustments

When directed by TxDOT, the traffic volumes for the analysis hours should be adjusted for the peak season, in cases where seasonal traffic data are available.

4.4.5 Data Collection Requirements

All data should be collected in accordance with the latest edition of the ITE *Manual of Traffic Engineering Studies*, or as directed by TxDOT.

4.4.5.1 Turning Movement Counts

Manual turning movement counts should be obtained for all existing cross-street intersections to be analyzed during the morning, evening, and Saturday peak periods (as applicable). Turning movement counts may be required during other periods as directed by TxDOT. Turning movement counts may be extrapolated from existing turning movement counts, no more than two years old, with the concurrence of TxDOT.

4.4.5.2 Daily Traffic Volumes

The current and projected daily traffic volumes should be presented in the report. If available, daily count data from the local agencies may be extrapolated to a maximum of two years with the concurrence of TxDOT. Where daily count data are not available, mechanical counts will be required at locations agreed upon by TxDOT.

4.4.5.3 Crash Data

Traffic crash data should be obtained for the most current three-year period available.

4.4.5.4 Roadway and Intersection Geometrics

Roadway geometric information should be obtained. This includes, but is not limited to, roadway width, number of lanes, turning lanes, vertical grade, location of nearby driveways, and lane configuration at intersections.

4.4.5.5 Traffic Control Devices

The location and type of traffic controls should be identified at all locations to be analyzed.

4.4.6 Trip Generation

The latest edition of ITE's *Trip Generation* manual should be used for selecting trip generation rates (*40*).

Other rates may be used with the approval of TxDOT in cases where *Trip Generation* does not include trip rates for a specific land use category, or includes only limited data, or where local trip rates have been shown to differ from the ITE rates.

Site traffic data should be generated for daily, morning, evening, and Saturday peak-hour periods as determined applicable in **Section 4.2, Initial Work Activity**. Adjustments made for "pass-by," "diverted-link," or "mixed-use" traffic volumes should follow the methodology outlined in the latest edition of the ITE *Trip Generation* (*40*) manual or the ITE *Trip Generation Handbook* (*41*). A "pass-by" traffic volume discount for commercial centers should not exceed 25 percent unless approved by TxDOT.

A trip generation table should be prepared by phase showing proposed land use, trip rates, and vehicle trips for daily and peak-hour periods and appropriate traffic volume adjustments, if applicable.

4.4.7 Trip Distribution and Assignment

Projected trips should be distributed and added to the projected non-site traffic on the roadways and intersections under analysis. The district engineer or designated representative should review the specific assumptions and data sources used in deriving trip distribution and assignment, and the report should document them. Future traffic volumes should be estimated using information from transportation models or applying an annual growth rate to the base-line traffic volumes. The future traffic volumes should be representative of the horizon year for project development.

If the annual growth rate method is used, TxDOT must give prior approval to the growth rate used. While preparing this information, it is recommended that the developer shall work with the district engineer, or his/her designated representative, to finalize any major land use or transportation system changes that have occurred or are expected to occur in the study area during the analysis period. Traffic generated by all approved and reasonably expected development ("on-line" development) in the study area should be obtained and included in the analysis. The increase in traffic from the "on-line" development should be compared to the increase in traffic by applying the annual growth rate.

If modeling information is unavailable, the greatest traffic increase from either the "on-line" developments, the application of an annual growth rate, or a combination of an annual growth rate and "on-line" developments should be used to forecast the future traffic volumes.

The site-generated traffic should be assigned to the street network in the study area based on the approved trip distribution percentages. The site traffic should be combined with the forecasted traffic volumes to show the total traffic conditions estimated at development completion. A figure should show daily and peak-period turning movement volumes for each traffic analysis intersection. In addition, a figure should be prepared showing the base-line volumes with site-generated traffic added to the street network. These figures should display the base-line volumes with site-generated traffic added to the street network and will represent site-specific traffic impacts to existing conditions.

4.4.8 Capacity Analysis

LOS should be computed for signalized and unsignalized intersections in accordance with the latest edition of the HCM. The intersection LOS should be calculated for each of the following conditions (if applicable):

- existing peak hour traffic volumes (figure required);
- existing peak hour traffic volumes including site-generated traffic (figure required);
- future traffic volumes not including site traffic (figure required);
- future traffic volumes including site traffic (figure required); and
- LOS results for each traffic volume scenario (table required).

The LOS table should include LOS results for all applicable peak periods. The table should show LOS conditions with corresponding vehicle delays for signalized intersections and LOS conditions for the critical movements at unsignalized intersections. For signalized intersections, the LOS conditions and average vehicle delay should be provided for each approach and the intersection as a whole.

If the new development is scheduled to be completed in phases, the TIA will, if directed by TxDOT, include an LOS analysis for each separate development phase in addition to the TIA for each horizon year. The incremental increases in site traffic from each phase should be included in the LOS analysis for each preceding year of development completion. A figure will be required for each horizon year of phased development.

4.4.9 Traffic Signal Needs

A traffic signal needs analysis should be conducted for all new proposed signals for the base year. If the signal warrants are not met for the base year, they should be evaluated for each year in the five-year horizon. Traffic signal needs studies should be conducted according to the most current Texas MUTCD.

4.4.10 Crash Analysis

An analysis of three-year crash data should be conducted to determine if the level of safety would deteriorate due to the addition of site traffic, to identify trends in existing crash data, and to determine from an engineering standpoint if there would be any negative impacts on safety as a result of the proposed development

4.4.11 Speed Considerations

Vehicle speed provides a basis to estimate safe stopping and cross-corner sight distances. In general, the posted speed limit is representative of the 85th percentile speed and should be used to calculate safe stopping and cross-corner sight distances.

4.4.12 Improvement Analysis

The roadways and intersections within the study area should be analyzed with and without the proposed development to identify any projected impacts with regard to LOS and safety.

- Where the highway will operate at LOS C or better without the development, the traffic impact of the development on the roadways and intersections within the study area should be mitigated such that the LOS drops by only one level (i.e., LOS B to LOS C), with worst case LOS D for arterial and collector streets and LOS C on all other streets during peak hours of travel. Mitigation to LOS D on other streets may be acceptable with the concurrence of the district engineer or his/her designated representative.

- In areas where current LOS is D or E, this baseline LOS must be maintained or improved after development. For example, if the LOS prior to the development is E, then once the development is in place, the LOS must be at least E.
- In areas where current LOS is F, the traffic impact of the development on the roadways and intersections within the study area should be mitigated such that the LOS criteria (i.e., delay or speed) do not deteriorate beyond background conditions. The district engineer or his/her designated representative must approve any deterioration beyond these conditions.

Recommendations for improvements should include both off-site and on-site locations. Recommendations should reflect scheduled and recommended roadway network improvements and additional developments in and near the site. Resulting recommendations may be classified into four major categories:

- regional or sub-regional network improvements serving the development site;
- local improvements adjacent to the development site;
- site specific access improvements; and
- program changes.

4.5 REPORT FORMAT

This section provides the format requirements for the general text arrangement of a TIA. Deviations from this format must receive prior approval of TxDOT.

I. INTRODUCTION AND SUMMARY

1. Purpose of report and analysis objectives
2. Executive summary
    a. Site location and study area
    b. Development description
    c. Principle findings
    d. Conclusions
    e. Recommendations

II. PROPOSED DEVELOPMENT

1. Off-site development
2. Description of on-site development
    a. Land use and intensity
    b. Site location
    c. Site plan (including access geometrics)
    d. Zoning
    e. Development phasing and timing

III. STUDY AREA CONDITIONS

1. Study area
    a. Area of significant traffic impact
    b. Area of influence
2. Land use
    a. Existing land use and zoning
    b. Anticipated future development
3. Site accessibility
    a. Existing and future area roadway system
    b. Traffic volumes and conditions
    c. Access geometrics
    d. Others as applicable

IV. ANALYSIS OF EXISTING CONDITIONS

1. Physical characteristics
    a. Roadway characteristics
    b. Traffic control devices
    c. Transit service
    d. Pedestrian/bicycle facilities
    e. Existing transportation demand management

2. Traffic volumes
    a. Daily, morning, evening, and Saturday peak period (as applicable)
3. Level of service
    a. Morning, evening, and Saturday peak hour (as applicable)
4. Safety

V. PROJECTED TRAFFIC

1. Site traffic forecasts (each horizon year)
    a. Trip generation
    b. Trip distribution
    c. Mode split
    d. Pass-by traffic (if applicable)
    e. Trip assignment
2. Non-site traffic forecasting (each horizon year)
    a. Projections of non-site (background) traffic (methodology for the projections should receive prior approval of TxDOT)
3. Total traffic (each horizon year)

VI. TRAFFIC AND IMPROVEMENT ANALYSIS

1. Site access
2. Capacity and level of service analysis
    a. Without project (for each horizon year, including any programmed improvements)
    b. With project (for each horizon year, including any programmed improvements)
3. Roadway improvements
    a. Improvements programmed to accommodate non-site (background) traffic\
    b. Additional alternative improvements to accommodate site traffic
4. Traffic safety
    a. Sight distance
    b. Acceleration/deceleration lanes, left-turn lanes
    c. Adequacy of location and design of driveway access
    d. Pedestrian considerations

e. Speed considerations

f. Traffic control needs

g. Traffic signal needs (base plus each year, in five-year horizon)

h. Site circulation and parking

i. Transportation demand management

VII. FINDINGS

1. Site accessibility
2. Traffic impacts
3. Need for improvements
4. Compliance with applicable local codes

VIII. RECOMMENDATIONS/CONCLUSIONS

1. Site access/circulation plan
2. Roadway improvements
   a. On-site
   b. Off-site
   c. Phasing (as applicable)
3. Transportation demand management actions (as applicable)
4. Other

APPENDICES

1. Existing traffic volume summary
2. Trip generation/trip distribution analysis
3. Capacity analysis worksheets
4. Traffic signal needs studies
5. Crash data and summaries

FIGURES AND TABLES

The following items should be documented in the text or appendices:

- site location;
- site plan;
- existing transportation system;

- existing peak hour turning volumes;
- three year crash history (including collision diagrams);
- estimated site traffic generation;
- directional distribution of site traffic;
- site traffic;
- non-site traffic;
- total future traffic;
- projected levels of service; and
- recommended improvements.

For Category I, many of the items may be documented within the text. For other categories, the items should be included in legible figures and/or tables.

DESIGN STANDARD REFERENCE

Designs should use the following design standards:

- design in accordance with current TxDOT standards and manuals,
- signal warrants in accordance with current Texas MUTCD, and
- conduct capacity analysis in accordance with the latest edition of the *Highway Capacity Manual.*

4.6 APPROVALS

The traffic impact analysis shall be submitted to the district engineer, or his/her designated representative, who shall approve or disapprove the TIA.

CHAPTER 5.0

RECOMMENDATIONS AND DISCUSSION

The preservation of access along arterial streets has proven itself to be worthwhile in many parts of the United States through both research and implementation. With the increase in traffic volumes and congestion that has occurred in recent years throughout the state of Texas, the movement of vehicles combined with continued preservation of access must be taken seriously. The results of this research effort have determined that access management is an important step in preserving the access, accessibility, movement, and mobility of Texas' arterial streets. To provide both good access and good accessibility, access management techniques must be incorporated into both new design and retrofit of existing corridors. The techniques outlined in the preceding chapters should be considered. The matrix found in Table 3-2a and Table 3-2b summarizes these techniques and provides quick reference to the sections within this report in which detailed guidelines can be found. A listing of the techniques recommended for implementation is as follows:

- signalized intersection access spacing;
- unsignalized intersection access spacing;
- signalized intersection corner clearance criteria;
- unsignalized intersection corner clearance criteria;
- directional median spacing criteria;
- full median spacing criteria;
- auxiliary lanes (including right-turn and left-turn lane criteria);
- alternatives for left-turn treatments (U-turn and jughandle);
- access separation at interchanges;
- arterial frontage roads;
- freeway frontage roads; and
- site development traffic impact analysis guidelines.

To ensure that the techniques outlined can be implemented within the current TxDOT process, it is recommended that the results of this research project be incorporated into the TxDOT *Roadway Design Manual*. The results will also be incorporated into an *Access Management*

Guidebook that will be completed in the second year of the project. The *Guidebook* will contain both the techniques and criteria outlined in this report as well as additional criteria and policy documentation that will be developed in year two of the project. The *Guidebook* is anticipated to be useful to planners and engineers in understanding the importance of various access management treatments and further identifying criteria for their recommended use. The *Guidebook* is anticipated to be used in providing policy support for access management decision-making and as a tool for consistent access control by design for affected communities.

In addition to providing the updated TxDOT *Roadway Design Manual* and the *Access Management Guidebook* as a reference to planners and engineers on access management, it is further recommended that a statewide access management coordinator be appointed within the Department to oversee access management from a statewide perspective. The states that have demonstrated the most success with their access management programs are those states in which a DOT employee supervised the efforts and was on hand during the implementation, organization, and initial setup of the program. In addition to a statewide coordinator, it is also recommended that district access management coordinators be assigned in each of the TxDOT districts as well. These local access management coordinators would fill the role as the district engineer's designated representative on access management and would have the responsibility of ensuring that access management practices are followed within jurisdictions. Coordinators have been a key to the success of several programs, particularly by providing consistency throughout the district and statewide through coordination with the statewide access management coordinator.

Success of the proposed access management comprehensive program will not happen overnight. This program will require a great deal of investment before the results will begin to be noticed throughout the state. Access management requires a commitment from the department as an organization and from the staff members individually to reap the benefits that it can provide to the roadway network.

It is also recommended that an access management committee be organized as needed under the direction of the district engineer. As outlined previously in this report, the access management committee, if desired, will be comprised of local agencies, TxDOT district representatives, and representatives from TxDOT headquarters and is anticipated to consist of the following: local district staff members, local area engineers, local MPO representative (where applicable), local city/county representatives (where applicable), and the statewide access management coordinator. The district engineer will look at roadway segments on an as-needed basis and make a determination on the appropriate access classification. The access classification determination should include discussion of future (20+ years) projected traffic volumes, future land use projections, primary purpose of the roadway (access vs. mobility), right-of-way considerations, existing crash rates, and existing and projected roadway functional classification. As with roadway functional classification, the access classification should be chosen based on the access functionality of the roadway, the primary purpose of the roadway, and its ability to provide safe and efficient traffic movement. The access classification designation will be key to preserving access along arterials and balancing access and mobility throughout the state.

The final recommendation of a site development TIA will aid implementation of the comprehensive access management program, and in providing consistency in permitting and making recommendations for access management decisions. A site development TIA shall be required for all new development that meets the criteria outlined in this report. The purpose of the TIA will be to provide consistency among development and to provide an opportunity to analyze the impacts of development and the associated recommendations to help overcome these impacts. Roadway segments within the study area of the TIA shall be analyzed based on the access classification determined by the district engineer.

These recommendations, combined with the continued research that will occur in year two of this project, will provide the state with the groundwork to begin preserving the safety and mobility of the transportation network. The key ingredients to be added in year two include detailed guidelines on permitting, implementation, and the development of the *Guidebook*. The guidelines and subsequent *Access Management Guidebook* will then be organized into a training course to train both Department personnel and local city, state, and MPO representatives as well. This implementation, information, and *Guidebook* will provide the background of the project. Additionally, research will also be performed to verify the spacing standards outlined in this project and to better quantify driveway spacing requirements, median alternatives, and others.

CHAPTER 6.0

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APPENDIX

Access Management Presentation Summary

ACCESS MANAGEMENT OVERVIEW

- Project 0-4141 "Techniques for Managing Access on Arterials"
- Internal Stakeholders Meeting
- September 2000 - August 2002
- Jim Heacock (HOU), Project Director
- Mary Owen (TYL), Program Coordinator
- Bill Frawley and Bill Eisele, TTI, Co-Research Supervisors

Presentation Outline

- What is access management?
- Why use access management?
- How to use access management?
- Working with the public.

What is Access Management?

- Set of tools to help protect public investments in roadways and improve safety
- Balances access to developed land with traffic mobility needs
- Works with Functional Classification hierarchy

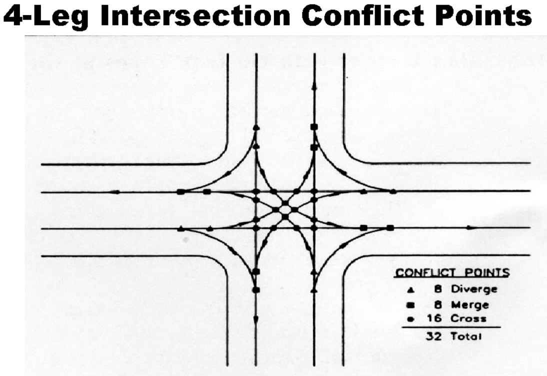
Why Use Access Management?

- Safety
- Efficiency
- Functional Classification preservation
- Financial
- Not for benefit of adjacent property

Safety

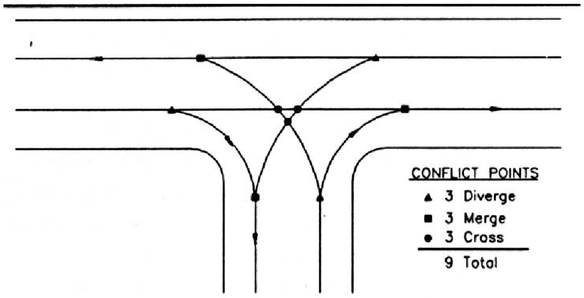
- Remove speed differentials
- Reduce conflict points at Intersections
  - Driveways are intersections too!!
- Increase driver expectations

4-Leg Intersection Conflict Points



Source: NHI Course 15255

3-Leg Intersection Conflict Points



Source - NHI Course 15255

Accidents

- 50-55% Related to Intersections
  - 60% in Urban areas
  - 40% in Rural areas
- Remember, Driveways are Intersections Too!!

Accidents

- Studies: Reductions of 30-70%
  - -Depends on Conditions
  - -Depends on Techniques
- Every new access point increases the opportunity for accidents

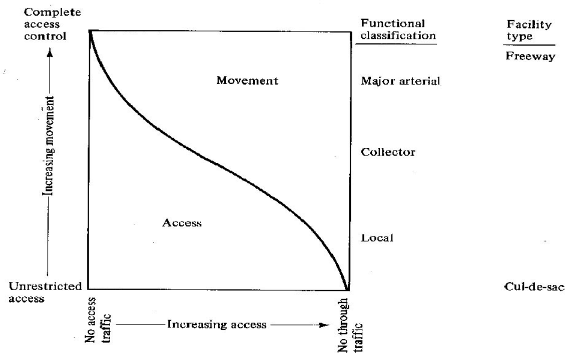
Safety - Reduce Conflict Points

Safety - Reduce Accidents

Increased Mobility

- Less stop and go traffic
- Reduce delay
- Increase and preserve capacity
- Reduce fuel consumption

Functional Classification



Source: Koepke/Stover - Transportation and Land Development

Access Management Tools

- Driveway Spacing
- Turn Lanes
- Medians
- Signal Spacing

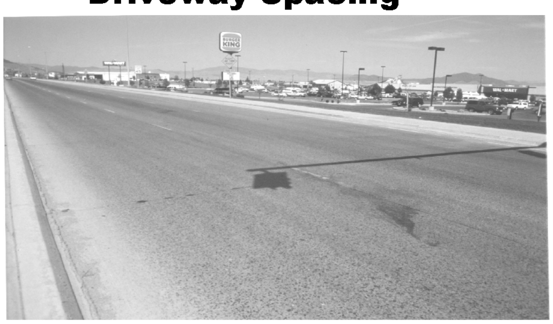
Access Management Tools

- ⌘Frontage/Backage Roads
- ⌘Interchange Spacing
- ⌘Jug Handles
- ⌘Roundabouts

Turn Lanes

- Separate Speeds & Create Havens

Driveway Spacing



- ⌘Maintains Movement & Increases Driver Expectations

Medians

- ⌘ Reduce Conflict Points & Congestion
- ⌘ Increase Driver Expectations

Signal Spacing

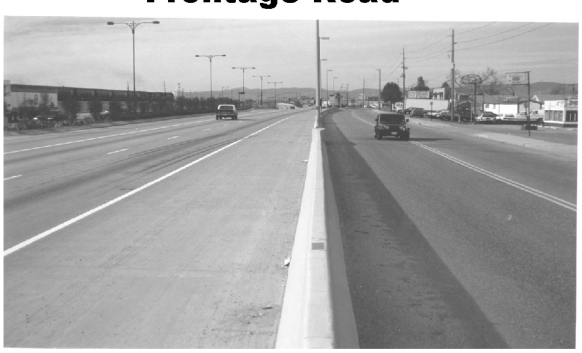
⌘Maintains Progression / Movement

Build It and They Will Still Come!

Traffic Circle / Roundabout

"Pork Chop" Island

Frontage Road



Frontage Roads - Residential

- Allow roadway to maintain arterial function
- Move access points away from arterial

Backage Road

Backage Road

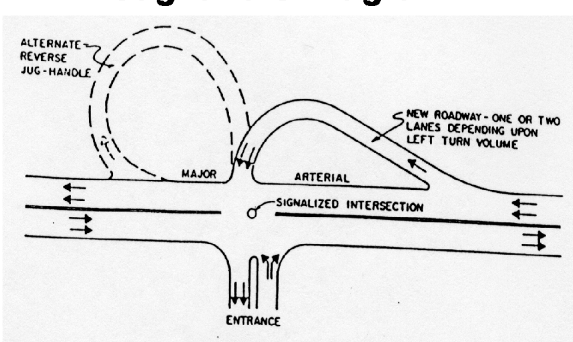
Interchange Spacing

- Increases Driver Expectations
- Allows for Weaving

Michigan U-Turn

- Removes U-Turn from Intersection

Jughandle Diagram



Source: Barkan & Levinson - "Retrofitting Shopping Centers - Concepts and Case Studies"

U-Turn Jug Handle

Left-turn, then Merge with Traffic

Jug Handle

(Reverse) Jug Handle

District Survey Results (Project 0-1847)

- Knowledge varies among and within districts
- Basic overall understanding of concepts
- Believe access points cause problems

District Survey Results Potential Benefits

- Design consistency
- Improved road capacity and mobility
- Improved safety

District Survey Results Desires

- Training
- Improved guidelines
- Improved driveway standards