National Cooperative Highway Research Program

NCHRP Report 348

Access Management Guidelines for Activity Centers

Transportation Research Board
National Research Council

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Access Management Guidelines for Activity Centers

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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FOREWORD

By Staff
Transportation Research Board

This report will be of interest and use to state departments of transportation, city and county traffic engineering and transportation planning agencies, and private developers concerned with preserving and improving the capacity and safety of the overall highway system within the vicinity of activity centers through better management of access control. The objective of the research 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. The findings are based on 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.

Streets and highways constitute a major public investment and it is essential to operate them safely and efficiently. Inadequate access management is an important factor behind the operational deterioration of many streets and highways. There is a need to identify better methods for applying access management practices to different classes of highways within the vicinity of activity centers, and for implementing such practices on highways experiencing access management problems.

NCHRP Project 3-38(7), "Access Management Guidelines for Activity Centers," was conducted jointly by Metro Transportation Group, Inc., Bloomingdale, Illinois, and Herbert S. Levinson, New Haven, Connecticut. The research investigated and documented the state of the art in access control and the broader concept of access management.

Access management involves providing (or managing) access to land development while simultaneously preserving the flow of traffic on the surrounding road system in terms of safety, capacity, and speed. The research indicates that "access management" has emerged over the last decade as a new philosophy of "access control" that applies to all types of roads and streets. It calls for setting access standards for various types of roadways, keying designs to these standards, having the access standards incorporated into legislation, and having the legislation upheld in the courts.

Access management views the highway and its surrounding activities as part of a single "system." Individual parts of the "system" include the activity center and its circulation systems, access to and from the center, the availability of public transportation, and the roads serving the center. All parts are important and interact with each other. The goal is to coordinate the planning and design of each to preserve the capacity of the overall system, and to allow efficient access to and from the activities.

Access management extends traffic engineering principles to the location, design, and operation of access roads serving activities along streets and highways. It also includes evaluating the suitability of a site for given developments from an access standpoint. It is, in many respects, an effective application of transportation system management where the town planner, traffic engineer, and developer can work together. But it is far broader as well, for it addresses the basic questions—when, where, and how should access be provided or denied, and what legal and institutional changes are necessary to reinforce this decision?

NCHRP Report 348 defines the overall concept of Access Management, reviews the state of the art of current practice, and sets forth basic policy, planning, and design guidelines. The guidelines cover (1) legal and institutional bases for controlling access, (2) access permit procedures and studies, (3) access categories (levels) and spacing standards, and (4) design concepts and criteria.

The research reported here is the product of the second in a series of three NCHRP projects addressing the response to traffic congestion in and around major activity centers. Project 3-38(2) has resulted in *NCHRP Report 323,* "Travel Characteristics at Large-Scale Suburban Activity Centers (SACs)," which was published in 1989. *Report 323* assists transportation planners with the evaluation of traffic impacts of SACs and provides information on the site impacts of individual buildings, the regional traffic impact of SACs, and the internal trip characteristics of SACs.

The results of the third effort in the series, NCHRP Project 3-38(6), "Cost Sharing for Transportation Improvements Near Suburban Activity Centers," are expected to be available in late 1992 or early 1993. The report from Project 3-38(6) will provide guidance on the most equitable methods of financing SAC highway improvements through impact fees. Further, the two most popular forms of impact fees, fiscal-based and recoupment-based, will be compared to property tax financing.

CONTENTS

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ACCESS MANAGEMENT GUIDELINES FOR ACTIVITY CENTERS

SUMMARY

This report defines the overall concept of access management, reviews current practice, and sets forth basic policy, planning, and design guidelines. The guidelines cover: (1) legal and institutional bases for controlling access, (2) access permit procedures and traffic impact studies, (3) access categories (levels) and spacing standards, and (4) design concepts and criteria.

The research was undertaken in response to the need for more consistent and effective access management policies. New federal requirements relating to congestion management and air quality give further impetus to improved street and highway transportation.

The Access Management Concept

Access management is a new response to the problems of congestion, capacity loss, and accidents along the nation's roadways. It calls for significant improvements in access control, spacing, and design to preserve the functional integrity and operational viability of the road system. It attempts to balance the movement and access functions associated with streets and highways. Access management is the process that provides or manages access to land development while simultaneously preserving the flow of traffic on the surrounding road system in terms of safety, capacity needs, and speed.

It is a rational approach to coordinating transportation with land development—a new philosophy of access control that applies to all types of roads and streets. Its key elements include: (1) defining allowable access levels and spacings for various classes of roadways, (2) providing a mechanism for granting variances when reasonable access cannot be provided, and (3) establishing a means of enforcing standards. Transportation management and land use controls are complementary actions for activity centers. The degree of access control and management is determined by statute, deeds, zoning, and by operational and geometric standards.

Access management is, in a sense, a new element of roadway design. Traditional roadway design addresses general geometric design features such as number of lanes, treatment of medians, and provisions of curbs, gutters, or shoulders. Access design and location recognizes that access control elements, just like traditional geometric elements, must progress in a logical manner that leads to improved travel capacity, safety, and maintenance of travel speeds.

Modern access management, in broad context, requires that land use planning and development be coordinated with transportation. It calls for land use controls and incentives that are keyed to development policies and transport system capabilities. It is how to maintain and transform roadside environments into safe, accessible, and viable areas in the years ahead. The challenge is to develop effective access standards

that find a balance between land development plans, and the functional integrity of the roadways that serve the developments and the region.

Current Practices

Most public agencies apply some form of access control to their streets and highways. These controls normally take the form of highway design standards, and driveway permit criteria. Traffic impact analyses are required to assure that any problems that might result from proposed developments are identified and ameliorated.

All state, counties, and cities provide full access control along freeways. Relatively few provide "partial" access control along expressways or arterials. Santa Clara's (California) expressway system is perhaps the most significant example combining control of abutting access with traffic signal controlled junctions. Several states differentiate between limited access (i.e., freeways) and controlled access (i.e., expressway, arterials). However, broadly based access management programs are the exception rather than the rule.

Colorado's decade-old access management code was the first comprehensive program developed and it has withstood the test of time. It has served as a prototype for access management codes in Florida and New Jersey.

Developers of activity centers and shopping centers appear more interested in the provision of access, rather than the control of access. Developers and administrators of large activity centers are more willing to develop planned access systems (and share in their costs) than those involved in small developments or strip centers. Some developers want activity centers to be viewed as "another CBD" with respect to freeway access; others expressed a need for more road capacity in the environs of their centers. However, for the most part, the concept of access management is neither clearly understood nor accepted. An important need remains to convey the benefits of access management to developers.

Program Development and Planning

An access management program should have a legal and regulatory basis that specifies its authority and scope, contains technical guidelines relative to permitted access such as spacing and design, and specifies means of enforcement. Complementary activities, usually by local jurisdictions, include zoning regulations, subdivision approval, site plan review, development ordinances, and driveway, building and occupancy permits.

An access management plan should complement comprehensive land use plans and show prospective developers where access can be provided. This plan should show by map and narrative where and how access can be provided. It should specify: (1) responsibilities of each of the participants for the improvements contemplated by the plan, (2) the manner in which the timing and sequence of construction of the improvements is to be implemented, (3) necessary provisions for temporary access pending completion of the improvements, and (4) expected future mitigation measures, including traffic limitations, for nonconforming lots.

The design and arrangement of commercial activities can enhance access management. Multiuse activity centers that integrate retail, office, residential, and recreational activities can reduce vehicle trips because many workers do not have to go elsewhere to shop or live. They provide opportunities for transit and pedestrian friendly design. Clustering activities, in contrast to traditional strip developments, can result in fewer, more carefully designed access points, reduce vehicle trips between proximate activities, and foster pedestrian and transit trips.

Legal Considerations

Access control techniques can be implemented with two basic legal powers: police power and eminent domain. This first power allows a state to restrict individual actions for the public welfare. The second power allows a state to take property for public use provided an owner is compensated for his loss. Police power provides sufficient authority for most access control techniques associated with highway operations, driveway location, driveway design, and access denials. A state must cite eminent domain when building local service roads, buying abutting property, acquiring additional right-of-way, and taking access rights. However, an agency usually may deny direct access by police power when alternate reasonable access is available.

States generally have adequate power to manage access as long as reasonable access is provided to property. Coordinating access policy into a clear and definitive regulation facilitates the use of the police power.

Each state should evaluate its legal powers for controlling access, because authority and interpretations vary from state to state. Certain techniques may not be legally feasible in a state that has neither the policy nor precedent to uphold them.

Access Application Procedure

Access application procedures should be modified to reflect allowable access and spacing requirements. The procedure should consider: (1) the classification of the roadway to which access is requested, (2) the type of access requested relative to the allowable access, (3) relevant spacing standards, (4) highway and intersection capacity, (5) geometric design considerations, (6) the type of proposed traffic control, (7) guidelines for access denial where reasonable alternative access exists, and (8) the need, if required, for any variances to access permit criteria.

Access Classification Systems

The allowable access between public highways and activity centers covers a broad spectrum. Seven levels of access have been defined for application to any state, county, or local road system. These levels range from full control of access (level 1, Freeways) to access control only for safety reasons (level 7, Local and Collector streets and frontage roads). Access level 1 governs limited access highways, and levels 2 through 6 apply to "controlled access" highways. The seven access levels, shown in Table S-1, may be modified to reflect design practices of specific agencies. These access levels should be keyed to the functional classification of the road system.

Direct property access should be discouraged or denied from strategic and principal arterials, except where no alternative access exists, or where it is in the public interest to do so. This is generally possible in undeveloped areas, but it may be more difficult to achieve in urban or suburban settings. Where access must be provided, it should be limited to right turns (access level 3), and to right- and left-turn entry and right-turn exit (access level 4).

Table S-1. Access classification system (access levels keyed to roadway type).

ACCESS LEVEL	DESCRIPTION OF ALLOWABLE ACCESS	ROADWAY CLASSIFICATION	GENERAL ROADWAY DESIGN FEATURES
Level 1	Access at Interchanges Only (Uninterrupted Flow)	Freeway	Multi-Lane, Median
Level 2	Access at Public Street Intersections or at Interchanges Only (Uninterrupted Flow)	Expressway	Multi-lane, Median
Level 3	Right Turn Access Only (or Access at Interchange) (Uninterrupted Flow)	Strategic Arterial	Multi-Lane, Median
Level 4	Right and Left Turn with Left Turn Lane In and out Required (Interrupted Flow-Both Directions)	Principal Arterial	Multi-lane, Median (a)
Level 5	Right and Left Turn with Left Turn Lane In and Out Required (Interrupted Flow-Both Directions)	Other Arterial	Multi-Lane or 2-Lanes
Level 6	Right and Left Turn In and Out with Left Turn Lane Optional-In and Out (Uninterrupted Flow-Both Directions)	Collector	2-Lanes
Level 7	Right and Left Turn In and Out (Safety Requirements Only)	Local/Frontage Road	2-Lanes

(a) Might be two lanes in some rural areas

Access Spacing

Access spacing guidelines should be keyed to allowable access levels, roadway speeds, and operating environments. They should apply to new developments and to significant changes in the size and nature of existing developments. They do not have to be consistent with existing practices. Because of historical conditions, access to land parcels that do not conform to the spacing criteria may be necessary when no alternative reasonable access is provided; however, the basis for these variances should be clearly indicated.

The spacing guidelines should minimize the need for variances or exceptions, while simultaneously protecting arterial traffic flow. They should view driveways to major activity centers as intersecting arterial roads rather than as curb cuts.

Signalized Intersections. Traffic signal spacing criteria should apply to both intersecting public streets and access drives. They should take precedence over unsignalized spacing standards where there is a potential for signalization. Ideally, locations of signalized intersections should be identified first. Unsignalized right- and left-turn access points should be selected based on existing and possible future signal locations.

Cycle lengths should be as short as possible and cycle lengths of more than 120 sec should be avoided. Excessively long cycle lengths result in long delays. They indicate a need for corrective actions such as interchanges, rerouting left turns, or by improving the secondary street system to reduce left-turn volumes.

To assure efficient traffic flow, new signals should be limited to locations where the progressive movement of traffic will not be impeded significantly. The "optimum" distance between signals — where there is no loss in the through band width — depends on the cycle length and the prevailing speed. When signals are placed at other locations, there is a loss in band width and delay increases. When two major roads with the same access level intersect, the maximum specified band width never exceeds 50 percent.

Driveway signalization in conjunction with highway access should be permitted only when specified minimum band widths are attained or exceeded at designated operating speeds, and there is a proven need for the signal. Signal needs should be based on traffic projections for a 5-year period after a development is occupied, and potential locations should be coordinated with future public street signal needs.

Unsignalized Driveways. Unsignalized driveways influence all kinds of activity, not merely large activity centers. Traffic operational factors leading toward greater spacing of driveways (especially medium and higher volume driveways) include weaving and merging distances, safe stopping sight distances, acceleration rates, and storage distances for back-to-back left turns. From a spacing perspective, these driveways should be reviewed as public streets.

There is wide diversity of opinion regarding the spacing of unsignalized driveways. Strict application of traffic engineering criteria may push spacing requirements to 500 ft or more. However, such spacings may be unacceptable for land use and perceived economic reasons in many suburban and urban environments where development pressures opt for 100- to 200-ft spacing. Spacing guidelines should achieve a reasonable balance between these conflicting requirements. They should reflect access categories, roadway speed, and size of traffic generator. They should apply to both private driveways and unsignalized public streets where there is little likelihood for future signalization. Where signalization is imminent or likely, the signal spacing guidelines should take precedence.

Access points involving left-turn egress should be located where they would conform to coordinated signal spacing requirements wherever possible, and in all cases where median breaks are involved for major traffic generators. If future volumes warrant installing a traffic signal and signalized spacing requirements cannot be met, left-turn access should be considered for closure in one or both directions. If an undivided roadway becomes divided, left-turn access should also be considered for closure in one or both directions.

The spacing of right-turn access on each side of a divided roadway can be treated separately. However, where left turns at median breaks are involved, the access on both sides should line up or be offset from the median break by at least 300 ft.

On undivided roadways, access on both sides of the road should be aligned. Where this is not possible, driveways should be offset by at least 150 ft, when two minor traffic generators are involved, and 300 ft when two major traffic generators are involved.

All intersections of driveways with public highways should have adequate safe stopping sight distance. This is a design requirement rather than an access spacing guideline. Some agencies use safe stopping sight distance as the basis for unsignalized driveway spacing.

Median Openings. Median openings should be provided at signalized intersections and at unsignalized junctions of arterial and collector streets. They may be allowed where necessary and should be designed to minimize the impact on roadway flow. Ideally, the spacing of such breaks should be conducive to signalization. Median openings at driveways should be subject to closure where traffic volumes warrant signals and signal spacing criteria cannot be met. Storage and deceleration for left-turning vehicles should be adequate where openings are provided. Suggested minimum spacings range from 330 to 660 ft in urban areas and 660 to 1,320 ft in suburban and rural areas for access levels 4, 5, and 6.

Grade Separations. Grade separations may be appropriate where: (1) two expressways (i.e., access level 2) cross, or where an expressway crosses arterial roads (access levels 3, 4, and 5); (2) strategic or principal arterials (access levels 3 and 4) cross and the resulting available green time for any route would be less than 40 to 50 percent; (3) an existing at-grade signalized intersection along an arterial roadway operates at level of service "F" and there is no reasonable way to provide sufficient capacity; (4) a history of accidents indicates that a significant reduction in accidents can be realized by constructing a grade separation; (5) a new at-grade signalized intersection would result in levels of service "E" in urban and suburban settings and level of service "D" in rural areas; (6) signalization of the access point would impact the progressive flow along the roadway and there is no other reasonable access to a major activity center; (7) a major public street at-grade intersection is located near a major traffic generator and effective signal progression for both the through and generated traffic cannot be provided; and (8) the activity center is located along a major arterial where either direct access or left turns would be prohibited by the access code or otherwise would be undesirable.

Design Concepts and Criteria

Access planning and design should coordinate the three components of the access system — public roadway, private roadway, and the activity center site itself. All three must be treated as part of an overall system because neglecting one would merely transfer rather than alleviate problems. The specific techniques are simple and straightforward. They call for sensitive and sensible applications of established traffic engineering and roadway design principles. They involve: (1) limiting the number of conflict points, (2) separating conflict areas, (3) reducing acceleration and deceleration impacts at access points, (4) removing turning vehicles from through travel lanes, (5) spacing major intersections to facilitate progressive travel speeds along arteries, and (6) providing adequate on-site storage. The key is to apply these techniques in a coordinated way that preserves the integrity of arterial traffic flow while providing essential access to developments.

Critical intersections on the public road system in the vicinity of an activity center should be improved as necessary to avoid transferring problems from the immediate site environs to other locations along key arterial roads. Freeway (and expressway) interchange and service road designs should be integrated into the overall site access system, to maximize site access, better distribute site traffic, minimize delay, and maintain roadway speed. In all cases, however, the integrity of mainline traffic operations must not be compromised.

Access design should permit the safe and efficient processing of cars, service vehicles, and buses from public roadways onto access drives and into parking areas. This involves establishing the length and taper of auxiliary turning lanes, driveway turning radii, width and storage, and the appropriate traffic controls. Sensible application of established standards is necessary to assure safe and orderly traffic flow and to protect public agencies from tort liability. Applications should allow flexibility to avoid precluding viable operational solutions, especially in retrofit situations.

CHAPTER 1

INTRODUCTION AND RESEARCH APPROACH

IN BRIEF This report defines the overall concept of *access management,* reviews the state of the art and current practice, and sets forth basic policy, planning, and design guidelines. The guidelines cover (1) legal and institutional bases for controlling access, (2) access permit procedures and studies, (3) access categories (levels) and spacing standards, and (4) design concepts and criteria.

1.1 RESEARCH PROBLEM STATEMENT

Residential, commercial, and industrial development continue to proliferate along streets and highways throughout the United States. Accessibility and market forces play an important role in determining where development takes place. Development trends have brought about a dramatic change in the American areas; (6) signalization of the access point would impact the progressive flow along the roadway and there is no other reasonable access to a major activity center; (7) a major public street at-grade intersection is located near a major traffic generator and effective signal progression for both the through and generated traffic cannot be provided; and (8) the activity center is located along a major arterial where either direct access or left turns would be prohibited by the access code or otherwise would be undesirable.

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1.1 RESEARCH PROBLEM STATEMENT

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Major freeway interchanges and arterial road junctions have become focal points for new shopping centers, industrial parks, and office complexes. Urban and suburban arterial roadways are now lined with strips of roadside developments. The examples are many, and the scale is national. The roadsides along the Beltways around Baltimore, Washington, Houston, and many other cities, along radial freeways such as the Long Island Expressway and Santa Ana Freeway, and along arterial highways such as Sunrise Highway in New York, Skokie Highway north of Chicago, and Routes 1 and 9 in New Jersey illustrate the scale, character, and impacts of the surrounding developments.

At first the new developments were seen as a means of strengthening suburban growth and expanding the local tax base. Some projects were well planned with respect to roadway access, internal circulation, and building arrangements. But for the most part—from the Boston Post Road in Connecticut to Ventura Boulevard in California—the new developments have increased traffic flows and conflicts on the road system. Their many points of entry and exit add to conflicts, reduce safety, and contribute to the overall deterioration in traffic flow.

In partial response to these conditions, many public agencies have established roadway and driveway standards and have prescribed permit procedures for new or expanded developments. In addition, traffic impact studies are widely used to: (1) assess the traffic consequences, (2) determine needed traffic and transportation facility changes, (3) identify possible traffic mitigation improvements, and (4) establish funding responsibilities.

However, design criteria, driveway permit procedures, and traffic impact analysis requirements fall far short of maintaining desired operations levels of service on the affected roadways. Too often, traffic impact studies are done separately for specific projects and fail to consider the accumulative impacts of nearby or closely spaced developments with a multiplicity of curb cuts, intersections and traffic signals. The broader system implications of an additional driveway or traffic signal are overlooked.

Traffic impact studies typically deal with specific sites. The cumulative impact of a series of projects along a given highway, and an integrated design for the entire section of highway, often is lacking. The "single site approach" to minimizing impacts commonly results in varying road cross sections, rather than achieving a coherent and consistent roadway design. There is an obvious need for broader approaches that deal with collective, rather than individual, access requirements.

In some areas, public agencies rely on developers to provide the roadway improvements that could have been part of the existing road design, or should be part of an overall design to better meet traffic requirements.

Emphasis on geometric "design standards" rather than "operational techniques" limits the opportunities for and effectiveness of many treatments. Excessive delays resulting from unduly long traffic signal cycle lengths or complex phase arrangements are examples of these conditions.

Problems of equity may arise when a given developer must pay for improvements which later benefit other access; for example, a second developer with equal impacts may not be assessed to the same degree, because the problems already have been solved and financed by an earlier developer.

Many state agencies, by law, cannot designate "master plans" nor can they specify building setback requirements. The integration of land use design and roadway design varies significantly by state and between the various governmental agencies within a state.

It is difficult for many public agencies to control access onto roads other than freeways. On high-type roads, median islands sometimes preclude crossings and left turns, but controlling right-turn access is more difficult.

Access design and frequency has not been adjusted according to the roadway's importance in the system. All too often the "major" arterial has the greatest number of high volume driveways thereby severely restricting its ability to provide capacity for regional transportation requirements.

In broad perspective, there is usually a lack of effective access control. The problem is compounded by the wide differences in current practice and the absence of systematic bases for providing, designing, and limiting access. Thus, there is a need to identify better methods for applying and implementing access management practices to different classes of highways within the vicinity of activity centers. It is desirable to balance movement and access functions in a way that preserves the integrity of the road system while simultaneously providing reasonable access to adjoining property.

This need is most acute along the arterial road system. While freeways are designed with complete control of access and are largely protected from adjacent land developments, and local residential streets emphasize property access rather than movement, arterial streets and highways and collector roads must serve both *access* and *movement* needs. It is along these roads where the major problems of driveway access and traffic congestion are found—where political pressures too often take precedence over engineering and planning decisions. It is here where the emphasis on access management must be placed.

The challenge is how best to provide necessary site access while maintaining traffic mobility, how to achieve safe and efficient traffic flow by managing the access to and from adjacent properties, how to preserve investments in streets and highways by better managing access along public highways and within activity centers.

1.2 RESEARCH OBJECTIVES

This research was undertaken in response to the need for more consistent and efficient roadway access management practices. It is designed to produce a single reference source on the planning and application of access management actions. The specific project objective, as specified in the NCHRP Research Problem Statement, is "to develop policies and guidelines to preserve and improve the capacity and safety of the overall highway system within and in the vicinity of activity centers through better management of access control. These guidelines would apply to: (1) modification of access control on streets and highways where activity center development has already occurred, (2) planning access control in newly developed areas, and (3) management of access control within activity centers."

The research contains practical guidelines pertaining to policy, procedure, design, and operations. These guidelines show how to preserve the capacity and performance of the overall road system and how to maintain the planned integrity of the road system while providing efficient access to and from adjacent activity centers. They include possible legislative changes and enforcement procedures, as well as strategic design and operating guides. They are prepared for use by state highway agencies, city and county traffic and planning agencies, and private developers.

The research brings together the state of the art in access management, and — building on these materials — develops policy, planning, and design guidelines. It addresses questions such as: *How* do public agencies (state DOTs in particular) manage and control access? What policies and procedures exist at various levels of government? How are these policies perceived by developers?

What are the strengths and weaknesses of existing approaches, and how might they be changed? What are the successes and failures? What legal mechanisms exist for controlling access? Are changes needed in the legal or institutional framework? What additional legislation may be needed? Are there model access codes that may have general applicability?

What access management guidelines are appropriate for the various roadway types, operating environments, and activity centers? How can they be used by the public and private sectors to rationalize road access? How can planning and coordinating activities be improved? How can development intensity be better keyed to transport capacity?

What additional legal, design, and operational research, if any, is required?

1.3 RESEARCH FOCUS

The initial research focus was placed on access management for streets and highways in the vicinity activity centers. It became apparent that many activity centers — especially the "major" activity centers — have well planned and managed access systems. The need for better access management was more imminent in the environs of smaller activity centers and along the miles of strip developments that line city streets and suburban highways. Therefore, in developing access management guidelines, consideration was given to both activity centers and strip developments.

Activity centers vary mainly in size, type, and diversity. They range from a small community shopping center or free standing supermarket to a major multiuse development.

Major activity centers are characterized by a large transient population, and heavy traffic volumes and densities. They may include central business districts, major air terminals, large universities, regional shopping centers, industrial parks, medical facilities, and civic centers (*1*).

Large scale multiuse suburban centers are characterized by: (1) at least 5 million sq ft of office and retail (sometimes residential and hotel) space, (2) at least 600,000 sq ft of retail space, and (3) more employees than residents (*2*).

1.4 RESEARCH PLAN

The overall research plan includes five basic tasks (outlined in Figure 1-1).

1. State and local governments, and activity center developers and managers, were interviewed to identify (a) current successful practices for management of access to activity centers, and (b) problems currently experienced on highways and streets in the vicinity of activity centers. The goal was to identify both successful and unsuccessful on-going activities and actions that could provide a basis for an updated set of guidelines. The surveys were summarized in an interim state-of-the-art report. The pertinent findings are also contained in this document.

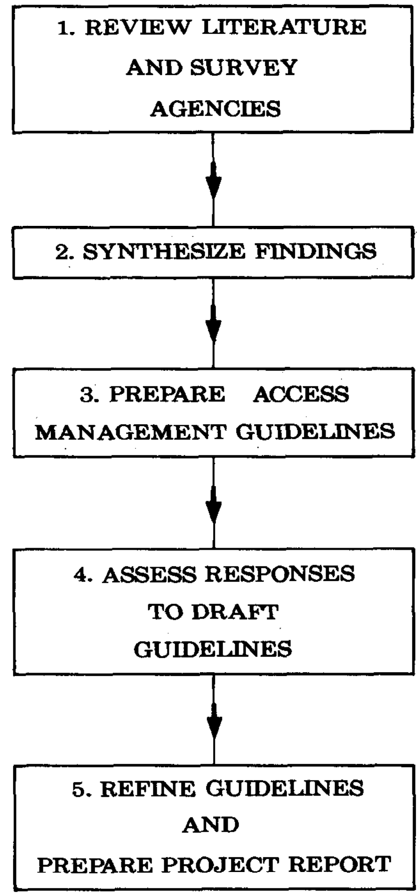


Figure 1-1. Research steps.

2. Draft guidelines for managing access on streets and highways in the vicinity of activity centers were prepared. These guidelines show how a coherent system of access can be provided in the vicinity of activity centers that reflects the type of highway, the surrounding environment, and the nature and size of the development. These draft guidelines were submitted to the NCHRP project panel and to a representative sample of survey respondents for review.

3. A summary and interpretation of respondent review comments was prepared and discussed with the NCHRP project panel.

4. A revised set of guidelines and the final project report was prepared.

1.5 THE ACCESS MANAGEMENT CONCEPT

Traffic and transportation engineers have developed and refined many methods for improving flow along city and suburban streets, rural roadways, and freeways over the past decades. They have shown how coordinated roadway design and traffic operations can reduce delays, cut accidents, and increase capacities. They have shown how traffic signal systems, curb parking restrictions, turn lanes and controls, median islands and intersection channelization can work together to improve traffic operation.

But these operational techniques alone do not offset the effects of poorly located and poorly planned or designed access to neighboring land. Nor can they always accommodate the large increases in traffic superimposed on existing roadways by major new developments that are placed without regard to the traffic carrying capabilities or operational requirements of the surrounding road system. The inability to effectively apply design standards and to coordinate land use with transportation has led to the need for improved access management.

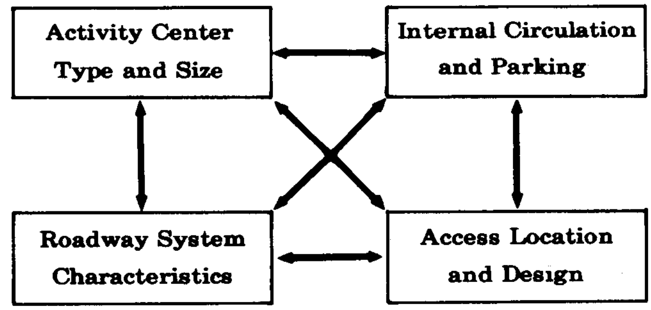


Figure 1-2. Access management system.

Definition

The concept of access management has emerged in response to the need to balance movement and access functions. It may be defined as follows: *Access management is the process that provides (or manages) access to land development while simultaneously preserving the flow of traffic on the surrounding road system in terms of safety, capacity and speed.*

Access management is a relatively new approach to coordinating transportation with land development by using a comprehensive set of design and operational policies. It is a new philosophy of access control that applies to all types of roads and streets. It calls for establishing access management guidelines for various types of roadways, for keying access location to the guidelines, and for the design of access that is compatible with the purpose of roadway and the size of the activity center.

In some ways, there is nothing new about access management that was not already known in past decades. What is new is the decision to extend the concept of access control to arterial roadways by committing to higher comprehensive standards and establishing the legislative authority to implement them. Three state legislatures (Colorado, Florida, and New Jersey) have viewed access management as the preservation of the functional integrity of roads to reduce capital expenditures, preserve public safety, increase arterial capacity, and improve traffic flow.

Elements

Access management includes: (1) classifying road systems based on their areawide importance into a logical functional hierarchy; (2) planning, designing, and maintaining roadway systems based on criteria such as functional classification and road geometry; (3) defining acceptable access for each class of roadway that does not degrade its function in the hierarchy (this involves determining when and where access can be permitted and setting appropriate standards for the spacing of access points); (4) applying appropriate geometric design criteria and traffic engineering analysis to each allowable access; and (5) utilizing driveway permit procedures and regulations to assure that decisions are reasonably enforceable and that the governmental agency can maintain control over roadway operation, and design.

The extent of access management will vary, depending on location, development type and density, and the nature of the road system. It can be achieved through a set of policies which, when translated into design guidelines and enforcement actions, identify where and how access can be provided. Typical elements include (1) guidelines and standards that define allowable access levels for various classes of roads, (2) access spacing criteria, (3) a mechanism for granting variances when site specific and historical conditions require a nonstandard solution, and (4) a means of enforcing standards and decisions.

Access management views the highway and its surrounding activities as part of a single "system." Components of the "system" include the activity center and its circulation system, access both to and from the center, the availability of public transport, and the road system serving the center. All are important and interact with each other (see Figure 1-2) to and from the activities along it.

Thus, access management extends traffic engineering principles to the location, design, and operation of access drives serving activities along the highway. It evaluates the suitability of the site for given developments from an access standpoint. It also identifies the need to maintain the utility of the roadway to serve nonactivity center needs, i.e., the through movement. It is, in many respects, an effective application of transportation system management where the town planner, traffic engineer, and developer can work together. But it is far broader as well, for it addresses the basic questions—when and where should access be provided or denied, and what legal institutional changes are necessary to reinforce this decision?

It draws upon the contemporary knowledge of interrelationships between land development and traffic. In the past, even when the planner and traffic engineer worked together, they did not have sufficient information or desirable standards to reference or support their decisions.

Access management actions involve both the design of new roadways and the retrofitting of existing roadways and driveways. Existing roadways and driveways can be retrofitted by building frontage roads; installing medians; closing or redesigning median openings; consolidating, relocating, reconstructing or closing driveways; and separating roadway grades. Transportation demand management (TDM) and transportation system management (TSM) can be viewed as complementary actions for activity centers.

Methods

The degree of access control and management is determined by statute, regulation, land use ordinances (zoning), and operational and geometric engineering and design standards.

Access Control by the Transportation Agency. Every state and local transportation agency has basic statutory authority to control all aspects of highway design to protect public safety, health, and welfare. The extent to which the agency can develop specific standards for driveways, traffic signal location, land use controls, and denial of direct access as it impacts the highway may be specifically addressed by legislation and to some degree by the state courts.

Access Control By Deed. States, counties, and cities have the basic right to acquire access rights. This is how freeways, many expressways, and in some cases, arterial highways are protected. Examples include the Interstate Highway System, the Westchester County (New York) Parkway System, Santa Clara County (California) expressway system, and Wisconsin's principal (rural) highways. The purchase of access rights may be expensive and time-consuming as compared to access regulation, but the purchase of access rights is a stronger and longer lasting solution. Regulations can change with political administrations and attitudes.

Access Control by Land Use Ordinance. Land use control is normally the authority used by local governments. Local zoning ordinances and subdivision standards specify site design, setback, parking and other elements that influence the type, volume and location of traffic generated.

Access Control by Driveway Regulation. Agencies may develop specific access and driveway standards by guidelines, regulation, or ordinance, provided there is specific statutory authority and do so within the limits of the legislation. Usually guidelines need no specific authority, but are very weak legally. Cities can pass ordinances containing access control standards. State agencies may develop regulations when authorized by enabling legislation. Once regulations or ordinances are passed, the effectiveness of access control depends on the standards and procedures contained. Regulations cannot "take" access rights; they can only regulate those rights in a reasonable and justifiable manner.

Agencies may specify how and where driveways can be provided for various types of roadways and developments. They can define allowable access for various kinds of highways and set appropriate driveway spacing standards and design requirements. These regulations may take the form of access codes as found in Colorado, Florida, New Jersey, or regulations as set forth in several other states.

Access Control by Geometric Design. Geometric design features, such as grade separations, frontage roads, median closures, and intersection channelization, control access. As in roadway design and construction projects, access design and construction standards and decisions may simply proceed with the authorization of a licensed engineer without the use of a specific access guideline or regulation. The degree to which agency engineers wish to follow and enforce good engineering judgment for access depends on their strength of character and the availability of reasonable and specific standards for reference and justification. Although the method is the most flexible, it is very piecemeal and difficult to enforce; therefore, it is open to inconsistencies and abuse.

Key Decisions

The key issues and options with regard to providing and managing activity center access include the following: (1) Should full access be provided between the development and the highway? Will the public be better served? Is more than one direct access necessary? (2) Should certain access turning movements be restricted? (3) Where should the access points be relocated relative to access to existing and future developments and nearby intersections? (4) To what extent should the access points be spread to separate conflicting turns into and out of the sites? (5) Should access be allowed only along secondary streets and prohibited along the arterial highway? (6) How can shared-access points be encouraged for existing developments? (7) How many access points are required for traffic operations and capacity versus how many are desired by the developer?

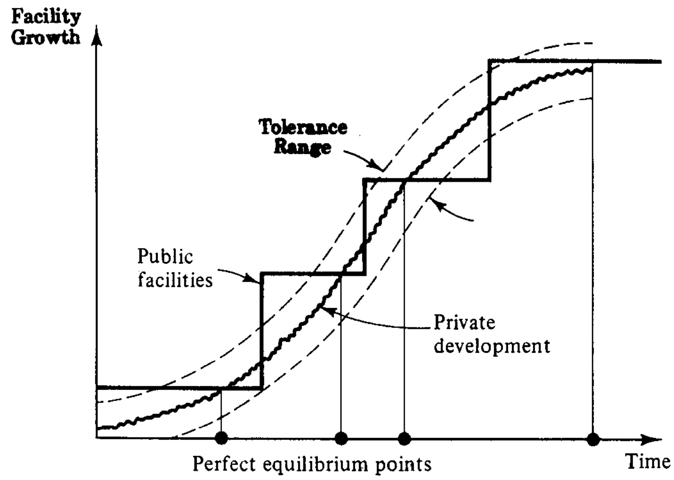


Figure 1-3. Land development vs. transportation facilities. (Source: Winick, R. M., "Balancing Future Development and Transportation in a High Growth Area," Institute of Transportation Engineers, 1985).

The general sequence of site access decisions as seen from volume-to-capacity and safety perspectives are: Should the access point(s) be modified, restricted, or prohibited? Should the size of the development be reduced or the type of development changed? Should the development be deferred until needed highway improvements are accomplished, or be prohibited because of adverse impacts?

These questions are normally addressed through traffic impact studies. Whenever possible, the impact studies should evaluate the combined impacts not only of the proposed development but also of the other likely developments along the major roadways. Thus, the typical "traffic impact study" for an individual development should be broadened by simultaneously assessing the collective impacts of many developments.

Each of these decisions calls for close cooperation between developers and public agencies. The goal is not to limit new development, per se, but rather to assure that it can be effectively managed from a transportation perspective.

Design Options

The specific design solution will depend on the type of highway, and the type and size of development. As an example, access points to a large regional shopping center are more in number and greater in capacity than those serving a small residential development.

The traffic design and operational techniques are simple and straightforward. They include better control of conflict points, separation of turning and through traffic, and coordination of access points with both the arterial roadway system and the internal circulation system. What is involved is their sensible, sensitive, systematic, and coordinated application with a high degree of quality control.

1.6 BENEFITS OF ACCESS MANAGEMENT

Inadequate and ineffective access management underlies the operational deterioration of many streets and highways. Insensitive or haphazard approaches to providing land access will erode a road's ability to serve surrounding land and the lack of a well-designed and effectively enforced access policy can lead to numerous curb cuts and driveways that make it difficult to enter, leave, or pass by adjoining developments. Inadequately designed and improperly located driveways, excessive and poorly coordinated traffic signal controls, and insufficient storage areas on access roadways contribute to accidents, confusion, and congestion. And, more importantly, they can degrade the character and capacity of the arterial street system. These problems persist at both small and large activity centers.

Without effective access management, communities are often faced with a chain of events that requires constant investment in roadway improvements and relocation. There is, in effect, a business growth and roadway improvement need in which increased business activity results in increased traffic that leads to roadway improvements, and, in turn, additional business activity. The problem exists because business development normally increases at a relatively steady rate, while roadway improvements come about in defined steps of improvement to provide an increase in the quality of traffic service. As business activity increases, there is a corresponding increase in the number of conflict points, and, over a period of time, traffic flow is eroded despite continued improvements. The growing number of conflict points increases delay and reduces safety.

It is better to thing of the balance between land development and transportation facilities represented by a tolerance range. The range in the tolerance level, as shown in Figure 1-3, can be increased by the use of efficient access management techniques. The level of transportation service required for ultimate buildout may not be attainable because of its high costs and extensive impacts.

Carefully conceived and well-implemented access management policies and programs can save tax dollars, time, and lives. They can preserve highway capacity and provide access to surrounding activities. They can achieve these goals without requiring large investments of capital funds for massive road reconstruction.

Effective access management translates into higher travel speeds, fewer traffic delays, and improved safety. By implementing one or a combination of traffic management techniques that minimize the adverse effects of vehicle conflicts, safety can be improved, delays reduced, and major capital expenditure postponed or eliminated (*3*). When traffic signals are too closely spaced, traffic will stop more often and travel times are increased. However, when signals are spaced farther apart, coordination is improved and stops, with associated delay, are reduced.

Control of driveway frequency and spacing will also produce safety benefits because the number of businesses, intersections, and driveways per mile has been found to influence the accident rate.

Figure 1-4 shows how the accident rate rises on 4-lane divided, noninterstate highways as the number of businesses and the number of at-grade intersections per mile increase. Table 1-1 indicates benefits that can be expected from the implementation of several access control management techniques. Table 1-2 shows how the accident rate rises as the number of intersections and businesses per mile increases.

The social and environmental aspects of access management also must be considered. When roadways are widened or relocated to new rights-of-way, dislocation of people and business is often the result. Natural features and landscaping are sometimes altered to the detriment of the community. Many access management techniques offer a viable alternative to major road construction.

1.7 ORGANIZATION OF REPORT

The chapters that follow provide general guidelines for developing access management programs. Chapter 2 summarizes current practice. Chapters 3, 4, and 5 describe legal, administrative and planning considerations, actions, and requirements. Chapters 6 and 7 define access classification systems and spacing criteria. Chapters 8 and 9 present design concepts and guidelines. Chapter 10 contains implications and directions. The appendixes

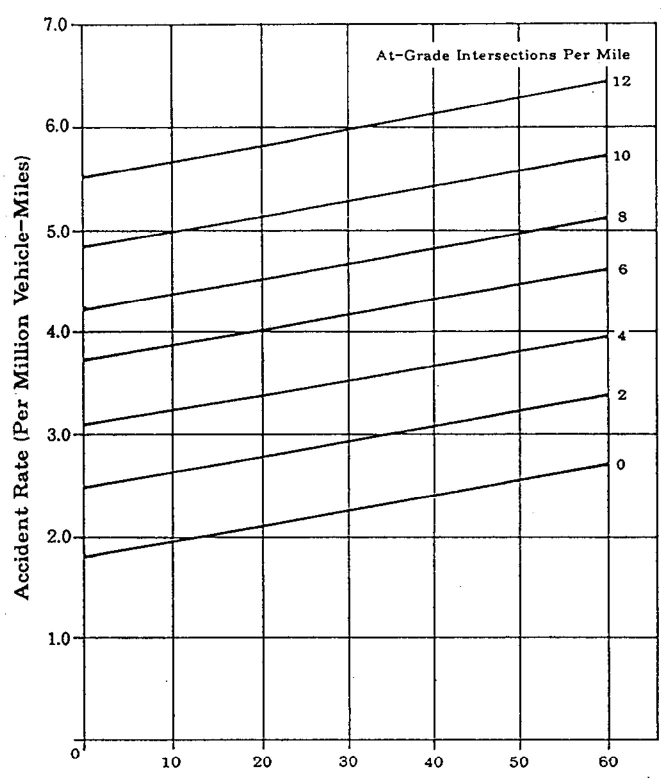
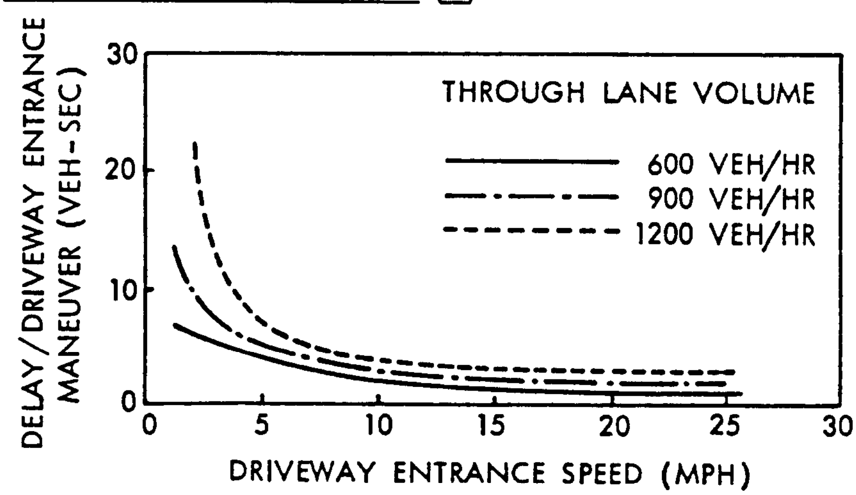


Figure 1-4. Accident rate (per million vehicle-miles). (Adapted from Fee, J. A., et al., "Interstate System Accident Research Study 1," U.S. Department of Transportation, Federal Highway Administration, October 1970).

Table 1-1. General benefits of access control management techniques. (Source: "Access Management for Streets and Highways," Federal Highway Administration, *Report FHWA-IP-82-3*, June 1982).

- **Two-Way Left Turn Lanes: 35 percent reduction in total accidents (7, 8).**
- **Alternating Left Turn Lanes: 28 percent reduction in total accidents (9).**
- **Driveway Width Controls: 0.40 accidents reduced annually per driveway (10).**
- **Visual Cues For Driveways: Suspended red-yellow flashing beacon at a single commercial driveway – 53 percent reduction in total accidents; advance warning sign and flashing beacon – 24 percent reduction in total accidents; and driveway illumination – 42 percent reduction in total accidents (11).**
- **Left Turn Deceleration Lanes: 50 percent reduction in total accidents (12, 13).**
- **Driveway Accident Breakdown: Right turn enter – 15 percent of total accidents; right turn exit – 15 percent of total accidents; left turn enter – 43 percent of total accidents; left turn exit – 27 percent of total accidents (10).**
- **Delay Versus Driveway Entrance Speed: (14)**



- **One-Way Operations: 25 percent reduction in total accidents (15); 25 percent reduction in delay (16).**
- **Parking: 15 percent reduction in total accidents by preventing parking on the traveled way (16, 17).**

Table 1-2. Effects of intersection and businesses on accident rates. (Source: *A Toolbox for Alleviating Traffic Congestion*, Institute of Transportation Engineers, Washington, D.C., 1989, M.D. Meyer, Ed.).

INTERSECTIONS PER MILE	BUSINESSES PER MILE	ACCIDENTS PER MILLION VEHICLE MILE
0.2	1	126
2.0	10	170
20.0	100	1718

provide examples of current practice, spacing guidelines, access codes, and related supporting information.

The guidelines are intended to aid state, regional, and local agencies in developing access management programs. Some flexibility in their application should be considered to reflect specific local conditions, policies, and precedents.

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2. Hooper, K.G., "Travel Characteristics at Large-Scale Suburban Activity Centers." *NCHRP Report 323*, Transportation Research Board, National Research Council, Washington, D.C. (Oct. 1989).

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CHAPTER 2

CURRENT ACCESS MANAGEMENT PRACTICES

IN BRIEF The concept of "access management" has emerged steadily over the past decade. It has received growing attention by state, county, and local governments. Governmental policies vary greatly among states, counties, and cities, reflecting differing precedents, perspectives, and needs. This chapter summarizes current access management practice. Its findings and analyses are based on a literature review and surveys of public agencies, developers, and activity center representatives. Its objectives are to: (1) summarize and assess the state of the art, (2) identify successful practices for management of access along major streets and highways in the vicinity of activity centers, (3) indicate problems encountered in applying access management techniques, and (4) suggest emerging directions for establishing access management guidelines. The following sections summarize the state-of-the-art survey, identify the more promising access management programs, cite successful applications, and indicate key implications. Case studies of selected access management programs are included in the appendixes.

2.1 STATE-OF-THE-ART SURVEY

A "state-of-the-art" survey was conducted to establish a data base on which to build a series of access management guidelines. Public agencies and private developers were canvassed for their current practices and policies, relevant codes and regulations, design standards and manuals, and perspectives on the viability and workability of various policies. Respondents provided a broad cross section of groups involved in access management.

Survey Design

In August 1989, 221 survey questionnaires were sent to various governmental agencies, developers, and consulting firms involved with providing access to all types of land development. Questionnaires were sent to the State Traffic Engineer in each state plus, depending on state population and land use density, selected State District Engineers. The questionnaires were also sent to the Engineer or Director of Public Works of city and county agencies, whichever applied, and to select private consultants and developers.

The primary purpose was to ascertain the state of the art of access management practices, policies, and designs. The goals were threefold: (1) to obtain a reasonable representation by geographic location, city or county size, and types of access control; (2) to assess current programs, policies, and perspectives; and (3) to identify innovative approaches to access control and management.

Initial Questionnaire. A total of 80 responses were initially received, representing an overall return of 36 percent. Discussions with traffic engineers from several large cities indicated a lack of available or enforced policies and a "we do what we can" approach to access management; therefore, they did not respond to the questionnaire.

Table 2-1. Survey responses.

ORGANIZATION	SENT	RESPONDED	PERCENTAGE
State Traffic Engineer	50	45	90%
State District Engineer	23	3	13%
City	99	25	26%
County	32	11	34%
Council of Governments	6	6	100%
Private	17	11	65%
TOTALS:	225	101	45%

To supplement the responses, primarily at the state or large city level, individual telephone calls were made to some cities and states that had not returned a questionnaire.

Supplemental Survey. Because of the low response of private developers to the original questionnaire (3 out of 17), a special letter was sent to nonresponders, and then followed up with a telephone call. The telephone survey not only increased the overall data base, but, more importantly, it increased responses from the private sector. A noteworthy finding was the unanimous opposition by private developers to legislated access management standards and policies. However, they also agreed the uniform guidelines, if applied equally, would be beneficial to all those concerned with safe and efficient traffic movement.

Survey Coverage. The final results of the combination of questionnaires and telephone conversations are summarized in Table 2-1.

The survey responses were uniformly distributed with respect to geographic location and type of agency. An excellent response was obtained from state traffic engineers. In contrast, relatively few large, densely developed cities responded to the survey. This may reflect the limited need for access management in view of development prospects and development parcel constraints. It may also reflect a lack of concern in view of local political realities.

Survey Overview

An overview of current practice indicates that 71 percent of the governmental agencies have some type of formal access policy, and that 78 percent of these policies have been legislated into law. Seventy-three percent of the agencies stated that their current policies should be updated.

Most public agencies have established design standards and have defined procedures for assessing traffic impacts or obtaining driveway permits. However, only a few agencies, usually states, have newer comprehensive access management policies.

Most states, cities, and counties have some type of roadway design standards. These standards often include design elements for driveways and, in some cases, they contain guidelines for spacing of driveways. A limited number of guidelines cover types of generators and setbacks from nearby intersections. Often, those standards merely adapt AASHTO or ITE design criteria. Seventy-seven percent of the policies varied by roadway speed, volume, or functional class.

However, comparatively few public agencies have formal access policies that specifically relate the type and frequency of access to the class of roadway. Moreover, most public agencies find it difficult to distinguish between access management codes, policies, impact studies, "driveway policies," and permit procedures. While many policies actually encompass driveway design and spacing requirements, such requirements normally do not vary by highway classification or allowable access.

Traffic impact studies are used widely by public agencies to assess impacts, to identify needed improvements, and in some cases to establish funding responsibilities. Seventy-nine percent of the policies included requirements for some form of traffic impact analysis (TIA).

Traffic management associations (TMAs) and transportation systems management (TSM) plans are popular in a few large metropolitan areas. However, survey respondents, both public and private, hardly identified those approaches. Twenty-six percent of the policies included an incentive for a TSM program.

A review of current access management practice indicates that the control of access is commonly separated into three categories: full control, partial control, and uncontrolled.

Driveway geometric design and sight distance criteria are, for the most part, well defined. However, warrants for developer constructed auxiliary turn lanes are not.

Driveway spacing is sometimes included, but the distances vary by location throughout the United States. There are few explicit requirements regarding the spacing of signalized access drives.

Functional road classification schemes are common, but are associated with allowable access or access frequency in only a few cases.

Most access codes and driveway policies have been upheld by the courts. The methodology used to obtain access permits is usually well defined.

Several pertinent comments permeated the surveys: (1) The concept of access management varies and lacks consistent definition. (2) Access management is usually a public sector responsibility. (3) Formal access management policies should be adopted, incorporated into law, and enforced. (4) Some degree of consistency should exist among state, county, and city policies. (5) Policies that have been upheld in a court challenge have, for the most part, been formally adopted by the state, county, or city. (6) The effectiveness of policies should be reviewed and evaluated on a regular basis. (7) Policies should be simple and straight forward, but should show flexibility in application. (8) Policies should vary depending on roadway classification, speed and volume, and a development's type and size. (9) Large activity centers should be afforded additional freeway access. (10) Developers of large activity centers are more amenable to access management policies than developers of small projects.

Current Policies

Most cities, counties, and states have driveway design standards, permit procedures, and traffic impact requirements. They perceive these as access management, but they fail to distinguish between them and a more comprehensive program.

Access Management Programs—States

Existing access management programs are concentrated in a few states. Except for New Jersey and Florida, no comprehensive programs were found in the more urbanized states or major cities. Thus, where the need is greatest, the programs are least extensive.

Eight states have what might be considered as comprehensive access management programs. These states are Colorado, Florida, Idaho, Nebraska, Washington, Wisconsin, and to a lesser extent, Minnesota. New Jersey, in response to a state legislative mandate, is completing its plan. Oregon has conducted extensive research, but has not as yet prepared a formal plan or code.

State laws, administrative policies, and design manuals provide the legal basis for the programs. Colorado's State Highway Access Code has undergone several revisions since its inception in 1981.

The access management programs cover all state highways in Colorado, Florida, Iowa, Minnesota, Nebraska, and New Jersey. They cover only rural highways in Washington and Nebraska.

Various allowable access categories are normally specified, along with driveway spacing standards. Existing programs define 3 to 7 categories (Colorado, for example, defines 5, New Jersey 6, and Florida 7).

The Colorado, Florida, and New Jersey access codes are the most extensive. They specify spacing requirements for both signalized and unsignalized intersections, and (in the case of Florida) median openings. Florida and New Jersey exempt single family residences from meeting spacing requirements for most access categories. New Jersey defines "nonconforming lots" where desirable unsignalized spacings cannot be met; its code specifies ways to determine the maximum allowable traffic generation in such cases. The Colorado access code involves three basic steps: (1) Should the property have direct access? Is there other reasonable access available, where the access category does not allow it? (2) If direct property access is allowed, where should it be located? (3) "Desirable" AASHTO standards are applied for specific access geometry.

Access management programs and controls in the other six states mainly apply to rural state highways. They usually define allowable access levels and spacings, but do not specify signal spacing. Minnesota's program is the least extensive of these; it specifies only three levels of access control, but does not specify driveway spacing for arterial roadways.

The significant access management programs are summarized in Table 2-2 and are further detailed in Appendix B.

Access Management Programs—Local Governments

The Ohio-Kentucky-Indiana Council of Governments prepared a model access management code for consideration by

Table 2-2. Summary comparison of selected state management plans. (Source: Compiled from Questionnaire Survey)

State	Legal Basis	Roads Covered	Access Categories	Signal Spacing Standards	Unsignalized Driveway Spacing Standards
Colorado	State Law,	State Highways	5	Spacing & Band Width	AASHTO Safe Stopping Sight Distance
Florida	State Law	State Highways	7	Spacing Distances Specified	Speed, Median Treatment, Access Class
Idaho	Administrative Policy	Rural State Highways	5	No	No
Iowa	State Code, 1980	State Highways	4	No	Functional Classification Area Type
Minnesota	State Design Manual	State Highways	3 (Full, Partial Access Control, Unlimited Access)	Not Formally Specified	Specified For Collectors Only
Nebraska	Administrative Policy	State Highways	5	No	Access Class
New Jersey	State Law	State Highways	6	Spacing and Band Width	Overlapping Right Turns Desirable-24 feet min.
Oregon	None	State Highways	4 Suggested	No	No
Washington	State Design Manual	Rural State Highways (Some)	3 (Full, Partial and Modified Access	No	Functional Class
Wisconsin	State Administrative Statutes	Mainly the 1500 Mile Rural State Hwy System	Designated Rural System	No	Yes

towns and counties. This was the only example that was found of such a code on the regional, county, or city level.

No cities or counties queried reported comprehensive programs. Cities and counties, like states, include permit procedures, traffic impact study requirements, and driveway design standards. Driveway spacing requirements are sometimes included—these may relate to the type of driveway or the type of traffic generation.

Austin, Texas, for example, provides de facto access management through its land development code and transportation criteria manual. These documents not only identify traffic impact study requirements and design standards, but they also identify typical cross-street spacing, minimum spacing between median openings, and minimum spacing of driveways stratified by 12 types of streets.

Charlotte, North Carolina, specifies driveway spacing based on the level of traffic generation. Lakewood, Colorado, adopted the bulk of the Colorado State Code and then adjusted and added to meet local street criteria. Dallas, Texas, has proposed, but not as yet adopted, driveway spacing guidelines.

Lee County, Florida, has managed access through its County Turn Lane policy, traffic impact statement guidelines, and Lee County Development Ordinance since 1985.

Legal Basis

Most existing policies have a basis in state laws and design standards. Colorado and Florida, in contrast, have special access codes that key access levels to road classes. Virtually all of the legislation has been upheld in court. Courts generally uphold the concept of reasonable access to private property in situations where direct access is prohibited.

Many states are able to designate partial, as well as full, access control. Often, such access rights are obtained by designation (new highways) or by purchase along existing highways. Less common, however, is a program of access control that extends to all classes of highway.

Retrofit

Retrofit of access control on existing streets and highways within the vicinity of an activity center is more a matter of detailed traffic engineering design on a site-specific basis. It is a common problem in many states.

Michigan, for example, expressed definite concern, especially in smaller urbanized areas over highway corridors that are evolving into strip commercial development. A plan for 28th Street in Grand Rapids, which involved installing median islands and limiting exits to right turns, was upheld by the courts because sufficient side street access was provided. (It is of interest that the *28th Street Study* (prepared for West Michigan Regional Planning Commission by WBDC, Inc., Grand Rapids, Michigan, in association with DeLeuw Cather & Company, Chicago, March 1982) in the Grand Rapids urbanized area attempted to control development areas and to retrofit existing commercial development along a 13-mile commercial corridor. The overall plan divided the corridor into four segments and made specific proposals for each segment. A commercial zoning ordinance was developed and adopted by each of the five government agencies along the corridor. The plan called for installing median islands and limiting exits to right turns. The corridor access control system allows direct left-turn entry, but permits only right turns for exits from private driveways. "U"-turn arrangements are integrated with the left-turn entrance access. Signals at driveways stop traffic in only one direction of travel. Although legal action was taken against the plan, the courts upheld the decision of the local municipality to restrict access onto 28th Street because two access points were granted onto a side street.)

Design and Spacing

Design standards are usually incorporated into access controls. In some cases, they are complementary.

Driveway spacing guidelines, where specified, are keyed to factors such as road type (Austin, Texas), operating speed and signal progression (Colorado), and traffic generation per major activity center size (Charlotte, North Carolina). Population and development density and activity center characteristics are not explicitly identified.

Many ordinances specify one driveway per property unless there is wide frontage (e.g., over 600 ft) along the highway. Some design guidelines allow gas stations and drive-in facilities to have multiple access points.

There is a growing tendency for states to manage driveway access by allowing left turns in, but only right turns out along principal arterial roadways. Such treatments obviously benefit the arterial roadway by reducing conflicts, simplifying traffic signal sequences, and facilitating signal coordination. However, unless carefully planned, they could compound capacity problems on nearby streets entering the artery.

Driveway consolidation is viewed as desirable and is often encouraged. However, because of its site-specific nature, driveway consolidation is not specified in design or permit policies and, for the most part, difficult to implement.

Most public agencies consider the signalization of access drives in terms of MUTCD (or state) warrants or traffic engineering requirements. They do not generally specify traffic signal spacing requirements. Access codes in Colorado, Florida, and New Jersey specify minimum spacing distances or bandwidth requirements.

There is little consensus among public agencies on the optimum spacing of unsignalized driveways along arterial roads.

Traffic Impact Assessment

Most public agencies require a traffic impact assessment for new developments. Access control regulations typically use traffic volumes to determine when traffic impact studies are required. Idaho requires a traffic study for developments of more than 50 peak-hour trips. Florida requires studies for developments with more than 1,500 trips per day, and sometimes for smaller developments.

Most traffic impact studies look at a specific activity center or traffic generator. In some cases, generators in close proximity to the one being studied are taken into consideration. While some corridor analyses have been performed, these are the exceptions rather than the rule. For example, in developing a Transportation System Management (TSM) plan for Route 7 between Norfolk and Wilton, Connecticut, the analyses projected traffic for all planned developments along the corridor in a 10-year time frame (*1*). The resulting traffic volumes were used to estimate lane requirements.

Coordination

States generally have jurisdiction over state highways. The survey respondents did not identify problems associated with overlapping jurisdictions. However, the need for coordination meetings between the various governmental agencies and developers to help coordinate access management was frequently cited.

Transportation System Management (TSM)

Most states do not incorporate TSM requirements into their access management or permit procedures. Public transport does not seem to be a salient concern of most state agencies. Transit within large activity centers is perceived as both a benefit and a concern. Many activity centers have bus stops adjacent to buildings; in other cases, activity centers view transit terminals as a location for loitering and are detrimental to business. Certainly, transit and ridesharing are essential parts of transport management strategies for large activity centers.

2.2 EMERGING APPROACHES

Several alternate approaches to access management have emerged in recent years. Vermont and Newfoundland use land use controls to discourage strip zoning. California's Santa Clara County developed access control along its expressway system largely through advance purchase of access rights. The concept of "super-streets"/strategic regional arterials has been proposed in Illinois and Texas as a means of limiting driveway access to right turns and minimizing the effects of left turns at public street intersections. Massachusetts has defined "corridors of critical concern" for which access planning is done at a centralized location. The following sections of this chapter describe these additional methods of access control.

Land-Use Controls

The management of highway access can be achieved through land-use actions that control the use of adjacent properties. Actions that encourage cluster developments and discourage strip zoning have been reported by Newfoundland and Vermont.

Vermont requires that regional and local plans be consistent with the 12 basic goals of Vermont's Municipal and Regional Planning and Development Act (*2*). One of these goals, goal (1), clearly discourages the proliferation of strip development. An excerpt from this Act follows:

> To plan development so as to maintain the historic settlement pattern of compact village and urban centers separated by rural countryside:
>
> (A) Intensive residential development should be encouraged primarily in areas related to community centers, and strip development along highways should be discouraged.
>
> (B) Economic growth should be encouraged in locally designated growth centers.
>
> (C) Public investments, including the construction or expansion of infrastructure, should reinforce the general character and planned growth patterns of the area.

The State gives incentives to those towns that adopt its goals. Accordingly, six out of seven town plans submitted to the State in recent years have been approved, of which four have been adopted by the town. A "growth center" concept has been adopted as the alternative to strip development.

In conjunction with a major rejuvenation and expansion of its road network, Canada's Province of Newfoundland and Labrador launched an innovative program of land use controls along its major highways to protect roadside beauty and ensure traffic safety without seriously restricting convenience of highway services and other appropriate roadside developments. The "protected road zoning" program involves a two-pronged approach: (1) planning and zoning of strip land along each protected road, and (2) establishing a rigorous permit system for roadside development (*3*).

Access Control by Land Acquisition

Most highway agencies have developed their freeway and expressway systems through acquisition of the rights-of-way, and purchase of access rights. In several situations, these techniques have also been used on parkways and arterials. Examples include California's expressways, New York's Saw Mill River and Taconic parkways, and many "urban arterials" developed throughout New York State in the 1950s and 1960s.

The Santa Clara County (California) system is an excellent example of access management, through the purchase of access rights. The initial system established in the 1960s had complete control of land access, with access provided only by means of intersecting public streets. More recent expansion of the system (where access rights have not been purchased) allows right-turn access only at about 600-ft intervals; median breaks are prohibited. County policy requires a 12-ft merge lane at locations where there is no access control. About 40 percent of the 69-mile expressway system has access control.

Strategic Arterial Roadways

The concept of a strategic regional arterial (SRA) system has emerged in several states as a complement to expressways. This system would be one step below freeways and expressways in terms of function and design features; it would be designed to emphasize movement of regional traffic rather than abutting land access.

The Illinois Department of Transportation (*4*) has defined a 1,340-mi network of existing roads covering a six-county area in Northeastern Illinois. Access management is an internal part of the proposed concept. Access management proposals include the provision of raised medium whenever possible. Curb cut access, where permitted on urban and rural routes, should allow only right-turn entry and exit. On suburban routes, access should be consolidated into access spacing 500 ft apart. On rural highways, frontage roads should be provided by the year 2010, and they should "bulge out" at least 400 ft at intersection, thereby allowing for a possible future grade separation or interchange.

A University of Texas research study proposed a strategic arterial street system for Harris County, Texas (*5*). The principal access control and design features include: (1) median barriers— separated roadways; (2) no left turns—all turning movements turn from the right-hand lanes; (3) auxiliary right-hand lanes for emergency parking and speed changes; (4) provisions for U-turns; (5) signalized, at grade, intersections at intervals of about 1 to 2 miles, with approximately 70 percent of the green time devoted to the strategic arterial (or "superstreet"); (6) grade separations where necessary to accommodate crossing traffic that cannot be accommodated by the allocated green time, see Figure 2-1 (a,b,c).

The Massachusetts Department of Public Works (*6*) has adopted an alternative approach to access management. It has reviewed various concerns in the State for their commercial development and redevelopment opportunities. Based on these reviews, a 1-year moratorium on development was imposed on key corridors, pending a 1-year study of access requirements. These access requirements were defined for 1-, 5-, and 20-year time frames.

The development moratorium was declared by the Commissioner of Public Works, based on recommendations of the Direction of the Bureau of Transportation Planning and Development. No legal problems have been reported to date.

As an outgrowth of these studies, several corridors in Massachusetts were defined as "corridors of critical concern." All access permits that are pending in such corridors are subject to a central review by the Bureau of Transportation Planning and Development. The Bureau is able to establish customized special requirements for access permits and to assure their conformity with the recommended improvement actions.

To date, five corridors have been defined as "corridors of critical concern." These include Routes 7 and 20 in the Berkshires, Route 9 in Hadley, Route 1A, and Route 289 in the South Cape.

The access management recommendations for the Route 7/20 corridor in Lenox and Pittsfield, Massachusetts, for example, call for designating the roadways as a "corridor of critical concern." This designation requires that the following actions be taken (*7*):

1. All access permits that are pending approval by the District Highway Office, for parcels directly abutting or significantly impacting the corridor, will be reviewed by the Boston MDPW Office.
2. All new access permits will specify that only right turns (right in and right out) will be permitted, and that the driveway access will be designed in a manner to prohibit left turns, unless other configurations are advantageous for improved safety or traffic flow, or it is determined that allowing the left turn will not have an adverse effect on through traffic in the corridor or introduce undesirable traffic conflicts.
3. A Route 7/20 corridor advisory board shall be formed and will include the District Highway Engineer, MDPW staff, and

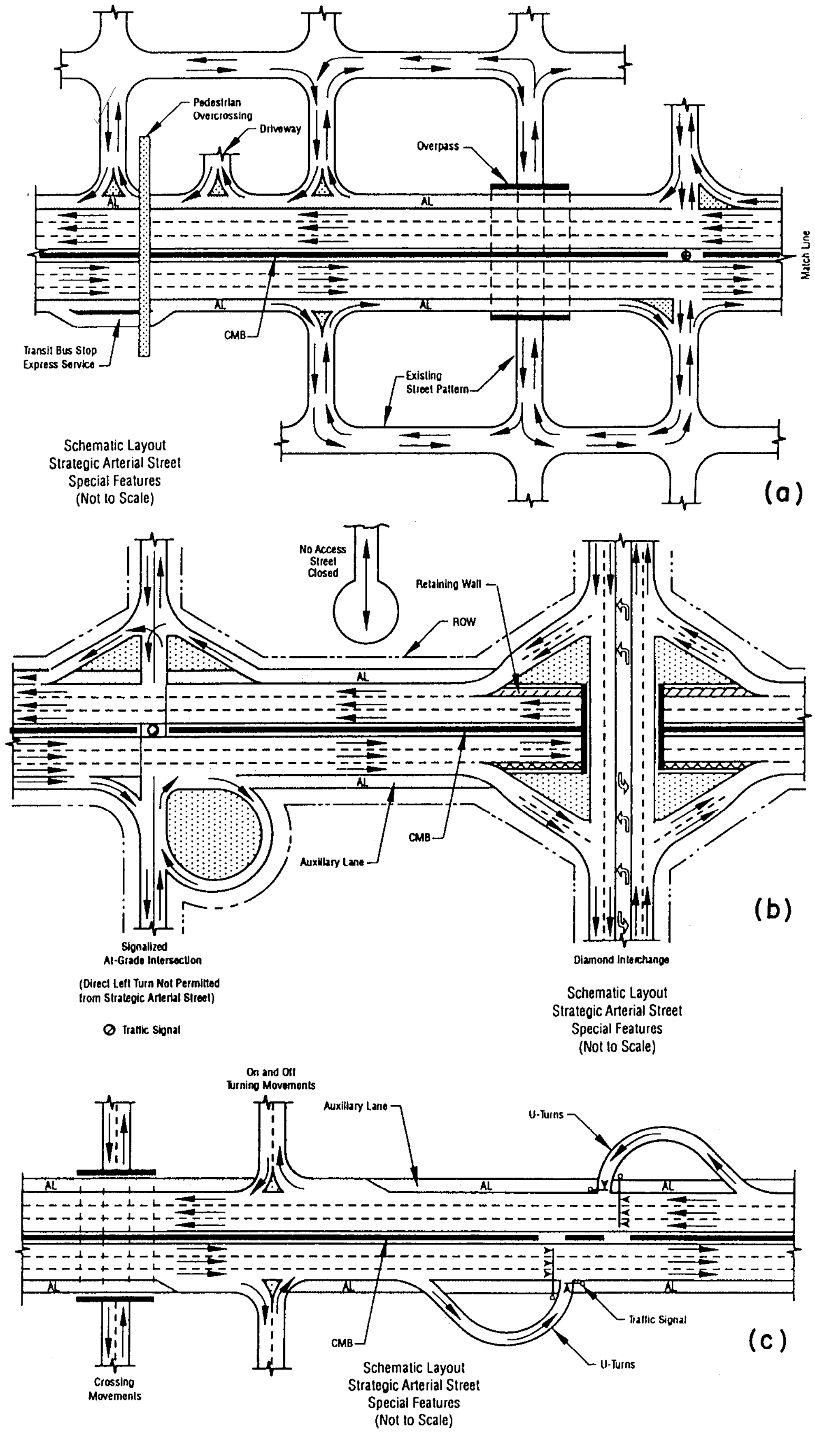

Figure 2-1. Schematic layouts of strategic arterial street.

local planning board members. This board will meet monthly to discuss all issues and developments relevant to the corridor.

4. Only one driveway per development shall be allowed in order to encourage development of adequate internal circulation, and to minimize the number of curb cuts on the corridor. This requirement will apply to all new curb cuts unless it is advantageous in terms of improving safety and expediting through traffic flow to have more than one driveway.

5. In the absence of substantial capital improvements, traffic generation for new altered access permits will be limited in accordance with the existing highway capacity, so that the through travel capacity is not degraded. As an alternative, by authority of Chapter 81, Section 21, the Department of Public Works will require contributions for the design and construction of projects that will enhance the capacity and safety of the highway.

6. New traffic signals will be considered only at public road intersections and will not be allowed for the convenience of access to individual parcels, unless some overriding public benefit will be gained by an alternate location for the traffic signals.

7. Existing signals will be reevaluated to determine compliance with the *Manual of Uniform Traffic Control Devices'* signal warrants. In addition, signals will be evaluated to determine their consistency with alternatives identified for further study in this report.

8. As a condition of an access permit, a monitoring or self-reporting program may be required, as necessary, to monitor driveway volumes and conditions.

It should be noted that progression analysis, bandwidth, and capacity impact are not mentioned regarding new signals.

2.3 ACTIVITY CENTER SURVEYS

Special interviews were conducted with representatives of major activity centers development organizations to obtain their perceptions and attitudes about access management. Respondents were queried regarding (1) their concept of access management, (2) desired access controls, including the desirability of varying access control by type of road, (3) need for consistent access policies and guidelines, (4) successes and problems, and (5) financial implications. The survey responses are summarized in Tables 2-3 and 2-4.

Large Activity Centers

The activity centers surveyed were, for the most part, the same as those analyzed in NCHRP Report 323 (*8*). Respondents included representatives from developer associations, private consultants, and public agencies.

Access Management. Most public officials and private groups associated with activity centers access, view access management as some form of controlling access to developments. Developers express ambivalence regarding access control—some want it elsewhere but not at their development.

Desired Access Controls. Several respondents indicated a need for road improvements on the approaches to the activity center. One suggested viewing activity centers at CBDs from an access standpoint and providing more direct freeway connections. Physical medians, while desirable, may prove difficult in retrofit situations. There was general concurrence that higher type arterials could have the greatest amount of access control.

Access Policies and Guidelines. There was general consensus on the need for consistent access control policies or guidelines. The need for flexibility in applications was stressed, and there was little support for legislated guidelines.

Problems Encountered. The problems encountered varied. Concern was expressed regarding the development of improvements on a piecemeal basis, and retailers preference for continuous access rather than having access inhibited by adding physical medians.

Financing Improvements. Developers appear willing to donate right-of-way and a "fair-share" contribution to improvement costs. Needs should be cited "up-front" in advance of project development.

An Activity Center Perspective

Activity center developers and managers have a somewhat different perspective on access management from that of public agencies. Even more so than city and state highway agencies, most developers have little comprehension of the access management concept. More significantly, their main concern is with financial viability, and access is seen as a means to this end.

Most developers are pragmatists with little long-term vision. Thus, they generally do not like planning solutions unless those solutions give them economic gain. They want needed access to property, but are less concerned with access impacts on highway flow.

The developers' concepts of access management also emphasized site-specific control of a site access. They were less positive about the need for consistent policies, but were opposed to legislated requirements. They cited a need for flexibility that recognizes site-specific requirements and for cooperative public-private sector approaches to access improvements.

There appears to be some difference in attitudes between developers of large and small activity centers. Major developers are much less cost sensitive. They are more likely to be amenable to planned versus random access.

Many large activity centers, especially those with mixed land uses, place increasing emphasis on transportation demand management. Most TDM plans, however, do not mention or incorporate access control and access management concepts.

Managers of activity centers and of Transportation Management Associations (TMA) mainly manage the area within a development and have little, if any, control over access to or from the activity center. Houston's Post Oak-Galleria is an exception; its "Uptown Association" is concerned with access over a large area.

Access management from an activity center perspective should form part of broader transportation management actions. There is an input and need to incorporate access management and control provisions into overall transportation demand management programs.

2.4 SUCCESS IN ACCESS MANAGEMENT

Success and failure in access management can be viewed from several perspectives. These include: (1) ability to implement ac-

Table 2-3. Activity center attitudes toward access management.

ACTIVITY CENTER	RESPONDENT	ACCESS MAINTENANCE CONCEPT	DESIRED ACCESS CONTROLS	VARIATIONS BY TYPE OF ROADWAY	NEED FOR CONSISTENT POLICIES AND/OR GUIDELINES	PROBLEMS ENCOUNTERED	SUCCESS IN MANAGING ACCESS PROBLEMS ENCOUNTERED	FINANCING/ IMPROVEMENTS
Perimeter Center Atlanta, GA	Regional Commission (Private)	Provide site layout that encourages internal pedestrian trips and internal roads suitable for transit. Provide access in both immediate area and to/from interstate highways. Concentrate access at intersections and provide suitable internal distribution roads. Developers are ambivalent about access management. Provide urban interchanges on arterials.	Medians are desirable, but "retrofit" medians have resulted in businesses suing county and state. Encourage state or county to grant driveway permits based upon traffic volumes; i.e., conditional driveways.	Limit access spacing frequency according to number of travel lanes (i.e., on 6 lane roads, prohibit within 300 feet of intersections.	Yes; legislate	Dealing with development on a piece by piece basis.	--	Larger developers are willing to pay for improvement and/or donate right-of-way when it is done up front.
South Coast Metro California	Business Alliance (Private)	Working with public agency to provide needed access infrastructure.	--	--	Yes; but guidelines should be voluntary.	--	Continued actions have been taken to improve driveway continuity.	Developers provide rights-of-way. Improvements result from development fees collected by City.
Post Oak Galleria Houston, TX	Uptown Association (Private)	Prefers planned access to indiscriminate access.	Look at major activity centers as a mini-CBD, and provide more direct access from freeways.	Tie access to class of road.	Yes; preferably at local level.	Retailers use continuous access. This has inhibited adding medians to streets.	--	Willing to grant right-of-way and pay for some improvements.
Parkway Center Dallas, TX	Consultant	Access management means control and constraint to developers; i.e., provide good access management elsewhere.	Large parcels call for intelligent application of standards by communities.	Developers respect major arterials and are willing to accept more limited access from these roads, but want it everywhere on other roads.	Yes; consistency is necessary, but some flexibility is needed.	A few developers believed that access was too restricted.	Good control on divided roads.	Some developers would like better advanced planning of road and access. Some willingness, under normal economic conditions, to give right-of-way or pay for part of roadway costs.
Bellevue, WA (Suburban CBD)	City (Public)	Controlling access to and from development; i.e, consolidating driveways.	Consolidate driveways on each block face (locate opposite each other). Provide mid-block signals. Encourage direct access from minor streets. Separate service vehicle access from cars/pedestrians.	--	Yes; include provisions in city code, or at minimum in development standards. Leave flexibility.	Some driveways are too close to each other or to street intersections.	--	City buying rights-of-way. City will do some projects and use impact fees to access developers.
Tysons Corner, VA	County (Public)	Manage or control access consistent with class of road to minimize disruption of through movement.	Zoning ordinances can require service drives and control patron entrances on a site-specific basis. Remove congestion on road approaches to centers.	The higher functional type of road should have the greatest access control.	Yes; at least for major transportation facilities. Guidelines may pose problems of who would pay for improvements, and how to deal with "grandfather" situations.	Most problems encountered relate to congestion on approach road system.	Good control on one principal arterial, less on the other.	Developers have paid for many on-site roads. Dedicating right-of-way is achieved by granting density bonus.

Table 2-4. Developer attitudes toward access management. (Source: Telephone Interviews)

RESPONDENT/ DEVELOPER	ACCESS MANAGEMENT CONCEPT	DESIRED ACCESS CONTROL	VARIATION BY TYPE OF ROADWAY	PROBLEMS ENCOUNTERED	NEED FOR CONSISTENT POLICIES AND/OR GUIDELINES
A.	Control traffic movement, improve safety.	Consistent rules for all developments	Yes	None stated.	Yes, but not legislated.
B.	Proper access spacing on both sides of the road.	Must be site specific.	Yes	Off-site congestion.	No
C.	Restrict vehicle access from arterial roads.	Municipal guidelines.	Yes	None stated.	Ordinances subject to variances.
D.	Ability to enter and leave conveniently, safely and without undue delay.		Yes, by relation to surrounding properties.	None stated.	No
E.	Control ingress and egress.	No	No	None stated.	Procedures - yes; guidelines - no. Do not legislate.

Table 2-5. Results of FHWA-sponsored access control demonstration projects. (Source: *Access Control Demonstration Projects,* Federal Highway Administration, Washington, D.C., December 1985).

	ARKANSAS	COLORADO	NEW HAMPSHIRE
Proposed Location	U.S.63 Bypass, Jonesboro, 4-Lanes	Southeast suburban part of Denver metropolitan area, Arapahoe and Parker Roads 4-Lanes	NH Route 9 from Brattleboro, VA, to Keene, NH 2-Lanes
Length - Miles	9.2	9.5	11.4
Work Involved	Acquisition of rights-of-access; construction of 5.09 miles of frontage roads	Regulation of rights-of-access; construction of median and auxiliary lanes; signalization of intersections; relocation of access road	Acquisition of rights-of-access; construction of speed changes lanes, travel climbing lanes, and frontage roads; intersection modification; resurfacing and shoulder widening
Cost - Dollars	$ 11,982,819	$ 13,188,849	$ 14,066,943
Access Points: Before 1978 After 1985	 68 55	 250 (potential) 63	 218 (388 potential) 157 (266 potential)
Accidents (Per Million Vehicle Miles): Before 1978 After 1985	 66 (4.00) 65 (3.13)	 Other Roads (8.00 - 12.00) Two Access Controlled Roads (4.00)	 N/A N/A
Travel Speeds	N/A	42 MPH on "Controlled Access" highway versus 25 MPH on other highways	N/A
Community Effects	• Highway believed safer • Frontage roads did not significantly affect total revenues	• Favorable responses prevailed • Most dissatisfaction from business/retail sector	N/A

N/A = Not Available

cess management codes, (2) reported changes in highway performance resulting from access control, and (3) improved site plans for developers.

In terms of overall access management codes, the Colorado experience is viewed as the most successful effort to date. The code has been in effect for more than a decade, has been upheld in court, and has been progressively modified to improve its effectiveness. On going efforts by Florida and New Jersey in implementing similar codes also can be viewed as a success.

The travel time and safety benefits of freeways have been long recognized. Several FHWA-sponsored access control demonstration projects in Arkansas, Colorado, and New Hampshire have reported reduced conflicts, accidents, and travel times (see Table 2-5).

Access management, by reducing or restricting direct private access, discourages the continuation of strip commercial developments. It encourages grouped commercial complexes where activities are clustered around large parking facilities that have less frequent, but well-designed, reasonable access.

Successful developments, in terms of managed access, include planned communities such as Las Calinas, Texas, and Irvine, California.

In summary, most public agencies apply some form of access control to their streets and highways. These controls normally take the form of highway design standards, and driveway permit criteria. Traffic impact analyses are required to assure that any problems that might result from proposed developments are ameliorated. However, broadly based access management programs are the exception, rather than the rule.

All states, counties, and cities provide full access control along freeways. Relatively few provide "partial" access control along expressways or arterials. Santa Clara's (California) expressway system is perhaps the most significant example combining control of abutting access with traffic signal controlled junctions.

There is, however, a trend toward greater access control also on highways other than freeways. Several states differentiate between limited access (i.e., freeways) and controlled access (i.e., expressways, arterials). Although the concept of expressways has been long established, the control of arterial access appears to be less common.

Counties and cities have not developed comprehensive programs. Here the need is greater, but program development and implementation is more difficult. New models and concepts may be needed—especially in areas with high development density and small lot frontage.

The state-of-the-art surveys found that most states are concerned with access to activity centers, but few have active management programs. Colorado has had an extensive program for more than 10 years; it has withstood the test of time. Florida and New Jersey have implemented programs, thereby introducing access management to urbanized and urbanizing environments. And, Massachusetts has identified procedures for dealing with "corridors of critical concern."

Setting standards keyed to highway type is feasible, but it calls for a "new perspective" by most public agencies. Because of the wide variability in specific state and local needs, one "blueprint" may not be possible. The need to balance general versus specific needs must be reasonable to be upheld by law.

Developers of activity centers and shopping centers appear more interested in the provision of access, rather than the control of access. Developers and administrators of large activity centers are more willing to develop planned access systems (and share in their costs) than those involved in small developments or strip centers. Several developers want activity centers to be viewed as "another CBD" with respect to freeway access; others expressed a need for more road capacity in the environs of their centers. For the most part, the concept of access management is neither clearly understood nor accepted. An important need remains to convey the benefits of access management to developers.

Several research needs emerged from the state-of-the-art surveys and the preparation of access management guidelines. These included: (1) the need for additional research on the spacing of unsignalized driveways, (2) the effects on adjacent public road intersections of denying access to activity centers from one of more surrounding highways, (3) the relationship between access management and suburban traffic congestion, and (4) further documentation of the benefits resulting from improved access management.

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CHAPTER 3

ADMINISTRATION AND PLANNING

IN BRIEF Managing access on streets and highways calls for coordinating actions between the public and private sector and among the various governmental agencies involved in planning and regulation. It requires consistent access control policies at state and town levels, and a sound legal basis. Access management from an activity center perspective is far broader than the provision, prohibition, and spacing of access points along public highways. It calls for interactive approaches to manage on-site circulation movements and travel demands; to identify and arrange traffic activities, to maximize walking; and to encourage transit ridership and reduce the number of trips by car. It requires the careful coordination of transportation and land use, and the establishment of land use policies that discourage or preclude commercial strip developments. It suggests the systematic cost sharing of needed improvements between the public and private sector and of land use policies that discourage or preclude commercial strip developments. This chapter addresses the program development and policy concerns that form the underpinnings of access management.

3.1 PROGRAM DEVELOPMENT OVERVIEW

The cooperative development of an access management program by all affected jurisdictions is the first step towards improving arterial street flow. The content and form of the program should recognize the specific concerns of developed and undeveloped areas and the activity centers that it impacts. The program should assure the integrity of traffic flow, but it should not deter development within a community.

The program should have a legislative basis that specifies its scope, jurisdiction, key policy issues, and the means and extent of enforcement. State regulations (or codes) extend the legislation into technical standards, procedures, and enforcement action. Complementary activities — usually by local jurisdictions — include zoning regulations, subdivision approval, site plan review, and driveway, building and occupancy permits.

Access policies should reflect a range of roadway types, environments, and design conditions. Techniques and regulations that are suitable for rural areas may not be practical in urban areas. An access management plan should specify allowable access on a corridor, area, or activity center basis.

Legislation

All highway agencies have the basic authority to control highway design and operation to protect public safety — but only to the extent authorized by legislation. Without appropriate legislation, the public highway agency could not control access by any method (see Chapter 4). Only a few state legislatures have passed specific statutes that address access issues. Recent statutes in Colorado, Florida, and New Jersey tighten access controls, including the right to deny direct access. Other states, in contrast, specifically grant the right of direct property access to the highway unless the state purchases the right by deed (i.e., North Carolina).

A clear legal basis, therefore, is essential for an implementable access policy. This basis provides for more uniform and equitable application of regulatory measures, thereby minimizing potential controversy and claims of discrimination. The access policy or "code" should include: authority and purpose for program establishment, designation of administering authority, categorization of roadways to determine extent and application of access control, access spacing criteria, procedures for application including possible variances, appropriate design and construction guidelines, and finally methods of enforcement.

The preparation and adoption of a highway access code may take several years. It requires a reasonable set of proposals, continuing refinements to reflect citizen and community concerns, and sustained support by the top transportation officials. A time frame of 2 to 3 years can be anticipated to translate proposals into law.

Access Categories. Access categories (or levels) should be defined for various roadway functions and types. Intersection and driveway spacing criteria should be identified for each access level (see Chapters 6 and 7). The categories may range from no direct access (i.e., freeway) to direct access limited by safety considerations only (local streets or frontage roads). Five to seven access categories normally will be required, depending on the degree of stratification desired.

The primary difference among access categories is whether or not direct property access is permitted, and, if so, where should it be and what should the spacing be between intersecting street and driveways. Each roadway should be assigned to a relevant access category. The assignment should be done cooperatively by the various jurisdictions involved.

Access Permit Applications. The legislative aspects should outline procedures for obtaining permits, for identifying the time frames involved, for the relative responsibilities of state and local governments, and for the traffic impact study requirements (see Chapter 5).

Variances. Most agencies recognize that conditions will occur that may place undue hardship on an individual if the guidelines of an access policy are strictly followed. Consequently, provisions should be made for review of each situation. Variations should be made within prescribed guidelines based on the sound application of engineering principles and judgment. These variances must be carefully applied and controlled, otherwise they become standard practice or cause claims of discrimination or of being arbitrary and capricious.

Technical Provisions. The specification of access levels should be accompanied by spacing and design guidelines. These guidelines should include the number, location, spacing, and design of access points for each access class. Adoption of the guidelines is essential for uniform and fair implementation of the program. Moreover, the public should be aware of what is required when buying or selling a parcel of land or submitting an application for access (see Chapters 6 and 7).

Enforcement. The legislation should specify provisions for monitoring adherence to regulations and for taking action against violators. The enforcement process should not be unduly expensive or so cumbersome that the responsible agencies become lax, because this will lead to the dissolution of the program.

Policy development should include consideration of how provisions will be enforced. Will there be enough manpower to adequately follow-up and inspect construction to assure compliance with permit requirements? This could be a major consideration in whether the process is administered at a state or local level.

Coordination Aspects

Activities of the various agencies that are directly or indirectly involved in access management should be coordinated to assure consistency in program administration and enforcement. The following administrative processes, often under several different agencies, can complement any access management code.

Zoning. Many local zoning ordinances contain access control techniques. Typically, they include curb-cut and driveway regulations, parking space and design standards, building setback and sight-distance lines, and landscaping or buffering requirements. Zoning is also an effective tool when a developer (or activity center) seeks to change the designated use of a property that would attract more traffic.

Zoning ordinances can aid access management by encouraging planned multiuse developments, by specifying street and public transportation requirements for new developments, and by discouraging strip commercial development.

Subdivision Approval. The subdivision approval process that affords authorities the opportunity to control access to major roads in most subdivision regulations is as follows: (1) establish minimum building setback distances from major highways or reference right-of-way lines; (2) minimize connecting points with major roadways; (3) require internal street systems of adequate capacity to serve generated traffic; and (4) assure adequate frontage to provide proper ingress and egress and reservoir space.

Site Plan Review. Before issuing permits for improvements, many jurisdictions require that the plan for physical site improvements be reviewed by applicable agencies. This review usually includes those responsible for traffic management and gives them the chance to regulate access point location or design. Modifications can be required to reduce or eliminate the adverse effect that poorly designed access could have on the roadway. Access control techniques can be required to offset projected adverse effects on traffic.

Building Permits. Before issuing a building permit for all structures other than one- or two-family dwellings, many localities require written certification from the applicable agency that the site plan has been reviewed and approval is granted. The building permit process, therefore, is another means of assuring that access has been adequately considered.

Occupancy Permit. Many cities require the issuance of a Certificate of Use and Occupancy whenever the use of a structure changes. The certificate is granted only after approval of various agencies including those responsible for traffic management.

Driveway (Curb-Cut) Permits. The single most widely used process for controlling access to public streets is the driveway permit process. Generally, before construction of any type of access to a public street, a permit must be acquired from the governmental agency with responsibility for the roadway. Plans must be submitted, and general guidelines for geometrics and construction followed. This is potentially a powerful tool for access management, provided that the guidelines are sound and are consistently applied. Permits should cover all access between a site and the surrounding roadways.

Retrofit Requirements. The application of access control techniques to existing "retrofit" situations requires careful coordination between public agencies and the general public. Well-documented engineering studies are especially important. These studies should clearly outline objectives of proposed improvements, define and quantify specific problems (accidents, delays), and develop alternative solutions to reduce the impact of these problems. Alternatives should be realistically evaluated and, where benefits clearly outweigh costs, proposed for implementation.

It is essential that the public be kept informed. Public meetings should be held in the area to be affected as soon as it is decided that studies should be undertaken. The reaction of business, along a roadway where it is proposed to install a median, to close access driveways or to reduce their width may be negative. A full understanding of the likely impacts and benefits is essential. It is also important that the general public, as well as the businesses directly affected, be made knowledgeable of potential impacts, inasmuch as they are the ones who stand to gain the most.

Politically, a retrofit program may be difficult for election officials to support because of the perceived impacts on affected businesses. It is important, therefore, to document these individual impacts as well as those accruing to the general public. The alternative cost of new construction or new rights-of-way to accommodate existing and projected traffic safely and at reasonable levels of service is often a very persuasive argument. It is essential that the elected officials have full documentation and adequate reasons and that local legal counsel be involved from the outset. Legal interpretations regarding marginal access changes have varied and should be reviewed from the standpoint of local precedent.

3.2 ACCESS MANAGEMENT PLAN

An emerging concept for the coordination of access between public roads and surrounding developments is the preparation of an access management plan (AMP). These plans are especially helpful where there are jurisdictional overlaps such as a state highway agency and a local government land use authority. The AMP takes the form of an interagency agreement and provides the framework for access decisions by various public agencies and the private sector. The plan details features of the comprehensive development plan that relate to access and shows how access can be defined for specific areas and improvements. Table 3-1 shows how the access management plan, as perceived by Oregon, relates to comprehensive and construction plans. Figure 3-1 presents an illustrative comprehensive plan, and Figure 3-2 gives the access management plan for the same area. Figures 3-

Table 3-1. Comparisons of various plans. (Source: *Guidebook for Access Management,* Oregon Department of Transportation, July 1989)

ITEM	COMPREHENSIVE PLAN		ACCESS MANAGEMENT PLAN		CONSTRUCTION PLANS (PUBLIC STREETS, PRIVATE DEVELOPMENTS)	
	MAP	TEXT	MAP	TEXT	MAPS/DRAWINGS	TEXT
Street: Functional Designation	-Shows the designation of the streets	-Purpose of designation -Description of functions	-Shows the functional designation	-Describes considerations unique to any selections shown	Public - - Exact details of what is to be built, where and how	-Specifications -Timetables -Coordination list
Anticipated Improvements	-Travel sections -Intersections -Signals	-Number of travel lanes -Capacity -Design speeds -Conditions under which the ultimate capacity may be reached -If improvements are to be phased, which portions and when	-Travel sections, intersections (location & widths of lanes planned for travel, acceleration/deceleration lanes, turning, parking, emergency parking, etc.)	-Basis for standards used -Tailoring for any unique situations -Timing and conditions that will cause need for improvement		
Right-of-Way	-Typical widths for: ..travel sections ..intersections	-Conditions under which right-of-way may be needed -General principles of who pays for what, when (including when additional ROW may become a condition of approval) -Setbacks for future rights-of-way	-Amount and location of right-of-way necessary	-Conditions under which the right-of-way may be obtained	Public - - Exact right-of-way locations	-Legal descriptions

Table 3-2. Typical information to be contained on access management plan map. (Adapted from: Summary Background Report, Task 4 *Procedures for Initiation and Development of Access Management Plans,* Prepared for New Jersey Department of Transportation by Urbitran Associates in Association with Richard K. Brail, February 9, 1990)

- Subject study area and highway segments with identifying information.

    Through and turning lanes
    Median Barriers
    Sidewalks
    Driveways/Access Points
    Curb Parking Regulations
    Traffic Signal Locations

- Map should extend at least 1000 feet beyond each end of specified road segments. Each highway should encompass a width of at least 500 feet on each side to cover all lots and possible improvements.

- Tax, land use, and zoning information for study area lots.

    Building Outlines
    Parcel Boundaries
    Site Boundaries
    Parking Areas (stalls)

- Municipal, County and special transportation district boundaries within the study area.

- Locations of existing and proposed access for lots fronting onto streets within the study area.

3 and 3-4 show how this access plan would evolve over time as development increases.

Objectives

The access management plan has several important features. (1) *It is designed to achieve better long-range planning for highway access.* It enables state and local jurisdictions to specify, in advance, where access in a given area or along a given stretch of highway can be provided. It also enables these agencies to identify current access problems and to work toward their alleviation. (2) *It provides a coherent frame of reference for developers and local governments.* It provides a predictable and consistent basis by which to plan and locate access points, thereby introducing access considerations into the local planning process. It gives property owners guidance for sharing access between two adjacent lots, consolidating access for contiguous lots, and obtaining alternative access via collector streets, local streets, or frontage roads. (3) *The improved road capacity resulting from better traffic management may permit higher density of development.* This translates into higher land values. (4) *It can facilitate the administration of access regulations and the issuance of permits.* It assists municipalities and developers by defining the conditions under which access permits will be issued. A developer can use the plan to establish permissible access points, and can be assured that access permits will be forthcoming where access conforms to the plan.

Contents

The access management plan (AMP) should include a map and an accompanying report. It should show where and how access can be provided. It should specify: (1) responsibilities of each of the participants for the improvements contemplated by the plan, (2) the manner in which the timing and sequence of construction of the improvements are to be implemented, (3) provisions for temporary access pending completion of the improvements, if necessary, and (4) expected future mitigation measures, including traffic limitations, and lots with "nonconforming" access (as in Florida and New Jersey). It should be a clear and concise document.

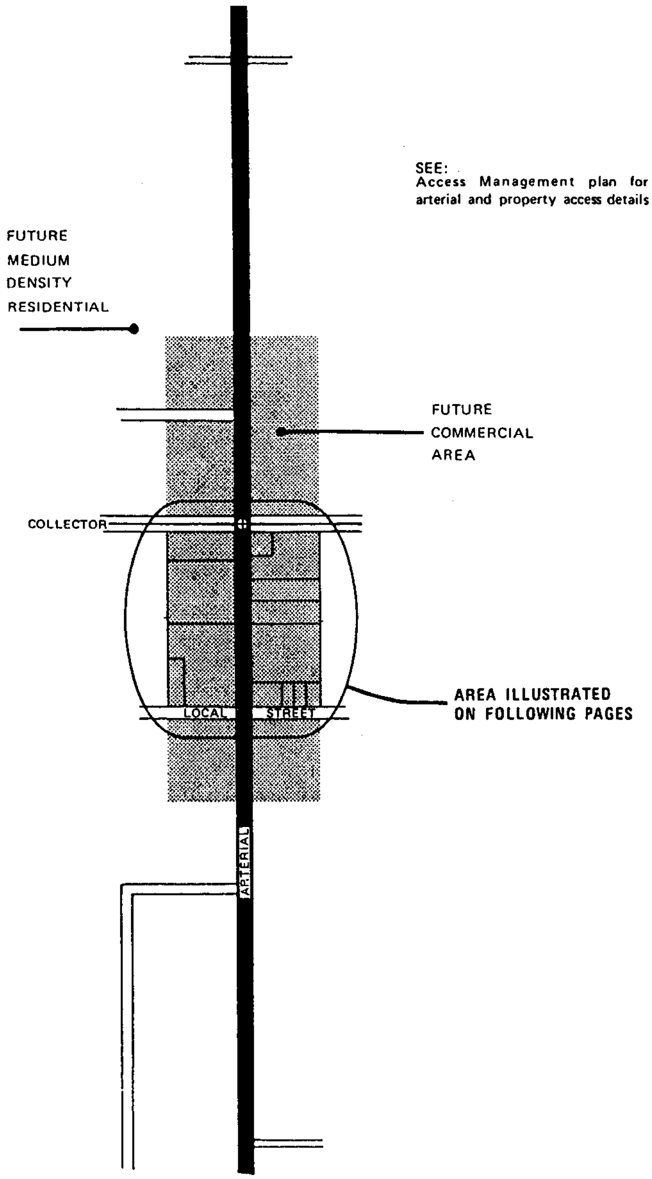

Figure 3-1. Comprehensive plan (see access management plan for arterial and property access details). (Source: Oregon Department of Transportation)

The map information should delineate the study area, and jurisdictional boundaries, existing traffic controls and access points, land use and zoning, lot ownership, building outlines, and other factors that influence driveway locations and access control (see Table 3-2). The report should identify study participants, planned uses for study lots, conditions for implementing the access management plan, and other supporting information.

In Colorado, an access management plan is a binding interagency agreement. It consists of a resolution of adoption signed by local officials and the state highway agency. The AMP is an attachment to the agreement that is written in very direct terms. It does not include a map. The text locates each and every current, temporary, and future access. It describes current and future turning movements or closures. All other research documents, maps, consultant reports, letters, analysis, and so on, are filed as working papers. In this way, the AMP is very straightforward, not subject to confusion and debate, and becomes a very useful and used document. The average AMP in Colorado covers 5 mi in seven pages of text.

Implementation Aspects

The access management plan should become a legal requirement. It should be a requirement for state financial participation in municipal road improvements. New Jersey, for example, is considering making the preparations of an access management plan a prerequisite before the state will participate in financing urban road improvement.

The plans should be initiated by a state, municipality, or preferably both. It may be desirable to provide incentives that encourage local governments to initiate and develop plans. Such incentives could include state and local sharing of costs, and facilitation of the permit review process.

3.3 TRANSPORTATION MANAGEMENT

Activity center transportation management (or transportation system management) includes a wide range of actions that is designed to maintain mobility and the competitive posture of the center. The underlying goal is to move people more efficiently.

Key Elements

The transportation management strategies include actions that (1) make better use of street space, (2) improve transit service, and (3) reduce travel demands. Figure 3-5 lists some of the actions that each of these strategies normally include.

Traffic and parking improvements are the most widely implemented management actions—both within activity centers and in the environs. They should be designed to achieve safe and convenient travel from public roadways to parking areas via site access drives and internal circulation roads.

Public transport service is important in large activity centers, even though suburban environments are less transit-oriented than the city center. Site roads should be able to accommodate buses, and suitable terminals should be provided. Service patterns should be keyed to markets.

Transportation System Management

The development of transportation system management (TSM) plans was mandated by the United States Department of Transportation (USDOT) in 1975. The primary responsibility for the development of a TSM program lies with metropolitan planning organizations (MPOs).

TSM programs include traffic management, parking management, work schedule management, ridesharing, and paratransit management. The programs are typically managerially intensive rather than capital intensive. Programs assume that: (1) the transportation infrastructure is essentially in place, (2) financial resources for expanding capacity are limited, and (3) increases

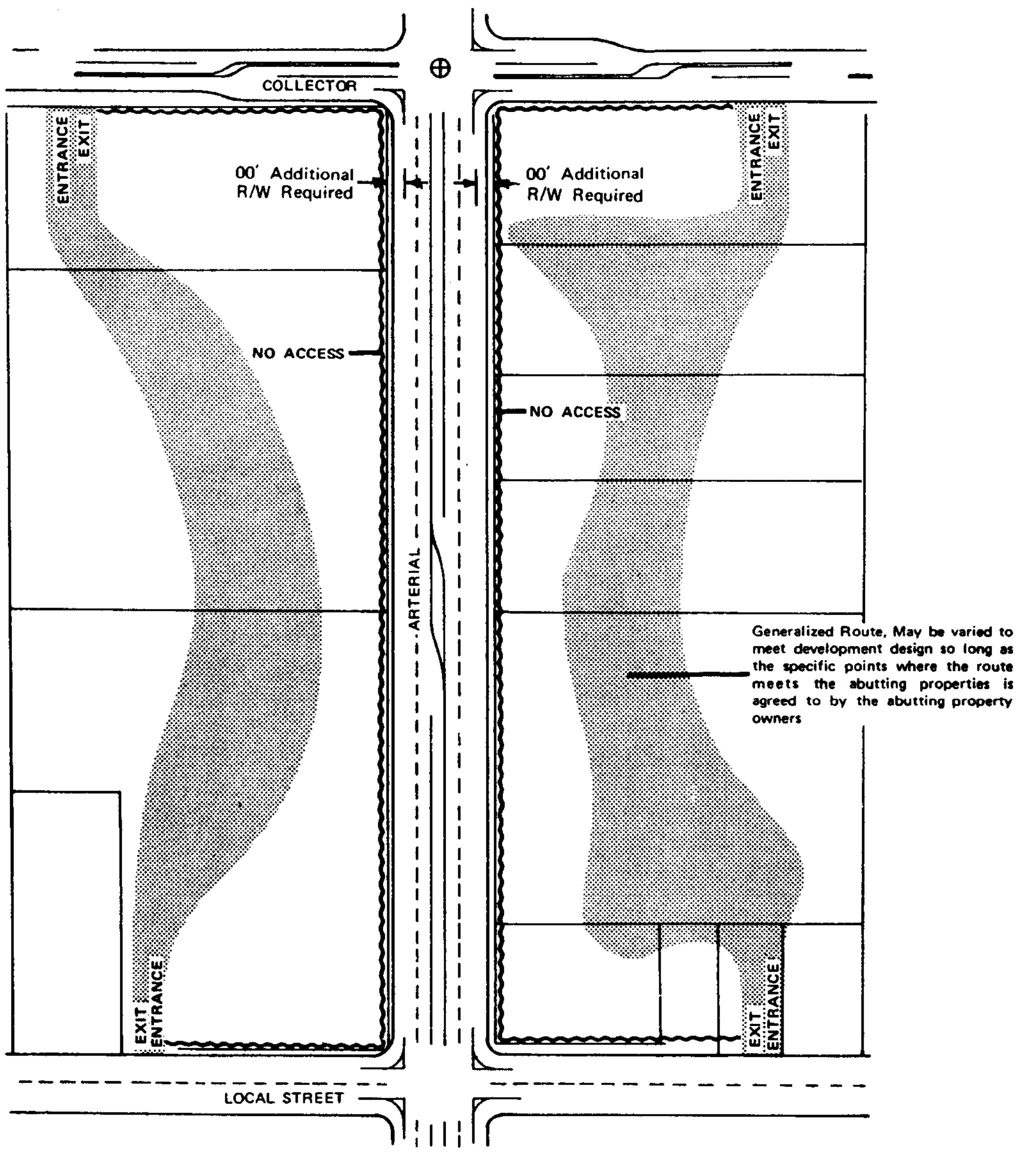

Figure 3-2. Access management plan. (Source: Oregon Department of Transportation)

in the number of person trips will be accommodated by riding rather than driving.

Although the concept of TSM is not new, what is new is the emphasis on coordination and incorporation of a variety of managerial, regulatory and low-cost physical and operational actions in to the transportation planning, funding, and implementation process.

TSM planning differs from long-range planning in that it determines good, efficient, low-cost solutions to near-term problems rather than the higher cost, regional scale, more detailed and analytical approach of long-range planning. However, plans should be coordinated with overall long-range transportation improvement plans.

TSM plans usually include the following:

1. *Traffic Engineering Improvements.* Traffic engineering actions include intersection channelization, intersection widening, right- and left-turn lanes, one-way streets, reversible traffic lanes, bus turnout bays, and improved signing and pavement marking.

2. *Traffic Signal Control Systems.* Traffic signal systems are designed to reduce travel time and intersection delay, to improve capacity and safety, and to coordinate access to new developments.

3. *Priority Treatment for High Occupancy Vehicles (HOVs).* The preferential treatment of HOVs is aimed to encourage the use of buses and carpools or vanpools to increase vehicle occupancy and, thereby, decrease traffic volumes. Actions include designating bus or carpool lanes, allocating special parking spaces, and timing traffic signals to allow more green time for buses.

4. *Parking Management.* Parking management actions include on-street parking restrictions, either short-term or long-term, off-street pricing discounts for carpool and vanpool vehicles, and on-street parking enforcement programs. Priorities of

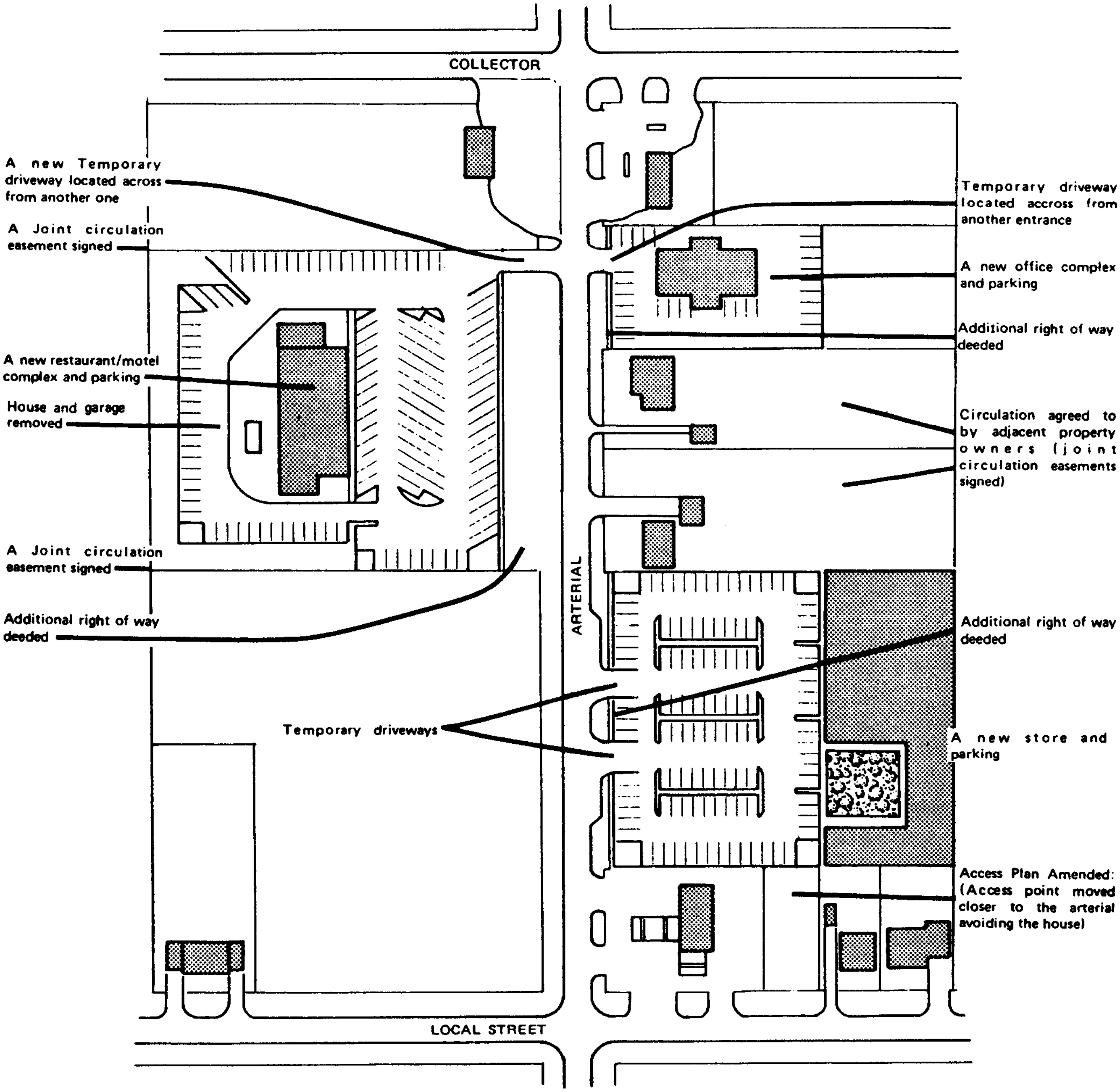

Figure 3-3. Access management plan — 5 years after plan approval. (Source: Oregon Department of Transportation)

curb lane management on the arterial street system should be arranged to provide: (a) traffic movement, (b) loading and unloading, (c) short-term curb parking, and (d) long-term curb parking. Parking requirements for activity centers should take into account the reductive effects resulting from shared land uses and the availability of public transportation at major activity centers.

5. *Transit Service Improvements.* Transit service improvements should be aimed at providing reliable and convenient bus operations in and adjacent to activity centers. Improvements can include fare-free zones, shopping loop or shuttle service, remote parking shuttle service, and coordinated transfer operations. Malls or other automobile restricted areas can be implemented to improve transit and pedestrian service.

Transportation Demand Management

Transportation demand management (TDM) (that part of the overall management program that emphasizes shaping travel demand rather than effecting improvements on the transportation system itself) works best in activity centers with a large employment base — often with a single or only a few major employers. Because it is targeted to the journeys to or from work,

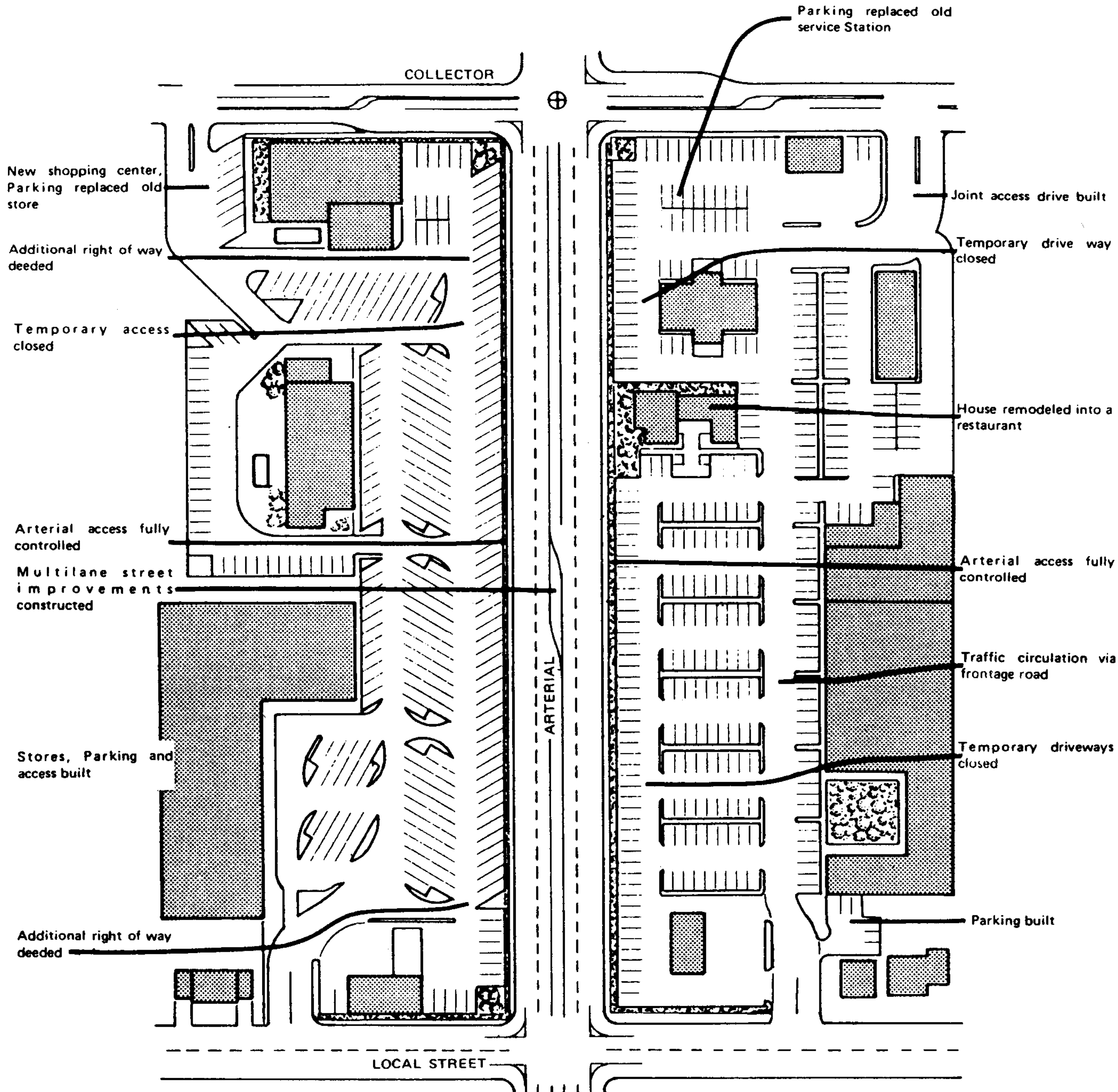

Figure 3-4. Access management plan—15 years after plan approval. (Source: Oregon Department of Transportation)

it is usually not applicable to other peak periods. Large-scale carpooling and vanpooling require trips of 20 mi (30 min or more). Cost of program administration may inhibit participation by small businesses.

Employer-based TDM programs normally include: (1) preferential parking for vanpools and carpools, (2) company endowment of vans, (3) transit passes (Atlantic Richfield), (4) provision of fulltime ridesharing coordination at large employers, and (5) flextime.

Public sector incentives include free parking at freeway interchanges (Connecticut DOT), financial support of public transport, provision of HOV lanes (especially queue-bypasses), and developer agreements to encourage ridesharing.

Table 3-3 summarizes the characteristics and effectiveness of successful demand management programs at three west coast suburban activity centers. The data show vehicle trip reductions of 9 percent to 18 percent. The highest reduction was reported in Bellevue, Washington, a suburban CBD, where development standards on new construction reduce setbacks and constrain on-site parking to a maximum of 2.4 spaces per thousand square feet of space.

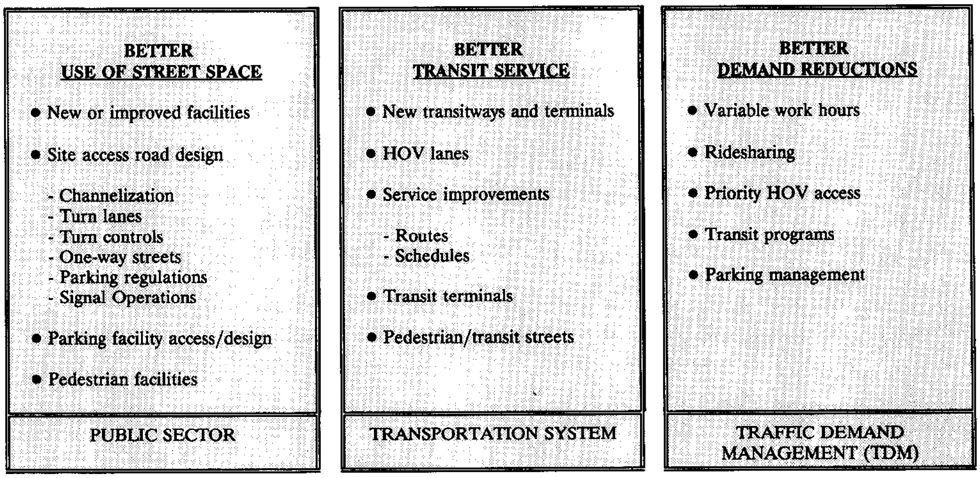

Figure 3-5. Traffic management strategies.

Table 3-3. Summary of TDM program results at three activity centers. (Source: S. Richard Kugmyak and Eric N. Schieffler, "Evaluation of Travel Demand Measures to Relieve Congestion," Comsis Corporation, *FHWA Report SA-90-005,* February 1990)

	Downtown Bellevue, WA	Bishop Ranch San Ramon, CA	Hacienda Business Park Pleasonton, CA
Type of Center	Suburban Activity Center	Suburban Business Park	Suburban Business Park
Legal Requirement (ICTDM Ordinance)	Yes	Yes	Yes
Parking Policy	Max. 2.4 Spaces Per 1,000 sq. ft.	-	-
TMA	Yes	Yes	Yes (Owner's Association
Employment	24,000	14,000	8,000
Reported % of Vehicle Trip Reduction	17.8	16.6	9.1

Parking charges, which cannot be imposed on customers or visitors in many suburban settings without impairing viability, appear to be the most effective incentive to group transportation. Other TDM measures indicate good faith on the part of developers, owners and tenants; they may have significant impacts if motor fuel shortages reinforce TDM efforts.

Thus, TDM should be viewed as a complement to other management actions. More importantly, ingress and egress to activity centers should be designed for the contingency that planned TDM programs may not achieve anticipated results in other locations.

Transportation Management Associations

Transportation management associations (TMAs) are a relatively new and effective private organization strategy that facilitates the implementation of transportation improvement programs. TMAs can give the activity center or business community a vehicle from which to participate in traffic improvement programs.

TMAs can establish some innovative mechanism to help mitigate traffic problems. There are more than 30 TMAs across the United States, most of which are located in areas of high suburban traffic and congestion. Some of the responsibilities of a typical TMA include: coordinating a staggered work-hour program, managing a ridesharing program, managing a shuttle bus system to commuter stations, administering parking management programs, and instituting programs of traffic flow improvement.

TMAs generate their own revenue through membership dues and individual or voluntary assessments. Some operate their own services, while others contract with professional transportation service consultants. They share a common goal—to improve public mobility. They provide a forum for cooperative public and private transportation decision-making.

The following guidelines should be considered when applying transportation management strategies to activity centers (*1*).

1. Opportunities exist for private sector participation in the planning, financing, implementation, and operation of transportation management actions, especially for new suburban development sites.
2. Coordination among public services at all stages of development is essential to the success of the transportation management actions.
3. By starting with one action that is successfully implemented, the gradual implementation of additional complementary transportation management actions may be realized.
4. With many transportation management actions, monitoring is essential for continued operation, modification, or alteration.
5. Institutional changes in organizations, regulations, laws, and ordinances may be necessary to effectively implement the transportation management actions.

3.4 PLANNING OPPORTUNITIES

The design and arrangement of commercial activities can enhance access management. Clustering of activities, in contrast to traditional strip developments, can encourage fewer carefully designed access points rather than random access. It can foster

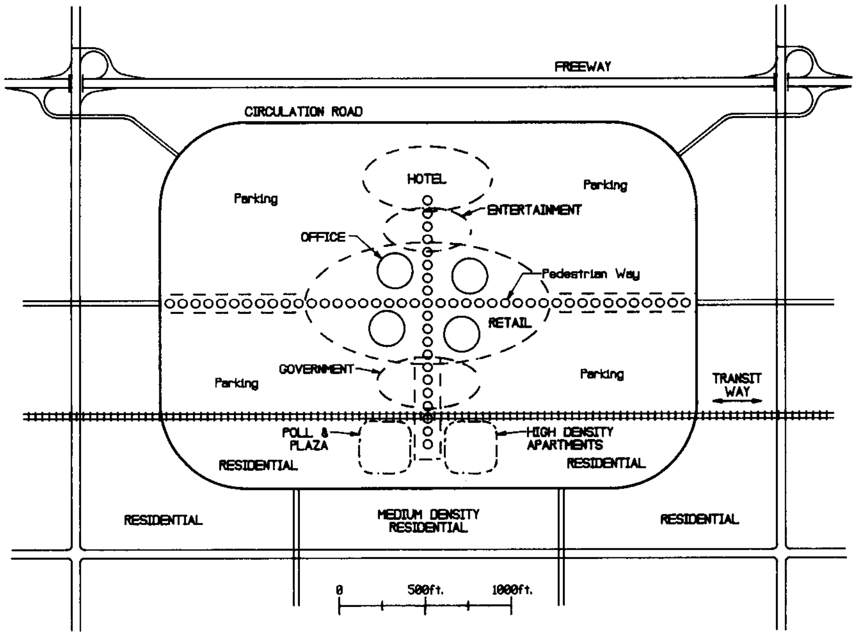

Figure 3-6. Mixed-use development concept.

pedestrian and transit use, and reduce trips between proximate activities.

Multiuse Activity Centers

The concept of multiuse or "mixed-use" activity centers has merit from the standpoints of both patron convenience and traffic impacts. The integration of retail, office, residential, and recreational activities, especially in large activity centers, recreates the traditional city center in suburban environments, and it reduces the need to travel because many tenants do not have to go elsewhere to work or shop. Thus, it enables retail shops and restaurants to draw patrons from offices. This interaction works best when the different activities are located close to each other.

Clustering offices, stores, restaurants, and entertainment activities near to each other facilitates walking trips and lets each activity reenforce the others. Intermingling residential and commercial areas, or locating medium to high density residential areas near the main business centers can increase interaction and reduce vehicle travel. A pedestrian and transit friendly design should be essential to achieve these benefits.

Figure 3-6 shows how the various activities can be integrated to maximize pedestrian flows and transit access in a large mixed-use development. Mixed-use centers would generally include some, but not all, of the activities shown.

Within the central business district of most cities, half or more of all shopping trips come from the downtown work force. A similar pattern prevails at very large activity centers, especially where employment exceeds 20,000. This is apparent from Table 3-4, which summarizes the travel characteristics for six large suburban activity centers with employment ranging from 17,000 to 48,000. Differences in the proportions of retail trips made wholly within the center reflect the intensity, mix, and location of activity centers.

Transit Access

Public transportation is essential for most city centers. It can also serve as an access management aid in suburban activity centers, especially the larger ones. It enables the size and intensity of the center to increase, without a proportionate increase in automobile trips.

An important design concept is to cluster buildings together within an activity center. This will encourage walking trips between activities within the activity center. Public transport will be able to serve the site more efficiently if the activities are concentrated rather than dispersed. Bus service can be supported at activity centers when there are at least 10 million sq ft within less than a square mile, and the tributary area has a density of at least 7 dwellings per acre. Lesser activity center densities can be supported where the activity center is located along the bus line (*2*).

Transit access can be provided in various ways. In the large mega-centers, private right-of-way may be desirable, either through the heart of the center or between the center and nearby high occupancy vehicle lanes in freeways (see Figure 3.7).

Most activity centers should have a bus terminal that is located contiguous to the buildings. The terminal should be removed from the main circulation roads and parking aisles, provide space for layover or staging of buses, include shelters, and afford direct pedestrian connections to major building concentrations. The terminal can serve as a conventional or timed transfer between various bus routes.

Geometry should be suitable for bus access. Shuttle transit services may be appropriate between a large activity center and nearby trunk line transit services such as a rail or express bus lines.

Small centers and strip development should be more transit pedestrian friendly. The building footprints should be "inverted" so that the buildings lie close to the arterial streets and the

Table 3-4. Internal retail trips at major activity centers. (Source: Kevin G. Hooper, "Travel Characteristics at Large-Scale Suburban Activity Centers." *NCHRP Report 323,* Transportation Research Board, October 1989)

Activity Center	Center Employment	SIZE				Retail Trips	
		Office G.S.F. (million)	Retail G.L.A. (million)	Residential Units	Hotel Rooms	PROPORTION OF TRIPS THAT ARE INTERNAL TO THE CENTER Noon	PM Rush
Parkway Center Dallas, TX	48,400	17	7	15,000	3,100	68[a] 47[b]	57[a] 41[b]
Perimeter Center Atlanta, GA	42,400	13	2	200	1,800	50	18
Bellevue Square Bellevue, WA	19,000	4.7	3	-	1,000	32	21
Southdale Mall Minneapolis, MN	19,900	4	3	2,200	3,000	30	15
Tysons Corner Fairfax County, VA	37,600	13	3	2,000	900	22	7
South Coast Plaza California	17,300	3.5	4	2,300	1,800	7	7

(a) Prestonwood Town Center
(b) Galleria

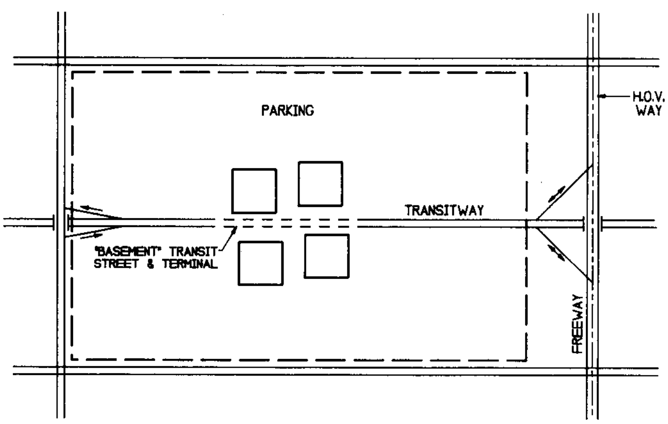

Figure 3-7. Conceptual treatment of transit at large activity centers.

parking is located in the rear. This concept, shown in Figure 3-8, achieves several important objectives: (1) it gives a "village center" look to the developments, (2) the building groups on both sides of the street are within easy walking distance of each other, (3) buses can operate along the public street and conveniently serve both groups of buildings, and (4) reservoir or storage space between parking areas and public streets is increased. To make such a plan viable, it is essential to provide an adequate number of parking spaces and to clearly sign points of ingress and egress. With the transposed design, special care must be taken to plan building setbacks and locations to accommodate roadway and intersection improvements.

Existing retail areas can be adapted to this concept by preserving the cruciform design of retail activities and by progressively adding parking behind the stores. (The Franklin Avenue commercial area in Garden City, New York, illustrates such an adaptation.)

It is not always possible to reorient buildings adjacent to bus routes or to bring buses into activity centers. In such cases, suitable pathways should be provided between the activity centers and the bus line.

3.5 FINANCING ACCESS IMPROVEMENTS

The design of roadways adjacent to and on the approaches to activity centers may require added travel or turning lanes to provide the desired access and maintain adequate levels of service. Public agencies have used varying approaches to providing or paying for these changes. The key financing guidelines, from an access management standpoint, are to: (1) provide the desired access to activity centers consistent with established access level and spacing criteria, (2) maintain reasonably uniform roadway cross sections, and (3) equitably allocate costs between the public and private sectors.

Many public agencies require the developer to pay the total cost of constructing driveway and highway improvements directly related to the development's access. These can include the driveway, sidewalk modifications, drainage structures such as culverts and drains, auxiliary right-turn and left-turn lanes, revised signing and stripping, traffic signals, and widened shoulders. This approach is simple to administer, but it can result in varying cross sections along a given stretch of roadway.

A better approach is for the public agencies to establish design standards for each highway and to work toward achieving them. Developers could be assessed based on the impacts they create, and the incomes received could be used to defray the program costs. The caveat, of course, is that the funds collected be used to improve access at the specific activity centers involved.

The use of private funding for highways has evolved from financing on-site and minor off-site improvements to the use of private funds to help finance major highway improvements serving new developments (*3*). The major types of private funding that have recently evolved or come into increased use include development agreements, traffic impact fees, special assessment districts, joint ventures, toll financing, and tax increment financing. "Development agreements" usually involve the negotiated dedication of land for right-of-way and the construction or funding of specific highway improvements. "Traffic impact fees" are uniform charges imposed on all new development to pay for a portion of those highway improvements needed to serve it. "Special assessment districts" assess property within a specific area on an annual basis to pay for highway improvements that benefit those properties. "Joint ventures" include various types of funding involving both public and private funds, usually under a contract among two or more private parties and public agencies. "Toll financing," the purest form of user funding, is used in new projects undertaken by both public agencies and private consortiums. "Tax increment financing" uses a portion of tax revenues from new growth to finance the highway infrastructure needed to serve the new development.

Salient features of the three most commonly used financing methods—development agreements, traffic impact fees, and special assessment districts—are summarized in Table 3-5.

3.6 A PLANNING PERSPECTIVE

Access management calls for the use of design and operational standards to better preserve the functional integrity of the roadway at a level consistent with its place in the total transportation system.

However, access management can also be viewed as a land-use and traffic management issue. It calls for land-use controls and incentives that are keyed to the development policies of the community and the capabilities of the transport system. The planning challenge is not how to provide drive-ins or driveways or how to design roadways, storage areas, or parking; rather, it is how to transform roadside environments into attractive, accessible, functional, and equally viable areas in the years ahead.

Effective and innovative zoning and land-use controls at all levels of government can effectively implement highway access codes while maintaining mobility. The concept of establishing zoning envelopes along new highways in rural and undeveloped areas—in which the adjacent land is zoned for a specified distance beyond the highway—represents a long-range land-planning approach to the access management problem. It works toward the clustering of activity and the minimization of strip development.

The concept of transportation development districts should be expanded to integrate land use and zoning, access management, and funding. Each community should establish development districts with specific density, design, parking, and transport requirements. This makes it possible to customize requirements for the central business district, in-town commercial centers and suburban centers. An access management plan should then be prepared for each district, identifying both existing and future access points.

Table 3-5. Features of commonly used financing methods. (Source: Ref. 3)

ITEM	DEVELOPMENT AGREEMENT	TRAFFIC IMPACT FEE	SPECIAL ASSESSMENT DISTRICT
Legal Basis	Depends on state.	Depends on state.	Depends on state.
Equity	Least equitable.	Very good.	Good, depending on boundaries.
Economic	Good, if developed objectively.	Good, if fees by zone vary.	Fair, inequity between district and rest of area.
Administrative	Varies--can be considerable for complex agreements.	High initial cost, moderate cost for tracking funds.	Relatively low cost.
Political	Unpopular with developers.	Generally acceptable.	Generally good, but questions on maintenance may arise.
Financial	Requires high front end costs.	Unstable revenue source.	Tax advantage through bonding.

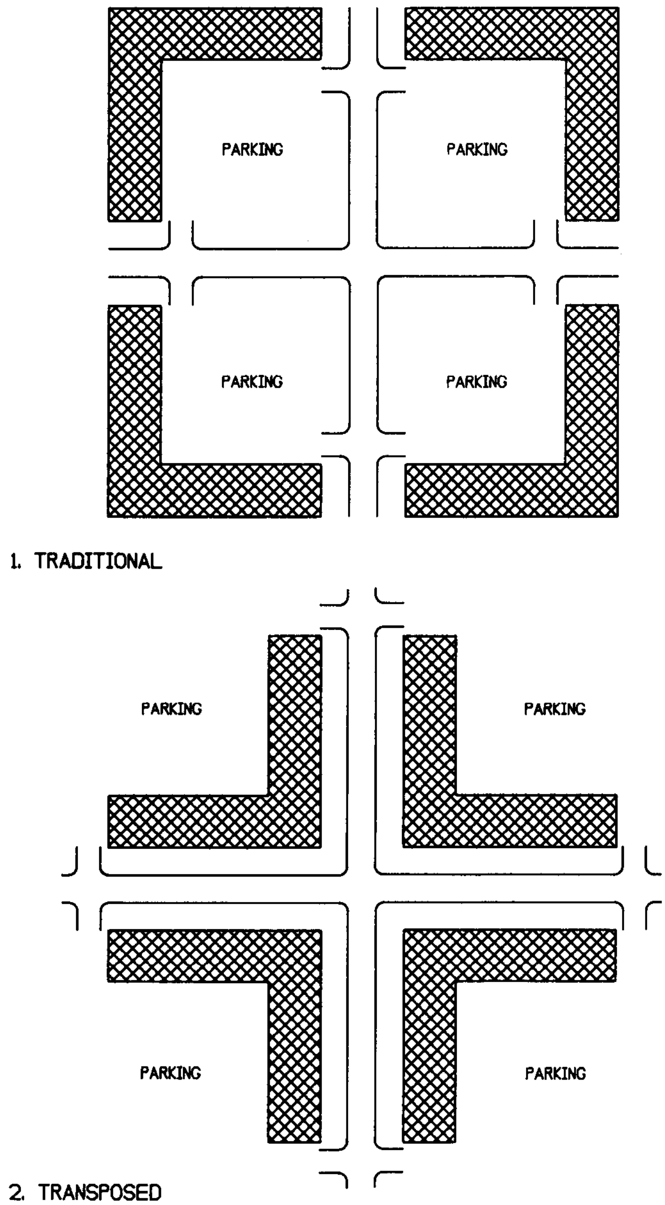

Figure 3-8. Modifying strip developments to improve transit access.

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CHAPTER 4

LEGAL CONSIDERATIONS

In Brief Modern highway policy and planning incorporate the concept of access control to protect the public investment and the public's health, safety, and welfare. The legal basis for controlling access on streets and highways provides the means for balancing the public interest and private property rights in making access management decisions. Access law is mainly implemented through public police powers and eminent domain. Each state should evaluate its legal powers for controlling access, because legal bases and interpretations may vary from state to state. Certain techniques may not be legally feasible in a state that has neither the policy nor precedent to uphold them. States have the authority to exercise powers that are not delegated to the federal government by the Constitution or prohibited by it. Cities and counties, in turn, derive their powers from the state. Many states hold that all powers of local government be specifically authorized by state statute. Some states hold that local governments may have broad powers under their police powers. Other states allow for some rule under the state constitution, permitting local jurisdictions to impose legislation not prohibited or preempted by the state. This chapter summarizes the relevant legal considerations that impact access changes within the roadway or along the surrounding right-of-way.

4.1 CONTEXT

The legal feasibility of various access control and management techniques is determined by assessing each state's legal authority to deny, to control, and to alter access points of landowners abutting a state highway. Two conflicting points underlie the legal feasibility of access control: (1) the public has the right of safe and efficient movement on state highways regardless of ingress and egress at commercial access points; and (2) a landowner, by the nature of his property and its position along the highway, is entitled to suitable and sufficient access. Access control techniques must effectively satisfy these two competing requirements (*1*).

The legal basis for the management of access control recognizes this conflict between the public interest (i.e., safe, efficient traffic movement) and private interests (property access). Direct access to an abutting street or highway is generally considered a valuable property right. Little unanimity can be found, however, among the decisions of various state courts as to whether a property owner has a right to compensation for loss of direct access when a frontage road or other indirect means of ingress and egress to his property is made available.

Courts in most jurisdictions have recognized that a landowner in such circumstances is entitled to compensation if his access has been unreasonably, substantially, or materially impaired by a change in the abutting street or highway. Some state courts have taken a more lenient view, permitting recovery for limitation of access without regard to the reasonableness of the remaining access. Other courts have applied a more stringent test, rejecting all claims for compensation if a frontage or service road is provided to the abutting owner regardless of the distance that must be traveled or the circuity of the route to enter the highway that was previously available by direct access.

Even in the jurisdictions that apply a "reasonableness" test, a wide variance exists as to the factors and standards that will be considered in determining whether or not and to what degree compensation for limitation of access will be given. The nature of the use of the property, the distance between the former direct access point and the new entrance to the street or highway, and the circuity of the route to the new access point are all facts that a court will take into account when deciding whether and how much compensation should be paid to an abutting land owner (*2*).

The courts and the public concede that abutters' interests, including access rights, must be recognized and protected from negligent and arbitrary abuse by the state. However, no right, including the right to access, is as paramount to the public's right to safe and efficient movement on public highways, and abutters' rights may be purchased, altered, or restricted by a government (*3*).

When a government alters or restricts access, the question which arises first is whether the alteration or restriction is significant enough to be considered a compensable limitation on access. For example, courts have held that a landowner has no property right in the flow of traffic along the street which abuts his premises and cannot complain of public improvements or regulations, such as traffic control devices, one-way streets and centerline medians that have the effect of diverting traffic to other streets or result in inconvenience and circuity of travel. If, however, the government-imposed alteration or restriction has the effect of eliminating or materially altering direct access to a street or highway, the landowner then has a right to compensation. The amount of the compensation may be mitigated, and possibly eliminated, by the provision or availability of alternative access.

Conflicts

The conflicting principal interests of abutting landowners and the corresponding legal conflicts between the interests of landowners and the interests of public highways are as follows (*4*):

1. An abutting landowner desires the right to be protected against private interference with his property. In some cases, private interference is also a public nuisance and can be the subject of a criminal or civil action by the appropriate govern-

mental authority against the interfering party. The abutting land owner can also bring a civil trespass or damage action against the interfering party.

2. An abutting landowner desires the right to be protected against any use of a highway for non-highway purposes. Such cases rarely arise because there is no longer any space for highway structures that do not directly contribute to efficient transportation. (Occupancy by utility lines would be an exception.)

3. The abutter desires the right to be protected against interference by changes in highway design and structure. The courts will maintain that an abutter always faces the risk and cost of adjusting to highway changes affecting an existing access point. The landowner is protected against being landlocked, but he is not entitled to direct access at all points or at preferred points on his frontage nor to each abutting street if he has more than one.

4. The abutter desires the right to direct access to the public highways. An abutter has no legal right to be able to travel from his property to any other place by the most direct route possible. An abutter's rights are legally satisfied by a reasonable access to the public highway even if this access is to the secondary side street, and from there to the highway.

5. The abutter desires the right to claim damages if traffic is diverted from his access point. Diversion of traffic does not violate the abutter's right to access, and courts have ruled consistently that any effects of traffic diversion are not compensable.

6. The abutter desires the right to refuse to comply with restrictions or regulations necessary for the safe movement of traffic. The modern highway policy in such cases is that any regulation applying to a highway such as prohibition of turns and cross-overs, medians, directional drives, and one-way streets is reasonable and any inconvenience suffered by a landowner is not compensable.

7. An abutter desires the right to seek access to new limited access highways. The government must pay only for what it takes, not for what it refuses to give. Therefore, denying access to highways constructed at new locations does not violate the abutter's rights. If part of the abutter's land is taken for the new highway, he has a right to be compensated for not only the part that was taken but also for the diminution in value of the part which remains.

Constraints

A state can legally control access, but it cannot deny a citizen due process of law. Therefore, the power that a state exercises to control access must be appropriate to individual situations. Powers to regulate property or property rights are distinct from powers to take property or property rights. The former power does not require compensation to the owner for inconveniences or for any consequential effects of regulation unless those effects are so pervasive that reasonable and beneficial use of the property is no longer available. The power to take or condemn requires, in all states, compensation to the owner for property damage. Thus, it is important to both state and abutter that the appropriate legal power be exercised in a correct manner.

Although a state has the authority necessary to control access, individual access control techniques are frequently challenged in court because a state did not use the appropriate authority to institute control. Court action establishes precedent for future access disputes. Unfortunately, legal procedures based on precedent have a disadvantage; a ruling made in favor of an abutting landowner or at least a lenient compromise in access control policy may be an opportunity to set precedent for lenient rulings in other cases.

If a state has little access control legislation, the courts will decide cases individually. This procedure requires time, money, and court action. Although the courts tend to decide in favor of access control in most reasonable cases, a state highway or transportation department has no advance guarantee that an untested access control technique will be upheld through court action (*5*). Consequently, access control legislation and rule making are desirable.

The Criterion of Reasonable Access

Generally, uncompensated abridgement of access rights hinges on the legal question of reasonable alternative access. Courts have generally interpreted "reasonable access" to mean that a property owner must have reasonable access to the general street system, rather than being guaranteed that potential patrons should have convenient access from a specific roadway to the owner's property. The access rights of abutters are protected by one general principle: the access granted must allow the property to be developed for a use which is appropriate and economically viable at that location. For example, the owner of a shopping center cannot be restricted to a driveway of a size normally considered standard for a single residential home because it would not handle the large traffic flow normally associated with such development.

Criteria for Compensation

Abutters are entitled to reasonable access, not unlimited access. Studies of access control legislation in Colorado, Ohio, Pennsylvania, and Oregon indicate that states can control access in the public interest through their police powers. Compensation for (or acquisition of) abutting property is not needed as long as reasonable access is provided.

The term "reasonable access" may prove difficult to define precisely. It has gone undefined in Colorado despite many attempts to describe it. Because of the very site-specific nature of the issue, Colorado lets the courts decide for each specific case when an appeal gets that far. It is not a market or competitive retail issue, but rather one of capacity, circulation ease and safety—an engineering approach.

Table 4-1 identifies the general conditions under which an abutting property is, or is not, entitled to compensation, depending on the nature and extent of access restrictions. This should not be interpreted as a legal description.

The number and location of access driveways to a particular land parcel may be regulated by the highway authority. The access permitted to an abutter may be indirect or circuitous; that is, an abutter may be required to travel a longer distance than desired to get to his property because of one-way streets, median barriers, or service roads. In addition, direct access to a highway may be denied if the abutter still retains reasonable access to the highway through the local street network.

Table 4-1. Compensatory and noncompensatory access restrictions and regulations (note: each state should evaluate the legal powers for controlling access because legal interpretations vary from state to state). (Source: Ref. 3)

Abutter Entitled to Compensation if:	Abutter Not Entitled to Compensation if:
1. All access to the highway network is totally denied;	1. Access is circuitous, or regulated reasonably;
2. Access permitted him is insufficient for "reasonable or beneficial use" of property;	2. Access restrictions are sufficient for the "highest and best use" of property;
3. Special injury is incurred to one specific property through access restrictions;	3. No special injury is suffered;
4. Highway frontage, if the otherwise landlocked property is rebuilt as limited access facility;	4. New limited access facility is constructed on new right-of-way;
5. Highway improvements damage his current use of property through relocation of access points.	5. Highway improvements require site design or parking area changes through relocation of access points.

An abutter is not entitled to direct access to new limited access highways or freeways. However, if an existing highway is redesignated as a limited access way, or if a new limited access road is constructed on the right-of-way of an existing uncontrolled facility, the owner is entitled to compensation for the loss of access where the loss in direct access denies reasonable access or where the access changes adversely impact the current use of the property.

Access can be revoked without requiring compensation where an abutter has access to a highway that is in some way deficient or dangerous to the general public. Moreover, if a highway department makes corridor improvements and decides to relocate existing access driveways as part of the improvement program, the abutter may be required to pay all costs for laying out his property to use the designated access points. In some states (e.g., Colorado), the improvement project pays for site revisions because the old driveway is a legal "grandfathered" nonconforming access. These two factors provide state highway departments with considerable leverage in making improvements to existing highways where unsafe access patterns exist.

The determination of when access restrictions are reasonable has, in general, been left to the courts on a case-by-case basis. New Jersey, for example, has limited access to right turns only on major highways for almost six decades; median access closures along arterial highways have been upheld in Michigan. Colorado's Access Code has also been upheld in the courts, including two challenges in the Colorado Supreme Court in 1983 and 1990. In contrast, some median closures have been successfully challenged in Illinois.

4.2 LEGAL MEANS OF ACCESS CONTROL

The legal means of access control reflect several centuries of evolution, tracing its origin to Blackstone's commentaries on the Common Law of England, which informed the American colonists of the concept of public and private rights. It builds on the "due process" requirements as set forth in the U.S. Constitution and state constitutions.

The specific methods of controlling access and land development include: the law of nuisance, police powers, contractual agreements, and eminent domain.

The law of nuisance is a time-tested concept for dealing with circumstances in which an individual may be subjecting others to harm or inconvenience. "Historically, the action of nuisance was the normal method of protecting the interest of the public in the use of the highway under the common law of England and in the statute law of eighteenth- and nineteenth-century America" (*5*). Although other methods have attracted more attention in recent years, the law of nuisance is still the basis for cases dealing with highway access problems. The concept has expanded the rough ". . . twentieth-century laws enacted for the purpose of promoting positively the public convenience through zoning, subdivision controls, building codes, set-back lines, and similar measures. Frequently, violation of such land-use controls is specified to be a nuisance" (*5*).

Police power is the ability of a state (or community) to legislate and enforce restrictions on behalf of the public health, safety, and welfare. Because the courts accept these powers, and because they are enforceable to property owners, these powers are widely used. They cover traffic regulatory and operational controls, as well as subdivision controls, licensing procedures, zoning ordinances, and setback requirements.

Contractual agreements include restrictive covenants and conditional use agreements. Restrictive covenants between developers and subsequent owners may be entered into to restrict the use of property in accordance with the needs or plans of the development. Conditional use agreements between a public agency and the owner of the property abutting a highway may be used to define, for example, the allowed land uses for which present or future access to the highway may be granted (*5*).

The power of eminent domain has been described as "the power of the sovereign to take property for public use without the owner's consent" (*5*). The need for compensation is not inherent in the concept because it developed under English common law, but it has been imposed by both federal and state constitutions. Indeed, nearly half of all state constitutions require compensation for governmental actions which "damage" property as well as actions which "take" property. Eminent domain, because it involves a taking, is the most powerful as well as the most costly form of land control exercised by government.

Police Power

Police power is the power of a sovereign to legislate general regulations in behalf of public health, morals, or safety. With police power, a government may prevent persons under its jurisdiction from conducting themselves or using their property to the detriment of the general welfare. In other words, a state has the power to create and to enforce legislation protecting its citizens (*6*).

Nature and Limits. Police powers are regulatory powers. The regulations are noncompensable restrictions of citizens' rights. Therefore, a state may, through the lawful exercise of police power, regulate ingress and egress without compensation to the abutting landowner as long as access is not taken (*7*).

Police powers cannot deny a citizen due process of law, nor can they take or demand property. Any action that deprives an owner of reasonable use and enjoyment of his property does not come under police power; such actions require compensation.

An abutter can challenge any arbitrary, capricious, or unreasonable interpretation of a regulation. In most situations, a landowner should not suffer inconveniences or restrictions under police power that are not experienced by the general public. If a landowner suffers individual hardships or if a particular parcel is singled out for unusual application of a regulation, such application may be unlawful taking (*4*). If so, eminent domain must be used to implement an access control technique or to compensate the owner for his particular loss.

The prevalent attitude of the courts is to avoid compensation for access control (*8*). Most access control techniques are regulatory and, therefore, not compensable. Unless a landowner becomes completely landlocked and has his access rights taken, most courts maintain that he should: (1) expect and absorb the risks and the costs of highway design changes, (2) demand only reasonable access rather than direct or selected access to a highway, (3) bear the consequential effects of traffic diversion, (4) comply with regulations and devices established for safe traffic control, and (5) acknowledge that newly established limited access highways are limitations on abutters' rights (*5*). Generally, an abutter must recognize access control techniques implemented through police powers without any claim to compensation.

The legislative authority to establish access control is in the form of statutory delegation of power to a state transportation or highway department to properly construct, maintain, and protect streets and highways. A state grants its department, or other controlling agency, the power to make regulations and restrictions. The controlling agency then constructs some type of consistent policy, usually in the form of a code book or policy manual, which guides the process of regulating the streets and highways. This statutory delegation, executed under police power, is the general legal authority for restricting both highway abutters and users.

Highway Operations. Most access control techniques associated with highway operations and design, unless they require additional right-of-way or encroach onto private property, can be implemented with police powers. Netherton (*6*), in reviewing case law dealing with the introduction of upgrading of access control on existing facilities, found a contrast between the way improvements within the traveled way were treated as opposed to the way those improvements in the margin were treated. However, in the ensuing years, this "contrast" has been reduced.

The prohibition of turns, designation of one-way streets, and rerouting of traffic constitute a legitimate exercise of the police power and do not constitute compensable damages. For example, in the case of *Department of Public Works and Buildings v. Maybee, Illinois,* May 1961, a median was constructed in an existing roadway in front of a service station. In denying compensation, the court followed the theory that where the property owner's free and direct access to the lane of traffic abutting his property has not been taken or impaired, there is no taking. Once on the highway, he is in the same position and subject to the same police power as every other member of the traveling public.

A property owner's claim to unreasonable access when left turns are restricted usually occurs when the highway provides the only access to the property, and the owner believes that he has the right to access from all directions.

However, when the access control measures are applied to the margin of the traveled-way or the right-of-way (e.g., curbs, fences, refusal to permit driveway cuts, driveway closures, etc.), or when the facility is reconstructed at a wider cross section, the use of the police power becomes more controversial.

An abutter must comply with regulations necessary for efficient traffic movement. Thus, when access is indirectly restricted by median strips, one-way streets, crossovers, curbs, guardrails, driveway permits, and parking ordinances, the restriction is a consequence of highway operational control and is a legitimate application of police powers needed to manage traffic movement (*7*).

Access control techniques that can be implemented through existing or future traffic laws, traffic regulations, and restrictions on the use and construction of highways can be implemented through police power even though they may directly or indirectly affect access. Compensation will not be granted for improvements in highway operation, nor will compensation be granted when a by-pass road is constructed or when traffic is rerouted. Any adjustment a landowner may have to make for operational controls does not constitute taking or damaging of property. A state does not need power stronger than regulatory power to control highway operations (*5*).

Driveways. The most clear-cut access control policy is the administration of driveway permits. Access control is managed by issuing driveway permits that require an abutting landowner to follow access regulations, and permit requirements are delineated in access policy manuals. Driveway permits are designed to regulate access; they are not designed to take or to damage property. Therefore, police power is sufficient to legislate the administration of driveway permits. As in any set of regulations, there must be a basis to ensure that the procedures and standards are reasonable and necessary in the public interest.

Access control techniques governing driveway location or design are more successful if they are made general policy. The measure of a state's current access control authority can be estimated by examining its access policy manuals or access code:

- Installing a physical barrier to prevent uncontrolled access along property frontage appears to be accepted practice. Effective regulation may sometimes be achieved by constructing curbs where the abutter formerly had unlimited access to a highway at all points along his frontage. In Georgia, for example, the authority of the State Highway Department to do this was sustained (*8*).
- Rerouting or diverting through traffic is a police power regulation and the incidental result of a lawful act; it is not the taking or damaging of a property right (*8*).
- When owners complain of median barriers or channelization, they are usually told that when they are on the highway to which they have free access they are subject to the same police power regulations as every other member of the traveling public. Reasonable traffic regulations, diversion of traffic, and circuity of travel do not deny access rights even though such operational changes may indirectly affect access convenience.

A key concern in closing some driveways to a development is whether or not a city is "... authorized under the police power to close driveways on one street where there is access to the property from other streets" (*9*). The acceptance of this practice is mixed. However, some courts agree with the closure or prevention of curb cuts if "... it leaves reasonable access from the property to another street" (*9*). Colorado law and the Colorado Supreme Court acknowledge denial of direct access as a reasonable exercise of police power and not a taking, provided that other reasonable access exists.

If the highway agency has a general policy and standards for access management, and the driveway closure brings the access condition more into conformance with the standards, the agency will have an easier time in court. The courts will usually uphold access control that is established standard practice for public safety.

Several cases uphold the legality of limiting curb cuts in development. One such case is the 1957 Nebraska ruling in *Hillerege v. Scottsbluff.* In this case, the state installed curbs along the edges of a roadway as part of an intersection improvement project (*5*). One curb cut was allowed for each tract of abutting property, but those "... landowners complained that this reconstruction of the intersection impaired their right of access" (*5*). The state court ruled that the "action of the city was within the scope of the police power" (*5*).

Another case involving curb installation is the 1958 Iowa Supreme Court ruling in *Wilson v. Iowa State Highway Commission.* In this case, Wilson, who owned a restaurant, gasoline station, and truckers' rest quarters, sued the Iowa State Highway Commission for installing a barrier curb along the edge of his property (*5*). His establishment was located at the intersection of a major arterial highway and a secondary roadway. The Iowa State Highway Commission installed the barrier curb along the property's right-of-way adjacent to the major arterial highway. Access was still allowed to the lesser street. The Iowa Supreme Court ruled that Wilson was not entitled to compensation "... since the installation of the curb could be carried out under the state's police powers and did not constitute a taking of plaintiff's right of access" (*5*). This opinion is supported by such cases as the 1958 Texas case, *San Antonio v. Pigeonhole Parking of Texas,* and the 1946 Minnesota case, *Alexander v. Owatonna* (*9*).

Eminent Domain

Eminent domain is a sovereign's power to take or appropriate land for public use. It is based on the concept that no property or property right is superior to the welfare of the public. Its four application requirements are: (1) a transportation or highway department (or other agency acting in the name of a state) must have the authority to condemn property, (2) a public necessity for condemning the land must exist, (3) condemnation can be used only after all other feasible negotiations have been tried, and (4) the owner must be compensated for property taken or damaged. Eminent domain does not restrict property; it takes property for which an owner must be compensated (*5*).

Eminent domain can be used to implement access control after negotiation or techniques enforced by police power have been exhausted or have been found ineffective. It involves compensation for taking of property, and compensation for any damaging of property. Condemnation may be necessary if an owner refuses to settle and sell.

Any access control technique that takes property must be implemented through eminent domain. Moreover, if a state denies access or inflicts upon a landowner inconveniences not suffered by the public in general, the legal authority for such action is eminent domain. This is because these techniques take or damage rather than restrict individual property and property rights.

Constructing a local service road may require eminent domain, where it is construed to impair access rights. However, when service roads are conceived as part of the highway, they constitute access to the highway, and an abutter's argument that access has been denied or impaired is invalid. Court decisions turn on the circumstances in each case.

Denying access to small frontages may require compensation for the taking of access rights. In Wisconsin and Colorado, courts ruled that closing of existing access, if it merely restricts unlimited access to reasonable access, is a police power. However, if access regulation completely denies all existing access or destroys its total usefulness, the access right must be purchased or condemned (*5*). (Colorado Supreme Court Decision [Colo. 626 P.2d 661 (1991) and 791 P.2d 119 (1990)] involves a frontage road construction involving direct access.)

Requiring access on collector streets may or may not require eminent domain, depending on compensatory policy defined by the state constitution (*8*). Some courts rule that such a requirement provides indirect access and, therefore, does not deny access nor require taking of property. Thus, police power is adequate to support reasonable denial of a request for new access where indirect access exists to that street or some other street (*8*).

However, other courts maintain that requiring access on a collector street in lieu of additional driveways damages access rights and that compensation must be granted for loss of direct access.

4.3 LAND-USE CONTROLS

The police power provides the basis for land-use controls by state and local governments. Local controls are implemented based on state enabling legislation.

Zoning

Zoning regulations provide a means by which local jurisdictions can relate transportation to development, including access control provisions. They are a form of police power granted to municipalities and counties by state enabling legislation. They usually define districts within a city and stipulate the types of activities that are permissible within each district. They also may specify parking requirements for specific land uses for each district. Zoning ordinances typically include a map showing the districts and a written specification describing the permissible land uses. Zoning ordinances are not generally compensable except where they damage or remove land from property owners.

Historical Overview

The concept of "districting" by population density or by type of activity is centuries old. Three hundred years ago, "The Massachusetts Bay Colony passed a law requiring the towns of Boston, Charleston, and Salem to designate areas 'where butchers and slaughtermen, distillers, chandlers, and [leather] curriers shall exercise their respective trades and mysteries' with a minimum of annoyance to residential areas" (*10*). Such separations, *de facto* if not *de jure*, can be found in the culture of ancient cities in Europe and other parts of the world.

Districting, as applied in German cities in 1884, regulated building size in proportion to lot area as a density control. Further refinements were obtained later by the grouping together of buildings devoted to similar or allied uses.

Municipalities in the United States were slow in adopting zoning regulations. This was because local governments had little control of private development within their jurisdiction, and their attempts to gain control were hindered by the fact that such control "... by public law lacked clear support from state and federal supreme courts" (*11*). It was not until states began to pass enabling legislation that public entities began to challenge the private community by passing ordinances to control and limit growth.

The first known instance was the building height restriction ordinance. The first land use zoning ordinance was passed in Los Angeles in 1909. It was "... applicable to large areas of undeveloped land" and "... signaled the beginning of an era in which zoning could be used to shape future development" (*12*). However, the legislation was incomplete and discretionary, since its principal purpose was to exclude certain undesirable industrial districts from residential areas. In 1913, New Jersey initiated additional development controls that "... required all subdivision plats to be reviewed by the local planning board" (*11*).

The beginning of zoning is often traced to 1913 when New York City's Board of Estimate and Apportionment appointed a commission to propose regulations for limiting the size and height of buildings. New York City regulations enacted in 1916 were the first to embody regulation over building use, height, and floor area — the three elements generally found in later zoning ordinances. In 1926, the Standard State Enabling Act was formulated.

Parking problems related to land use were recognized early by some cities. Columbus, Ohio, instituted off-street parking requirements for multiple family dwelling units in 1923. Fresno, California, acting in 1939, may have been the first city to extend the provisions to nonresidential uses (*12*). Fresno regulations subjected hotels and hospitals to mandatory parking provisions.

Zoning for parking was the main municipal zoning activity after World War II. Today it is common not only in North American cities but in cities throughout the world.

Legal Basis

Early in the twentieth century, the legality of public control of private development was challenged in several court cases. Each of these cases solidified a local government's ability to exercise control for the benefit of the urban community.

The first of these cases, *Eubank v. City of Richmond*, involved the issue of building setback regulations. In 1912, the United States Supreme Court ruled in *Eubank v. City of Richmond* that the control of the location of buildings on private property by the enforcement of setback regulations was constitutional (*11*).

The landmark case for zoning, *Village of Euclid v. Ambler Realty Company*, occurred in 1926. In 1922, the community of Euclid, Ohio passed a zoning ordinance that divided the village into residential, commercial, and industrial areas. It was immediately attacked by Ambler Realty Company, which had property it intended for industrial purposes that was zoned for residential uses (*13*). Ambler Realty instigated legal action in federal district court on the basis that the zoning ordinance greatly diminished the value of its property and, thereby, violated its rights against taking of its property without just compensation guaranteed by the fourteenth amendment of the U.S. Constitution. The Supreme Court ruled in favor of Euclid in 1926. This ruling established that comprehensive zoning and all of its associated parts were constitutional (*12*).

The case against Euclid was important because it challenged the basic concept of zoning and not simply the application of a zoning ordinance. The idea of controlling land use was questionable until this time. Most individuals felt that the ownership of land granted them the power to use that land in any way they saw fit. However, the ruling of the Supreme Court established that a local government can control land use as a means of controlling growth and development in a positive manner that benefits the community. As long as the landowner has reasonable use of his land and as long as the zoning ordinance is not arbitrary in its application, the local government is within its legal rights to zone.

This Supreme Court decision provides the basis for much subsequent legal opinion on the propriety of governmental regulation of private property, and the right to use police powers became firmly established.

In 1972, the Town of Ramapo, New York, passed a zoning ordinance that "... made issuance of a development permit contingent on the presence of public utilities, drainage facilities, parks, road access, and firehouses" (*11*). The ordinance ensured that development proceeded according to Ramapo's capital improvements program. In *Golden v. Planning Board of the Town of Ramapo*, the city was sued for this growth management practice, and the New York Court of Appeals upheld the ordinance in 1972, ruling that such a growth management system was constitutional (*13*).

The City of Petaluma, California, established a growth management program in 1971 in which a key aspect was the issuance of a limited number of building permits each year. Permits were issued to those developers whose projects coincided with the goals of the city's comprehensive plan. Projects that failed to support the goals of the plan were denied permits. In *Construction Industry Assoc. of Sonoma Co. v. City of Petaluma*, the Construction Industry Association of Sonoma County sued the city, and the federal district court ruled the practice unconstitutional. The city appealed, and the U.S. Circuit Court of Appeals for the Ninth Circuit overturned the lower court decision in 1975. A second appeal was taken to the U.S. Supreme Court which refused to review the case, thereby upholding the Court of Appeals ruling (*11*).

Legal Requirements

Land use regulations, such as zoning, must pass certain tests of fairness according to the requirements of the Fifth and Fourteenth Amendments to the U.S. Constitution and similar provisions found in state constitutions. Courts reviewing the constitutional validity of a land use regulation relevant to the due process of the law will typically require: (1) whether the government's end or purpose in enacting the ordinance is legitimate and (2) whether the means (i.e., provisions of the ordinance) are reasonable or rational relative to the government's purpose.

If the regulations have a reasonable basis, the first criterion is easily met. Courts have uniformly upheld zoning as the legitimate exercise of local police power to promote and protect the public health, safety, and welfare [e.g., *Village of Euclid v. Amber Realty Company,* 272 U.S. 365 (1926)].

The second test is more difficult to meet. A reviewing court is faced with the choice of (1) whether the regulations should be merely rationally related to the government purpose (a relatively easy requirement for the government to meet), (2) narrowly tailored to promote a compelling government interest (a difficult test under which the government usually loses), or (3) whether the regulations should bear some intermediate relationship to the government purpose.

A recent landmark case discussing these issues is the U.S. Supreme Court decision in *Nollan v. California Coastal Commission,* 483 U.S. 875 (1987). A synopsis of this case follows.

The Nollans sought a permit from the California Coastal Commission to replace an existing bungalow on a beach front lot with a larger house. The Commission found that construction of the larger house would impair the public's visual access to the beach, would add to the "psychological barrier" to public use of the beach created by a developed waterfront, and would increase private use of the shorefront and cause congestion on the adjacent public beaches. The Commission, therefore, conditioned the permit on the Nollans' granting the public an easement to walk laterally across the beach front portion of their property.

The Supreme Court invalidated the lateral access condition as an unconstitutional taking, because the physical access condition imposed did not substantially advance the same state interest in public visual access originally articulated as the reason for regulating the construction of the new house.

The court reasoned that, for the state to require such a permanent physical occupation of a portion of the Nollans' property (which would in the absence of the permit program clearly constitute an uncompensated taking), (1) there must be a legitimate state interest, (2) the proposed project must substantially impede the state interest so as to warrant denial of the permit, and (3) the permit condition imposed must serve the same state interest as prohibition of the project. In the *Nollan* case, the Court (without deciding that the first two of these tests were met) invalidated the condition based on the third test; i.e., requiring the Nollans to allow persons already on the public beaches to walk across the Nollans' property would not serve the articulated purpose of protecting the public's visual access to the beach. The court found that "[T]he lack of nexus between the condition and the original purpose of the building restriction converts that purpose to something other than what it was. The purpose then becomes, quite simply, the obtaining of an easement to serve some valid government purpose, but without payment of compensation."

Another recent landmark case discussing the limits of zoning regulations is the U.S. Supreme Court decision in *First English Evangelical Lutheran Church of Glendale v. County of Los Angeles,* 482 U.S. 304 (1987). In that case, the County adopted an interim flood protection ordinance prohibiting construction within a designated flood protection area that contained a campground for handicapped children, which was operated by the church. The County cited health and safety reasons relating to flooding and property damage as the basis for the ordinance. The church claimed that the regulation denied it all reasonable use of its property and sought a monetary remedy. The U.S. Supreme Court held that monetary compensation was proper where government regulation prevented all reasonable use of private property, regardless of whether the regulatory taking was permanent or temporary (*13*).

Building Setbacks (Ref. 15)

Municipalities commonly require building setbacks from the lot line or from the edge of the street right-of-way, either in a separately enacted ordinance or as part of a zoning ordinance. The constitutionality of setback regulations is well established. The U.S. Supreme Court upheld a setback requirement in a residential area in the early case of *Gorieb v. Fox* (1926). The court held that setback requirements implement a number of valid regulatory purposes, including a greater separation from the noise of the street, improving the attractiveness of residential environments and securing the availability of light and air. The state and federal courts have followed *Gorieb* and hold setback ordinances constitutional.

Several court cases have, however, indicated that municipalities may not use setback ordinance only to reserve the land for future widenings. These cases include: *Gordon v. City of Warren Manning and Urban Renewal Commission* (Michigan, 1972), *Galt v. Cook County* (Illinois, 1950) and *Maryland National Capitol Bank and Planning Commission v. Chadwick* (Maryland, 1961) and *Howard County v. SSM Inc.* (Maryland, 1984). In this latter case, the court relied on *Chadwick,* and held that a reservation of land in a subdivision for a highway was a taking of property without compensation. In *J & B Development Co., Inc. v. King County,* (1981), the court held that the county could impose a setback to reserve land for a street widening, but the supreme court affirmed this case on other grounds.

A review of these cases suggests that the courts will uphold setbacks when (1) the setback bears a perceptible relation to the public health, safety, comfort, and general welfare; (2) the setback improves the residential environment; (3) the setback is not excessive to what the municipality generally requires; and (4) the setback is not construed as a taking without compensation.

Setback ordinances may contain variance provisions that allow a variance from the setback restriction if it imposes hardship on the landowner, but these provisions undercut the use of setbacks for right-of-way reservation. A court may uphold the grant of a variance when a setback is used for this purpose. A landowner will also be able to obtain a variance if a setback used to reserve highway right-of-way reduces the buildable area of his lot below a usable size. A setback imposed to reserve right-of-way may have this effect.

Subdivision Controls

Subdivision controls may be employed for traffic benefits by controlling the number and location of access points, or by requiring properties abutting a highway to be given access instead to a local street or frontage road. The official map is a means of designating future public rights-of-way by recording the proposals on municipal maps. Landowners who subsequently develop property on designated rights-of-way may not expect compensation when the street construction comes about. License procedures cover certain business activities and the public agency issuing the license may deny applications if the circumstances are found potentially hazardous to public safety, health, and welfare.

Subdivision regulations generally specify minimum design and engineering standards, such as specifications for horizontal and vertical alignments, block lengths, and driveway widths, and locational standards such as corner clearances, structure setbacks, and structure separation distances.

Subdivision control authorizes local governments to approve the division of land into lots and blocks on recorded plats. State-enabling legislation authorizes local governments to enact subdivision control ordinances. The primary purpose is to assure that lots and blocks in the subdivision plat and roads and other facilities in the subdivision meet standards provided by the ordinance. The subdivision control ordinance can be applied to residential, industrial and commercial developments and subdivisions.

Subdivision control ordinances usually require the subdivider to dedicate and construct internal streets. They may also require the subdivider to dedicate land for the widening of established adjacent streets. The subdivider does not receive compensation for a dedication. A dedication of this type is known as a subdivision "exaction."

The courts have upheld the constitutionality of dedications for adjacent street widenings under a number of tests. The tests used by the courts to determine the constitutionality of dedications vary. Courts have used a variety of phrases to describe the required test, including "reasonable relationship," ... "rational nexus," ... "reasonable attributable," ... "reasonable connection," ... and "rational basis. . . ."

These rules authorize the dedication of land for streets and street widenings when additional traffic generated by the subdivision creates the need for the street. Under these rules, requiring a subdivider to dedicate land for the widening of an adjacent street to serve community needs rather than the needs of the subdivision, is unconstitutional.

An alternative technique sometimes used in subdivision control ordinances is to require the subdivider to reserve land in the subdivision for a new street or highway or for the widening of an adjacent street or highway. The state or municipality must compensate the subdivider for the reserved land when it is acquired for highway purposes. The reservation may or may not be limited in time. Some state subdivision control legislation authorizes this kind of highway reservation. It is similar in concept to an official map act.

A Kansas case, *Ventures in Property I v. City of Wichita* (1979), indicates that a city may not deny approval of a subdivision when a subdivider refuses to reserve land for a highway that is not planned and when its construction is uncertain.

The Supreme Court confined its decision "to the factual situation presented" and held that a taking had occurred and that an inverse condemnation action for compensation was proper. It held that a taking had occurred because the subdivision was subject to "... the sole restriction that a portion of the land in a defined highway corridor within the proposed plat be reserved in its undeveloped state for possible highway purposes at some indefinite date in the distant future. . . ."

4.4 IMPLEMENTATION ASPECTS

Access control techniques can be implemented with two basic legal powers: police power and eminent domain. The first power allows a state to restrict individual power for public welfare. The second power allows a state to take property for public use provided an owner is compensated for his loss. Police power is sufficient authority for most access control techniques associated with highway operations, driveway location, and driveway design. A state must cite eminent domain when building local service roads, buying abutting property and taking additional right-of-way, or denying reasonable access. Certain public protection from negligent use of access control exists. Cities and counties derive their powers from the state.

Police power allows a state ability to legislate restrictions for public welfare, but these restrictions must be part of general policy and must be reasonably consistent. Moreover, the reason for the regulation and the nature of the regulation must be compatible. This power can be applied to both roadway access and land use controls.

Eminent domain requires a state to indicate that taking property or property rights is necessary for public purposes.

Legislation contributing to police power can be reviewed and subsequently replaced or reinforced by additional standards. For easy use of police power, consistent, consolidated, clear, and forceful regulatory policies should be enacted. *Coordinating access policy into a clear and definitive code is necessary.* Providing concrete evidence (traffic counts, accident counts, visual accounts of site conditions) confirming the hazards of access points or the improvements made by access control techniques will promote additional legislation and help attain access control.

Policies and guidelines provide a point of departure. However, codes and regulations that carry full weight of the law afford a firmer basis for enforcing actions in the courts. This added legal strength underlies the access codes established in Colorado, Florida, and New Jersey. Oregon is also moving from a general policy to firm regulations.

Most states have adequate power to effectively control access. As long as reasonable access is provided, access regulation can be implemented and enforced. The control of future access points can be covered by an access code. The retrofit of existing access points may also be covered by code where major changes in the nature in the size of the developments occur. The more typical "retrofit" access management operations may require extensive traffic engineering and safety rationale and negotiation among the activity centers or developments involved.

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CHAPTER 5

ACCESS PERMITS

IN BRIEF A comprehensive access regulation program preserves roadway safety and capacity, reduces delays and accidents, and permits compatible land use and economic development. It requires the various policies, procedures, and techniques to be applied in a comprehensive, consistent, and coordinated fashion. For a governmental agency to have an access permit program, authority for such must be given by the elected officials (the state legislature or local municipality council). Most agencies have some degree of permit authority. The strength of that authority and the extent the agency chooses to enforce that authority vary greatly from state to state. This chapter describes how the permit application process and traffic impact analysis procedure can be broadened to reflect basic access management objectives.

5.1 OVERVIEW OF THE ACCESS PERMIT PROCESS

Normally, the governmental agency responsible for the roadway to be accessed has the discretion to grant or deny an access permit based on the material submitted in comparison to a set of agency standards. The agency may grant access as requested, require design modifications, or deny access. A variance to applicable codes or criteria can be requested when requested access is below desirable standards, but still within engineering and safety minimums. Some communities have enacted an "adequate

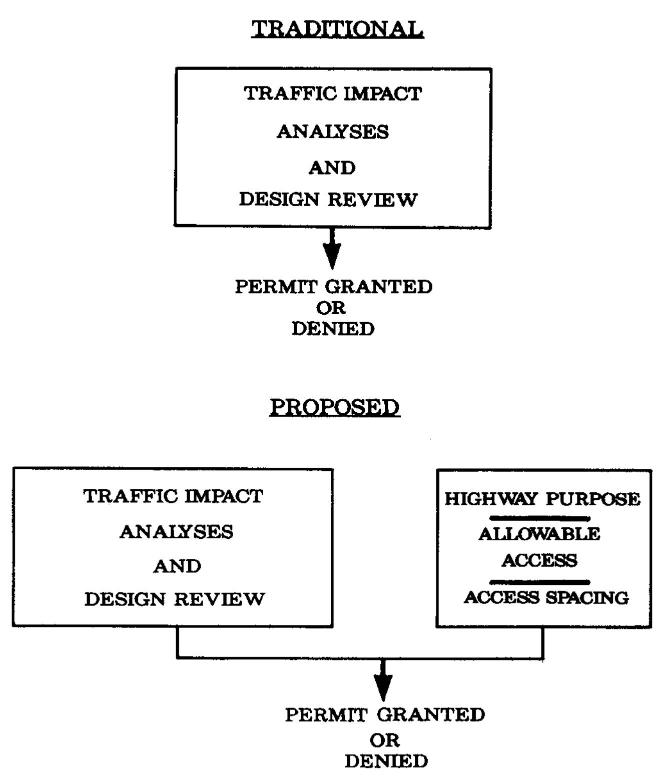

Figure 5-1. Traditional and proposed permit procedures.

Road into Limited-Access Highway," 43 A.L.R. 3d 13 197, Department of Public Works and Building v. Wilson and Company, Inc., 62 Ill.2d 131, 340 N.E.2d 12 (Ill.Sup.Ct. 1976).
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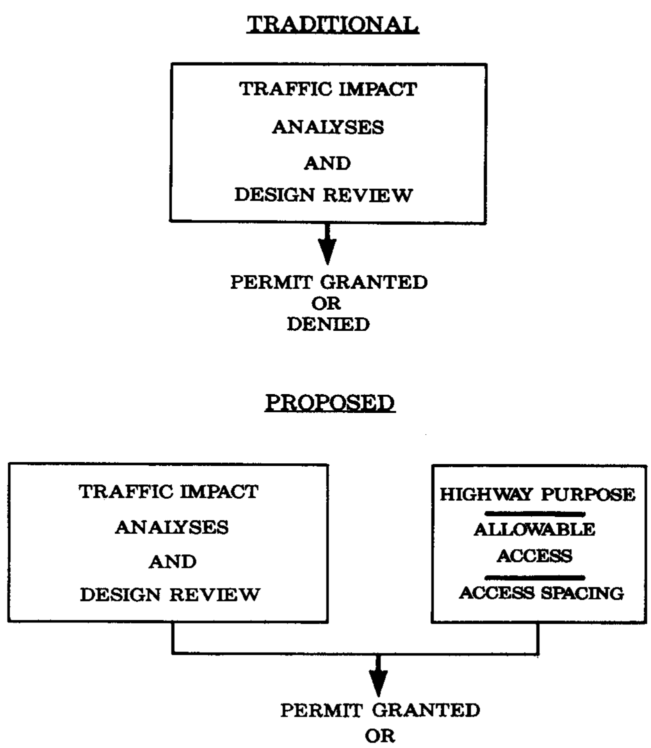


Figure 5-1. Traditional and proposed permit procedures.

public facilities ordinance" to ensure adequate infrastructure or require the size of developments to be reduced.

Traditional Approach

The typical access application procedure used by many public agencies includes the following steps:

1. Identify roadway classification.
2. Determine if requested access meets direct access criteria.
   a. If not, see if access is available along a lower class of roadway. (1) If yes, direct access to the lower classified roadway and issue permit. (2) If no, deny access or see if access request meets permit variance criteria.
   b. If yes, determine if adequate roadway capacity is available, and roadway safety can be maintained. (1) If yes, and traffic signal is warranted, issue permit for signal controlled access. (2) If yes, and traffic signal is not warranted, issue permit for unsignalized access. (3) If no, deny access or require variance.
   c. If yes, determine if standards for location and geometric design can be met. (1) If yes, issue permit with appropriate terms, conditions and, if any, restrictions. (2) If no, deny access or see if variance can be allowed.

Suggested Modifications

The access application procedure should be modified to reflect the importance of the highway and spacing requirements (see Figure 5.1). This results in a more comprehensive procedure, such as shown in Figure 5-2. The procedure considers: (1) the classification of the roadway to which access is requested, (2) the type of access requested relative to the allowable levels and types of access, (3) relevant spacing standards, (4) highway and intersection capacity, (5) geometric design considerations, (6) the type of proposed traffic control, and (7) the need, if required, for any variances to permit criteria. It should include guidelines for access denial where alternative access is available, and the alternative is better for overall traffic safety and operation.

A determination of the type of traffic control should also follow a selection procedure. The process, as shown in Figure 5-3, also considers the possibility of requesting a variance or the denial of the access point.

5.2 PERMIT APPLICATIONS—STEPS AND PROCEDURES

The principal element controlling access to the roadway system is the access permit procedure. An access permit is a legal document that grants approval to construct and operate a driveway or other access of a certain design at a specified location on a given roadway for specific purposes.

A permit should be required for the construction of any new point of access or the modification of any existing driveway within roadway right-of-way when the work is being done by any person or agency other than the agency that has jurisdiction over the roadway being accessed. It should be required when

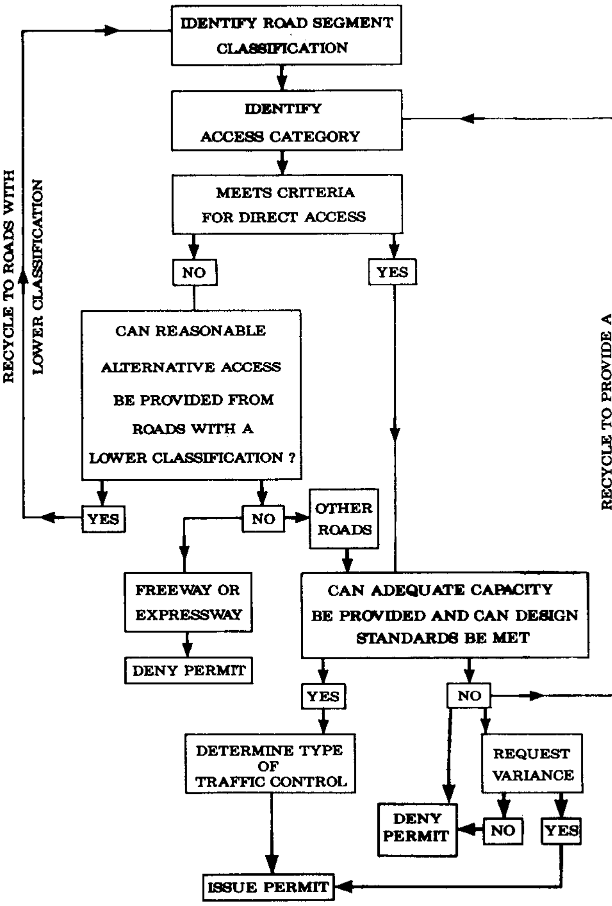


Figure 5-2. Access application procedure.

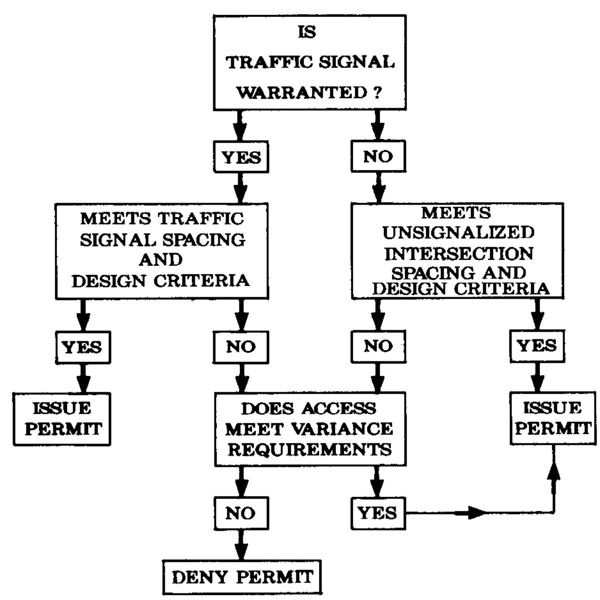


Figure 5-3. Traffic control determination.

new activity centers are planned or where major expansion or change of use of existing activity centers is envisioned, even though modification to existing access is not required. A separate access permit should cover each access point between a site and the surrounding road system.

Steps

The permit application process should go through the following separate phases:

1. *Initial Request or Inquiry.* Prior to the initial request for site plan approval or a building permit, the developer should obtain a copy of the access requirements of the governmental agency that has jurisdiction over the adjacent roadway. It is suggested that the developer or his representative contact the jurisdictional agency to inform them of development plans that call for roadway access. The agency responsible for land use approval may not be related to the roadway agency.

2. *Initial or Preliminary Proposal.* The initial submittal by a developer should include, but not be limited to, a letter of explanation and request for consideration, a Preliminary Survey Plat, a Preliminary Site Plan, and a Preliminary Traffic Impact Analysis. This procedure allows the agency to guide the applicant in the preferred direction. (This step can be skipped where a proposal is very minor, is previously approved in an access management plan, or a complete application can be prepared by an experienced consultant.)

3. *Final Submittal.* Upon review and further detailing of the Site Plan and its revisions to the initial submittal, the developer should submit the final site plan and, if required, necessary support documentation. This documentation can include engineering plans, traffic impact analyses, and other supplemental studies and, when required, a cost estimate for the proposed access driveway and associated improvements to the adjacent roadways. A performance bond and Certificate of Insurance also may be required at this time.

4. *Access Permit Issuance.* Upon receipt and approval of the plans, specifications, reports and studies, and other data submitted to the responsible agency, the agency should issue an Access Permit and construction work may begin. If the request fails to meet established criteria, a formal denial should be submitted to the applicant.

5. *Field Inspections.* The agency should conduct periodic field inspections during the course of construction. Any deficiencies noted by the agency should be corrected by the developer before a final inspection. When all work has been satisfactorily corrected, the construction work shall be accepted and approved.

Submittal Requirements

Submittal requirements normally include the following:

1. *Preliminary Plan Requirements.* The preliminary plan should be submitted with the initial request for an access driveway. The following information should be included on the plan. (a) scale: 1 in. = 100 ft or as normally required by the controlling agency; (b) the name, address, and telephone number of the owner(s) and that of the applicant where the applicant is an agent of the owner (contractor, tenant, consultant); (c) the name of the property or development; (d) the location of the property in relation to municipal and township boundaries and all roads within one and one-half miles of the property—a location map with an appropriate scale should indicate the location of the property with respect to the area; (e) a description of the current and proposed land use and all access within 300 ft of the property—at minimum, proposal developments that have been approved, but not yet constructed, should be indicated; (f) the identification of any legal right-of-ways or easements affecting the property as it relates to the roadway and proposed right-of-way acquisitions and alternate access, if appropriate (i.e., an access easement across neighboring property to a secondary road); (g) the existing and proposed dimensions of the highway including through and turning lanes, shoulders, curbs, medians, etc.; (h) the number, location, and dimensions of proposed accesses (driveways and new public intersections); and (i) all site characteristics, such as existing structures, utilities, natural drainage, floodplains, and wetlands within 300 ft of the highway.

The governmental agency may waive any of the foregoing required information for a minor access, or a temporary access, if it is determined that any of the information mentioned above is not needed to secure an access permit.

2. *Engineering Plans, Specifications and Estimates of Cost.* Engineering plans, specifications and estimates of costs may be required by the governmental agency having jurisdiction over roadways impacted by the proposed development.

3. *Special Surveys.* Soil surveys may be required for high-volume, major access driveways and when any driveway construction requires the widening of the roadway pavement by more than 6 ft. Such surveys shall be conducted before the completion of the final engineering plans and specifications to determine the existence of unsatisfactory subgrade materials or the need for remedial underground drainage. The results of the soil survey shall be submitted along with the engineering plans and specifications for review by the agency. Surveys may be required to conduct soils analysis and to identify hazardous materials or sites (i.e., converted gas station sites or older industrial areas).

4. *Drainage Study.* The agency may request that a drainage study be prepared for the proposed development.

5. *Traffic Impact Analysis.* The governmental agency may request that a Traffic Impact Analysis (TIA) should be prepared for proposed developments consistent with its policies. A detailed description of the methodology and necessary data is included later in this chapter.

Variances

Where the governmental agency finds that extraordinary hardships or practical difficulties may result from strict compliance with approved requirements, the agency may approve variations to the requirements, provided that at least the minimum safety standards are met, so that the public interest is served. The agency may require that a Traffic Impact Analysis or other information or studies be submitted when reviewing a request for a variation. Variances may be necessary for exceptions to turning restrictions or spacing standards where it can be demonstrated that no other reasonable options are available.

Economic development factors may be considered for development projects that will bring new job opportunities into the area. However, safety standards should not be compromised for purely economic reasons. In some cases the governmental agency may elect to fund some or part of the mitigating costs due to the traffic impacts.

A petition for any variation should be submitted in writing to the responsible governmental agency by the developer. The developer must prove that the variation will not be contrary to the public interest and that unavoidable practical difficulty or unnecessary hardship will result if it is not granted. The developer shall establish and substantiate that the variation conforms to the agency's requirements and standards.

Care must be taken in issuing variances. No variation should be granted unless it is found that the following relevant requirements and conditions are satisfied. The agency may grant variations whenever it is determined that all of the following have been met.

1. The granting of the variation should be in harmony with the general purpose and intent of the regulations and shall not result in undue delay or congestion or be detrimental to the safety of the motoring public using the roadway.
2. There must be proof of unique or existing special circumstances or conditions where the strict application of the provisions would deprive the developer of reasonable access. Circumstances that would allow reasonable access by a road or street other than a primary roadway, circumstances where indirect or restricted access can be obtained, or circumstances where engineering or construction solutions can be applied to mitigate the condition shall not be considered unique or special.
3. There must be proof of the need for the access and a clear documentation of the practical difficulty or unnecessary hardship. It is not sufficient to show that greater profit or economic gain would result if the variation would be granted. Furthermore, the hardship or difficulty cannot be self-created or self-imposed; nor can it be established on this basis by the owner who purchases with or without knowledge of the applicable provisions. The difficulty or hardship must result from the strict application of the provision, and it must be suffered directly and solely by the owner or developer of the property in question.

Upon receipt of relevant information, facts and necessary data, the governmental agency should review the information and render a decision in writing to the developer. Materials documenting the variance should be maintained in the agency's permit files. Failure to document decisions could open an agency to potential charges of irregular conduct, with little evidence available for defense.

5.3 TRAFFIC IMPACT ANALYSIS

Traffic access or traffic impact analyses (TIAs) are specialized studies of the transportation needs and traffic impacts of a development on the surrounding roadnet. They can respond to a wide variety of issues ranging from preliminary site plan review, to the determination of necessary roadway improvements, and to a comprehensive study of thoroughfare, transit, pedestrian, and environmental issues.

A TIA should be an integral part of the site development review process. It is specifically concerned with site traffic generation, the directional distribution and assignment of site traffic onto available or future roadways, public safety requirements, and the determination of transportation needs of the site and the surrounding road system. Public agencies should clearly indicate when a TIA is required. This should not be an arbitrary decision by the agency, and thereby a decision an applicant would not be able to predict.

Traffic impact studies are essential for many access management decisions. Wherever possible it is desirable to evaluate the combined impacts not only of the proposed development but also of other likely nearby developments along the major roadways. Thus, the typical "traffic impact study" for an individual development should be broadened by simultaneously assessing the collective impacts of many developments. In all cases, access plans for a parcel must be integrated with access to adjacent properties or developments on opposite sides of the road, or within the proposed improvement area.

It is difficult to anticipate future development in the environs of a planned project. One approach is to consider the impacts of other developments that (1) are under construction, (2) have received land use approvals, or (3) have submitted applications.

Need for a TIA

The question frequently arises, "When is a traffic impact analysis needed?" A complete traffic impact analysis should be performed for each of the following situations:

1. All developments that can be expected to generate more than 100 new peak-hour vehicle trips on the adjacent street or for a lesser volume when a review of the site plan indicates the need for such additional data.
2. In some cases, a development that generates less than 100 new peak-hour trips should require a TIA if it affects local "problem" areas. These would include high accident locations, currently congested areas, or areas of critical local concern.
3. All applications for rezoning.
4. All applications for annexation.
5. Any change in the land use or density that will change the site traffic generation by more than 15 percent, where at least 100 new peak-hour trips are involved.
6. Any change in the land use that will cause the directional distribution of site traffic to change by more than 20 percent.
7. When the original TIA is more than 2 years old, access decisions are still outstanding, and changes in development have occurred in the site environs.
8. Necessary development agreements to determine "fair share" contributions to major roadway improvements.

Traffic impact studies may be desirable when less than 100 new peak-hour trips are generated. The use of a lower threshold minimizes the chance that developments will be approved without a study. Bellevue, Washington, for example, has used 30 peak-hour trips with good success. Agencies that require studies for lower volumes have the option of reducing the required scope of the TIA.

Coordination of Analysis

A complete analysis of the traffic impacts of development is essential with respect to the transportation well being of both the development and the areawide roadway system. To competently address this need, the TIA should be prepared under the supervision of qualified and experienced transportation engineers (often

Table 5-1. Suggested traffic impact study horizon years. (Source: *Traffic Access Impact Studies for Site Development*, Institute of Transportation Engineers, 1988)

Development Size	Suggested Horizon(s)
Small (generating less than 500 peak hour trips)	Anticipated opening year, assuming full buildout and occupancy.
Moderate, single phase (500-1000 peak hour trips)	1. Anticipated opening year, assuming full buildout and occupancy. 2. Adopted transportation plan horizon year if the development is significantly larger than that included in the adopted plan or in forecasts for the area.
Large, single phase (over 1000 peak hour trips)	1. Anticipated opening year, assuming full buildout and occupancy. 2. Adopted transportation plan horizon year.
Moderate or large, multiple phase	1. Anticipated opening years of each major phase, assuming buildout and full occupancy of each phase. 2. Anticipated year of complete buildout and occupancy. 3. Adopted transportation plan horizon year. 4. Additional years when a major area transportation improvement is completed.

a transportation consultant) with specific experience in the preparation of traffic impact studies.

The responsible jurisdiction should designate a staff person to review the TIA, who is also technically qualified and has experience in the preparation or review of traffic impact studies. A typical review period should be 5 to 10 working days if the review is at the local (city or county) level and 10 to 20 working days if a state highway agency is also involved. The review period will protract with the increasing complexity and size of the development.

The traffic, or transportation, consultant should discuss the project with staff of the jurisdictional agency at the earliest stage in the study. Topics which should be discussed include: (1) available traffic data, (2) traffic counts to be taken (peak-hour and 24-hour counts), (3) safety considerations, (4) any plans for roadway improvements, (5) any anticipated major changes in land uses, (6) specific problems to be addressed, (7) methods of projecting future traffic volumes, (8) the appropriate method to be used in analyzing intersection capacities, and (9) the acceptable level of traffic service, and design and operation of the various access elements. The capacity and level-of-service criteria and analysis methods should be based on guidelines prepared by the governmental agency; however, these guidelines could be revised as pre-application criteria.

Horizon Years

Study target or horizon years should be determined. The selection of a study horizon year should be consistent with the size and build-out schedule of the development and anticipated major transportation system changes. Suggested TIA horizon years are given in Table 5-1.

The analysis should be based on a "horizon year" that reflects the time of opening of a development or a phase of development. This horizon reflects the fact that an applicant is responsible only for its traffic when superimposed on the conditions that will exist at the time of the opening. Many public agencies use a 5-year time horizon as a realistic design year when the project is expected to reach build-out within the 5-year period.

Scope of Studies

The traditional urban transportation planning process (UTP) evaluates alternative land use and transportation plans for large-scale developments and major roadway networks. It projects approximate traffic volumes within major travel corridors, thereby providing a basis for planning and programming major roadway improvements at a macroscopic level. It is usually long range in nature and broad in scale. Consequently, it is not suitable for projecting traffic at the microscopic level needed to analyze the access and transportation needs of a specific activity center. More site-specific traffic and analysis methods are required.

The scope of traffic impact studies will vary depending on the type, location, and scale of development. In activity centers, where walk-in and transit trips are common (or have potential), both total person-trips and vehicular trips should be analyzed. This will involve estimates of mode split and vehicle occupancy. The adequacy of the site plan for transit riders and pedestrians should be assessed.

The types of information needed to reach appropriate traffic and development decisions normally include the following: (1) characteristics of the existing roadway and public transport systems; (2) characteristics of proposed developments; (3) future development traffic; (4) composite traffic on surrounding and approach roads; (5) road system adequacy and needs; and (6) access plan.

A TIA should accurately analyze the impact of specific developments, the adequacy of site access, and the suitability of on-site circulation and parking. It should provide the following information to accurately gauge impacts, needs, and opportunities for change: (1) projections of traffic volumes on individual roadway segments; (2) projections of turn movements at individual intersections or access drives; (3) the effect of numerous access points along an arterial as opposed to only a few points of consolidated access; and (4) the effects of modest changes in land use on the location of individual land uses.

A general framework for site-specific analysis is shown in Figure 5-4. The actual content of a given TIA report will vary, depending on the type and size of the development and the prevailing traffic conditions. Although the guidelines established by public agencies may vary, each TIA should contain the following information:

1. *Introduction.* A brief description of (a) the purpose of the study, (b) the type and size of the proposed development, and (c) the site location within the general area.

2. *Existing Conditions.* The limits of the study area should be based on the type of land use, the size of the development, and an understanding of existing and future traffic conditions. The study area limits should be mutually agreed upon by the developer, the traffic consultant, and representatives of the jurisdic-

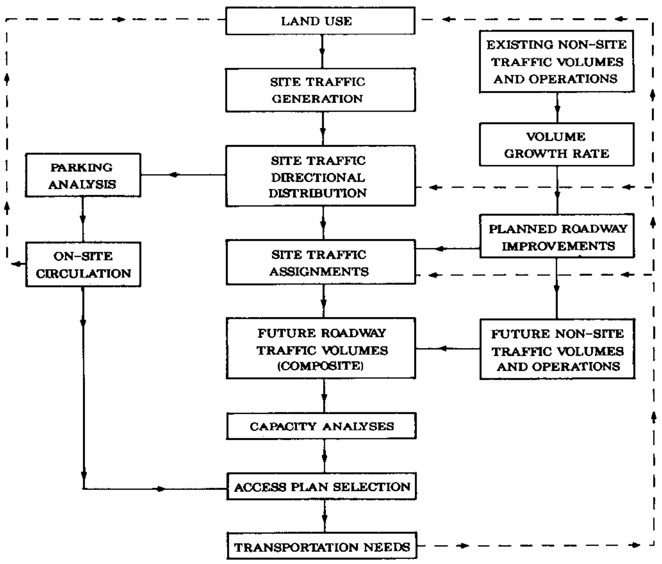


Figure 5-4. Traffic impact analysis process.

Table 5-2. Information needed for determination of influence and site traffic distribution. (Source: The Traffic Institute, Northwestern University Evanston, Illinois)

Land Use Activity	Factors for Determining Areas of Influence	Data Base Within the Area of Influence
Regional Shopping Center	1. Competing similar commercial developments 2. Travel time -- usually a maximum of 30 minutes	Population distribution* (sometimes weighted by projected spendable income in the proposed center)
Community Shopping Center	1. Competing similar commercial developments 2. Travel time -- usually a maximum of 20 minutes	Population distribution* (sometimes weighted by projected spendable income in the proposed center)
Industrial Park and Office Park	Travel time -- usually a maximum of 30 minutes or a distance of 10-15 miles is assumed	Population distribution*
Stadium	Travel time -- usually a maximum of 40 minutes or more, dependent on the size and character of the stadium	Population distribution* (sometimes weighted by travel time; i.e., the longer travel time is weighted less)
Residential	Travel time -- usually a maximum of 30 to 45 minutes or a distance of 10 to 15 miles is assumed	Employment-opportunity distribution*

* Projections of population and employment-opportunity data should be used for the design year if possible.

tional agency. The general terrain and road network features should be included in this section.

The study area or area of influence of a given development depends on the type and size of the development and the efficiency of the roadnet that will serve the site. New Jersey, for example, has established study areas ranging in size from one major intersection on either side of a development to locations 10 mi away from a 4-million-sq ft development. Table 5-2 gives the determinants with respect to the study area and the proportional assignment of site-generated traffic. Another frequently used method to determine study area limits is to carry the analysis to locations where site-generated traffic will represent 5 percent or more of the roadway's peak-hour approach capacity.

A vicinity map that shows the site, in relation to the surrounding transportation system, and development is essential to help orient the reviewer and avoid confusion.

A complete description of the existing land uses in the vicinity of the site, as well as their current zoning and use, or the likely use in the case of vacant tracts, should be included. Generally, much of this information can be obtained from the initial meetings with the city or county staff.

Identify and describe the existing roadways and intersections, (geometrics, traffic controls, and operations) including problems, if any.

Road improvements contemplated by government agencies within the study area would include the nature of the improvement project, its extent, implementation schedule, and the agency responsible for the funding source.

Current peak-hour and, as necessary, daily traffic volume data should be included. Peak-hour traffic volumes, separated into individual movements, should be indicated at critical intersections adjacent to or in close proximity to the site. Daily traffic volumes should be included on the major roadways within the study area, including trips to and from adjacent or opposite activity centers. Volumes to and from activity centers either adjacent to or opposite the proposed development should also be included.

3. *Proposed Site Uses.* The proposed use or uses of the site should be identified in terms of type and size of proposed developments.

4. *Site-Generated and Design Hour Volumes.* Site-generated traffic volumes vary with the type and intensity of the proposed development. Variables include critical or design hours and design days. For example, an office complex has little day-to-day variations, but has high entering volumes in the morning and high exiting volumes during the afternoon or evening. The directional distribution of a residential development is just the opposite—high outbound in the morning and high inbound in the evening. A large regional shopping center has its peak traffic periods during the evening or during midday on Saturday and Sunday. An office complex generates very little traffic on weekends.

A summary table listing each type of land use, the size proposed, the average vehicle trip generation rates used (total daily traffic, A.M./P.M. peaks and the peak-hours of development), and the resultant total trips generated should be provided. Trip generation volumes are most commonly calculated from the latest data contained within the Institute of Transportation Engineers (ITE) *Trip Generation Guide,* 5th Edition, 1991. In the event that data are not available or appropriate for the proposed land use, the city's approval of the proposed rates should be obtained as soon as possible.

A summary of ITE A.M. and P.M. peak-hour data for the more common land uses is presented in Table 5-3. These rates reflect travel characteristics in suburban areas, and they may not apply in densely developed areas or in city centers with walk-in and transit traffic. Also, large regional shopping centers (as well as recreational related activities) generate evening and weekend trip rates that may be more than double the values given in Table 5-3.

Some trips to a development will be attracted from the passing traffic stream. These "pass-by" trips should be deducted from the generated traffic volumes. Most pass-by or "intercepted" trips are associated with uses such as service stations, convenience stores, or general retail establishments.

The proportion of pass-by trips decreases with the size of the development—a retail development of 100,000 sq ft GLF could

Table 5-3. Summary of trip generation rates and average number of weekend trip ends. (Source: *Trip Generation*, 5th Edition, Institute of Transportation Engineers, 1991)

CODE	LAND USE	UNIT	DAILY TRIP ENDS		A.M. PEAK HOUR			P.M. PEAK HOUR		
			RATE	S.D.	IN	OUT	S.D.	IN	OUT	S.D.
110	Light Industry	1,000 G.S.F.	6.97	(4.24)	0.85	0.16	(1.07)	0.12	0.86	(1.16)
		Employees	3.02	(1.86)	0.37	0.07	(0.69)	0.05	0.37	(0.67)
130	Industrial Park	1,000 G.S.F.	6.97	(5.66)	0.76	0.16	(1.05)	0.19	0.72	(1.10)
		Employees	3.34	(2.38)	0.40	0.09	(0.73)	0.10	0.36	(0.73)
140	Manufacturing	1,000 G.S.F.	3.85	(3.09)	0.72	0.06	(1.07)	0.40	0.35	(1.02)
		Employees	2.09	(1.63)	0.40	0.03	(0.67)	0.20	0.19	(0.64)
150	Warehousing	1,000 G.S.F.	4.88	(4.03)	0.41	0.16	(0.83)	0.26	0.48	(0.98)
		Employees	3.89	(3.08)	0.37	0.14	(0.74)	0.21	0.38	(0.80)
210	Single Family Residential	D.U.	9.55	(3.66)	0.19	0.55	(0.90)	0.66	0.35	(1.05)
220	Apartment	D.U.	6.47	(2.91)	0.04	0.47	(0.73)	0.43	0.20	(0.84)
222	High-Rise Apartment	D.U.	4.20	(2.32)	0.08	0.22	(0.55)	0.21	0.14	(0.59)
230	Residential Condominium	D.U.	5.86	(3.09)	0.07	0.37	(0.69)	0.07	0.37	(0.69)
240	Mobile Home Park	Occupied D.U.	4.81	(2.60)	0.08	0.32	(0.66)	0.40	0.16	(0.76)
270	Residential P.U.D.	D.U.	7.44	(3.29)	0.11	0.40	(0.72)	0.41	0.21	(0.80)
310	Hotel	Occupied Rooms	8.70	(3.13)	0.40	0.27	(0.84)	0.41	0.35	(0.89)
320	Motel	Occupied Rooms	10.19	(4.04)	0.24	0.42	(0.85)	0.34	0.26	(0.79)
520	Elementary School	Employee	13.39	(6.44)	2.05	1.37	(2.25	1.73	1.37	(2.40)
560	Church	1,000 G.S.F.	9.32	(7.46)	0.47	0.27	(2.07)	0.39	0.33	(1.07)
610	Hospital	Employees	5.17	(2.90)	0.23	0.14	(0.58)	0.09	0.20	(0.54)
		Beds	11.77	(7.14)	0.76	0.31	(1.10)	0.37	0.85	(1.17)
620	Nursing Home	Occupied Beds	2.60	(11.68)	0.12	0.07	(0.45)	0.07	0.10	(0.42)
710	General Office	Employees								
	25 employees		6.00	NA	0.69	0.08	NA	0.16	.76	NA
	100 employees		4.74	NA	0.57	0.07	NA	0.12	.57	NA
	500 employees		3.62	NA	0.46	0.06	NA	0.08	.41	NA
	1,000 employees		3.22	NA	0.42	0.05	NA	0.07	.36	NA
	1,600 employees		2.98	NA	0.39	0.05	NA	0.07	.32	NA
	10,000 sq. ft.	1,000 G.S.F.	24.60	NA	2.85	0.35	NA	0.58	2.82	NA
	100,000 sq. ft.		14.03		1.69	0.21	NA	0.32	1.65	NA
	300,000 sq. ft.		10.77		1.33	0.17	NA	0.29	1.16	NA
	500,000 sq. ft.		9.45		1.18	0.15	NA	0.21	1.01	NA
	800,000 or more sq. ft.		8.46		1.07	0.13	NA	0.18	0.90	NA
714	Corporate Headquarters	Employees	2.19	(1.54)	0.41	0.03	(0.67)	0.04	0.33	(0.92)
		1,000 S.F. G.F.A.	6.27	(2.62)	1.37	0.10	(1.35)	0.15	1.25	(1.28)
715	Single Tenant Office Building	Employees	3.55	(2.43)	0.46	0.06	(0.74)	0.08	0.42	(0.72)
		1,000 S.F. G.F.A.	11.50	(8.60)	1.58	0.20	(1.51)	0.28	1.55	(1.50)
750	Office Park	1,000 S.F. G.F.A.	11.42	(4.69)	1.64	0.20	(1.50)	0.23	1.28	(1.34)
760	Research and Development Center	Employees	2.67	(2.07)	0.36	0.07	(0.67)	0.06	0.35	(0.66)
		1,000 S.F. G.S.F.	7.70	(5.84)	1.02	0.21	(1.34)	0.16	0.91	(1.19)
770	Business Park	Employees	4.58	(2.26)	0.48	0.08	(0.75)	0.10	0.37	(0.69)
		1,000 S.F. G.S.F.	14.37	(6.19)	1.38	0.24	(1.41)	0.33	1.15	(1.34)
820	Shopping Center	1,000 G.L.A.								
		100,000 G.L.A.	70.67	NA	1.02	0.60	NA	3.28	3.28	NA
		300,000 G.L.A.	46.81	NA	0.65	0.38	NA	2.20	2.20	NA
		500,000 G.L.A.	38.65	NA	0.53	0.29	NA	1.88	1.88	NA
		1,000,000 G.L.A.	32.09	NA	0.40	0.23	NA	1.49	1.49	NA
		1,600,000 G.L.A.	28.61	NA	0.33	0.19	NA	1.31	1.31	NA
831	Quality Restaurant	1,000 G.S.F.	96.51	(32.57)	0.86	0.06	(0.98)	5.36	2.30	(4.31)
		Seats	2.86	(1.95)	0.28	0.02	(0.16)	0.16	0.07	(0.49)
911	Walk-In Bank	Employees	72.79	(46.58)	0.71	1.35	(3.30)	4.50	4.87	(8.88)
		1,000 G.S.F.	265.21	(143.92)	6.25	4.91	(9.36)	20.94	22.69	(46.11)

S.D. = Standard Deviation
G.S.F. = Gross Square Feet
G.L.A. = Gross Leasable Area
D.U. = Dwelling Units

have about 40 percent pass-by trips, while a million square foot shopping center might have as little as 10 percent. However, for each size and type there is a wide range in the proportions of pass-by trips reported.

The intercepted or "pass-by" trips may be deducted from the background traffic when assigning site-generated traffic volumes to surrounding roads. However, these trips should not be deducted when evaluating traffic movements at access points or at points between where the access points and the diversion takes place. All trips must be counted in assessing impacts and needs, such as turn lane designs.

5. *Trip Distribution and Traffic Assignment.* The technical analysis steps, basic methods, and assumptions used in estimating the directions of approach and movements at critical intersections and at each accessed drive should be clearly and concisely identified.

The directions from which site traffic will approach or depart a development will vary, depending on site-specific factors such as: (a) type and size of the proposed development; (b) size of the area influenced by the development and, if applicable, the location of competing developments (e.g., shopping centers); (c) surrounding land uses and population distribution; (d) conditions and efficiency of the existing street system; and (e) effects on proposed improvements or additions to the existing street system.

Since a wide range of situations is probable, municipal codes or ordinances should not require the use of specific traffic distribution techniques. The analyst preparing the TIA should be allowed to exercise appropriate judgment.

Where a market analysis is available, as is common for large retail developments, a table should be prepared showing how the directions of approach relate to the effective trade area of the proposed development.

6. *Existing and Projected Traffic Volumes.* The volume of existing traffic on streets adjacent to and in the vicinity of a proposed development can be readily obtained by conventional traffic count procedures. Existing traffic volumes provide background data from which projected traffic volumes can be estimated. Again, depending on: (a) the type and size of a development, (b) whether or not phase development is planned, and (c) when full build-out is anticipated, horizon years should be determined. Horizon years may also depend on local planning schedules of major transportation system changes.

The background traffic should include traffic to and from adjacent activity centers. It should also reflect traffic flows for developments under construction, approval, or submitted for application.

The inclusion of existing traffic count data, which should include volumes associated with existing adjacent or opposite activity centers, was described in item 3. With respect to projected traffic volumes, the data should include the total of site generated traffic volumes plus background traffic that cause the most critical impacts. Accordingly, the following should be estimated and presented in the report. (a) site traffic—A.M., P.M., and when appropriate, evening, Saturday and Sunday peak hours; (b) total traffic—A.M., P.M., and when appropriate, evening, Saturday and Sunday peak hours.

The background traffic portion of total traffic volumes should be non-site traffic adjusted for a horizon year or for several horizon years. Care should be exercised to avoid understating or overstating background traffic growth. Past population, vehicle registration, travel trends in a project influence area, and traffic growth trends on boundary roads can provide a basis for projecting peak-hour background traffic to the horizon year.

The phrase "when appropriate" refers to the critical peak traffic volumes of various land uses. The A.M. peak-hour traffic conditions are normally not critical with respect to shopping centers, while Saturday and Sunday conditions are normally not critical with respect to most office uses. Traffic count data and analysis worksheets should be provided in the report as necessary.

7. *Traffic Accidents.* Traffic accidents at intersections and along roadways adjacent to the site should be analyzed to determine if the proposed development will contribute to an already existing problem or if proposed roadway or traffic control improvements might help alleviate the problem. An on-the-ground inspection of the horizontal and vertical alignment should be made to determine if the proposed location and design of access along with intersection sight distance restrictions will create a traffic accident potential.

8. *Capacity Analysis.* The capacity of critical intersections adjacent to and in the vicinity of the site as well as the capacity of the access drives should be summarized together with the analysis procedure used. The criteria used to evaluate traffic operation is referred to as the level of service (LOS). Methods used to calculate the LOS of street intersection, driveways, or street segments should conform to the techniques described in the "Highway Capacity Manual," *Special Report 209,* published by the Transportation Research Board. Because of the assumptions involved in estimating development traffic and background traffic growth, planning types of capacity analyses may be appropriate. Detailed calculations may be included in the appendix.

9. *Traffic Improvement Recommendations.* Changes at existing intersections should be specifically identified (e.g., extend left-turn lane, add channelized right-turn lane, changes in signal operation) together with proposed signals, right-of-way widening, or other improvements. Where traffic signals exist or are proposed within 3,000 ft of each other, a traffic engineering analysis should be made of the two-way progression at various combinations of cycle lengths, splits, and speeds.

10. *Signalization Warrants.* If it is anticipated that the development's driveways will satisfy signalization warrants soon after the development has been completed, a warrant analysis should be conducted using the projected volumes determined from the trip generation analyses. The results of such an analysis shall be tabulated and can be included in an appendix.

11. *Illustrative Site Plan.* An illustrative site plan should show how the site access is coordinated with the internal road system. It should indicate the traffic, public transport, and pedestrian adequacy of the overall site and access.

12. *Demand Management Plan.* A traffic impact study may include a travel demand management plan. This plan should indicate a traffic reduction program and specify the actions that should be taken to reduce total peak-period vehicular trips.

13. *Fair Share Analysis.* The report may identify the "fair share" contributions of developers and public agencies to required road improvements. It should also indicate the basis or rationale underlying these decisions.

14. *Conclusions and Summary of Findings.* The conclusions should permit a clear and concise statement of the findings and recommendations. Ideally, it should serve as an executive summary. Depending on local preference, it might be the last chapter in the TIA report (located immediately before the appendixes) or it might be located immediately following the table of contents. The latter location will be appreciated by the individual who wishes to know the results and is not interested in, or does not have, the time to evaluate the entire report.

The TIA when completed should: (1) provide developers with recommendations with respect to site selection, site transportation planning, and anticipated traffic impacts and (2) assist public agencies in reviewing anticipated traffic conditions in the vicinity of proposed developments. The analysis also can be used by public agencies as a basis to determine development impact fees and to assess developer contributions to roadway improvements.

CHAPTER 6

ACCESS CLASSIFICATION SYSTEMS

IN BRIEF The access classification system forms the basis of access management. It defines where access can be allowed between proposed developments and public highways, and where it should be denied or discouraged; where access should be limited to right turns into and out of the driveways leading to or from activity centers; and where provisions, if any, should be made for left turns and out of connecting driveways. It correlates allowable access with a roadway's purpose and importance, functional characteristics, design features, and access spacing standards.

The key initial step is to define access categories for various highway types and functional characteristics. This makes it possible to apply access controls in a reasonable and equitable manner that is consistent with the intended purpose of the roads under consideration. Accordingly, this chapter defines access categories or levels for various roadway types, gives procedures for changing an access classification, and suggests guidelines for denying access. The following chapter, in turn, sets forth the specific spacing standards that apply to each access level. The various guidelines provide a framework for developing access standards for any state, county, or city. They should be modified, as appropriate, to reflect specific local needs. The access classification system for an area's roadways should be easy to understand and simple to apply. It should be applied in a consistent manner that is enforceable by the courts. It should be separate from urban boundaries and other administrative lines whenever possible. It should protect the functional purpose of a roadway, as defined in the long range transportation plan, and ensure that access decisions do not erode the road's effectiveness. Thus, the system should reflect the intended purpose of a road as well as its existing characteristics. It should minimize the access allowed to and from high-type roads. Thereby, it may involve access denial as well as provision. When access is to be provided, it should be provided by using as low an access level as possible.

6.1 ROADWAY CLASSIFICATION

Safe and efficient operation of streets and highways requires that these facilities be classified and designed for the functions that they will perform. The entire road system is traditionally classified by relating the proportion of through movement to the proportion of access such as shown in Figure 6-1. Freeways, which have full control of access and serve only the movement function, are at one end of the scale; the local street and cul-de-sac, which predominantly provide for land access, are at the other end of the scale because they have little or no through movement. Collector and arterial streets normally must provide a balance between movement and access functions; it is along these streets that access management actions become important. Public transport and pedestrian requirements may influence roadway classification in some situations.

The three main factors that separate these types of roads are traffic volumes (capacity), travel speed, and trip distance. The primary design element that impacts the functional integrity of most roads is the at-grade, full-movement, signalized intersection; a second element is the congestion caused by nonsignalized access.

A detailed classification of roads and streets in any jurisdiction is essential for intelligent access control and management. The classifications should consider factors such as: functions performed, traffic character and intensity, linkages between activity centers, land use and areas served, system continuity, design features, and location (urban, rural). Once the roadways are classified, the next step is to identify the allowable access for each class.

6.2. DEVELOPING ACCESS CATEGORIES

The access classification system and its application to a road system can be derived in several ways. The Colorado and Florida access codes, which apply only to state highways, define each access category in terms of road function, type of access permit-

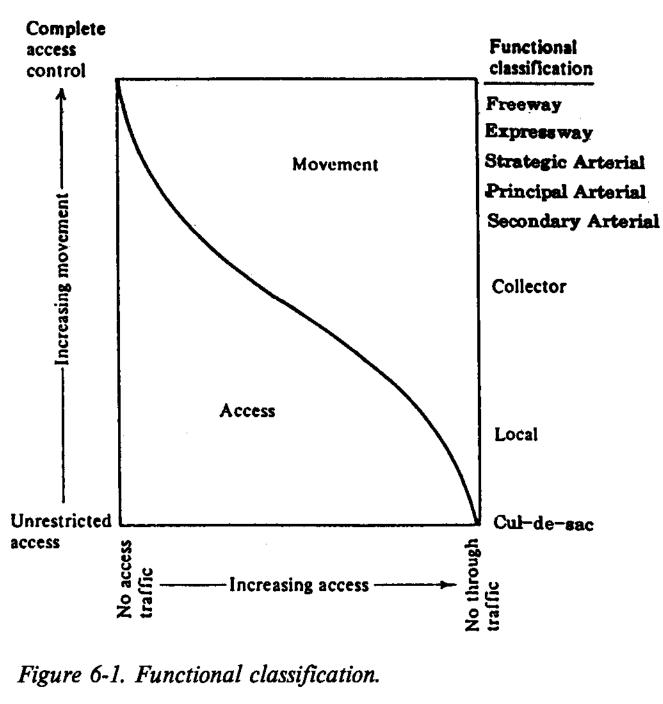


Figure 6-1. Functional classification.

ted, and access spacing (see (A) in Figure 6-2). Alternatively, as specified in the New Jersey access code ((B) in Figure 6-2), allowable access levels can be defined first and then related to the road system, based on road functions and design features. Both approaches, properly applied, can preserve highway access.

The "Colorado" Approach

Colorado uses a five-tier access-control classification system. Each segment of the state highway system is assigned to an access category, based on such classification criteria as roadway function, traffic volumes, speeds, trip length, and the availability of local road access, functional and funding classification (state and federal) and existing access conditions.

The State Highway Access Code specifies when direct access is allowed for each category. The access categories, roadway types, and allowable access are summarized in Table 6-1. The Code denies or discourages all direct private access to or from the state highway system, except for categories 4 (Arterials/Collectors) and 5 (Frontage/Service) roads. However, direct private access may be allowed for categories 2 (Expressway) and 3 (Arterial) when: (1) no alternate access is available and the cost of providing frontage or service roads is prohibitive; (2) the alternate access is not safe or desirable; and (3) the access meets street spacing requirements of ½ mi.

The Florida Access Code, patterned after Colorado's, defines seven road categories and specifies the access allowed for each category.

The "New Jersey" Approach

An alternative approach, patterned after New Jersey's procedures, is generally similar to that used in Colorado and Florida. However, it first defines the allowable access levels and then relates these levels to the road system. It can be applied to both state and local roads.

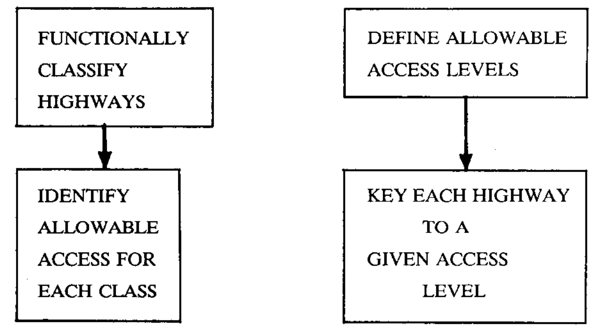
Defining Access Levels

The New Jersey approach defines seven allowable access levels between public highways and activity centers. These access levels cover the spectrum of possibilities.

The seven levels range from full control of access (level 1, freeways) to access control only for safety reasons (level 7, local and collector streets and frontage roads). Access level 1 governs limited access highways; levels 2 through 6 apply to "controlled access" highways. Access levels 1 and 2 permit uninterrupted flow along the public highway adjacent to activity centers; and level 3 permits uninterrupted flow in one-direction only. Levels 4 through 7 interrupt highway flow to provide activity center ingress and egress. Levels 1 through 6 should be subject to applicable spacing criteria for interchanges, signalized intersections, and unsignalized intersections. Level 7 should be subject to safety requirements only (i.e., sight distances).

The seven access levels are defined as follows:

- *Access Level 1, Access at Interchanges Only.* This is the most restrictive access level. It applies to freeways and to sections of



(A) COLORADO - FLORIDA SYSTEM (B) NEW JERSEY SYSTEM

Figure 6-2. Access classification systems.

other major highways that have (or need) complete access control. All access would be provided via interchanges. Access to large activity centers would be provided by special grade-separated interchanges. In other cases, indirect access would be permitted from existing or proposed interchanges or parallel roads. Any special grade-separated interchange would have to meet interchange spacing standards and demonstrate that overall benefits would be achieved. This access level normally requires deeded access rights.

- *Access Level 2, Access Via At-Grade Public Street Intersections or at Interchanges.* This access level applies where access rights have been purchased by public agencies and where speed, traffic volume, intersection proximity or safety conditions make it impractical or undesirable to provide direct access. Expressways, with some grade-separated interchanges and some signalized intersections fall into this category.

Activity centers would have to obtain indirect access from an intersecting (or parallel) public road unless no other reasonable access is available. A grade-separated interchange between the highway and adjacent developments would be permitted where adequate distance exists to adjacent intersections. However, such interchanges would be practical only for large developments.

Major intersection needs would have interchanges or grade separations; typical spacing of intersecting streets shall be 1 mi;

Table 6-1. Colorado highway classification system. (Source: *The State Highway Code,* amended by the Colorado State Highway Commission, August 15, 1988)

ACCESS CATEGORY	ROADWAY TYPE	DIRECT PROPERTY ACCESS
1	Freeway	None
2	Expressway	General prohibited. Right turns permitted if no other reasonable access exists.
3	Major Arterial	Preferably prohibited.Right turns permitted if no other reasonable access exists.
4	Arterial/ Collector	Permitted.
5	Frontage/ Service Roads	Permitted.

however, ½-mi spacing shall be permitted where no other reasonable access exists, or where required by existing street patterns.

This access category may represent an early stage of access level 1. Examples include the California expressways and sections of the Saw Mill River and Taconic State parkways in New York State.

- *Access Level 3, Right-Turn Access Driveway Only (or Access Via Interchange).* This access level applies to "strategic arterials"—normally divided multilane highways of major significance. Major intersections may be grade separated to assure a high proportion of green time. Access to developments or activity centers is restricted to right-turn movements only. Alternatively, left-turn access may be provided via interchanges. Access from intersecting or parallel streets with lower access classification should be encouraged, and a public agency may want to restrict driveway access if reasonable alternate access is available. Examples include sections of Routes 4 and 22 in New Jersey where continuous medians limit all property access to right turns.
- *Access Level 4, Right- and Left-Turn Access In, Right-Turn Access Out.* This access level applies to divided, multilane highways. Both left-turn and right-turn access into activity centers are provided. However, exits are limited to right turns. This access level has several positive features: (1) it does not impede signal progression along the public highway because only one direction of travel is signalized at any point, and (2) it reduces the number of left turns at adjacent public street intersections.
- *Access Level 5, Right- and Left-Turn Access Into and Out of Activity Center—Left-Turn Lanes Required.* This access level applies to both divided and undivided highways. Full access would be provided between public highways and activity centers. Signalized spacing standards would govern left turn *exit* spacings on divided highways. Left-turn lanes would be required along the public activity centers.
- *Access Level 6, Right- and Left-Turn Access Into and Out of Activity Center—Left-Turn Lanes Optional.* This access level would apply to multilane and two-lane undivided roadways. It would permit full access to and from activity centers. Left-turn lanes for entering traffic would be optional; their application would depend on the size of the activity center and the hours to be served. If the left-turn movement requires signalization, a separate left-turn lane would be required.
- *Access Level 7, Right- and Left-Turn Access Into and Out of Activity Center—Driveway Spacing Limited by Safety Requirements Only.* This access level applies to frontage roads and to two-lane collector or local roads.

The seven access levels may be modified to reflect design practices of specific agencies. For example, an access level 3 may be introduced where jughandles are used along multilane divided highways. Similarly, an agency may reduce the number of access levels as appropriate. The seven access levels are summarized in Table 6-2 and shown schematically in Figure 6-3.

Under this access level classification system, roads with denial of access to developments would be placed in level 2. However, roads would be placed in level 3 where right-turn access can be allowed, and in level 4 where left-turn entrances can be permitted. Using this approach, many roads classified as principal or strategic arterials might be treated as "expressways" (i.e., level 2) in terms of their access control.

Table 6-2. Level of access to developments.

ACCESS LEVEL	DESCRIPTION
Level 1	Access at Interchanges Only (Uninterrupted Flow)
Level 2	Access at Public Street Intersections or at Interchanges Only (Uninterrupted Flow)
Level 3	Right Turn Access Only (or Access at Interchange) (Uninterrupted Flow)
Level 4	Right Turn Out, Left and Right Turn In (Interrupted Flow - One Direction)
Level 5	Right and Left Turn with Left Turn Lane In and Out Required (Interrupted Flow - Both Directions)
Level 6	Right and Left Turn In and Out with Left Turn Lane Optional - In and Out (Uninterrupted Flow - Both Directions)
Level 7	Right and Left Turn In and Out (Safety Requirements Only)

Assigning Access Levels

The most straightforward approach is to key each access level or category to a particular functional class of road. Each of these levels, in turn, would have specific geometric design features (such as number of travel lanes and medians), and specific access spacing standards. However, many road systems, especially in developed areas, do not correlate cross-section features with the functional class of roadway. In some situations, local conditions may mitigate more restrictive classifications.

Accordingly, a more refined system of assigning access levels to specific sections of highways was developed. This system reflects (1) the functional class of highway, (2) highway design features (especially the presence or absence of a median divider), and (3) degree of urbanization (a proxy for development intensity, intersection frequency, and travel speed).

"Urban" can be construed to represent the central city, or other areas where density exceeds 6,000 persons per square mile.

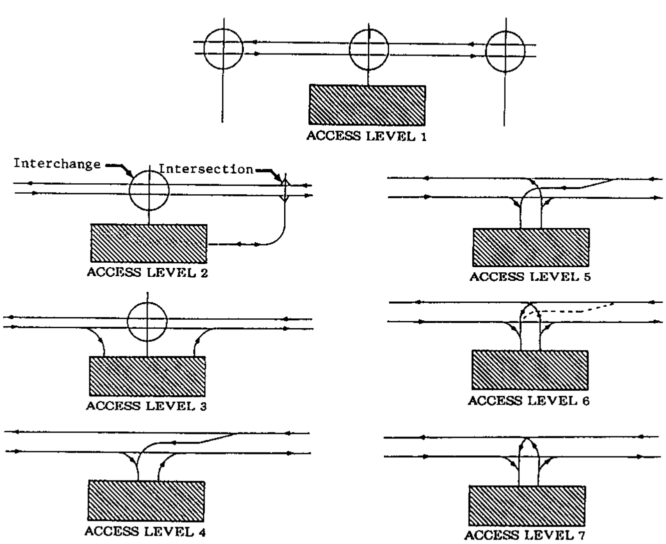


Figure 6-3. Access levels for developments.

Table 6-3. Access level by type of rural road.

Access Level	Freeway	Expressway	Strategic Arterial	Principal Arterial	Secondary Arterial	Collector	Frontage
1	All						
2		All	Divided				
3			Divided	(Divided)	(Divided)		
4				Divided (Multi- & 2-Lane)	(Divided)		
5				(Divided) Multi-Lane	Divided Multi- & 2-Lane	Divided	
6					(Multi-Lane) 2-Lane	Multi-Lane	
7						2-Lane	All

( ) = Optional

Table 6-4. Access level by type of suburban road.

Access Level	Freeway	Expressway	Strategic Arterial	Principal Arterial	Secondary Arterial	Collector	Frontage
1	All						
2		All	(Divided)				
3			Divided	(Divided)	(Divided)		
4				Divided (Multi & 2-Lane)	(Divided)		
5				(Divided) Multi- & 2-Lane	Divided Multi-Lane	Divided	
6					(Multi-Lane) 2-Lane	Multi-Lane	
7						2-Lane	All

( ) = Optional

Table 6-5. Access level by type of urban road.

Access Level	Freeway	Expressway	Strategic Arterial	Principal Arterial	Secondary Arterial	Collector	Frontage
1	All						
2		All	(Divided)				
3			Divided (Multi- & 2-Lane)	(Divided)			
4				Divided (Multi- & 2-Lane)	(Divided)		
5				(Divided) Multi- & 2-Lane	Divided Multi-Lane	Divided	
6					(Multi-Lane) 2-Lane	Multi-Lane	
7						2-Lane	All

( ) = Optional

"Suburban" can be defined as all parts of an urbanized area other than the central city. "Rural" represents all other areas.

The roadways are grouped into the categories normally used in classifying highways: freeway, expressway, strategic arterial, principal and secondary arterials, and collector and frontage roads. The likely presence or absence of physical median islands is also considered.

Tables 6-3, 6-4, and 6-5 give suggested access levels for rural, suburban, and urban environments, taking into account both functional classification and geometric design. Entries in parentheses are listed as optional and may be appropriate in some circumstances.

Access levels 3 and 4, which limit left turns to or from activity centers, are suggested only for divided highways. This is because it is difficult to enforce left turn prohibitions from undivided highways.

Each roadway (or section of roadway) should be assigned to one of the seven access levels based on the guidelines given in Tables 6-1, 6-3, 6-4, and 6-5. This process should be done by the appropriate jurisdiction and should consider specific development conditions and design constraints. Operating conditions and travel speeds might require "downgrading" access levels in built-up areas. These exceptions, however, should be kept to a minimum.

The guidelines should apply to the likely future function and design, rather than merely to the present road. This will serve to protect roads, planned to be upgraded, from undue encroachment. For example, the most important roadway in a region might be a two-lane facility at present; but it is planned for widening to four lanes. In this case, the future multilane features should govern its access level determination.

Generalized Access Classification System

A general approach to assigning access categories or levels to a road system is given in Table 6-6. This table shows how each of the seven types of allowable access relates to the seven basic road classes—freeways, expressways, strategic arterials, principal arterials, secondary arterials, collectors, and local and frontage roads, and the general design features associated with each class.

It can be seen from the table that direct property access is prohibited from freeways and expressways, access levels 1 and 2. Direct property access should be denied or restricted from access levels 3 and 4, strategic and principal arterials, respectively. However, access may be provided where no reasonable alternative access is available, or where it is in the general public interest to do so. This generally is possible in undeveloped areas, but it may not be practical in urban and suburban settings. Where access must be provided, it should be limited to right turns only for access level 3, and to right- and left-turn entry and right-turn exit for access level 4. Direct property access may be permitted for access levels 5 and 6; it is desirable at level 7.

Table 6-6. Access categories keyed to roadway type.

Access Category	Roadway Classification	Direct Property Access	General Design Features
1	Freeway	No	Multi-lane Median
2	Expressway	No	Multi-lane Median
3	Strategic Arterial	Restrict or Deny (a)	Multi-Lane Median
4	Principal Arterial	Restrict or Deny (b)	Multi-Lane (c) Median
5	Other Arterial	Yes	Multi-Lane or 2-Lanes
6	Collector	Yes	2-Lanes
7	Local/Frontage Road	Yes	2-Lanes

(a) Right turns only when provided

(b) Right and left turn entry and right turn only exit when provided

(c) Might be two-lanes in some rural areas

6.3 RELATED CONSIDERATIONS

Criteria for denying access and procedures for changing highway access categories are integral parts of the roadway classification system.

Access Denial Criteria

Access generally should be denied under the following circumstances: (1) when reasonable alternative access can be provided from roadways with a lower classification (applies to levels 3 and 4); (2) when the denial does not significantly compound problems at nearby intersections of public roads (applies to levels 3 and 4); (3) when the denial does not undesirably increase travel on residential streets or through neighborhoods (applies to levels 3 and 4); (4) when the proposed access does not meet spacing standards (applies to levels 3 and 4; and to levels 5 and 6 when reasonable access can be provided elsewhere); (5) when the proposed access cannot meet design or safety requirements (applies to all access levels); and (6) when proposals call for more than one access per land parcel or contiguous parcels with less than 200 ft of frontage.

Access Classification Changes

Each public agency should define the access levels for highways within its jurisdiction. These regulations should be reviewed regularly for their reasonableness and practicality.

Any individual or group desiring a change in access classification should submit the following materials to the agency for consideration: (1) a description of the roadway involved, including relevant maps, zoning information, and desired changes in classification; (2) a justification for the proposed change in terms of development intensity, safety, or other supportive reasons; (3) an analysis of the areawide advantages and disadvantages associated with the reclassification; (4) a determination that the highway, with the proposed change, will meet, or will fail to meet, future capacity, specified in a 20-year road plan, and safety needs; and (5) a determination if lowering the access classification adversely affects the future capacity and operational viability, and an indication of how the capacity will be recaptured, and who will pay for the added capacity.

State and local agencies may modify the suggested access classification systems to meet their specific requirements. They can combine or restructure the access categories, and they can further define the allowable access in each category. However, the underlying theme of modern access management must be retained—namely, extending aspects of access control to arterial roads and protecting the functional integrity of the road system.

CHAPTER 7

ACCESS SPACING GUIDELINES

IN BRIEF Three elements affect management for highways and activity centers: (1) the allowable access for each type of highway, (2) related site planning and geometric design standards, and (3) spacing criteria for each access category or level. Spacing is also influenced by the highway cross section. This chapter presents suggested approaches and guidelines for access spacing. It also contains background information and the rationale that underlie the guidelines. The guidelines cover signalized driveways and intersections, unsignalized driveways and intersections, median openings, grade-separated interchanges, and lateral access restrictions. The spacing standards address the following questions for each access level: When should grade separations be considered? What is the desirable spacing of signals? What should the minimum driveway spacing be at unsignalized locations? What should be the limit on the number of access drives per property (whether they provide for full or partial access)? Should a proposed access point be lined up with the existing access to a development on the opposite side of an undivided highway or located elsewhere while maintaining a minimum offset?

7.1 GENERAL CONSIDERATIONS

The spacing guidelines are designed to preserve the functional integrity of highways, provide for smooth and safe flow, and afford abutting property an appropriate degree of access. The access criteria for signalized and unsignalized driveways and at-grade intersections reflect the following general considerations:

1. Allowable access should vary by access class, facility type, roadway speed, and development density.
2. Access spacing guidelines do not have to be consistent with existing access practices.
3. Guidelines should apply to new developments (where none exist) and to significant changes in the size or type of existing developments.
4. Allowable tolerances for deviations from the desired standards generally should vary with the access level or functional class of highway involved. These tolerances are greater for collectors and minor arterials than they are for principal arterials.
5. Traffic signal spacing for both driveways and at-grade public intersections should be related to speed (i.e., posted speed limit).
6. Signal spacing criteria should govern both intersecting public streets and access drives. They should take precedence over the unsignalized spacing standards in situations where there is the potential for future signalization.
7. Locations for signalized at-grade intersections ideally should be identified first. Unsignalized right- and left-turn access points should be selected based on existing and desirable future signal locations.
8. Grade separations may be needed in some circumstances where major roadways intersect or as a means of providing direct access between arterials and large traffic generators.
9. Reasonable alternative access must be considered. However, care should be exercised to avoid merely transferring problems.
10. Access for land parcels that do not conform to the spacing criteria may be necessary when no alternative reasonable access is available. The basis for these exceptions or variances should be identified.

The spacing guidelines are designed to minimize the need for variances or exceptions while simultaneously protecting arterial traffic flow. They recognize that driveways to major activity centers should be reviewed as intersecting high-volume roads, rather than merely as curb cuts.

7.2 GRADE SEPARATIONS

Grade-separated interchanges can increase capacities and reduce delays where major public highways cross or where large activity centers must be reached from major boundary roads.

Background

General criteria for grade-separated interchange warrants are contained in the AASHTO *Policy on Geometric Design of Highways and Streets* (*1*). However, AASHTO prefaces its presentation of warrants by stating: "An enumeration of the specific conditions or warrants justifying a grade-separated interchange at a given at-grade intersection is difficult and, in some instances, cannot be conclusively stated. Because of the wide variety of site conditions, traffic volumes, roadway types, and grade-separated interchange layouts, the warrants that justify a grade-separated interchange may differ at each location." The four general warrants are: (1) *design designation*—a roadway that is planned to be fully access controlled requires grade separations or grade-separated interchanges for all intersecting roadways; (2) *elimination of bottlenecks of spot congestion*—an at-grade intersection with intolerable congestion that cannot be alleviated by widening or traffic engineering techniques may acquire grade separation where development and right-of-way conditions permit; (3) *elimination of hazard*—where an at-grade intersection has a disproportionate rate of serious accidents and there are no less expensive methods of eliminating the hazards, a grade separation or grade-separated interchange may be warranted, and (4) *traffic* *volumes*—as noted by AASHTO: "A traffic volume warrant for grade-separated interchange treatment would be the most tangible of any grade-separated warrant. Although a specific volume of traffic at an at-grade separation cannot be completely rationalized as the warrant for a grade-separated interchange, it is an important guide, particularly when combined with the traffic distribution pattern and the effect of traffic behavior."

An FHWA-sponsored report on access management, drawing upon the Wisconsin State Highway Plan, suggested grade-separated interchanges along "standard arterials" under the following circumstances (*2*): (1) *suburban*—arterials carrying more than 20,000 vpd crossing arterials carrying more than 10,000 vpd; and (2) *rural*—arterials carrying more than 5,000 vpd crossing arterials carrying more than 3,000 vpd.

However, at today's cost of $5 million to $10 million to construct an interchange, these volume warrants would not survive a benefit-cost analysis.

Guidelines

Interchanges in an access management context provide several important functions. They enable the signal green time and, hence, the through bands to be maximized along expressways and major arterials. (If two streets with 60-40 signal split favoring each street meet, the interchange eliminates the reduction in green time that would otherwise result.) They also allow access to large activity centers where such access might be precluded by traffic signal spacing criteria.

More specifically, a grade-separated interchange may be appropriate in the following situations: (1) where two expressways (i.e., access level 2) cross, or where an expressway crosses arterial roads (access levels 3, 4, or 5); (2) where strategic or principal arterials (access levels 3 and 4) cross and the resulting available green time for any route would be less than 50 percent; (3) where an existing at-grade signalized intersection along an arterial roadway operates at level of service "F" and there is no reasonable improvement that can be made to provide sufficient capacity; (4) where a history of accidents indicates a significant reduction in accidents can be realized by constructing a grade separation; (5) where a new at-grade signalized intersection in urban and suburban settings would result in level of service "E". In rural settings, the level of service should not be worse than "C"; (6) when the location to be signalized does not meet the signal spacing criteria and signalization of the access point would impact the progressive flow along the roadway and there is no other reasonable access to a major activity center; (7) where a major public street at-grade intersection is located near a major traffic generator and effective signal progression for both the through and generated traffic cannot be provided; (8) the activity center is located along a major arterial where either direct access or left turns would be prohibited by the access code or would otherwise be undesirable; and (9) where it is necessary to reduce hazard or to improve safety. Suggested application guidelines that reflect these objectives are given in Table 7-1.

Table 7-1. Interchange applications guidelines.

Access Level	1	2	3	4	5	6	7	Activity Center Driveway Access
1	•	•	•	•	•	•	•	*
2		•	•	(•)	(•)			•*
3			(•)	(•)				(•)*
4				(•)				(•)
5								
6								
7								

(•) Optional

* Special case

Minimum interchange spacing along various roadways should be as follows:

	Urban/Suburban	Rural
Freeway	1 mile	3 miles
Expressway	1 mile	2 miles
Strategic Arterial	½ mile	2 miles

Spacing may be closer where access is provided to or from collector-distributor roads. Privately developed interchanges should become part of a regional transportation plan to ensure they are consistent with local and regional plans.

7.3 SIGNALIZED INTERSECTION SPACING

Preserving the quality of flow and safety along public streets and roads requires spacings of traffic signals that assure continuous, progressive movement. This normally entails: (1) relatively uniform spacing of traffic signals, and (2) sufficient distances between signals to allow vehicles to travel at reasonable speeds. Spacing standards for signalized intersections should achieve these objectives.

Background

Road system spacing patterns in the United States reflect history, topography, and how the land was surveyed. Most of the country west of the Appalachian Mountains was surveyed by the USGS into a grid of 1- by 1-mi units (sections) that combine to create townships, 6 by 6 mi. Farms and later development patterns generally followed this system. Colorado, for example, chose a ½-mi spacing system for major arterials because it fits most consistently with property boundaries and where public streets are most frequently dedicated. Chicago's arterial street system is spaced at ½-mi by 1-mi intervals, while roads in the surrounding suburbs are usually spaced 1-mi apart.

In the 13 original states and in many older cities, both land subdivision and street systems have no consistent patterns. The irregular and sometimes close spacing of arterial roads makes optimum signal timing difficult. The ½-mi uniform spacing, which is desirable in suburban areas to maintain high progressive speeds at cycle lengths of approximately 90 sec, cannot usually be achieved. Using a ⅓-mi spacing of signalized suburban junctions (including access points) may provide the needed flexibility. However, the sacrifice in progression and through band capacity must be recaptured by other means.

Several traffic signal spacing guidelines emerged from the review of existing practices. Colorado's State Highway Access Code calls for a standard of ½-mi (2,640-ft) spacing between

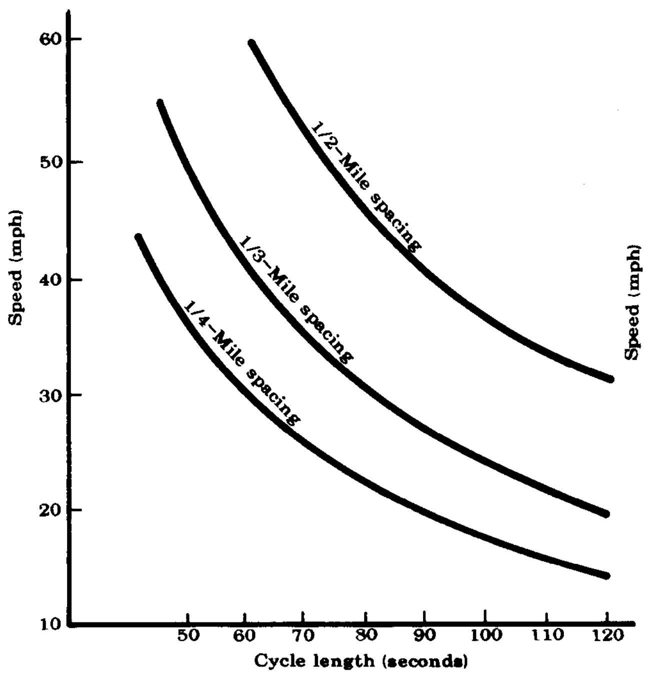


Figure 7-1. Speed of traffic progression as a function of cycle length and signal spacing.

signalized at-grade intersections. Where this cannot be achieved, the bandwidth for through traffic becomes the criterion for determining allowable traffic signal locations. Stover and Koepke (*3*) recommended signal spacings of ⅓ (1,760 ft) to ½ mi (2,640 ft) for major arterial streets and ¼ mi (1,320 ft) for minor arterial streets. New Jersey has adopted similar spacing criteria. New Jersey also specifies minimum bandwidths for each type of highway, and Florida specifies minimum signal spacings of 1,320 to 2,640 ft, depending on the designated access class.

The optimal spacing of signals depends on the cycle length and the posted speed. Long cycle lengths combined with high speeds require long distances between signals. Shorter cycle lengths and lower speeds enable closer spacing between signals. Figure 7-1 shows these relationships.

Speeds of 40 mph with a 90-sec cycle require that signals be located at uniform intervals of ½ mi (2,640 ft). Speeds of 35 mph with a 70-sec cycle require signals to be uniformly spaced ⅓-mi (1,760 ft) apart. Speeds of 30 mph with a 60-sec cycle require signals to be uniformly spaced at ¼-mi (1,320 ft) intervals.

Many heavily used arterials now use 90-sec to 120-sec cycle lengths. This causes progression problems for systems originally laid out at ¼-mi and ⅓-mi spacing and 60-sec and 70-sec cycles. As turning movements increase at cross streets and activity centers, the signals are forced to 90 sec and higher cycle lengths. At a 100-sec cycle, ¼-mi spacing means 18-mph progression, and ⅓-mi spacing gives 25-mph progression. Thus, the highway agency in selecting a signal spacing must consider future cycle lengths when calculating the future capacity and flow of the arterial at a given speed.

Uniform, or near uniform, spacing of signals is essential. A uniform spacing, based on the optimal location, permits a through band equal to the green time (Figure 7-2). The through bandwidth indicates the amount of traffic that can pass through a series of signals during the green phase. As the signals are placed away from the optimum location, there is a corresponding reduction in the through band or time during which the progression is maintained. Thus, placing a signal at point "C"—midway between signals at points "A" and "B"—allows a full through band in both travel directions. If the signals are located elsewhere, the through band is reduced. If the signals are located at point "X," there is a corresponding reduction in the bandwidth. When the signals are located midway between the optimum location and an existing signal (point "Y"), the bandwidth is cut

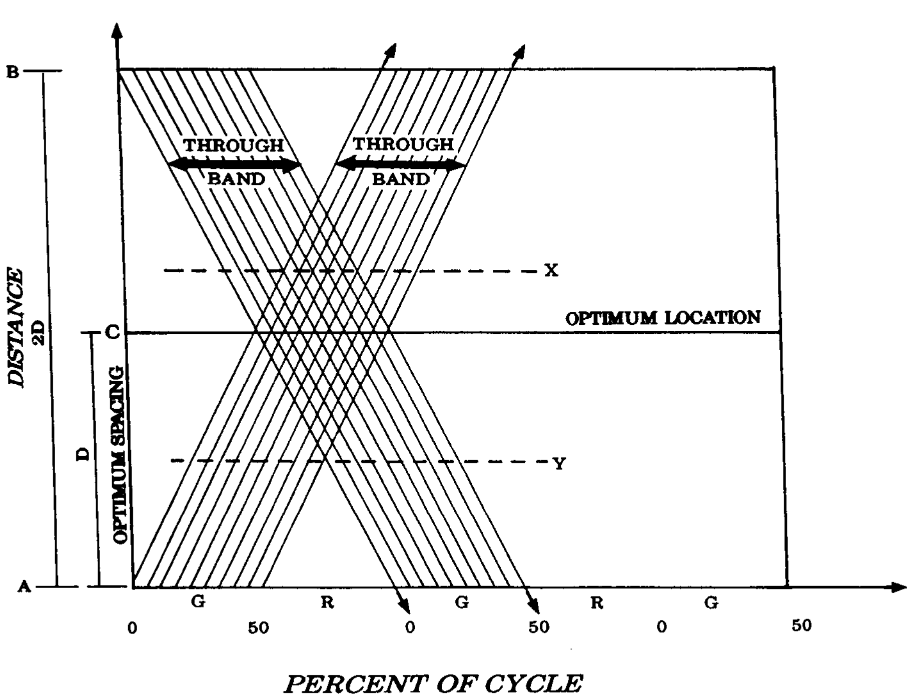


Figure 7-2. Time-space pattern.

in half, to 25 percent. In general terms, there is a ½ percent decrease in bandwidth for every 1 percent deviation from the optimum distance, assuming constant green times and two-way progression.

Guidelines

The choice of cycle length depends on the ability to pass traffic through critical intersections, to clear pedestrians across wide streets, and to achieve efficient signal coordination at desired speeds. The cycle lengths selected, therefore, may not be ideal from a coordination standpoint.

Cycle lengths should be as short as possible and cycle lengths of more than 120 sec should be avoided. Excessively long cycle lengths (i.e., more than 2 min) result in long delays. They usually result from complex multiple phase operations (i.e., 4 phases per intersection) with separate phases for through and left turning movements. They indicate a need for corrective actions such as interchanges, rerouting left turns, or providing closer street spacing to reduce left-turn volumes.

To assure efficient traffic flow, new signals should be limited to locations where the progressive movement of traffic will not be impeded significantly. The "optimum" distance between signals depends on the cycle length and the prevailing speed. At the optimum distance, there is no loss in bandwidth. When signals are placed at nonoptimum locations, there is a loss in bandwidth and delay increases.

Accordingly, each transportation agency should identify the "ideal" or optimum locations for traffic signals. These spacings then should be used to assess the conformity or compatibility of new locations. Where proposed signals do not "fit," through bandwidth criteria should be applied to determine where signals can be allowed.

The "ideal" future signal locations(s) should be established using Table 7-2. This table shows the optimum spacings between successive signalized at-grade intersections for various progressive speeds and cycle lengths.

The minimum bandwidths that could be achieved with proposed signals should be computed based on posted speed limits and cycle lengths and should take into account the existing and desirable future signals. The minimum bandwidth guidelines set forth in Table 7-3 should be used as a guide. The ranges in speeds and bandwidths given in the table allow public agencies latitude in application.

Because two major roads with the same level of access may intersect, the maximum specified bandwidth never exceeds 50 percent. The minimum acceptable bandwidths decrease as access levels increase. The minimum values are as follows:

Access Level	Minimum Through Bandwidth (%)
2 to 3 (at public streets)	45–50
4	40–45
5	35–40
6	30–35

Driveway signalization in conjunction with highway access should be permitted only when these minimum bandwidths are attained or exceeded and there is a proven necessity for the signal. Signal locations should be based on traffic projections for a 5-year period, after a development is occupied, and should be coordinated with future public street signal needs. Normally, priority should be given to public streets.

7.4 UNSIGNALIZED DRIVEWAY ACCESS SPACING

Unsignalized driveways are far more common and ubiquitous than signalized driveways. They affect all kinds of activity, not merely large activity centers. Traffic operational factors leading toward wider spacing of driveways (especially medium and higher volume driveways) include weaving and merging distances, stopping sight distance, acceleration rates, and storage distance for back-to-back left turns. From a spacing perspective, these driveways should be treated the same as public streets.

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. Guidelines have been developed that achieve a reasonable balance between these conflicting requirements.

Background

Current research and practices have not identified any clear method of establishing spacing standards for unsignalized intersections; moreover, many proposed guidelines have never been implemented.

Standards based on posted or operating speeds are used by Colorado and Oregon. This speed approach is recommended by several technical references. Colorado uses the AASHTO safe stopping sight distances for establishing minimum spacing between drives and for determining lengths of nonoverlapping acceleration and deceleration lanes for major traffic generators. The use of safe stopping sight distance ensures that motorists traveling along an arterial roadway can safely stop when a vehicle enters from an access drive.

New Jersey's access code specifies spacing distances that are similar to those prepared by Glennon et al. (*4*) to minimize right turn overlap. The state accepted the Glennon distances, but not any single method to establish them (*4*). However, these standards exempt existing, planned, or zoned single-family residences. Other types of traffic generators that do not meet these standards are defined as nonconforming lots. In these cases, vehicle volume limitations are specified, based on formulas.

Standards based on roadway functional class are cited in several technical references. These standards can be further stratified by traffic volume and suburban–rural environment. Recommended spacing increases with higher functional classes.

Florida's access code keys spacing to access level and operating speed. Spacings are given for speeds above and below 45 mph.

Spacing standards based on type of traffic generator are used by Illinois DOT, North Carolina DOT, and Oregon DOT. High volume generators require the longest spacing.

Using what is referred to as a "rule of thumb," some agencies space driveways at least five times the driveway width. Thus, the minimum distance between 24-ft-wide driveways is 120 ft, and the minimum spacing between 50-ft-wide driveways is 250 ft.

Table 7-2. Optimum spacing of signalized intersections for various progressive speeds and cycle lengths.

Cycle Length (Seconds)	OPERATING SPEED (mph)							
	20	25	30	35	40	45	50	55
	Distances in Feet							
60	880	1,100	1,320	1,540	1,760	1.980	2,200	2,430
70	1,020	1,280	1,540	1,800	2,050	2,310	2,560	2,830
80	1,160	1,460	1,760	2,050	2,350	2,640	2,930	3,230
90	1,310	1,640	1,980	2,310	2,640	2,970	3,300	3,630
100	1,460	1,820	2,200	2,570	2,930	3,300	3,670	4,030
110	1,610	2,010	2,420	2,830	3,220	3,630	4,040	4,430
120	1,760	2,200	2,640	3,080	3,520	3,960	4,400	4,840
150*	2,200	2,750	3,300	3,850	4,400	4,950	5,500	6,050

* Represents maximum cycle length for actuated signal if all phases are fully used. This cycle length or greater cycle lengths should be avoided. One-half mile (2,640 feet) spacing may apply where optimum spacing exceeds one-half mile.

Table 7-3. Ranges in minimum acceptable through bandwidth for evaluating signal locations.

ACCESS LEVEL/ CATEGORY	URBAN		SUBURBAN		RURAL	
	Speed mph	Min. Band Width(%)	Speed mph	Min. Band Width (%)	Speed mph	Min. Band Width (%)
1 Freeway	55	a	55	a	55	a
2 Expressway	40 - 45	45 - 50 b	45 - 50	45 - 50 b	50 - 55	45 - 50 b
3 Strategic Arterial	30 - 35	45 - 50 c	35 - 40	45 - 50 c	50 - 55	45 - 50 c
4 Principal Arterial	30 - 35	40 - 45	35 - 40	40 - 45	45 - 50	40 - 45
5 Minor Arterial	30 - 35	35 - 40	35 - 40	35 - 40	45 - 50	35 - 40
6 Collector	30 - 35	30 - 35	35 - 40	30 - 35	40 - 45	30 - 35
7 Local/ Frontage Rd	25 - 30	d	30 - 35	d	40 - 45	d

a = Not applicable.

b = Applies to signalized public streets only.

c = Generally applies to signalized public streets only.

d = Not specified.

The CALTRANS *Highway Design Manual* recommends minimizing direct access on highways with access control. If no alternative access is available, one direct access driveway per parcel is generally permitted. Minimum spacing is 2,640 ft (½ mi).

The various criteria reflect factors such as the speed of travel, type and design of the roadway (including presence or absence of a barrier median), size of generators, and the surrounding land use. Table 7-4 gives the basic variables and factors. Guidelines drawn from the state-of-the-art survey are provided in Table 7-5. Appendix D contains a detailed description of contemporary practice.

Guidelines

Guidelines for unsignalized driveway spacing are given in Table 7-6. These conceptual guidelines consider speed, access level, and size of generator (or activity center). They give the ranges in minimum driveway spacing as multiples of the posted (or operation) speed.

Three sizes of traffic generators have been used in developing the spacing criteria: (1) *minimum use generator*—single-family residences or other activities that generate less than 50 vehicle trips per day or five trips in the peak hour (total, both directions); (2) *minor generator*—51 to 5,000 vehicle trips per day or less than 500 trips in the peak hour (total, both directions); and (3) *major generator*—more than 5,000 vehicle trips per day or 500 trips in the peak hour (total, both directions). The generators would probably require signalized access control.

EXAMPLE:

Access Level = 6—Major Generator
Operating Speed = 40 mph
Driveway Spacing = 40 × (5 to 6) = 200 to 240 ft

Spacing increases as the size of generators and operating speed increases. It varies inversely with the access level. Thus, for a 40-mph operating speed, the spacings would be as follows for access levels 5 and 6, respectively.

	Generator Size		
Access Level	Minimum Use	Minor	Major
5	120 to 160 ft	200 to 240 ft	280 to 320 ft
6	80 to 120 ft	160 to 200 ft	200 to 240 ft

Illustrative guidelines for various operating speeds are given in Table 7-7. (The speeds for each access level are similar to those shown in Table 7-3.)

In applying these guidelines, it is necessary to consider adjacent land use in computing the generator size, including development located across the street. It is not good practice to look at generators in isolation.

Figures 7-3, 7-4, and 7-5 show how the suggested spacing guidelines compare with AASHTO safe stopping sight distances and the spacing distances needed to minimize overlapping right-turn conflicts. Spacing for major-use generators for access levels 3 and 4 are generally comparable with AASHTO requirements, while spacing for minor-use generators for access levels 5 and 6 are generally compatible with the overlap criteria. Spacing for minimum-use generators, such as for a single-family residence, are slightly less than the established criteria.

The safe stopping sight distance or the overlapping right-turn criteria shown in Figures 7-3, 7-4, and 7-5 could be used as spacing criteria if an agency so desires. These criteria are based on speed, reaction time, and distance, and are well documented. When they are applied, it may be desirable to exempt single-family residences.

The guidelines should apply to both private driveways and unsignalized public streets where there is little likelihood for future signalization. Where signalization is imminent or likely, the signal spacing guidelines should govern activity.

Table 7-4. Variables used in setting access standards for unsignalized driveways.

Basic Variables	Factors
A. Speed Related	1. Posted or operating speed 2. Safe stopping sight distance 3. Minimum distance to reduce collision potential due to overlapping right turns 4. Minimum distance to enable existing traffic to enter traffic stream without creating speed differences 5. Acceleration distance from STOP
B. Roadway Related	1. Functional class of road 2. Highway design type 3. Access level 4. Presence or absence of median 5. Access clearance or setback 6. Driveway width (i.e., spacing as a multiplier of width)
C. Generator	1. Type of generator 2. Number of driveways per generator
D. Development Density	1. Type of environment (urban, rural, suburban)

Table 7-5. General guidelines for unsignalized access spacing.

Condition	Guideline	
• Operating Speed:	30 mph 100-200+ feet 45 mph 300-550+ feet	
• Type of Facility:		
- Spacing		
Major (principal) arterials	300-500 feet	
Minor arterials	100-300 feet	
Collectors	100-200 feet	
• Corner Clearance:	Near Side	Far Side
Major arterials	450 ft.	350 ft.
Minor arterials	400 ft.	350 ft.
Collectors	200 ft.	200 ft.
Major collectors (residential)	150 ft.	150 ft.
• Type of Generator: Projected Driveway Volume	Distance From Street	Distance From Driveway
<500 ADT	5 - 50 ft.	5 - 60 ft.
500 - 1,500 ADT	50 - 100 ft.	100-400 ft.
>1,500 ADT	100 - 800 ft.	300-800 ft.

1. Unsignalized spacing standards should be used to determine the minimum acceptable distance between driveways and between driveways and public streets. The spacing between signalized at-grade intersections and driveways or unsignalized public streets should also be based on distances given in Table 7-6.

2. Access points involving left-turn egress should be located where they would conform to coordinated signal spacing requirements wherever possible, and in all cases where median breaks are involved for major traffic generators.

3. If future volumes warrant installing a traffic signal and signalized spacing requirements cannot be met, left-turn access should be subject to closure in one or both directions.

4. If an undivided roadway becomes divided, left-turn access should be subject to closure in one or both directions.

5. The spacing of right-turn access on each side of a divided roadway can be treated separately. However, where left turns at median breaks are involved, the access on both sides should line up or be offset from the median break by at least 300 ft.

6. The number of conflicts created by driveways along divided roadways should be significantly less than would occur on undivided roadways. Therefore, divided roadways result in improved traffic operations and more effective access control and management. However, driveways create side friction in the outside travel lane, thereby reducing the overall lane capacity and decreasing the average running speed.

7. On undivided roadways, access on both sides of the road should be aligned. Where this is not possible, driveways should be offset by at least 150 ft to 200 ft when two minor traffic generators are involved, and 300 ft to 400 ft when two major traffic generators are involved.

Table 7-6. Nonsignalized access spacing guidelines for driveways as multiples of speed.

Access Level	Minimum Use	Type of Generator Minor	Major
1	-	-	-
2	(a)	(a)	(a)
3	4 - 5 (b)	7 - 8(b)	9 - 10(c)
4	4 - 5 (c)	7 - 8(c)	9 - 10
5	3 - 4 (d)	5 - 6(d)	7 - 8(d)
6	2 - 3	4 - 5(d)	5 - 6(d) (see example)
7	e	e	e

NOTES:

(a.) Determined by interchange or cross-street spacing, no direct access allowed

(b.) Right turns allowed only when no other reasonable access is provided

(c.) Right turn access only

(d.) Left turn exit determined by signal spacing requirements

(e.) Minimum set by safety requirements

Table 7-7. Nonsignalized access spacing guidelines for driveways.

Access Level	Assumed Speed (mph)	Minimum Generator	Minor Generator	Major Generator
		Urban		
3	35	140-175 b	245-280 b, c	315-350 b, c
4	35	140-175 c	245-280 c	315-350 c
5	30	90-120	150-180 d	210-240 d
6	30	30-60	120-150 d	150-180 d
		Suburban		
3	45	180-225 b,c	315-360 b, c	405-450 c
4	45	180-225	315-360 c	405-450 c
5	35	105-140	175-210 d	245-280 d
6	35	35-70	140-175 d	175-210 d
		Rural		
3	50	200-250 b,c	350-400 b,c	450-500 c
4	45	180-225 c	315-360 c	405-450 c
5	45	135-180	225-270	315-360 d
6	40	40-80	160-200	200-240 d

NOTES:

(a) Speeds are generally consistent with the minimum speeds shown in Table 7-3 for access levels 5 and 6, and with the maximum speeds shown in Table 7-3 for access levels 3 and 4.
(b) Right turn access allowable only when no other reasonable access is available.
(c) Right-turn only
(d) Left turn exit determined by signal spacing requirements.

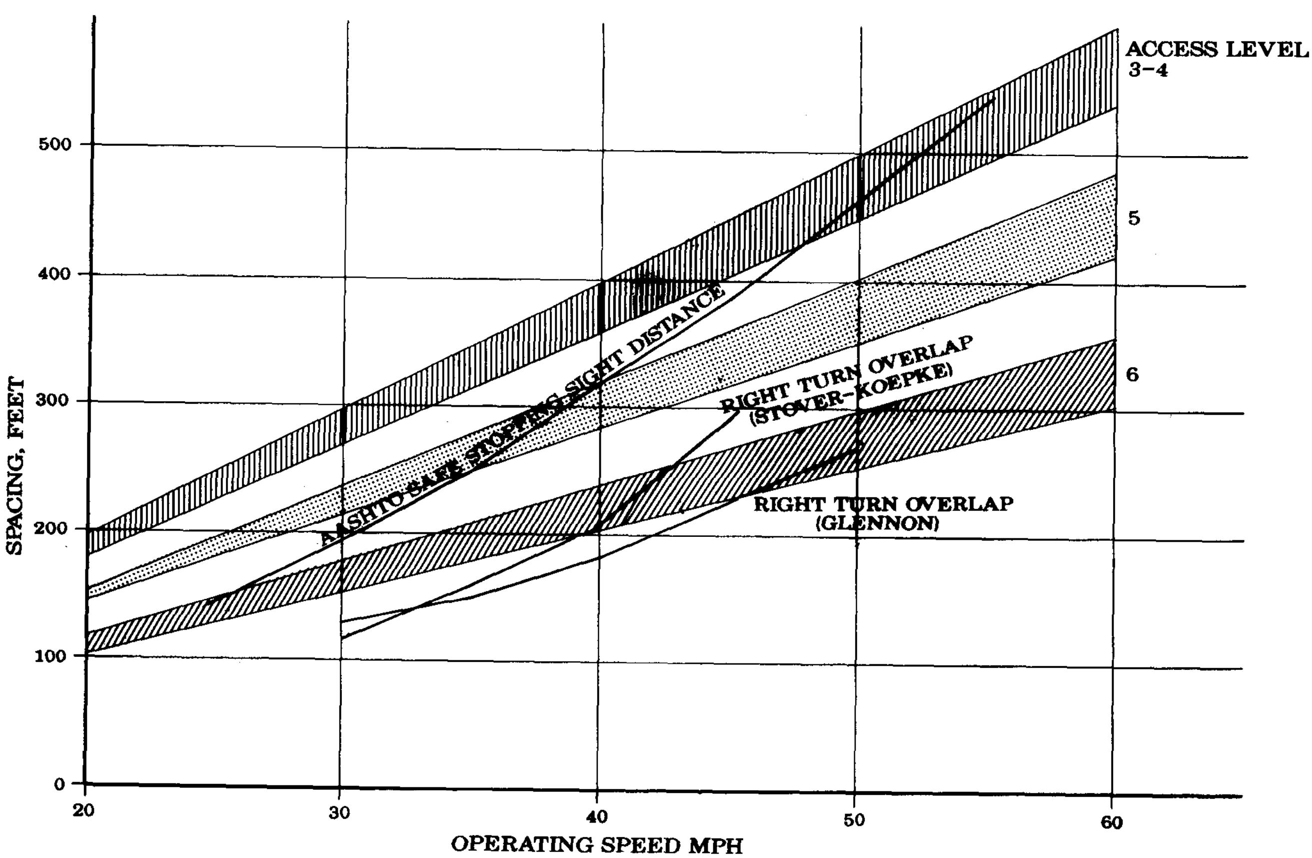


Figure 7-3. Unsignalized driveway spacing for major generator.

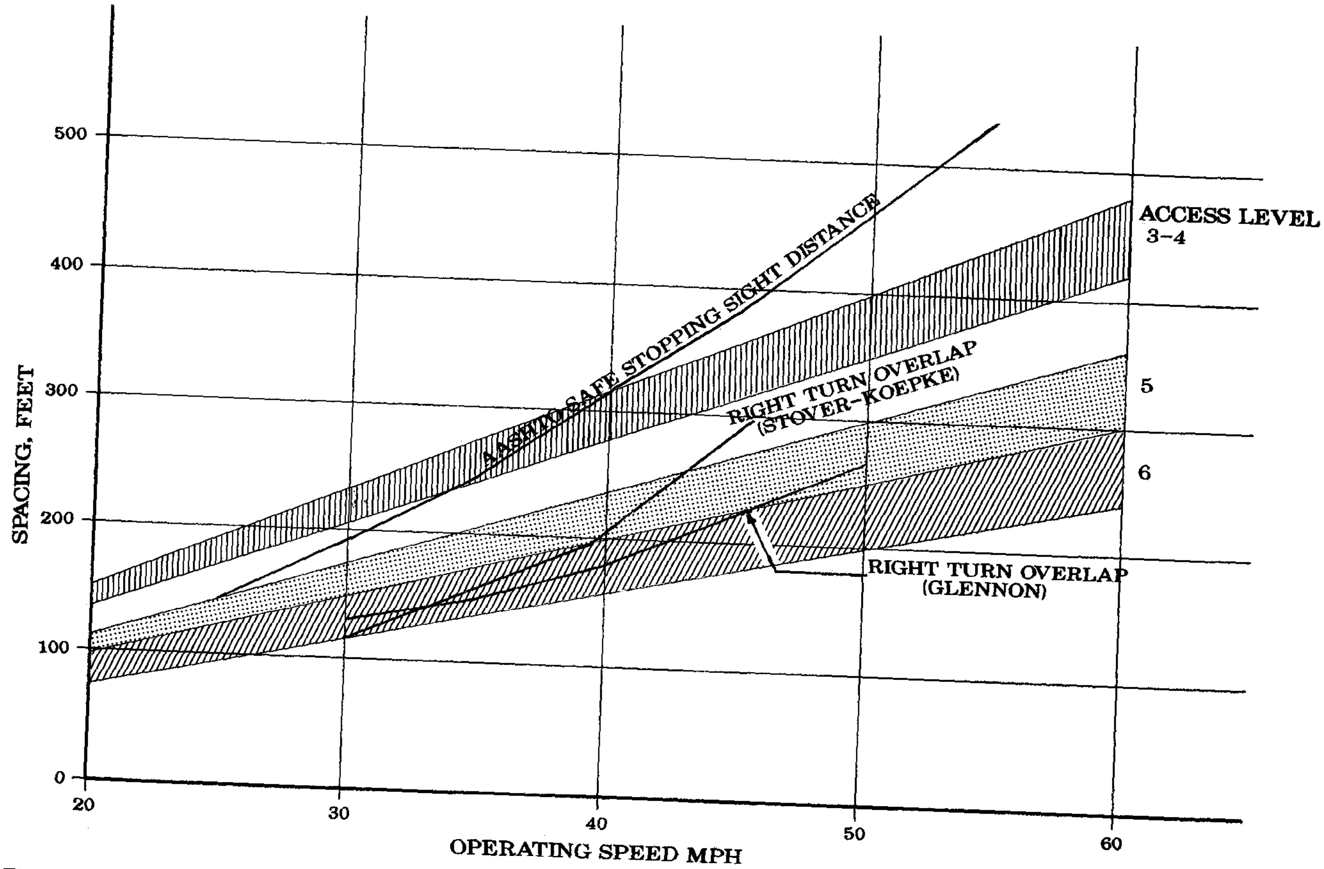


Figure 7-4. Unsignalized driveway spacing for minor generator.

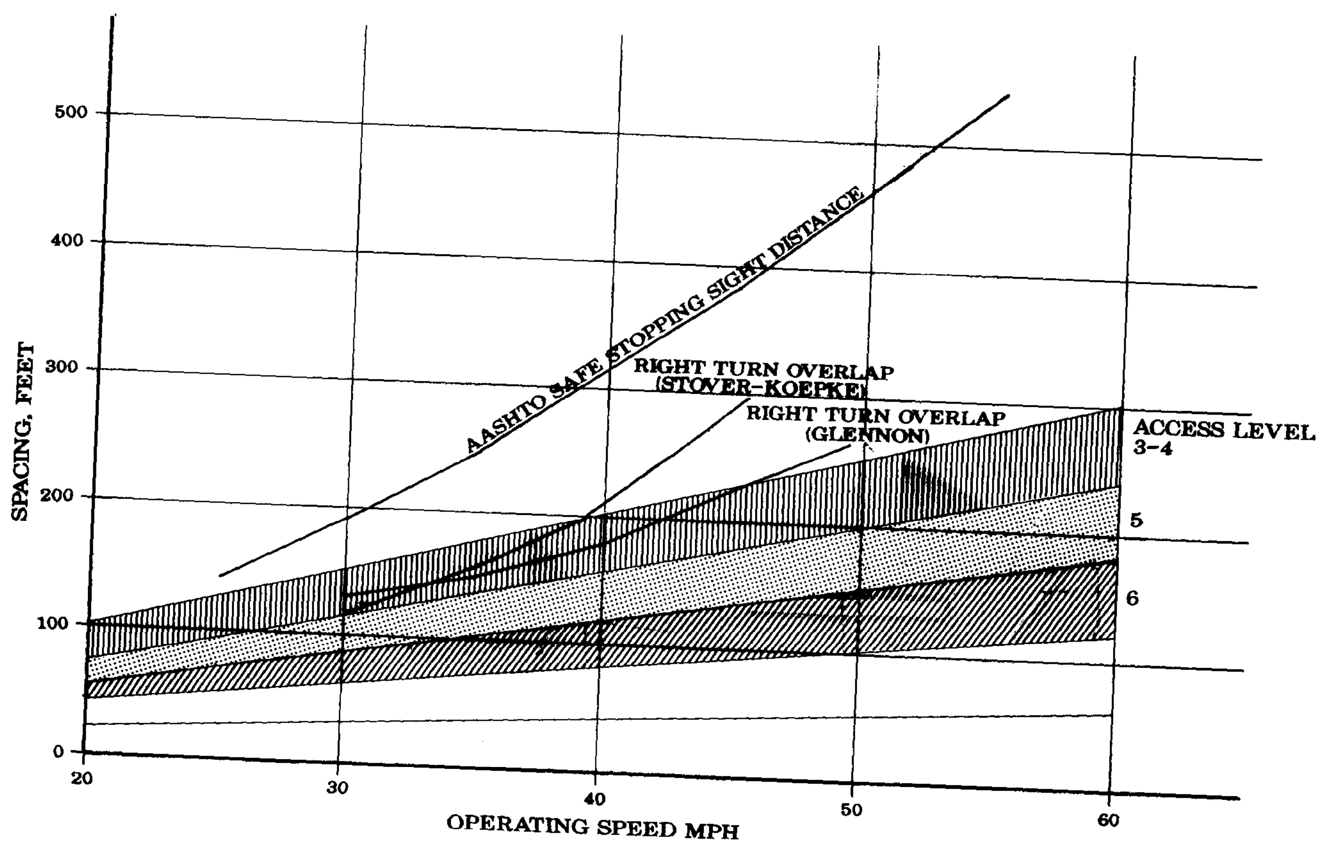


Figure 7-5. Unsignalized driveway spacing for minimum-use generator.

Driveways create side friction, primarily in the outside traffic lane. This friction reduces capacity, since through traffic avoids this lane. Accordingly, only one driveway should be provided for a minimum-use generator and, in general, only one driveway per development should be provided for a minor generator. Major generators should have only one driveway per property, except where it is in the public interest to provide additional access points. Activity centers—major activity centers in particular—will usually benefit from a series of planned access points.

Unsignalized intersections of driveways with public streets should have adequate safe stopping distance. This, however, is viewed as a design requirement rather than an access spacing guideline. Obviously, a public agency could, if it so desires, use safe stopping sight distance standards for access spacing purposes. (See Chapter 9 for a further discussion of sight distance guidelines.)

7.5 MEDIAN OPENINGS

Median openings are provided at all signalized at-grade intersections. They also are generally provided at unsignalized junctions of arterial and collector streets. They may be provided at driveways, where they will have minimum impact on roadway flow.

Background

Several states have set median opening criteria for urban and rural highways. These criteria, mainly applicable in suburban and rural environments, result in spacings ranging from 330 ft to 2,640 ft ($\frac{1}{16}$ to $\frac{1}{2}$ mi).

Minimum desired spacings of unsignalized median openings at driveways as a function of speed are given in Table 7-8. These spacings best apply to retrofit situations. Lower spacings generally will be appropriate for new driveways to avoid the accumulative impacts associated with repeated application of minimum standards.

Guidelines

The following guidelines are suggested for the spacing and design of median openings on divided roadways:

1. The spacing of median openings for signalized driveways should reflect traffic signal coordination requirements and the storage space needed for left turns.
2. The spacing of median openings for unsignalized driveways should be based on the values suggested in Table 7-9. Ideally, spacing of breaks should be conducive to signalization.
3. Median openings for left-turn entrances (where there is no left-turn exit from the activity center) should be spaced to allow sufficient storage for left-turning vehicles.
4. Median openings at driveways can be subject to closure where volumes warrant signals, but signal spacing would be inappropriate.
5. Median openings should be set far enough back from nearby signalized intersections to avoid possible interference with intersection queues.
6. **Note**: In all cases, storage for left turns must be adequate.

Table 7-8. Spacing criteria between (unsignalized) median openings on divided highways. NOTE: Provide openings at all arterials, all collectors, and some local streets. Desirable minimum spacing value based on 6.5 ft/sec^2 average deceleration rate and no deceleration in through-traffic lane. (Source: Ref. 5. Adapted from V.G. Stover, W.G. Adkins, and J.C. Goodknight, "Guidelines for Medial and Marginal Access Control on Major Roadways," *NCHRP Report 93,* Transportation Research Board, Washington, D.C., 1970, p. 19.)

Speed (mph)	Spacing Recommendations (feet) Desirable Minimum
30	370
35	460
40	530
45	670
50	780
55	910

Table 7-9. Guidelines for spacing of unsignalized median openings on divided roadways.

Level of Access	Urban	Suburban	Rural
1	NA	NA	NA
2	NA	NA	NA
3	NA	NA	NA
4	660(a)	660(a)	1320(a)
5	660	(b)	(b)
6	330	660	1320
7	-	-	-

NOTES:

NA Not Applicable

(a) Left turn entrance only - must accommodate left turn storage requirements, but may not be closer than values shown.

(b) Function of traffic signal spacing requirements.

Table 7-10. Suggested lateral access restrictions on streets entering arterial.

Access Levels of Arterial	Minimum Use Generator	Minor Generator	Major Generator
1 (a)	100	150	330
2	100	150	330
3	100	150	330
4	100	150	330
5	50	100	150
6	50	100	150

(a) from frontage roads or ramps

7.6 LATERAL ACCESS RESTRICTIONS

Access spacing along roads and streets that enter or cross arterial roads should be governed by the preceding guidelines wherever access codes apply to these facilities. In other situations, "lateral" access restrictions should be established to ensure adequate storage space between the arterial and the first access point on the cross street. Table 7-10 contains illustrative guidelines.

7.7 APPLICATION OF CRITERIA

The applications of access categories and spacing criteria, in granting or denying access permits, involve the following:

1. An access permit can be issued where a given driveway (or driveways) meets criteria for direct access based on the roadway classification, ability to provide adequate capacity, conformance with signal spacing, or unsignalized spacing criteria.
2. Where spacing criteria are not met, a variance may be necessary. This variance will depend on: (a) inability to provide reasonable alternative access, and (b) ability to ensure safe ingress and egress.
3. Where direct access is not permitted based on the access classification, it may be possible to provide direct access from roads with a lower access classification. In such cases the alternative access should meet the requirements specified in (1) and (2) above.
4. The guidelines for nonconforming land parcels may take several forms: (a) an alternate set of spacing requirements can be established such as adopted in Florida; (b) the access can be allowed, but the level of allowable peak-hour trip generation must be reduced as suggested in a draft New Jersey access code; and (c) certain land uses (i.e., single-family residential) may be exempted from the spacing criteria of certain access levels (as in Florida and New Jersey). In such cases a minimum spacing, such as 24 ft, can be specified.
5. The variances can be granted for an interim basis until suitable alternate access is available.

The spacing guidelines provide a point of departure for developing criteria specific to an individual agency. Flexibility in their application is essential. Care must be exercised to "fit" the guidelines to the specific environment, while simultaneously avoiding the repeated use of minimum standards.

REFERENCES

1. *Policy on Geometric Design for Highways and Streets.* American Association of State Highway and Transportation Officials, Washington, D.C. (1990).
2. "Access Management for Streets and Highways." *FHWA-IP-82-3* (June 1982).
3. Stover, V.G. and Koepke, F.J., *Transportation and Land Development.* Institute of Transportation Engineers, Prentice-Hall, Englewood Cliffs, New Jersey (1988).
4. Glennon, S.C., Valerta, J.J., Thorson, B.A., and Azzek, S.A. "Technical Guidelines for the Control of Direct Access to Arterial Highways." Volume II, *Detailed Description of Access Control Techniques,* FHMA (August 1975).

CHAPTER 8

ACCESS DESIGN CONCEPTS

In Brief This chapter sets forth highway and activity center access concepts that complement the access spacing criteria for the various types of highways. These concepts reflect the access requirements of public highways and the activity centers that these highways serve. They show how interchanges, intersections, driveways, and internal site design can be arranged to maintain the operational integrity of the surrounding roads while simultaneously providing essential access to activity centers.

8.1 ACCESS DESIGN PRINCIPLES

The following principles govern access planning and design. They should be applied in a coordinated way to the three components of the access system—the public roadway, the access point (driveway), and the activity center site itself. All three must be treated as part of an overall system because neglecting one would merely transfer problems. The underlying goal is to minimize disruption to through traffic while also providing reasonable access to developments.

1. A "time-space" perspective should guide the location, timing, and coordination of traffic signals; the placement of access points; and the design and operation of intersections. Optimum progressive travel speeds along arterial roadways should be maintained.
2. Conflicts at intersections and driveways should be separated and reduced as much as possible. This will enable traffic signal phasing to be simplified and signals to operate on shorter cycle lengths. It translates into closer allowable spacings of signalized access points for any given speed of travel.
3. Traffic signal phasing plans should minimize the number of phases at driveways and intersecting roads. The goal should be as few phases as possible. Exclusive pedestrian phases should

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1. A "time-space" perspective should guide the location, timing, and coordination of traffic signals; the placement of access points; and the design and operation of intersections. Optimum progressive travel speeds along arterial roadways should be maintained.
2. Conflicts at intersections and driveways should be separated and reduced as much as possible. This will enable traffic signal phasing to be simplified and signals to operate on shorter cycle lengths. It translates into closer allowable spacings of signalized access points for any given speed of travel.
3. Traffic signal phasing plans should minimize the number of phases at driveways and intersecting roads. The goal should be as few phases as possible. Exclusive pedestrian phases should

be the exception, not the rule; a "share-the-green" approach reduces delays to motorists and pedestrians, and conserves energy. Protected pedestrian crossings are only warranted where conflicting turning movements exceed 350 vph during peak periods.

Signal cycles should be as short as possible consistent with capacity, pedestrian clearance, and coordination requirements. A cycle length range of 60 to 100 sec is appropriate for most suburban environments. Cycle lengths should not exceed 120 sec.

Signal timing plans should accommodate the hourly variations in traffic flows at major generators such as regional shopping centers, office parks, and sports centers. Multiple patterns of operation should be provided in these cases by pretimed or semi-actuated signals operating on common cycle lengths.

Special phasing for left turns may be necessary for safety reasons, or where adequate gaps are not available. Continuing with more than two opposing through-travel lanes or where speeds exceed 35 to 40 mph may warrant permissive protective or exclusive left-turn phases. Obviously, heavy left-turn flows (over 200 to 250 vph) need phasing; however, ideally these movements should be diverted or rerouted.

4. Critical intersections on principal approaches to an activity center should be improved, as necessary, to avoid transferring problems from the immediate site environs to other locations along key arterial roads.

5. Freeway (and expressway) interchange and service road designs should be integrated into the overall site access system to maximize site access, better distribute site traffic, and minimize delay. In all cases, however, the integrity of mainline traffic operations must not be compromised.

6. Interference between through traffic and site traffic should be reduced by removing turning vehicles from through traffic lanes, and by providing adequate on-site storage and driveway dimensions. Fewer, properly placed and adequately designed driveways are preferable to a larger number of inadequate driveways, especially where spaced at least 500 ft apart.

7. Access opportunities at activity centers should be designed to effectively distribute site traffic on surrounding roads and to avoid undue concentrations at any access point.

8. Established traffic engineering techniques should be used in "retrofit" situations to reduce conflicts, minimize congestion, increase capacity, and improve safety. (Examples include adding turning lanes; installing or modifying medians; and closing, consolidating, widening, or relocating driveways.)

9. On-site circulation and parking systems should provide adequate internal capacity and efficient travel patterns.

The specific methods of managing access to developments are simple and straightforward. They call for sensitive and sensible applications of established traffic engineering and roadway design principles. They involve: (1) limiting the number of access points, (2) separating conflict areas, (3) reducing acceleration and deceleration requirements at access points, (4) removing turning vehicles from through-travel lanes, (5) spacing major intersections to facilitate progressive travel speeds along arteries, and (6) providing adequate on-site storage. The key is to apply these techniques in a coordinated way that preserves the integrity of arterial traffic flow while providing essential access.

8.2 INTERCHANGE CONCEPTS

Interchanges should be considered at or in the environs of large activity centers (1) to provide direct access from highways that would otherwise not be practical or possible and (2) to separate major arterial flows.

Freeway Interchange

A freeway interchange into a major activity center may be desirable, provided that a minimum weaving distance of about 2,600 ft is maintained along the main freeway lanes (see Figure 8-1). To avoid the "precedent-setting" problem of providing a direct interchange to private property, it is desirable to also let the interchange serve a public street.

Arterial Interchange

A major arterial roadway may be upgraded to controlled access standards where it passes through an area lined with activity centers along both sides. In such cases, a pair of frontage roads can be provided, and a series of bridges can connect the opposite sides of the roadway (see Figure 8-2). Given the right-of-way and construction costs ($18 million in 1991 dollars), this is an expensive solution.

More common, therefore, is the provision of an interchange between a major arterial and activity center, where physical or traffic conditions preclude a signalized junction (Figure 8-3). In such cases, a trumpet-type design may be used. It should be complemented with auxiliary right-turn access points to avoid undue traffic buildup at the terminus of the interchange access road within the activity center (costs would range from about $6 to $10 million).

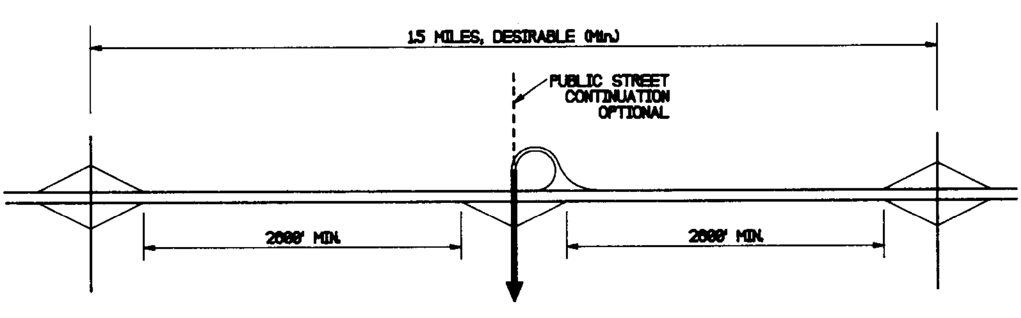


Figure 8-1. Freeway or expressway interchange to serve major activity centers.

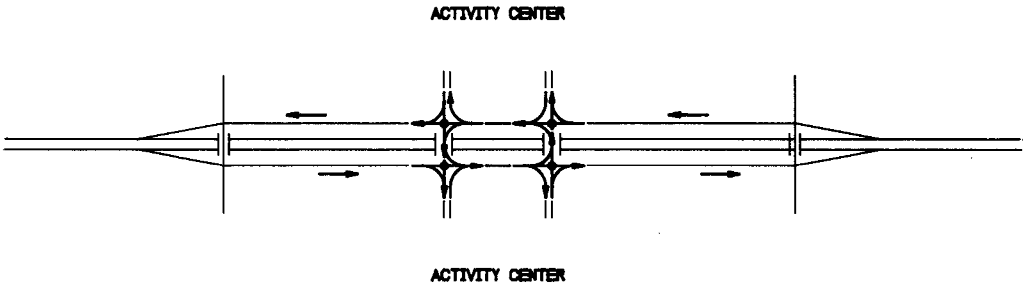


Figure 8-2. Interchange and frontage road system serving activity centers on opposite sides of roadway.

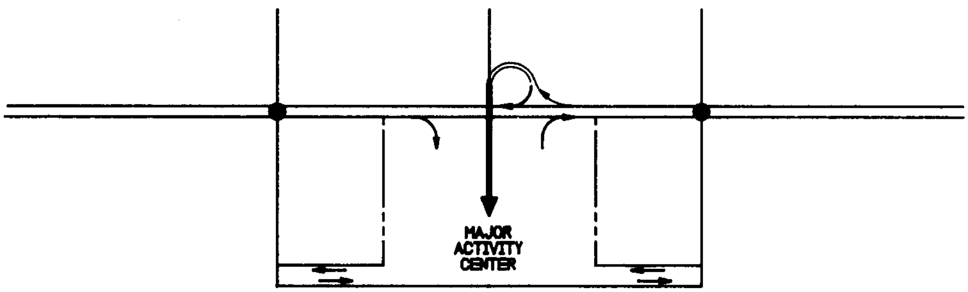


Figure 8-3. Interchange for major activity center from arterial streets.

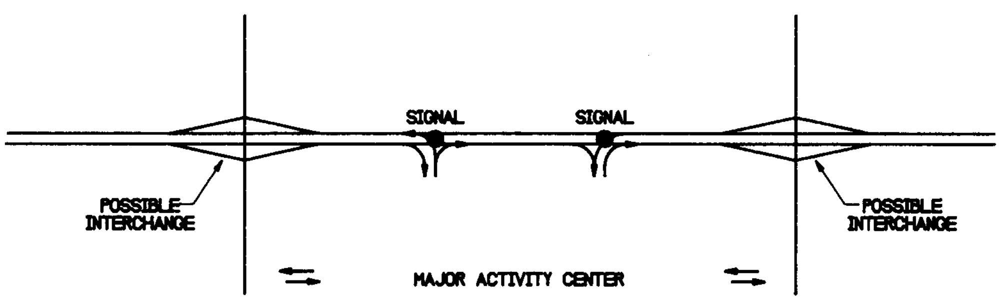


Figure 8-4. Arterial interchange to reduce turning movements.

Traffic analyses indicate that the nearby public street intersections are frequently more critical than intersections with activity center driveways. In such cases, it may be desirable to develop interchanges with the public roads and provide signal controlled access at the activity center driveways. The provision of interchanges at nearby junctions makes it easier to fit the driveway signals into the overall signal coordination system (see Figure 8-4).

Ramp Changes

Many major activity centers locate at the junction of a freeway (usually a beltway) and a major arterial. Under conventional interchange designs, site traffic using the freeway is superimposed on the arterial roadway, resulting in heavy flows and turning movements into and out of the activity center.

Overall traffic operations may be improved by modifying the ramp configurations to better accommodate site traffic. Figures 8-5(a, b, and c) show how such changes might be made. These concepts extend the on- or off-ramp adjacent to the activity center, allowing it to provide access to and from the site. They assume minimum 2,600-ft mainline and 1,300-ft frontage road weaving distances. Concept 4, which results in a continuous one-way service road adjacent to the site, dramatically increases accessibility to adjacent development.

Figure 8-5(b) design reduces travel times for people entering the activity center. However, it increases travel times, delays, and conflict for arterial-to-freeway travelers who originally enjoyed the direct access shown in Figure 8-5(a).

If the through volume on the new ramp and frontage road is high, the agency has made the general public sacrifice a significant amount of time and speed for the benefit of the activity center users and owners. The public now travels along an additional mile of collector before entering the freeway.

Conversely, if the movements to the major activity center dominate, these changes would be a net benefit to travelers. Thus, site-specific analysis of benefits and impacts is essential before this concept is implemented.

Where an interchange to an activity center involves public funds for construction or maintenance, the connecting cross street should continue into the local street system. This connection should be part of the site's circulation system and not part of a parking area. Signing should be adequate to minimize motorist confusion.

The selection of a new access circulation plan needs to include an accurate origin and destination analysis to determine a design that responds to anticipated demands.

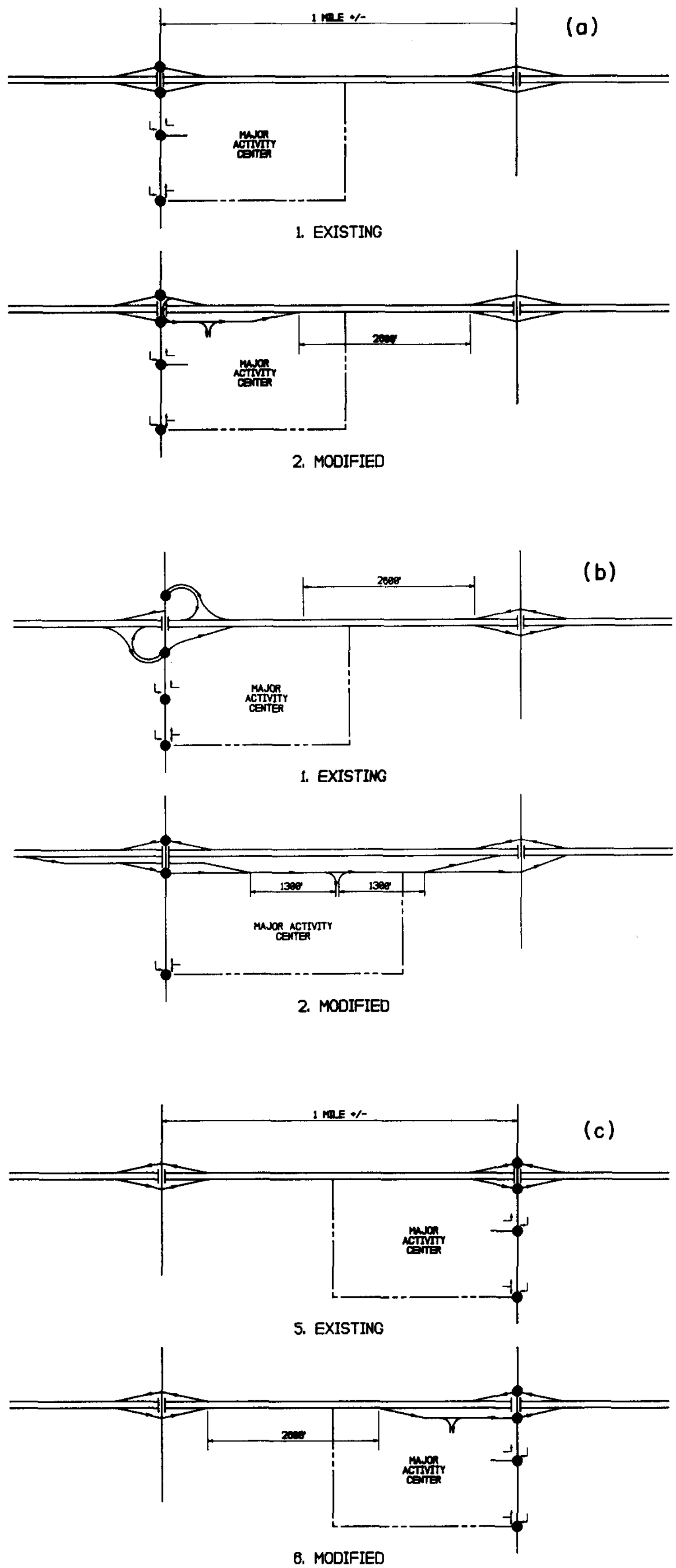


Figure 8-5(a,b,c). Freeway ramp modifications for major activity centers.

8.3 FRONTAGE ROADS

Frontage or service roads provide increased access to developments and reduce marginal conflicts along roads where access is not fully controlled. However, they complicate intersections along arterial streets and, unless carefully designed and selectively applied, in both new designs and in retrofit situations, they may prove counterproductive.

Freeways

Frontage or service roads along freeways and expressways provide access to adjacent properties and are used in many urban, suburban, and even rural environments. They generally operate one-way in developed areas and are integrated with ramping patterns—usually diamond ramps; sometimes "U"-turn loops are provided just short of interchanges with cross streets to permit reversal of direction.

Two-way frontage roads along freeways are usually found in rural or developing areas where land is available, distances between interchanges are longer, and where it is necessary to serve adjacent developments. The service roads may be continuous or discontinuous. If they require traffic signals, they should tie into the cross street a sufficient distance from the ramp terminal to provide turn storage and signal progression. This distance generally should be a least 500 ft.

Frontage roads along freeways, particularly one-way frontage roads integrated with the ramping system, are particularly desirable from a development and activity center perspective because they can increase the frontal area and access opportunities for a site that fronts along a freeway.

Arterial Roads

The provision of frontage roads along arterial roadways is not as straightforward. The frontage roads reduce marginal frictions, allow public agencies complete control of access to the arterial, and accommodate parking and loading. However, unless carefully designed, they can increase conflicts at junctions and increase delays on intersecting roads. Moreover, when commercial development occurs along frontage roads, the resulting traffic volumes may result in congestion and accident potential as a result of low capacity overlapping maneuver areas, close proximity of conflict points, and complex movements needed to enter and leave the main travel lanes.

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

1. Frontage roads for "retrofit" situations should operate one-way and should enter or leave the main level lanes as merging or diverging movements. There should be no signalized junctions along the artery or the frontage road in this area (Figure 8-6).
2. One-way frontage roads are desirable.
3. The separation of frontage roads at cross streets should be maximized to ensure sufficient storage for cross-road traffic between the frontage roads and the artery (see Figure 8-7). The absolute minimum separation should be 300 ft. This dimension is about the shortest acceptable length needed for placing signs and other traffic control devices.

   Spacings of 600 to 1,320 ft are desirable, especially where the crossroad is a major arterial. This dimension usually provides acceptable storage space on the crossroad in advance of the main intersection to avoid blocking the frontage road. The spacings of at least 300 ft (preferably more) enable turning movements to be made from the main lanes onto the frontage roads without seriously disrupting arterial traffic and, thereby minimize the potential of wrong-way entry onto the through lanes of the predominant highway.
4. "Reverse" frontage roads, with developments along each side, are desirable to "close-in" frontage roads. A desirable setback distance is 600 ft with a minimum distance of 300 ft. They may operate either one-way or two-way. Where two major arteries with frontage roads intersect, the mainline roads should be grade separated, or the frontage roads should be diverted (see Figure 8-8). Direct crossings of two major highways and their frontage roads must be avoided.
5. 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.
6. Where major activity centers front along an arterial roadway, frontage roads should be incorporated into the ring road or otherwise eliminated.
7. A minimum outer separation of 20 ft should be used to provide space for pedestrian refuge and safe placement of traffic control devices and landscaping.
8. Pedestrian and bicycle movements should utilize the frontage roads. Parking may be permitted where the frontage roads traverse residential areas.

A major problem associated with arterial frontage roads is the introduction of additional intersections on cross streets. This can result in three closely spaced intersections where one would otherwise exist. Where signals are required, the progression and bandwidth along the cross street would be adversely affected, especially where spacings are less than a $\frac{1}{4}$ mi from the artery. For these reasons, arterial frontage roads should be used selectively and sparingly.

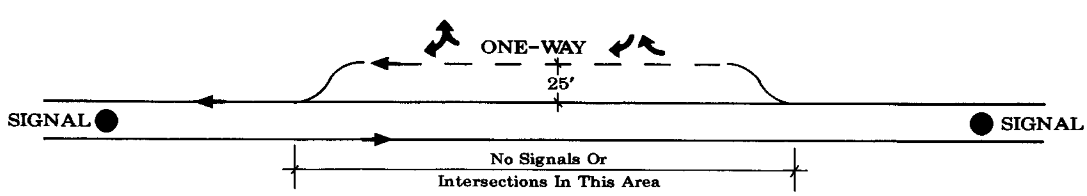


Figure 8-6. Frontage road concept for retrofit conditions.

Figure 8-7. Divided arterial streets with 2-way frontage road.

Expanding the Frontage Road Concept

The reverse frontage road concept can be applied in newly developing areas to create a network of controlled access arterials. Figure 8-9 illustrates the principles underlying the controlled access arterial concept.

Arterial roads would be located at ½- to 1-mi intervals. Intersections between two arterials would be signalized or grade separated.

Access along arterial streets is limited to specifically designated locations that fit the signal progression pattern. A series of collector roads intersect the arterials at these locations and link the arterial roads with the surrounding residential and commercial areas. A series of "loop" access roads link each community circulation system with the collector street. These reverse frontage roads serve developments on each side.

The pattern is modified at activity centers. To minimize left turns at the signalized arterial collector junctions, direct right-turn access, and in some cases left-turn entry, is provided from surrounding arterial roads, depending on the allowable access level.

This concept has several desirable attributes from an access management perspective: (1) it reduces "strip" developments along arterials and the attendant marginal interference; (2) it allows traffic signals only at locations that permit optimum progression, because the need for other signals is eliminated; (3) it provides a logical graduation of traffic movements from arterials to collectors to local streets; (4) it permits a cohesive internal design of residential and commercial areas that removes through traffic flow; and (5) it permits future upgrading of arterials to expressway standards (*1*).

The scale of the arterial and collector grid can be increased to allow a minimum ⅓- to ½-mi spacing between signals on the various public streets. This would allow acceptable progressive speeds at longer cycle lengths that are more attuned to contemporary needs. The key point, in both cases, is to limit the access points to locations that can be controlled by signals from a time-space perspective.

8.4 INTERSECTION CONCEPTS

The left-turn movements at intersections in the vicinity of an activity center should be given special attention because they complicate the traffic signal phasing and may lengthen the cycle. They can back up onto the main travel lanes and lower the overall level of service. The longer signal cycles also translate into wider required spacings between signalized access points at activity centers.

Left turns may be accommodated, prohibited, diverted, or separated, depending on specific circumstances. Table 8-1 summarizes the various ways of dealing with left turns and suggests where each applies.

Accommodating Left Turns

Left turns may be accommodated by permitting movements from shared lanes, or by providing single or dual left-turn lanes. Figure 8-10 gives examples of each.

Shared left-turn lanes should be allowed only along minor low-speed streets or where it is physically impossible to develop protected lanes (Figure 8-10a). Their accident history should be monitored, especially along principal roads. *Left*-turn lanes should be provided at signalized intersections wherever the turns are permitted (Figure 8-10b). *Dual* left-turn lanes are desirable where peak turning movements exceed 350 vph. They require a protected (exclusive) traffic signal phase and at least 28 ft of

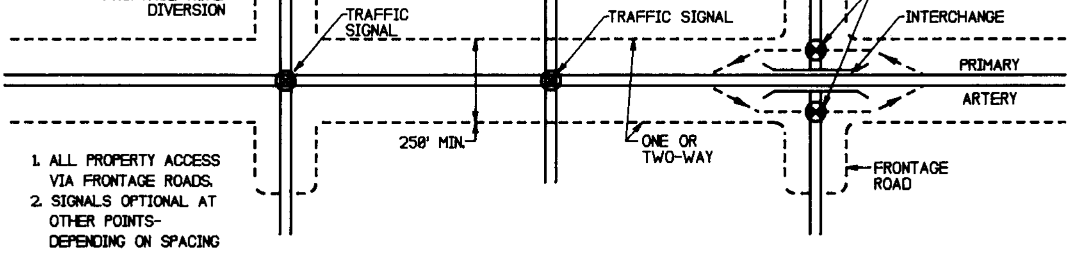


Figure 8-8. "Reverse" frontage road concept.

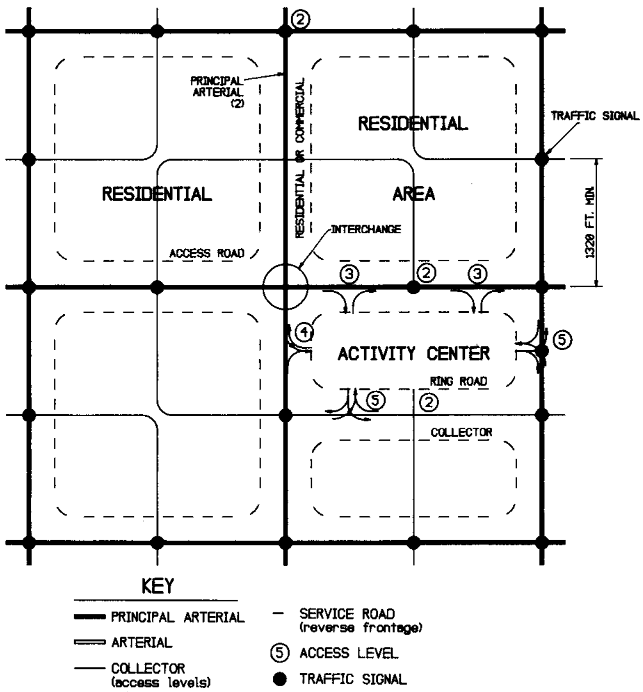


Figure 8-9. Controlled access arterial concept.

width on the departure lanes and a 26- to 30-ft median area (Figure 8-10c). The length of storage should be at least 1.5 to 2.0 times the expected left turns per cycle based on peak 15-min periods.

Low-volume low-speed conditions suggest permissive movement (i.e., simultaneously) with the opposing through traffic. High-volume high-speed conditions require protected phases. Permissive movements are appropriate where left-turn volumes are under 150 vph, speeds are under 40 mph, and there are no more than two opposing through lanes.

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

Prohibiting Left Turns

The peak-hour or full-time prohibition of left turns is common in urban settings where it is not practical to provide left turns and where alternate routes are available. Prohibitions are generally not found along suburban highways, except where they form part of an overall intersection treatment or areawide circulation plan.

Diverting Left Turns

The "jug-handle," in which traffic must go right to turn left, is sometimes used as an alternative to left turns. It may be used along high speed divided highways (as in New Jersey), or for site access where physical conditions preclude left-turn lanes. Requisites include a divided highway, a signalized intersection, and relatively minor traffic on side streets. Sufficient storage on side streets between the artery and jug-handle is essential (see Figure 8-11). The jug-handle permits two-phase signal controls, but it requires left turns to cross through traffic in the same direction.

On highways with a wide median, the Michigan "U"-turn concept can be used to achieve two-phase signal operation. This concept, shown in Figure 8-12, prohibits all left turns at the intersection. Instead, the turns are diverted in a "U"-turn manner, and then are translated into right turns or through movements. The "U"-turn entries into the arterial street may be signalized and the signals coordinated to achieve artery progression. Additional turning lanes are desirable along the artery to separate through and turning traffic.

The "U"-turn concept also can be applied along multilane divided highways with narrow medians to remove left turns from intersections and thereby simplify signal phasing. The examples shown in Figures 8-13 and 8-14 have greatest application in suburban areas where needed land can be assembled in advance of development.

The left turns are prohibited at the intersection. Instead, they cross the intersection as through vehicles and then reverse direction at a signalized junction about 300 to 400 ft beyond. The left-turning movement then takes place from a left-turn lane, during the same phase as the cross-street traffic. Cross-street left turns may be redirected via the "U"-turn slots if desired. In some cases, it may be necessary to provide the reversal of traffic by means of a jug-handle rather than via left-turn lanes. However,

Table 8-1. Treatment of left turns at intersections.

Maneuver	Condition	Criteria
Provide	Shared Lane	Limit to minor roads or places where R/W 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 Jug Handle	6-Lane divided highways
	Michigan "U"	Divided highways with wide median - Allows two-phase signals
Separate	Directional Design	Very heavy turns in one direction
	Left Turn Flyover	Very heavy turns in one direction
	Through Lane Flyover	Major congestion points

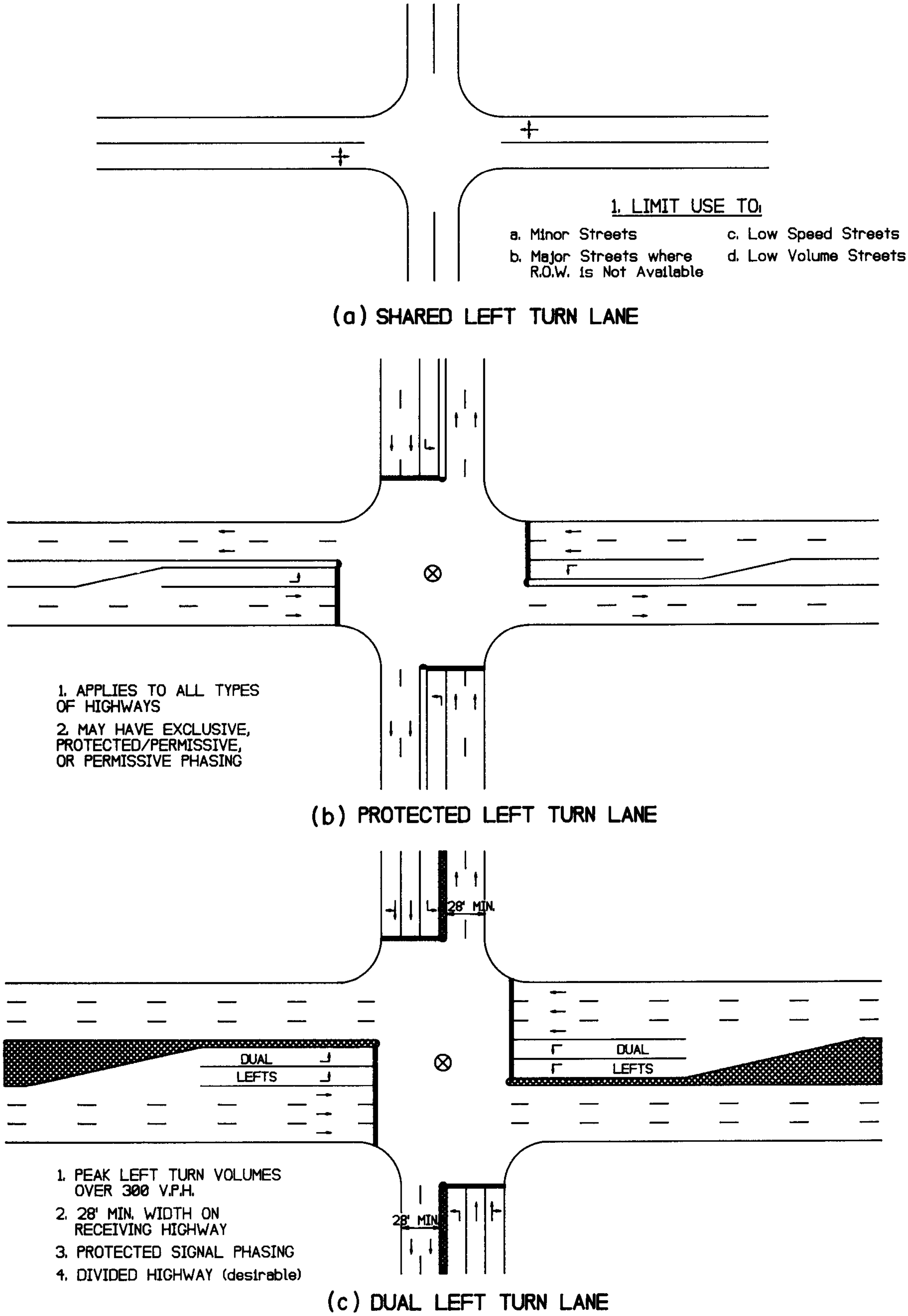


Figure 8-10. Typical treatments of left turns.

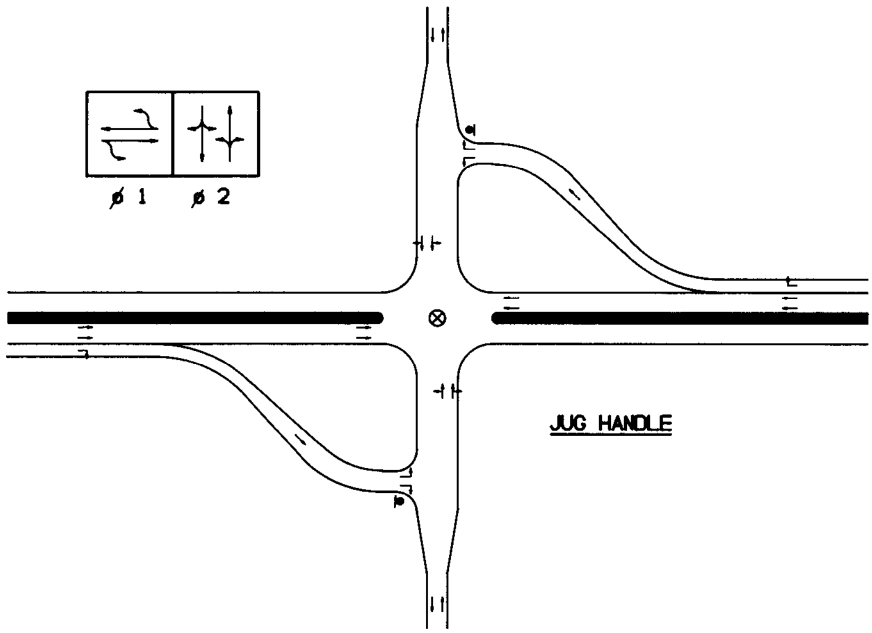


Figure 8-11. Divided highway signalized junction (2-phase) minor cross street.

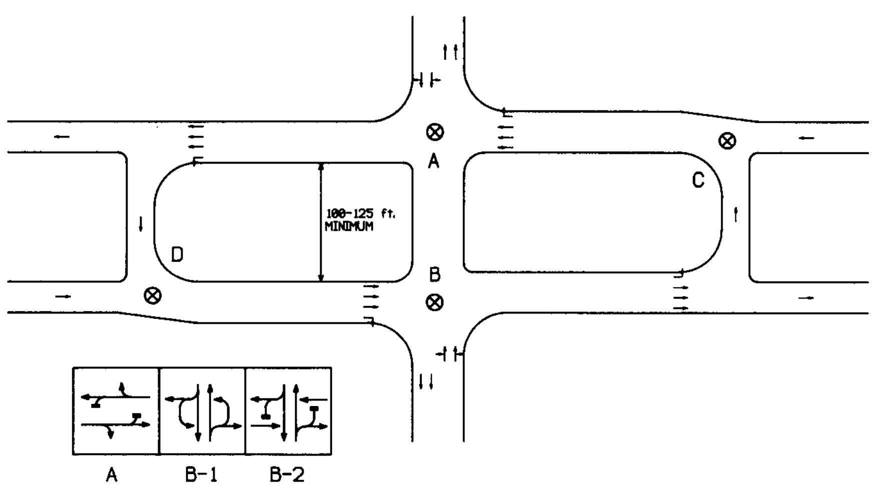


Figure 8-12. Michigan U-turn concept (2-phase signals).

this practice is less desirable because it could block through traffic.

The various U-turn treatments can also be used to provide reversal of direction along divided highways, especially where driveway or intersection traffic is limited to right-turn movements (see Figure 8-15). However, where such turns are signalized, it is essential that the median openings be located or designed to minimize disruption of artery traffic.

Separate U-turn openings may be appropriate in the following locations: (1) beyond interchanges to simplify intersection operations, (2) just ahead of an intersection to remove turning movements from the intersection, and (3) in conjunction with minor driveway or cross-road traffic, where traffic is not permitted to cross the major highway but instead is required to turn right, enter the through traffic stream, and weave to the left. (This design is generally not appropriate along high-speed highways or for major generators.)

Separating Left Turns

Special treatments for left turns are shown in Figure 8-16. At locations where heavy left turns take place in one quadrant, these

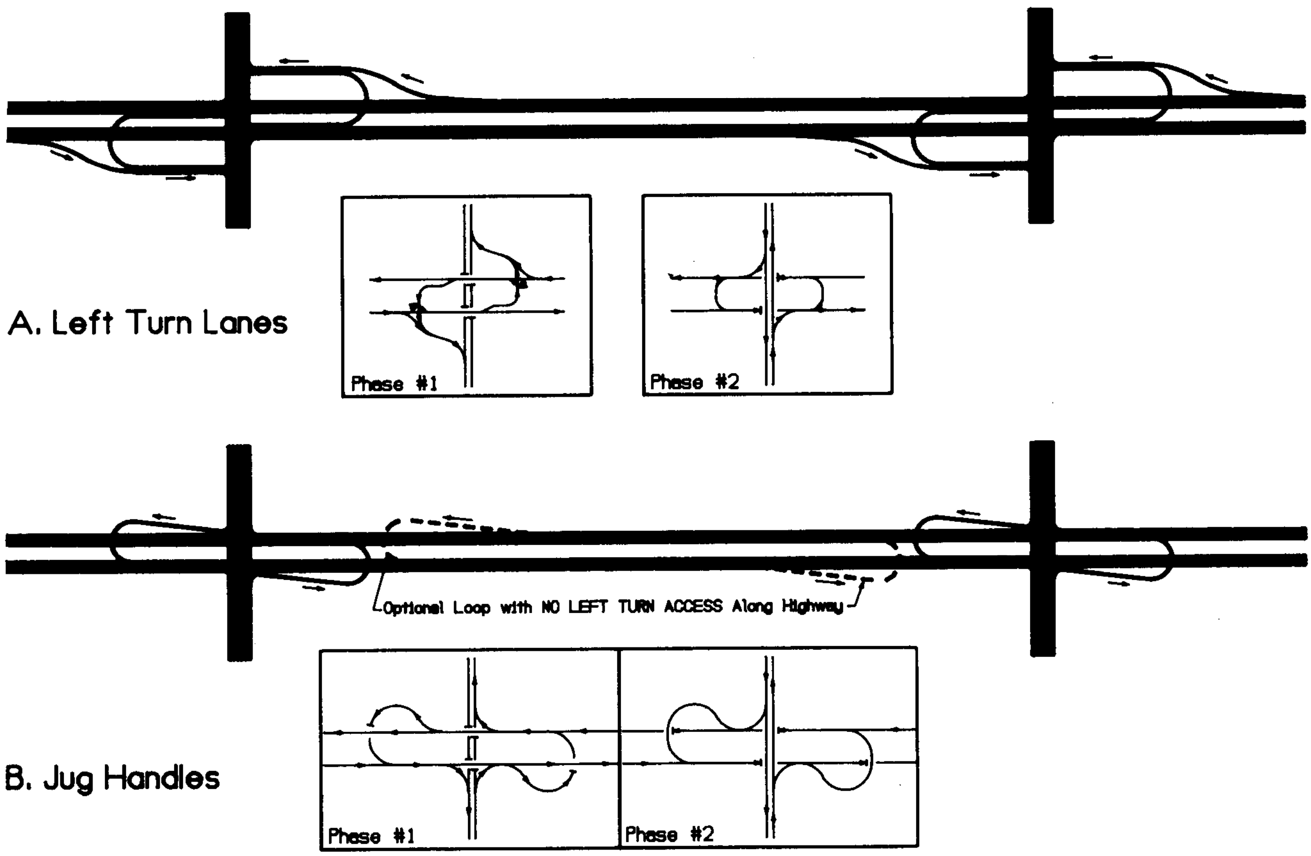


Figure 8-13. Concepts for diverting left turns along arterial highways.

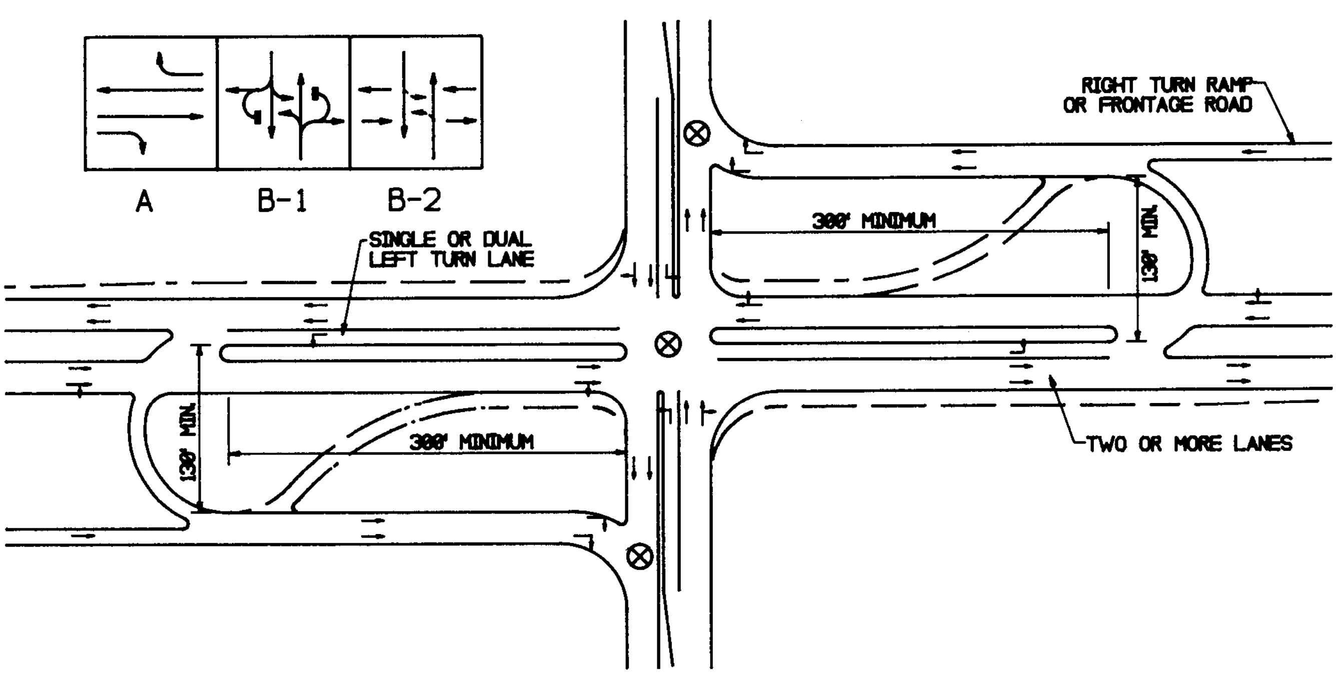


Figure 8-14. Left-turn diversion concept for arterial highways.

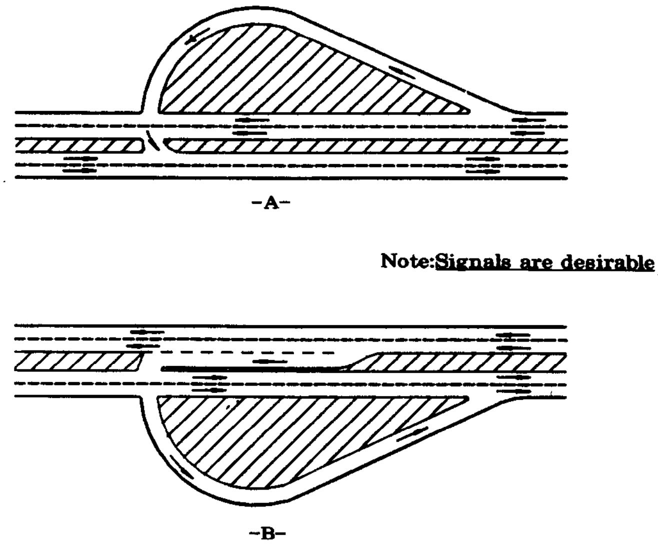


Figure 8-15. Special indirect U-turn with narrow medians.

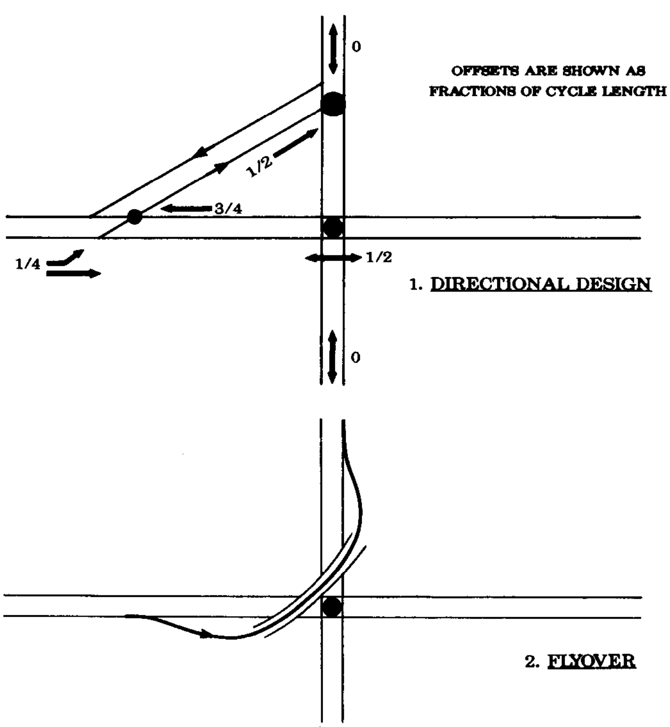


Figure 8-16. Special treatments for heavy left turns.

turns can be removed from the intersection by building a left-turn flyover or a special turning roadway. The geometry of the turning roadway can be designed to provide progressive flow for both arteries and for the left-turn movement.

Special designs should be chosen selectively. Design consistency should be encouraged whenever possible to reinforce motorist expectancy.

8.5 ACCESS DRIVEWAYS

Access driveways vary widely in their traffic and design requirements. A driveway leading to a single residence is usually a simple curb cut that is limited in size. Conversely, a driveway leading to a regional shopping center, corporate office park, or major activity center is really a street and must be treated as such; often such a driveway will have two or more travel lanes each way that are delineated by proper signing, by striping, or by a raised center island. Most driveways, of course, fall between these extremes.

Access driveways to activity centers and other developments may operate either one-way or two-way. They may permit all movements, may separate conflicting left turns, or may allow only right turns.

Driveways that enter arterial roads at traffic signals should have at least two outbound lanes—one for right turns and one for left turns. Dual left and right turning lanes should be used only with traffic signal control. Access driveways generally should not be more than 36 ft wide, unless lane delineation or medians are provided and maintained.

Driveway Location

Driveway location should be influenced by the following factors: the amount of site frontage available for access, the approach directions of development traffic, the locations of existing cross streets and traffic signals, the queuing patterns (backups) along the artery, the traffic signal coordination requirements, and the location of nearby driveways.

Driveways should be located opposite other access or street intersections and placed beyond the normal backups of traffic from signalized intersections. When signalized, they must fit the time-space patterns along the roadway. Spacing of driveways for new (or expanded) developments should be consistent with the spacing guidelines suggested in Chapter 6 for various access levels and operating requirements.

Typical Arrangements and Designs

Examples of typical driveway access configurations are shown in Figure 8-17. The typical site has two-way access driveways with complete access (see (a) in Figure 8-17); however, certain driveways along major arterials are limited to right-turn movements to preclude spillback from nearby signalized intersections.

One-way access driveways are desirable for narrow, often small, strip developments. They are also desirable to connect activity centers on both sides of an arterial (see (b) in Figure 8-17).

The typical access design provides movement in all directions between the artery and driveway. Left-turn storage is created either by widening the road or by narrowing the median. Although roadways are commonly widened on the entrance drive side, the widening may be on either side or equal on both sides.

Figure 8-18 shows the design most commonly used for major entrance driveways. It is desirable to locate access facilities for undeveloped properties opposite the existing access. This allows for efficient signalization and overall safe traffic operation.

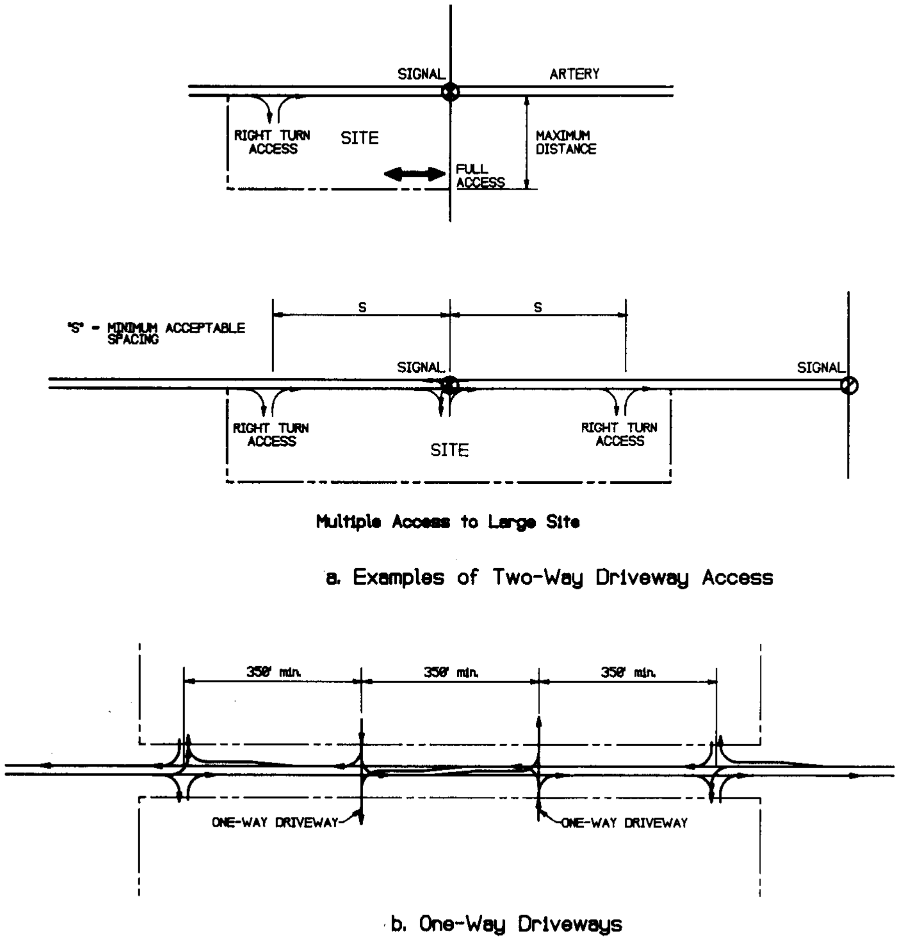


Figure 8-17. Typical driveway access.

Driveways that serve a major activity center should have high capacity type designs. There should be two (or more) lanes in each direction and a median island should separate entering and exiting traffic. Right-turn and left-turn lanes should be provided along the artery, and traffic signals should control conflicting movements; typically, three phases are needed.

Directional Designs

"Directional" designs of access roads separate major conflicting left-turn movements. They achieve high capacities because they permit two-phase signal operations at each intersection. They require divided highways and work well where dual left turn entry lanes are provided. Figure 8-19 shows how directional design simplifies conflicting traffic movements. Figure 8-20 shows how driveway spacing criteria should apply to directional access designs.

Special Designs

Examples of special access designs are shown in Figure 8-21. There are some situations where right-of-way is not available to provide dual protected left-turn lanes. In these cases, a "jug-handle" entry design may be appropriate because it requires less right-of-way (see (a) in Figure 8-21). However, unless left turns from the access road are prohibited, a three-phase signal would be required. Moreover, while left turns made from a center island only conflict with the bypassing direction of travel, the jug-handle requires artery traffic in both directions to stop.

Sometimes it is desirable to provide continuous flow along one direction of an arterial road. In such cases, a design similar to that shown in Figure 8-21(b) may be used. This design requires median islands wider than 20 ft and at least a 2,600-ft distance to the next downstream signal or major right turn point. Separating the entering and exiting left turns would allow two-phase signal operations.

These designs are applicable only where there is no need for access into property on the other side. Thus, their application is highly selective.

Coordinating Access Points

Access points on opposite sides of a road should be coordinated with each other to minimize disruption to through traffic.

The simplest technique is to prohibit all left turns by introducing a continuous physical median. A left-turn exit can be provided on cross streets with only left-turn entrance from the main highway. Such an arrangement, shown in Figure 8-22, makes it

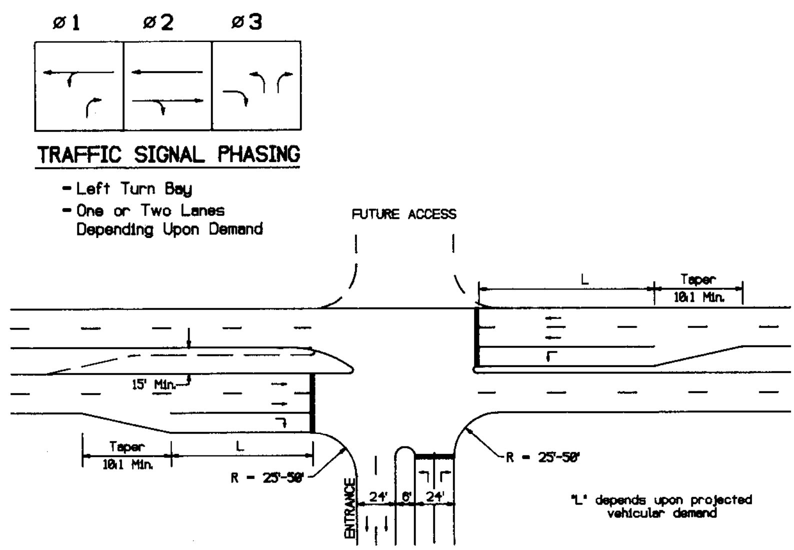


Figure 8-18. Typical access design.

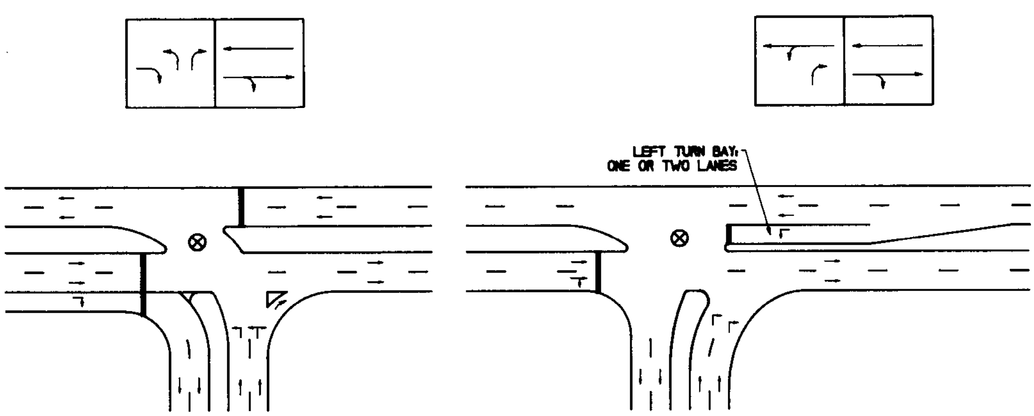


Figure 8-19. Directional access treatment.

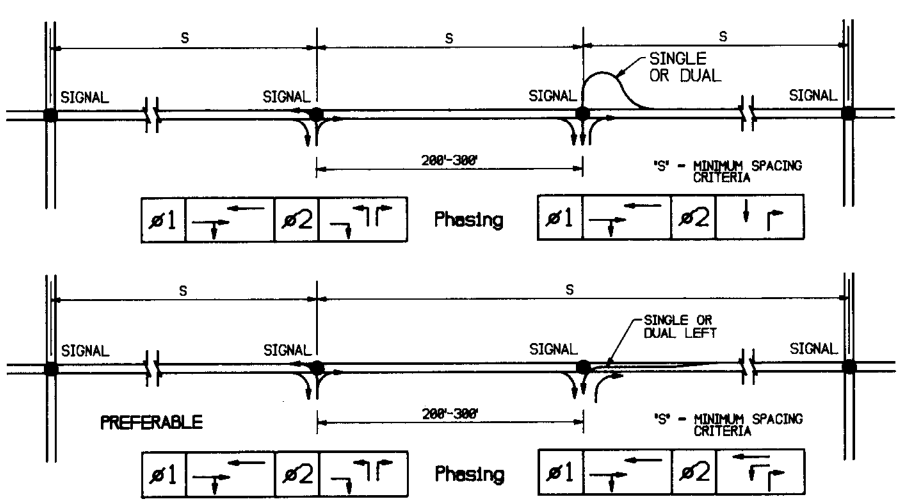


Figure 8-20. Directional designs for major arterial center (2-phase signals).

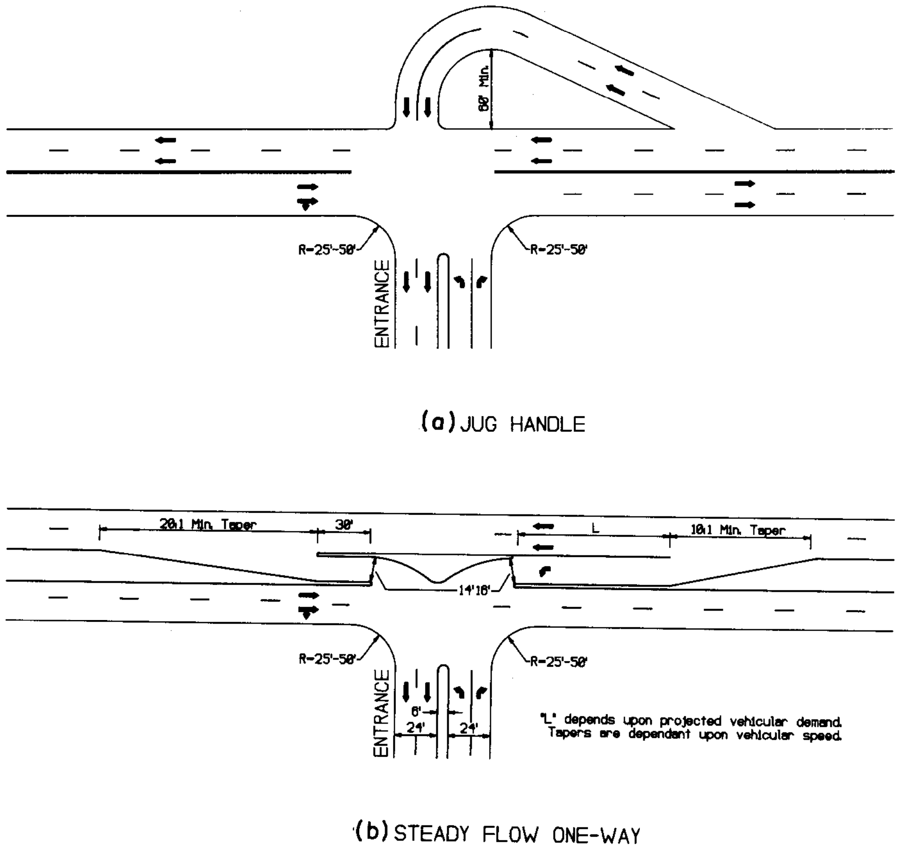


Figure 8-21. Special access designs.

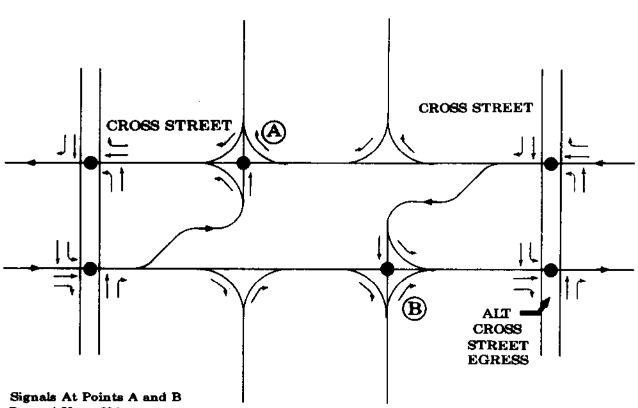


Figure 8-22. Signalized access from opposite sides of a divided highway.

possible to signalize each direction of the artery travel as though it were a one-way street, thereby achieving effective progression.

One-way access drives can directly connect developments on opposite sides of the highway, thereby eliminating left-turn conflicts along these driveways. In addition, right-turn movements can be permitted to and from each development without adding to the traffic signal or intersection complexity. A 600-ft minimum spacing is suggested; however, a 300-ft minimum spacing can be used along low-volume or low-speed roads. Examples are shown in Figure 8-23.

Traffic Signal Implications

The signalization of access points should meet two basic criteria: (1) specific locations should meet warrants for signals set forth in the *Manual on Uniform Traffic Control Devices for Streets and Highways*, and (2) the signals must protect the integrity of flow along the artery, consistent with the access spacing criteria.

The locations, therefore, must fit into the signal progression patterns along the artery. Thus, specific driveway spacing becomes a function of street patterns, travel speeds, and cycle length.

Driveway locations and signal coordination guidelines are shown in Figure 8-24. Ideally, the arterial traffic moves at each crossroad at the same time. The midpoint between crossroads is signalized with a 50 percent offset for the artery. Other intermediate points are signalized only in one direction of travel, if at all. The figure also shows how driveway spacing varies with cycle length and speed. A 30-mph speed and a 60-sec cycle allows a 1,320-ft spacing between the signalized driveway and each crossroad. In contrast, a 40-mph speed and a 90-sec cycle results in a 2,640-ft spacing.

8.6 SITE DESIGN

Site circulation planning should coordinate building locations and configurations, parking and service facilities, and internal circulation roads and site access points. It should provide for automobile, bicycle, taxi, bus, and pedestrian access. It should bring together the architect, developer, engineer, and planner in a cooperative and creative effort. The architect or site planner typically works from the buildings outward (they perceive traffic and parking as essentially a service). The traffic engineer works outward from the approach and boundary roads. An effective site plan assures that both approaches are compatible and coordinated.

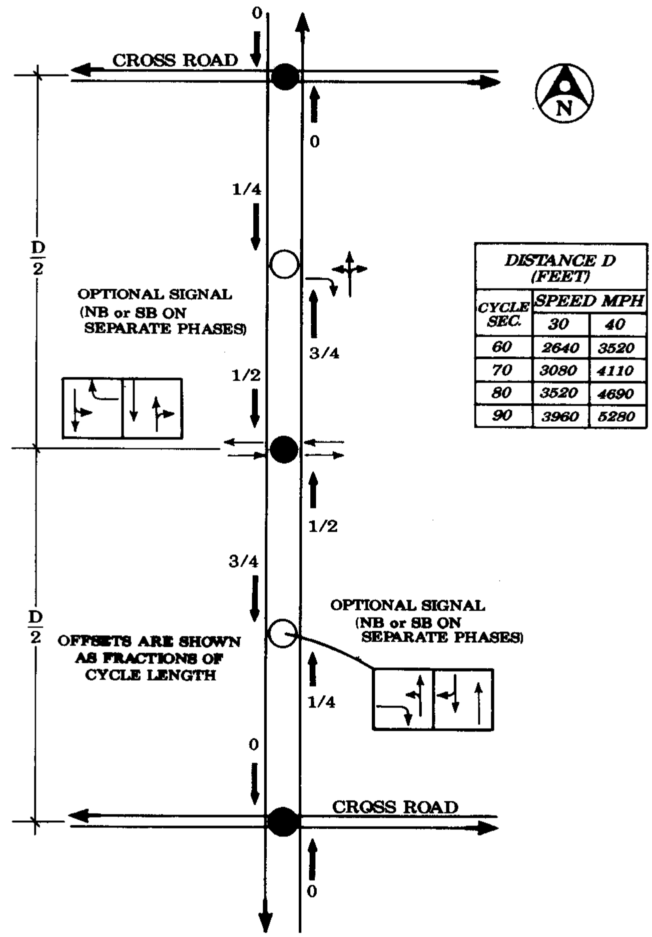
Site Characteristics

The general characteristics of the site and its suitability for the planned activity center development have important bearing on the access and circulation system and the traffic flow on surrounding highways. A good site from a circulation standpoint has ample size, regular shape, reasonably level terrain, and an adequate contact or frontal area with boundary roads; ideally, access should be available from several roads. The building's footprint must not only fit the terrain, but its envelope should conform to the general shape of the site.

Figure 8-25 illustrates the importance of maximizing the frontal area of a given site. As the frontal area increases, it is possible to provide access from several streets, to better comply with access spacing criteria and to distribute traffic more equitably.

Figure 8-26 illustrates the importance, from a traffic and parking perspective, of locating buildings along the axis of a site. When the building configuration is "tilted" to maximize visibility from approach highways, the parking distribution becomes uneven and the parking orientation less clear.

The desired size of a site will depend on (1) anticipated activity, (2) amount of parking required, (3) landscaping requirements, and (4) space desired for expansion and buffers. For regional shopping centers, the site area should be at least one acre for each 10,000 sq ft of gross leasable area. Thus, for a 1,000,000-sq ft regional shopping center, a 100-acre site will be needed.



DISTANCE D (FEET)		
CYCLE SEC.	SPEED MPH 30	40
60	2640	3520
70	3080	4110
80	3520	4690
90	3960	5280

Figure 8-24. Driveway signalized concept.

Access Guidelines

The circulation and parking plan for an activity center should achieve four basic objectives: (1) coordinate allowable access with existing or probable other access to the surrounding roadnet, (2) assure efficient access between the site and surrounding

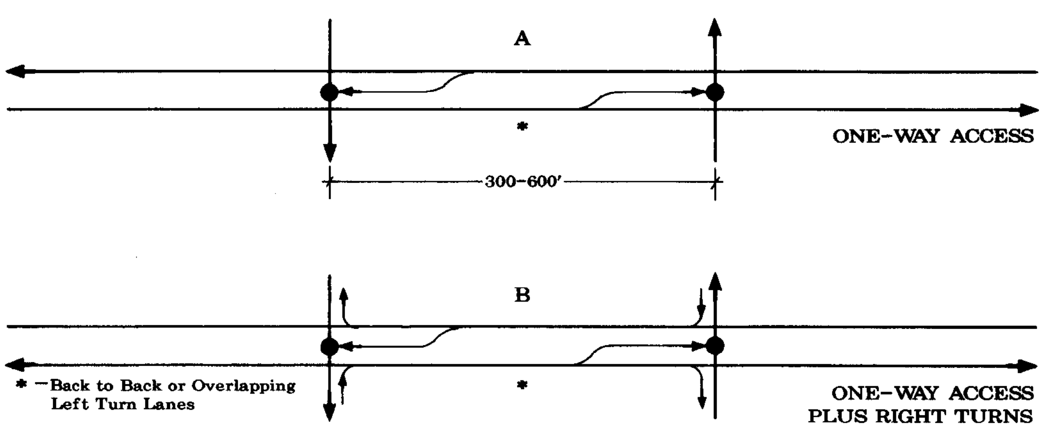


Figure 8-23. Signalized access from opposite sides (divided or undivided road).

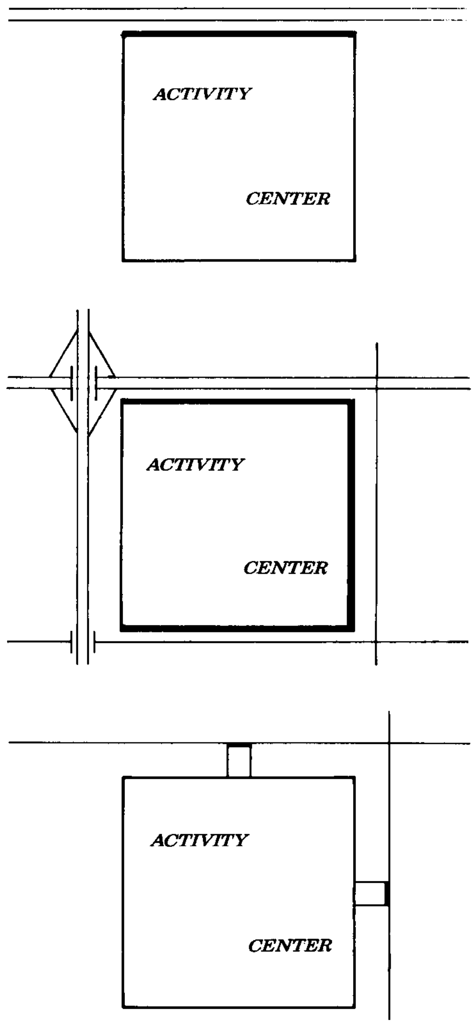


Figure 8-25. Examples of frontal area.

roads, (3) equitably distribute site traffic to parking area, and (4) allow convenient pedestrian access between parking places and buildings. Larger activity centers should also provide convenient public transportation and pedestrian access and circulation.

The site plan shown in Figure 8-27(a) shows how these objectives can be achieved. Figure 8-27(b) provides some design details.

1. The entire site is circumscribed by public roads. Access points are provided along each road to distribute traffic more evenly. Access location and design are consistent with the access levels and spacing criteria for surrounding roads. Only right-turn access is provided off one road, while another road allows only left-turn entry. Two roads allow complete access.

The right-turn only access from the "strategic arterial" on the north side of the site is optional. Although sufficient access is available from the other three roadways, the provision of this access reduces turning volume along the other roads.

2. Traffic signals at access points are located to allow efficient progression. Interchanges are shown along the principal cross arterials to avoid congestion on the approaches to the center, and to ensure adequate capacity and through "green bands" on each road.

3. Center islands separate opposing directions of travel in multilane access points.

4. The internal circulation road is set back several hundred feet to maximize on-site storage (150 ft is a desirable minimum; 70 ft the absolute minimum). "Canoe"-shaped islands prevent cars from entering the parking areas directly from the access roads.

5. The internal circulation or "ring road" connects parking access to access points. It operates two-way, and provides turning lanes at access points. It is generally located 300 to 400 ft from the buildings. The ring road must yield the right-of-way to inbound traffic.

6. The primary parking areas are located within 400 ft of the buildings. The areas on the far side of the ring road are available for overflow parking, landscaping, and automotive uses.

7. The parking areas are compartmentalized by means of islands and landscaping. The aisles are placed at 90-deg angles to the building block to facilitate pedestrian flow.

8. The building block is placed on the same axes as the surrounding roadways. This results in right angle intersections between the parking aisles and the roads between buildings. It also equalizes walking distances. The buildings are configured to discourage through traffic along their edge.

9. The office buildings are superimposed on the retail complex to create a mixed-use development. This maximizes pedestrian interaction between various types of activities and reduces vehicular traffic flow.

10. A bus terminal is located alongside the buildings. The goal is to provide convenient public transport access for patrons and workers.

11. The service areas are removed from the primary parking areas. They are screened from the parking areas.

These principles underlie contemporary transportation planning for activity centers, especially from an access management perspective. They can be adapted to specific situations.

8.7 RETROFIT ACTIONS

The access spacing guidelines and design concepts apply to new or expanded developments. They also provide a basis for making design and operating changes for "retrofit" conditions along developed arterial roadways.

Context

Introducing a "retrofit" program of access control to an existing roadway is often difficult. Land for needed improvements is often unavailable, making certain access management techniques impossible to implement and requiring the use of minimum rather than desirable standards. Rights of property access must be respected. Social and political pressures will emerge from abutting property owners who perceive that their access will be unduly restricted and their business hurt. The needed cooperation of proximate, sometimes competitive, developments in rationalizing on-site access and driveway locations may be

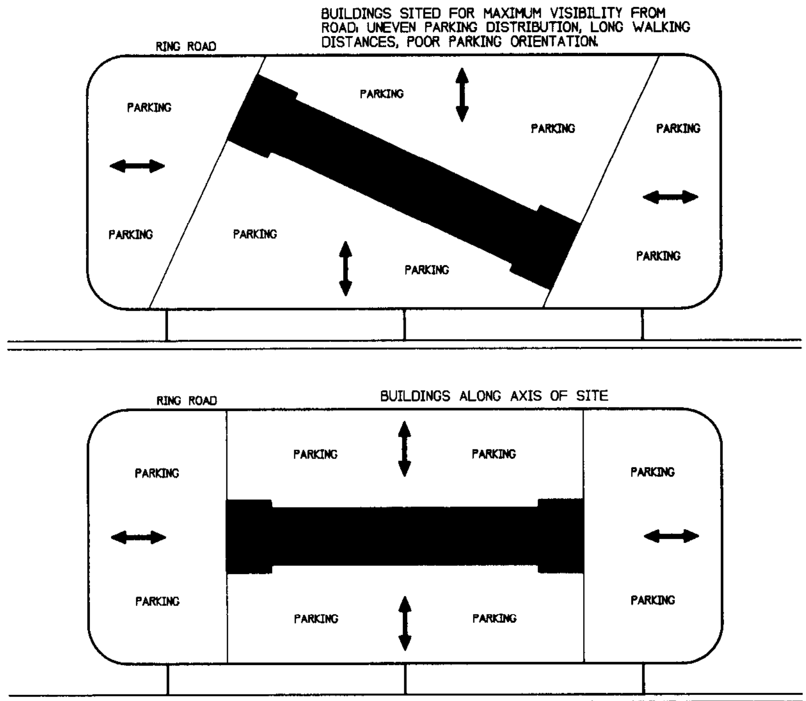


Figure 8-26. The effects of building orientation on parking and access.

difficult to achieve. And it may be difficult to compare the cost of economic hardship to an individual to the benefits accruing to the general public.

Accordingly, the discussions set forth in Chapter 3 concerning the legal, social, and political aspects of access management are particularly relevant in retrofit situations and should be thoroughly understood by public agencies and private groups responsible for implementing access control programs for retrofit projects.

The general reasons underlying retrofit actions include the following: (1) increased congestion and accidents along a given section of road that are attributed to random or inadequate access; (2) major construction or design plans for a road that make access management and control essential; (3) street expansions or improvements that make it practical to reorient access to a cross street and remove (or reduce) arterial access; and (4) coordinating driveways, on one side of a street, with those planned by a development on the other side.

Types of Action

Most retrofit actions involve the application of accepted traffic engineering techniques that limit the number of conflict points, separate basic conflict areas, limit speed adjustment problems, and remove turning vehicles from the through travel lanes. Table 8-2 presents the various access management techniques that achieve each of these objectives and mainly apply to retrofit situations.

The common types of retrofit treatments are summarized in Table 8-3. Roadway improvements include providing additional travel lanes (i.e., right turn, left turn, two-way turns), installing or closing medians, installing frontage roads, and signalizing driveways. Driveway improvements include widening, consolidating, reorienting, and closing. In addition, internal roads and parking areas may be modified.

The simplest and, perhaps, most common treatment is to provide left-turn or right-turn lanes by restriping or widening the roadway. Where *turn lanes* are provided, care should be exercised to avoid creating "hour-glass" road designs that continuously vary lane alignments and arrangements. Continuity of the through-travel lanes can be achieved by installing alternating left-turn lanes or continuous two-way left-turn lanes. Retrofit designs may have to use less than optimum standards (i.e., 10-ft to 11-ft through lanes and 9-ft to 10-ft turning or storage lanes). Where applicable, the pavement area must consider the turning characteristics of trucks and other large dimensional vehicles.

Right-turn lanes, by removing turning vehicles from the through traffic, reduce the speed differences in the main travel lanes, thereby reducing the frequency and severity of rear-end collisions. They also increase capacity at signalized intersections, and may allow refinements in phasing.

Right-turn deceleration lanes may be provided at a single access point, or they can be extended to accommodate several nearby driveways (Figure 8-28). However, to operate as intended, the continuous lane should not be longer than ¼ mi. Transition tapers generally should be 10–15 to 1.

Continuous right-turn lanes are desirable when there are more than 10 high volume driveways per mile. Even five driveways per mile can justify a continuous right-turn lane on high-type suburban highways.

Need and application should be site-specific and should be based on analyses of rear-end accident rates, turning volumes, and side frictions.

Left-turn storage lanes (Figure 8-29) are essential from both capacity and safety standpoints. Where left turns share the use of a through lane, they dramatically reduce both safety and capacity—especially when opposing traffic is heavy. One left turn per signal cycle delays 40 percent of the through vehicles in the shared lane; two turns per cycle delay 60 percent. Where

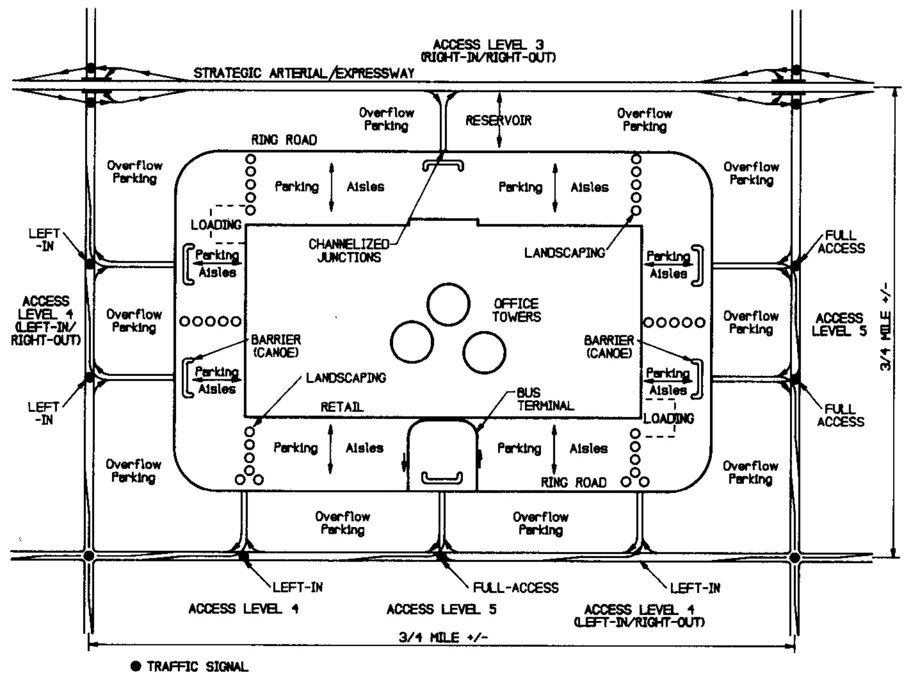


Figure 8-27(a). Site plan keyed to highway access.

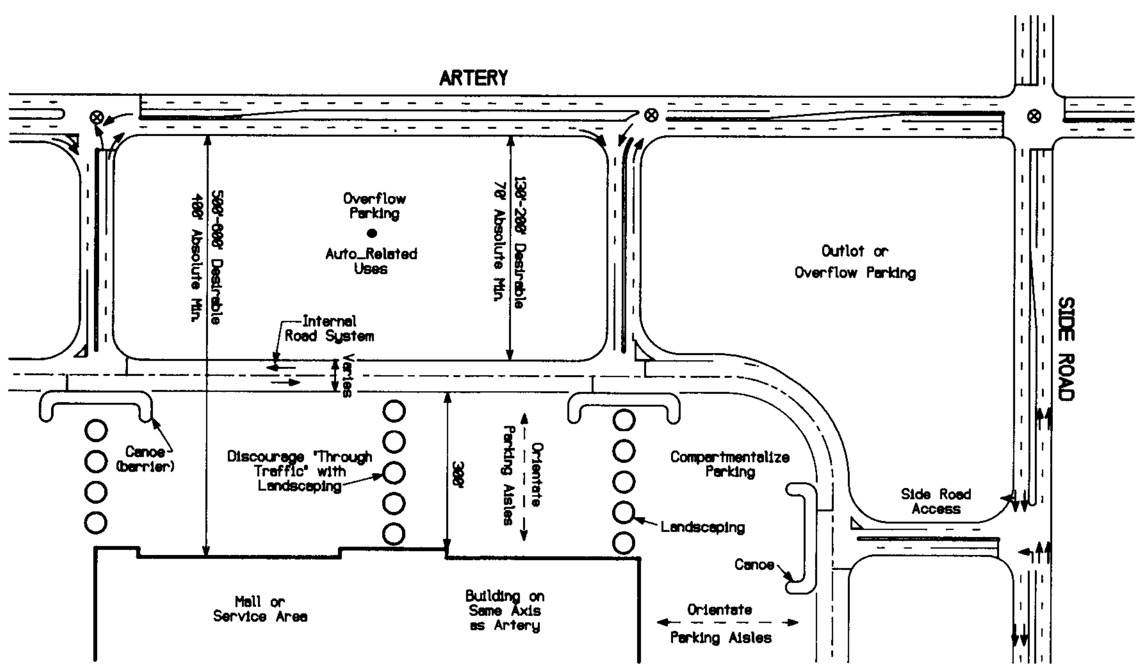


Figure 8-27(b). Site access concept.

cars enter major developments, left-turn volumes of 300 to 500 vph are common—such flows pre-empt an entire lane and seriously reduce arterial street capacity unless special lanes are provided. Often "double-left" turn lanes are desirable in such cases.

The transition taper into the lane should have at least a 1 to 10 ratio. The transition of through traffic around the lane should be approximately equal to the speed in miles per hour (i.e., 30 mph 1:30) but never less than 1 in 20.

A *physical median island* with a left-turn lane at major driveways reduces turning conflicts and accidents, but requires extra travel to reach minor access points. It is appropriate where there are heavy left turns into a few major driveways. One set of criteria suggests an ADT of more than 10,000 vpd, travel speeds of 30 mph to 45 mph, and peak-hour left turns of over 150 veh/mi. As for other treatments, medians may be warranted by a high accident rate. The minimum roadway width to accommo-

Table 8-2. Access management retrofit techniques. (Source: John W. Flora and Kenneth M. Keitt, "Access Management for Streets and Highways," Federal Highway Administration, *FHWA IP-82-3*, June 1982)

CATEGORY A

LIMIT NUMBER OF CONFLICT POINTS

- A-1: Install median barrier with no direct left-turn access
- A-2: Install raised median divider with left-turn deceleration lanes
- A-3: Install one-way operations on the highway
- A-4: Install traffic signal at high-volume driveways
- A-5: Channelize median openings to prevent left-turn ingress and/or egress maneuvers
- A-6: Widen right through lane to limit right-turn encroachment onto the adjacent lane to the left
- A-7: Install channelizing islands to prevent left-turn deceleration lane vehicles from returning to the through lanes
- A-8: Install physical barrier to prevent uncontrolled access along property frontages
- A-9: Install medial channelization to control the merge of left-turn egress vehicles
- A-10: Offset opposing driveways
- A-11: Locate driveway opposite a three-leg intersection or driveway and install traffic signals where warranted
- A-12: Install two one-way driveways in lieu of one two-way driveway
- A-13: Install two two-way driveways with limited turns in lieu of one standard two-way driveway
- A-14: Install two one-way driveways in lieu of two two-way driveways
- A-15: Install two two-way driveways with limited turns in lieu of two standard two-way driveways
- A-16: Install driveway channelizing island to prevent left-turn maneuvers
- A-17: Install driveway channelizing island to prevent driveway encroachment conflicts
- A-18: Install channelizing island to prevent right-turn deceleration lane vehicles from returning to the through lanes
- A-19: Install channelizing island to control the merge area of right-turn egress vehicles
- A-20: Regulate the maximum width of driveways

CATEGORY B

SEPARATE BASIC CONFLICT AREAS

- *B-1: Regulate minimum spacing of driveways
- B-2: Regulate minimum corner clearance
- B-3: Regulate minimum property clearance
- *B-4: Optimize driveway spacing in the permit authorization stage
- *B-5: Regulate maximum number of driveways per property frontage
- B-6: Consolidate access for adjacent properties
- B-7: Require highway damages for extra driveways
- B-8: Buy abutting properties
- B-9: Deny access to small frontage
- B-10: Consolidate existing access whenever separate parcels are assembled under one purpose, plan, entity, or usage
- *B-11: Designate the number of driveways regardless of future subdivision of that property
- B-12: Require access on collector street (when available) in lieu of additional driveway on highway

CATEGORY C

LIMIT DECELERATION REQUIREMENTS

- C-1: Install traffic signals to slow highway speeds and meter traffic for larger gaps
- C-2: Restrict parking on the roadway next to driveways to increase driveway turning speeds
- C-3: Install visual cues of the driveway
- C-4: Improve driveway sight distance
- C-5: Regulate minimum sight distance
- *C-6: Optimize sight distance in the permit authorization stage *
- C-7: Increase the effective approach width of the driveway (horizontal geometrics)
- C-8: Improve the vertical geometrics of the driveway
- C-9: Require driveway paving
- C-10: Regulate driveway construction (performance bond) and maintenance
- C-11: Install right-turn acceleration lane
- C-12: Install channelizing islands to prevent driveway vehicles from backing onto the highway
- C-13: Install channelizing islands to move ingress merge point laterally away from the highway
- C-14: Move sidewalk-driveway crossing laterally away from highway

CATEGORY D

REMOVE TURNING VEHICLES FROM THE THROUGH LANES

- D-1: Install two-way left-turn lane
- D-2: Install continuous left-turn lane
- D-3: Install alternating left-turn lane
- D-4: Install isolated median and deceleration lane to shadow and store left-turning vehicles
- D-5: Install left-turn deceleration lane in lieu of right-angle crossover
- D-6: Install medial storage for left-turn egress vehicles
- D-7: Increase storage capacity of existing left-turn deceleration lane
- D-8: Increase the turning speed of right-angle median crossovers by increasing the effective approach width
- D-9: Install continuous right-turn lane
- D-10: Construct a local service road
- *D-11: Construct a bypass road
- *D-12: Reroute through traffic
- D-13: Install supplementary one-way right-turn driveways to divided highway (noncapacity warrant)
- D-14: Install supplementary access on collector street when available (noncapacity warrant)
- D-15: Install additional driveway when total driveway demand exceeds capacity
- D-16: Install right-turn deceleration lane
- D-17: Install additional exit lane on driveway
- D-18: Encourage connections between adjacent properties (even when each has highway access)
- D-19: Require two-way driveway operation where internal circulation is not available
- D-20: Require adequate internal design and circulation plan

* Not Directly applicable for retrofit.

date four 11-ft through lanes and a 12-ft median is 56 ft. A more desirable design calls for 12-ft through lanes and a 16-ft to 20-ft median.

Alternating left-turn lanes provide protected access for one direction at a time. They require a center lane only 10 ft to 12 ft wide, versus the usual 14 ft. This design normally can be provided on arterial sections where the traffic volume and travel speeds exceed 10,000 vpd and 30 mph, respectively, and where left turns per mile exceed 15 percent of through traffic during peak traffic demand, or where warranted by accident rates resulting from left-turn maneuvers. It should reduce accidents by 25 percent.

Two-way left-turn lanes shadow left turning vehicles and simultaneously provide property access. They work well in developed areas with a high frequency of low volume driveways such as strip commercial developments. There should be at least 45 driveways per mile of which no more than 10 are high volume drives. However, the lanes are not applicable in all situations—at signal controlled intersections and major driveways, standard left-turn treatments should be provided.

Table 8-3. Common retrofit improvements.

1. Provide right turn lanes.
2. Provide left turn lanes (by widening, restriping or modifying median).
3. Provide two-way left turn lane.
4. Install median.
5. Close median.
6. Install frontage road.
7. Install or modify traffic signals.
8. Widen driveways and improve storage area.
9. Consolidate driveways.
10. Relocate or reorient access.
11. Close driveway.
12. Redesign internal road and parking system.
13. Replace curb parking with off-street parking.

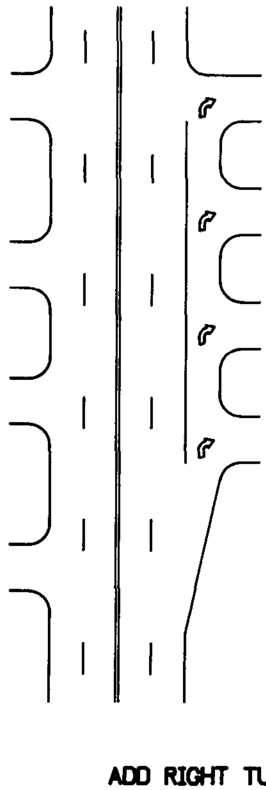


Figure 8-28. Example of retrofit arrangements.

Medians

Physical medians fully separate opposing traffic flows, clearly define where cross movements are permitted, provide space for single- and multiple-turning lanes at signalized intersections, and may limit certain access points to right-turn movements only. They also provide better pedestrian protection than painted islands. They may be continuous, allow only left-turn entry (or exit), or provide full openings at specified locations. Thus, medians are generally desirable at major activity centers where a few high volume channelized driveways provide property access. They are also desirable where volume or safety considerations require restricting property access to right turns.

Disadvantages of physical medians include installation costs, increased maintenance, and an increase in collision points where median islands begin.

Table 8-4 compares the advantages and disadvantages of two-way left-turn lanes and raised medians.

Median islands are desirable on multilane highways to provide pedestrian refuge and storage for left turns. A 14-ft to 16-ft physical median width can achieve these objectives, although narrower painted medians are and can be used. In the upgrading of a roadway from two to four or more lanes, the introduction of some type of median control should be considered.

On many roadways, especially those with a narrow median, it may be desirable to close the median or to channelize openings to prevent left-turn ingress and egress movements. This technique is appropriate on arterial streets with at least 30 driveways per mile, travel speeds of over 30 mph, and an ADT of at least 5,000 vpd. There should be no more than 100 prohibited left turns per day at any location. Closure is especially appropriate where a few left-turn movements create safety problems.

Figure 8-30 shows how median closures may be accomplished. The first method extends the median to physically prevent left turns from a driveway onto the arterial. This method, common on divided roads with left-turn deceleration lanes at major driveways, should reduce accident rates by 20 percent. For this design, the median must be at least 14 ft wide.

The second method channelizes the median to prevent left turns from the arterial into driveways; it may reduce accidents up to 30 percent. The third method closes the median, thereby preventing all left turns. This method, common for narrow medians, can reduce the accident rate by 50 percent.

The introduction of a revised median on an existing roadway in a developed area is sometimes controversial. Roadside businesses frequently object to the possible loss in business resulting

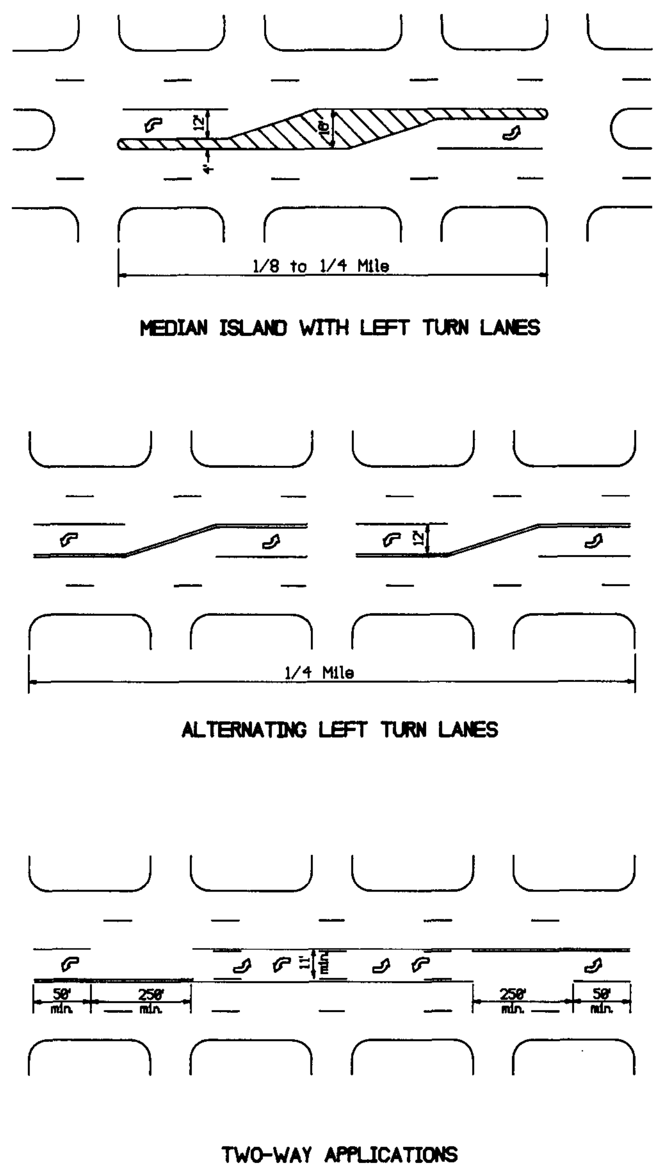


Figure 8-29. Left-turn lane designs.

Table 8-4. Comparison of raised median and 2-way left-turn lanes. (Adapted from Ref. 2)

RAISED MEDIAN	TWO-WAY LEFT TURN LANE
+ Discourages strip development + Allows better control of land uses by local government + Reduces number of conflicting maneuvers at driveways + Provides Drivers-Pedestrian refuge + If continuous, restricts access to right turns only + Reduces accidents in mid-block areas + Provides positive separation of opposing traffic recess	+ Makes use of "odd-lanes" + Reduces left turns from through lanes + Provides operational flexibility for emergency + Safer than roads with no left turn lanes or medians + Facilitates detours + Provides positive separation of opposing traffic recess
- Reduces operational flexibility for emergency vehicles - Increases left turn volumes at median openings - Increases travel time and circuity for some motorists - May increase accidents at openings - Limits direct access to property - Operating speed usually limited to 45 mph	- Encourages random access - Illegally used as a passing lane - No refuge for pedestrians - Poor visibility of markings - High maintenance cost - Operate poorly under high volume of through traffic - Allows Head-on collisions

+ Advantages
- Disadvantages

from the reduced access. The economic impacts of medians therefore must be considered in the retrofit situations.

The economic impacts will depend on the type of business, its marketing and management policies, dependence on pass-by or "intercept" traffic, extent of competition, and the general economic climate in the area. Results of before and after studies conducted in Texas cities in the 1970s are summarized in Table 8-5. While the results suggest some decline in sales volume in both traffic-serving and nontraffic-serving businesses after a median was installed, they do not appear consistent from city to city. (Traffic-serving businesses mainly include service stations, motels, and restaurants.)

The business effects of replacing a two-way left-turn lane on Jimmy Carter Boulevard in Guinnett County, Georgia, based on sales receipts in a 1990 study, were noted as follows (*2*): (1) Twenty-one businesses reported decreased sales receipts ranging from 0.25 percent to 56 percent. (2) Fifteen businesses reported increased sales receipts ranging from 0.32 percent to 848 percent. (3) Some mid-block businesses reported some short-term losses. Overall, no negative impact was found.

Frontage Roads

Frontage roads are sometimes considered for improving high-speed, high-volume arteries. However, their provision is costly and time consuming when right-of-way must be purchased. Moreover, any frontage road design must ensure that intersections along the arterial are not complicated.

Driveways

Driveway improvements and rationalization are an integral part of retrofit programs. Commonly used techniques include: closing improperly spaced or designed driveways; widening driveways and increasing storage area between driveway and parking area; limiting turning movements at the public highway and at the interior circulation road; channelizing intersections with the on-site road system; consolidating driveway access; and reorienting driveway access to side streets.

Relocation. The simplest retrofit action is to close or relocate driveways that are poorly placed. Driveways that are closer than 100 ft from a public street intersection are candidates for closure. Where driveways enter public highways within the normal queuing distance from a signalized intersection, they should be relocated or limited to right turns. Accordingly, left turns to or from driveways within 100 to 200 ft of a major signalized intersection should be prohibited by a sign or by a center median. Where closely spaced driveways serve the same development, access should be consolidated and some driveways should be closed.

Driveways may be relocated to line up to form the fourth leg

Table 8-5. Sales volume comparisons in Texas cities. (Source: John W. Flora and Kenneth M. Keitt, "Access Management for Streets and Highways," Federal Highway Administration, *FHWA IP-82-3*, June 1982)

	Sales Volume Before Median	Sales Volume After Median
Pleasanton:		
A. Traffic-Serving Businesses -		
1. Study Group	100	95.8
2. Control Group	100	100.8
B. Nontraffic-Serving Businesses -		
1. Study Group	100	82.4
2. Control Group	100	104.3
San Antonio:		
A. Traffic-Serving Businesses -		
1. Study Group	100	76.4
2. Control Group	100	102.0
B. Nontraffic-Serving Businesses -		
1. Study Group	100	103.4
2. Control Group	--	--

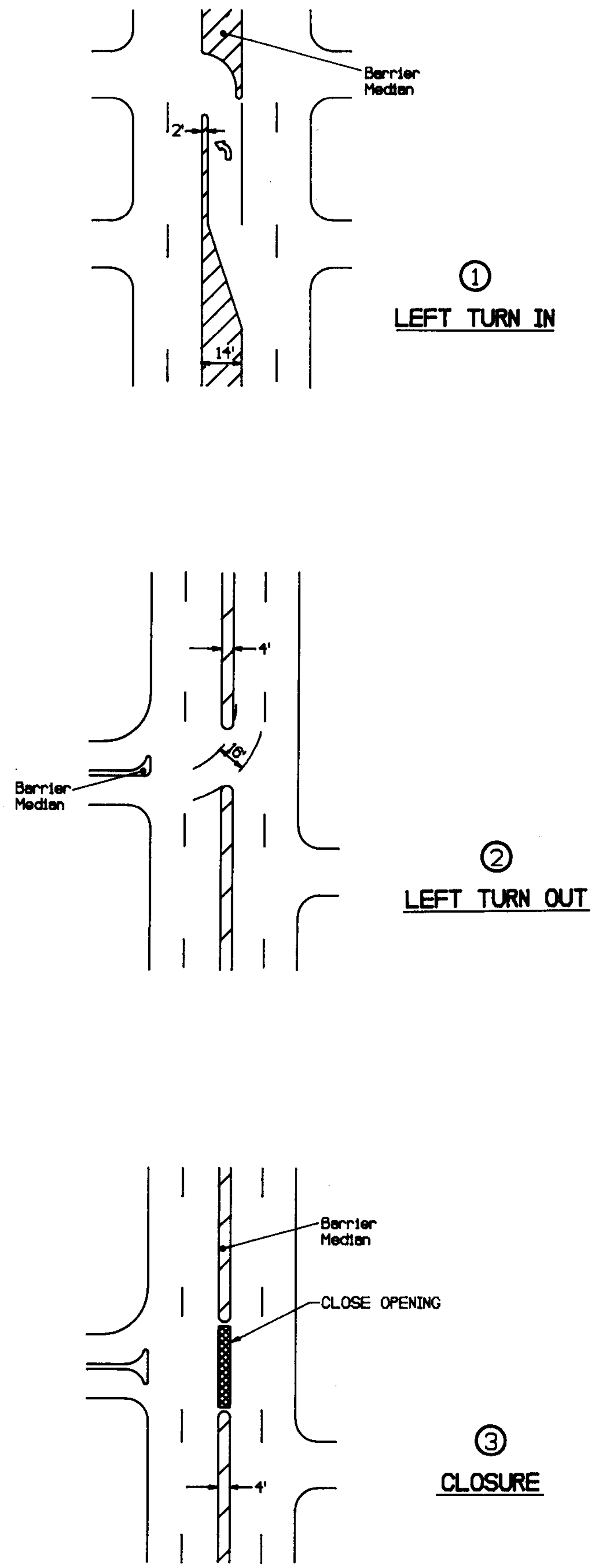


Figure 8-30. Median closing designs.

of an intersection with a public street (see Figure 8-31). Driveways that are less than 150 ft from a driveway on the opposite side of an undivided highway are candidates for relocation.

Design. Driveway design should be coordinated with internal site roads; random access should be discouraged. Storage areas should be increased and medians extended (see Figure 8-32).

A key retrofit action is to improve the back-to-back "H" resulting from driveway intersections with the public highway and the internal ring road system at activity centers. A closely spaced ring road and arterial road result in frequent conflicts. Channelizing both intersections, installing a median within the driveway, eliminating left turns from the highway, and increasing driveway storage space will reduce conflicts, simplify signal phasing, and increase capacity. Figure 8-33 shows how the back-to-back "H" can be improved by these actions. Figure 8-34 illustrates proposed driveway changes for an existing shopping center.

Consolidation. Driveway consolidation is especially desirable for adjacent strip developments along a highway. However, opportunities are frequently limited by differences in terrain, building placement, and internal road and parking arrangements that inhibit or preclude consolidation. An internal roadway that connects adjacent developments and their parking areas usually makes possible the consolidation of access points. In other cases, changes in parking arrangements can permit driveway closure or consolidation. One possibility is to provide a development bonus for such consolidation (see Figure 8-35).

Internal Site Changes

Retrofit opportunities within an activity center or among adjacent centers include: (1) rearranging internal circulation road, (2) expanding and channelizing key intersection, and (3) redesigning and reorienting parking areas (see Figures 8-36 and 8-37). These changes are usually done concurrently with driveway improvements.

Implications

The retrofitting process should be continuous. Access management and control techniques, just as other traffic engineering actions, may need modification as conditions change. Recommended spacing and design should be applied wherever possible.

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1. Levinson, H.S., *Operational Measures Future.* Proc., Institute of Traffic Engineers (1962).
2. Bretherton, Womble, Parsonson and Black, "One Suburban County: Policy for Selecting Median Treatments for Arterials." ITE, *Compendium of Technical Papers* (1990).

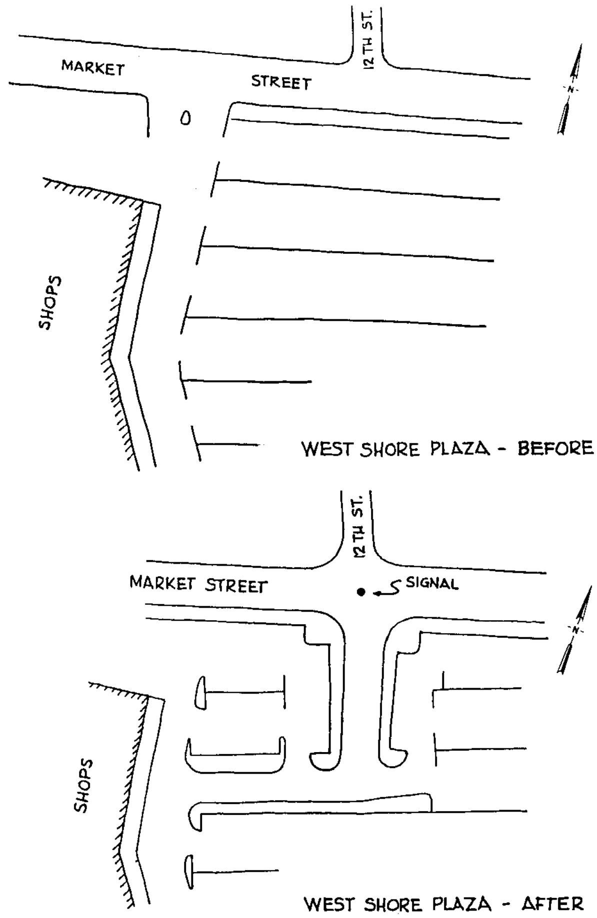


Figure 8-31. Relocation of driveway to link up with signalized intersections. (Source: Benedict G. Barkan, "Retrofitting Shopping Centers for Today's Traffic," Workshop on Access Management, University of Connecticut, 1984)

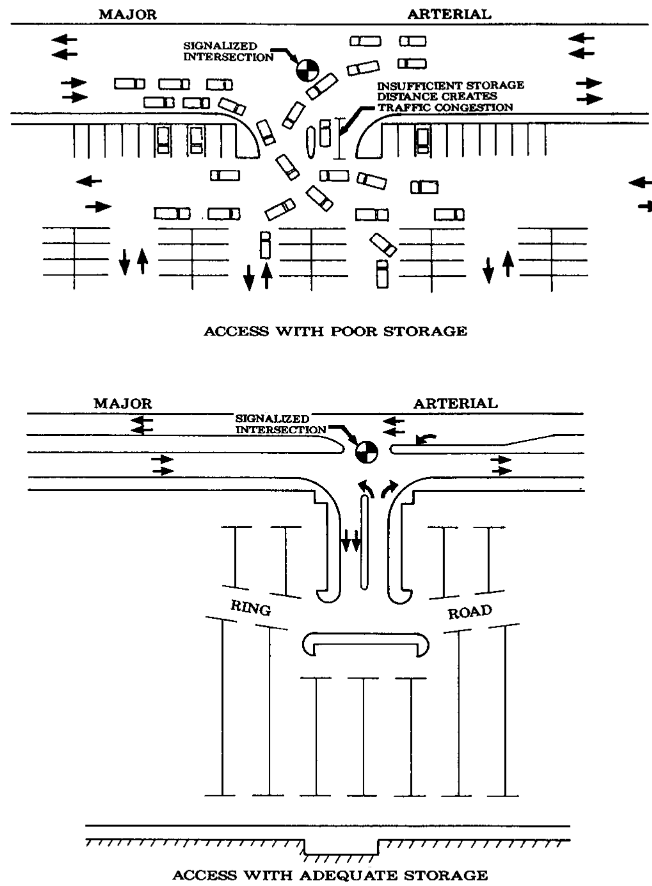


Figure 8-32. Driveway improvements to increase storage.

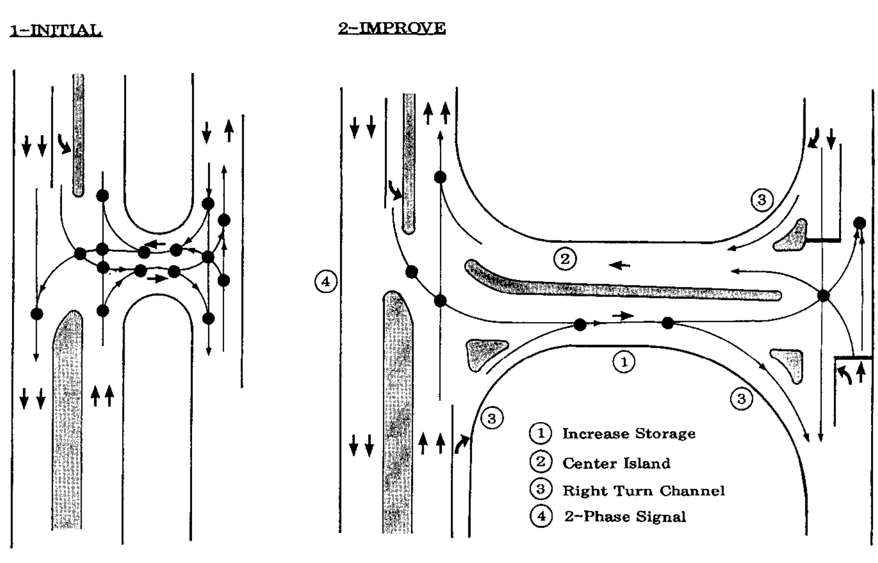


Figure 8-33. Improving the "back-to-back" H.

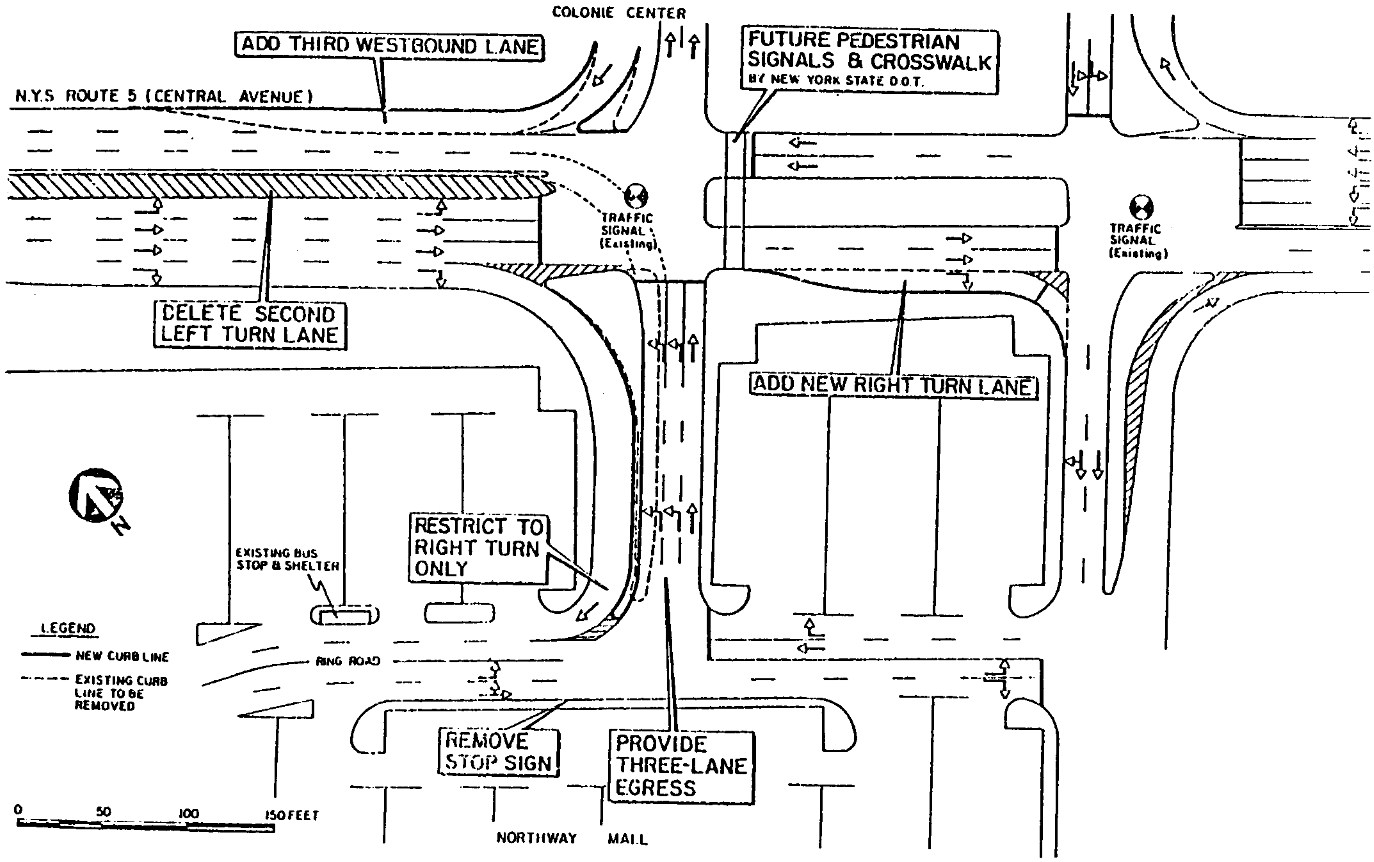


Figure 8-34. Recommended retrofit improvements for Northway Mall—Colonie, New York (Source: Barkan & Mess Associates, "Northway Mall Traffic Access Improvements," Colonie, N.Y., 1982)

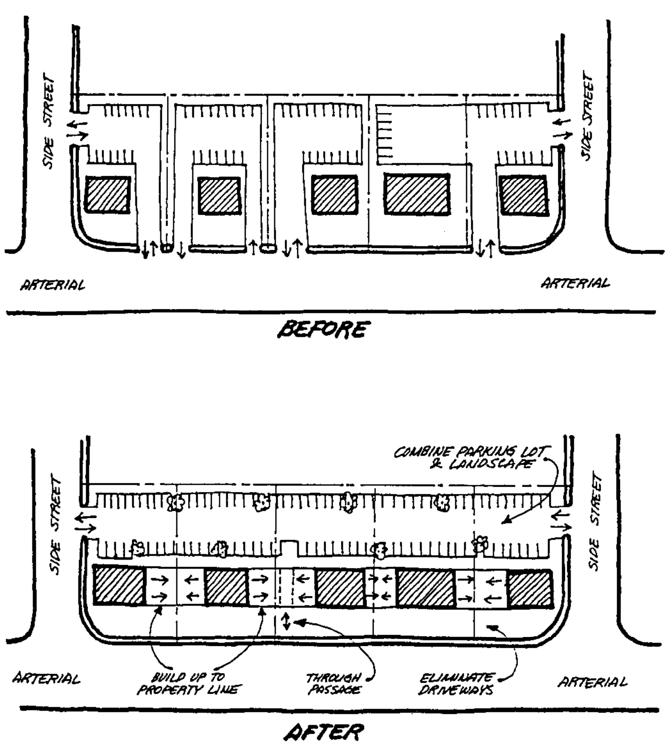


Figure 8-35. Development bonus for driveway and parking consolidation. (Source: George Jackquemart Associates, "Guide to Driveway Consolidation," 1989)

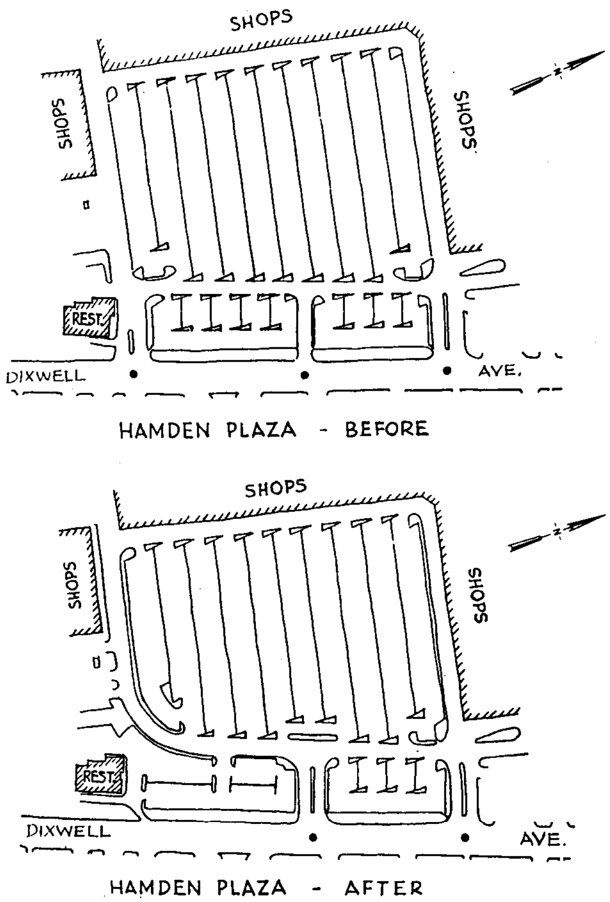


Figure 8-36. Example of internal site improvements—Hamden Plaza (Source: Benedict G. Barkan, "Retrofitting Shopping Centers for Today's Traffic," Workshop on Access Management, University of Connecticut, 1984)

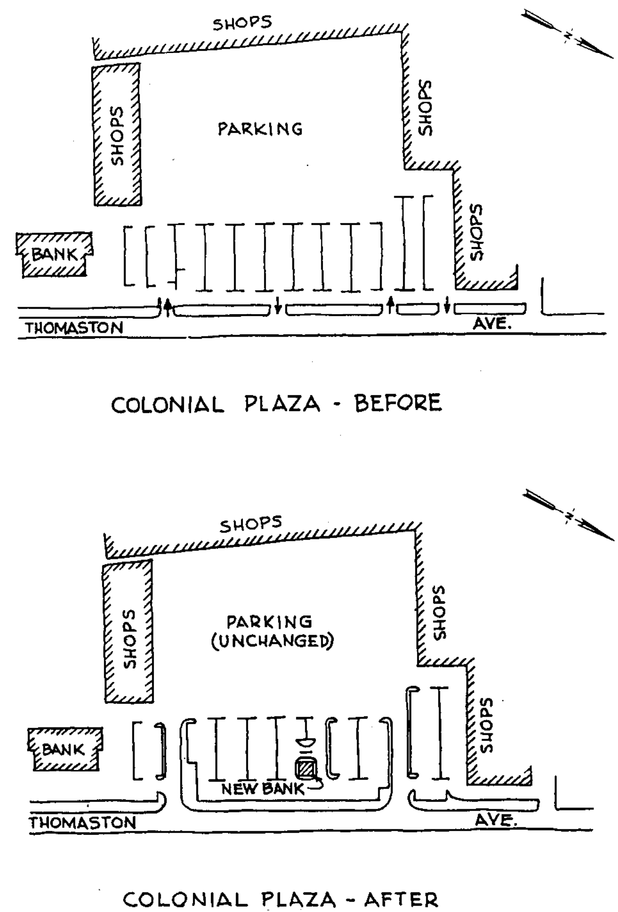


Figure 8-37. Example of internal site improvements—Colonial Plaza (Source: Benedict G. Barkan, "Retrofitting Shopping Centers for Today's Traffic," Workshop on Access Management, University of Connecticut, 1984)

CHAPTER 9

ACCESS DESIGN CRITERIA

In Brief Once the number of access driveways and their locations have been identified, proper geometric design must be applied to produce the desired operations. Design criteria should produce a consistency that is easily read by daily users and pass-by travelers alike. After design standards are established, opportunities to deviate, if necessary, from the recommended standards also must be available. Unlike the intersections of dedicated streets, private access driveways present the additional challenges that are inherently created by the conflicting goals of the public and private sectors. Frequently, attempts to regulate traffic for the public good are in conflict with the interests of the private sector. Access design standards are more easily applied to large parcel development than to small or multiple parcels with limited frontage on the roadway network. The goal is to produce an efficient design that can accommodate the access needs of the property while maintaining effective flow on surrounding roadways. This chapter establishes basic design criteria and suggests parameters for review of special situations. It builds on the best elements of contemporary practice.

9.1 DESIGN OBJECTIVES

Access design should permit the safe and efficient processing of cars, trucks, and buses from public roadways onto access driveways and into parking areas. This involves establishing the length and taper of auxiliary turning lanes, driveway turning radii, width and storage, and the appropriate traffic controls. It is, in a sense, scaling and dimensioning the access concepts presented in Chapter 8 as they relate to the spacing criteria for various access categories or levels.

Design criteria have evolved over many years. Each state and local highway agency has developed and upgraded its standards drawing upon AASHTO and ITE guidelines. Sensible application of these standards is necessary to assure safe and orderly traffic flow and to protect public agencies from tort liability. However, applications should allow flexibility to avoid precluding viable operational solutions that otherwise would be precluded.

The specific design elements for any particular situation must consider the operational requirements of users, the desired access levels, and the specific site characteristics. Figure 9-1 describes the steps in the access design process that lead to specific design solutions.

The following objectives should be kept in mind in establishing the design criteria for various types of driveways:

1. Preserve the original intent of the roadway being accessed.
2. Minimize the speed differential between through vehicles and those using the driveway.
3. Eliminate the encroachment of turning vehicles on adjacent lanes.
4. Provide adequate sight distance for vehicles exiting the driveway.
5. Provide sufficient storage within the driveway to prevent spillback onto public streets or into site parking areas.
6. Minimize the number of conflict points, especially those associated with more severe accidents or greater accident frequency.

Storage requirements for turn lanes and driveways should be adequate for the peak traffic demands of the activity center involved.

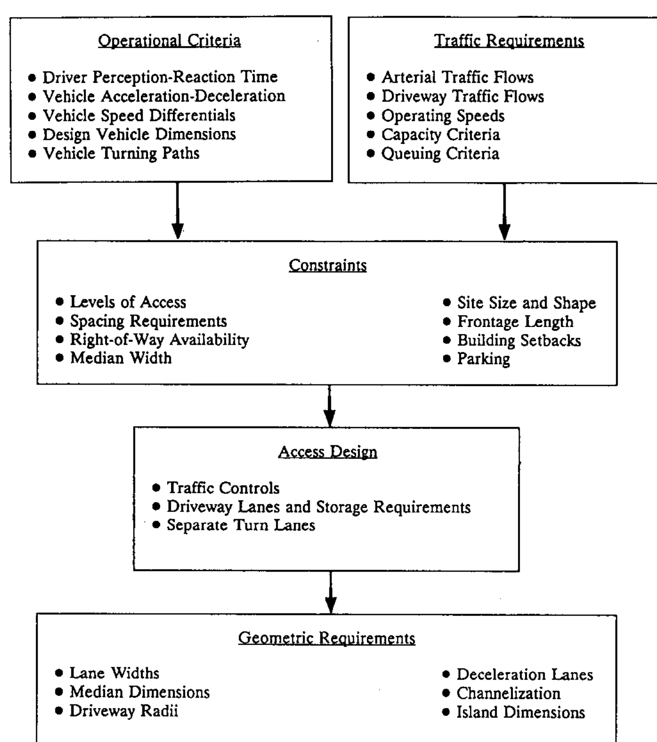


Figure 9-1. The access design process. (Adapted from John W. Flora and Kenneth M. Keitt, "Access Management for Streets and Highways," Federal Highway Administration, FHWA IP-82-3, June 1982)

9.2 DESIGN PARAMETERS

Two important parameters influence access design. Design vehicle dimensions govern lane widths, swept paths, and turning radii. Capacity criteria govern the number of lanes to be provided.

Design Vehicle

As a first step in planning the layout of a driveway, one should identify the critical "design vehicle" expected to be accommodated by the facility. For example, most residential and small commercial driveways only need to accommodate passenger cars; other commercial or industrial developments will usually require at least one driveway that can accommodate the efficient entry or exit of larger vehicles such as single unit trucks, buses, or perhaps even semitrailers (WB-40 or WB-50 design vehicles).

Critical dimensions for such design vehicles have been compiled by the American Association of State Highway and Transportation Officials (AASHTO). In addition, AASHTO publishes several templates that delineate the minimum turning radii and swept paths for each of the design vehicles. These vehicle turning templates should be used as a tool in checking for the provision of adequate maneuvering space in all driveway and parking design. Examples of design vehicle turning paths are shown in Figure 9.2.

After a design vehicle has been identified, a compatible driveway can be designed by selecting a suitable curb return radius and a corresponding driveway entry width. The entry width dimension depends on the adequacy of the curb return radius in transitioning the design vehicle through the turn necessary to exit or enter the driveway. A longer curb return radius provides the better turning transition and will require less entry width than a smaller radius.

Capacity Criteria

The capacity of an intersection depends on several basic factors. These factors include (1) the number and efficiency of moving travel lanes, (2) the nature and extent of interferences (i.e., signal timing, cross streets, or opposing traffic), and (3) the saturation flows (or headways) considering traffic composition and grades. Because various lanes perform differently, computations are normally done on a lane-by-lane or lane group basis. Detailed computational procedures are contained in the 1985 "Highway Capacity Manual" (*1*).

The critical lane analysis provides a quick method for estimating lane requirements, especially where traffic signal timing is not provided. It is based on lane configurations and use, traffic signal phasing, and the volumes of through and turning traffic. The critical volumes represent the largest per lane volumes of conflicting flows during each signal phase. The sum of these volumes is then compared to specified values to determine intersection performance.

A maximum of 1,800 passenger vehicles can cross a conflict point during an hour, assuming a 2-sec headway and no lost time per cycle. In reality, there is some lost time for each phase resulting in maximum critical conflict volumes ranging up to 1,650 vph depending on the cycle length and the number of phases. A further deduction is often necessary because the signal timing may not allocate time to each phase in precise proportions to individual demand volumes.

The capacity of a traffic lane at a signalized intersection can be estimated from the following formula:

$$c = (g/C)s \qquad (1)$$

where: c = capacity, vph; g = effective green time, sec (usually 3 to 5 sec less than actual green time); C = cycle length, sec; and s = saturation flow, vehicles per hour per lane.

When traffic composition and the effects of right-turning vehicles are considered, a realistic saturation flow rate in suburban areas is 1,600 to 1,650 vplph of green time. This value assumes that left-turning vehicles have their own exclusive lane. When left turners share lanes with through vehicles, capacities are considerably reduced and computational procedures become more complex.

A maximum volume-to-capacity ratio of 0.85 is suggested as the upper limit of system adequacy. This represents the approximate mid-point of level-of-service "D" operation. (Standards for capacity and levels of service are often set by local planning and highway agencies and specified in ordinances.)

Access Restrictions

Driveway access restrictions may be required for certain access levels or road types. A review of the number and location of access drives may also indicate that some access restrictions are required. Safety considerations associated with intersecting traffic volumes or visibility are the primary reasons. However, for large developments, capacity and delay considerations may also require access restrictions. Once the restrictions have been identified, designs can be implemented to produce the desired restriction.

The most common restrictions involve prohibiting the left-turning inbound or outbound maneuvers. Physical barriers are the most effective, with signage used as a less often heeded method of producing a restriction. These restrictions usually require a median barrier on the public highway.

Figure 9-3 illustrates the method of restricting a driveway to right turns in and out by use of a triangle island instead of a barrier median on the highway. Figure 9-4 illustrates prohibitions of left turns, both in and out, by a barrier median between directional traffic lanes. The barrier median provides more positive control than the island, especially on roadways four or more lanes wide.

Figure 9-5 illustrates a driveway design that prohibits the left-turn outbound maneuver. Both right turns and the inbound left-turn maneuvers are permitted.

Figure 9-6 illustrates a directional design that separates left-turn entry and exit movements. The prohibition of left turns at one of the intersections aids in improving the efficiency of two-way traffic progression where signals are provided. It also allows two-phase signal operations at each driveway point.

9.3 DRIVEWAY DESIGN

Driveways vary widely in their design requirements. A driveway leading to a single residence is usually a simple curb cut that is limited in size. Conversely, a driveway leading to a major

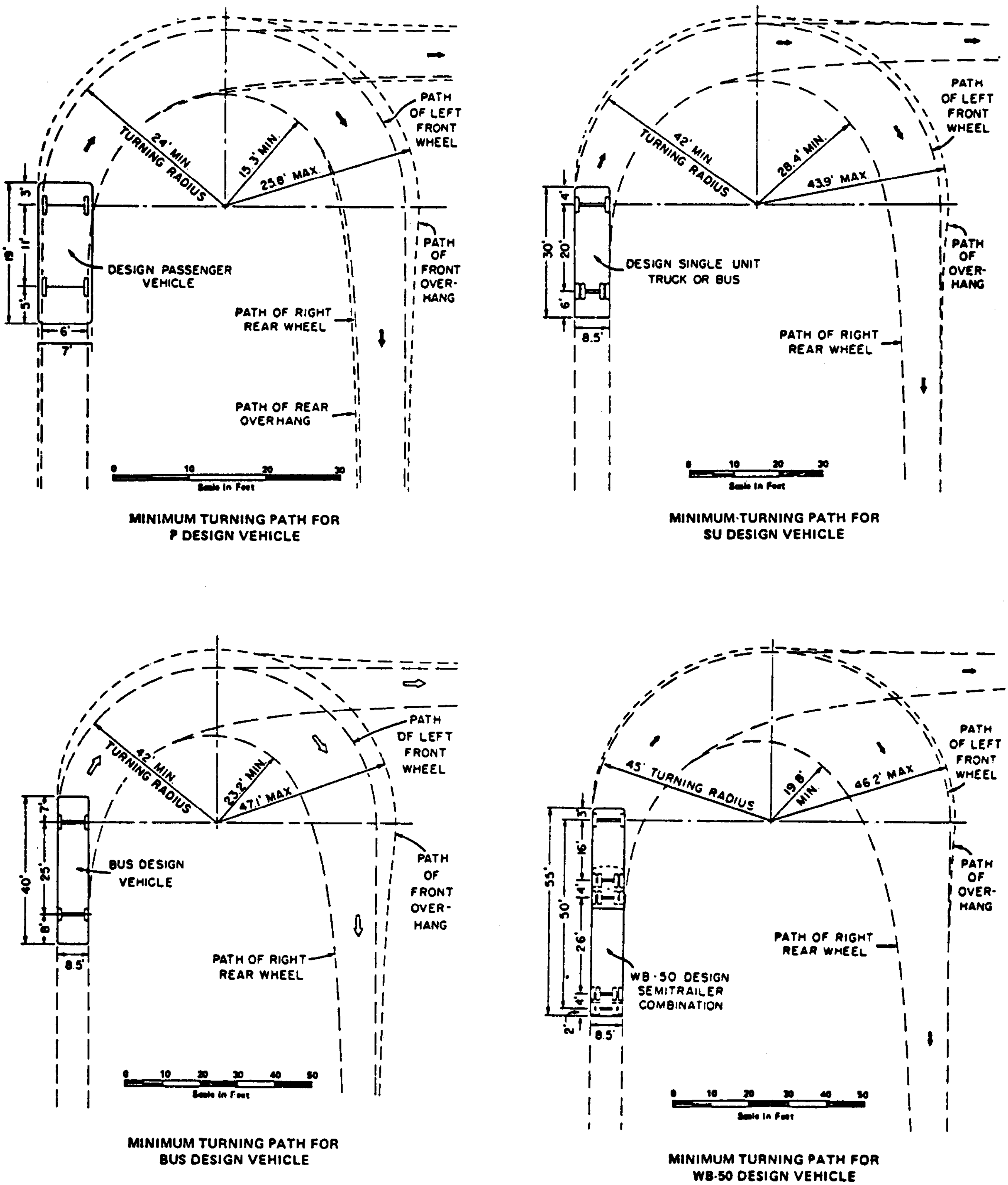


Figure 9-2. Minimum turning path for design vehicles. (Source: A Policy on Geometric Design of Highways and Streets, AASHTO, 1990)

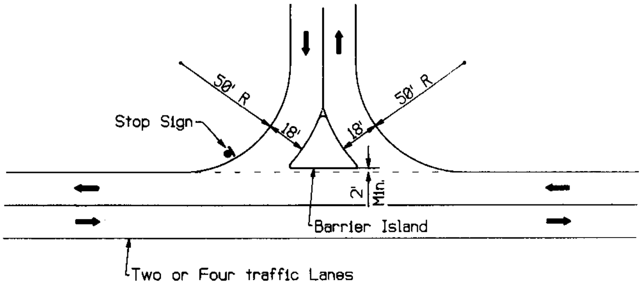


Figure 9-3. Left-turn restrictions—undivided roadway.

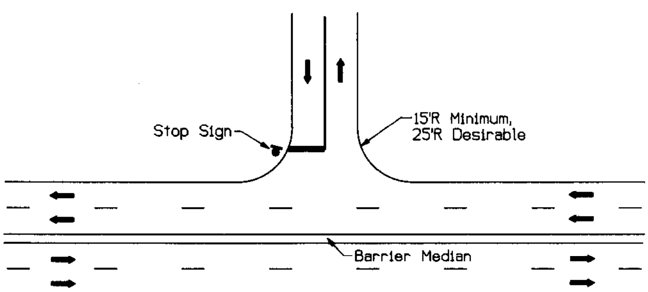


Figure 9-4. Left-turn restrictions—divided roadway.

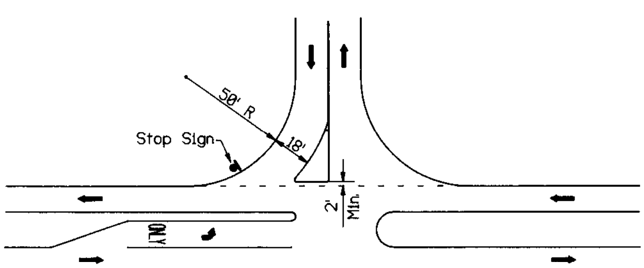


Figure 9-5. Right turn in and out—left turn in.

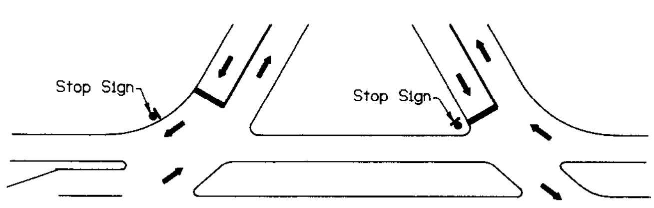


Figure 9-6. Separate directional access.

activity center, a shopping center, or a corporate office park is really an arterial street and must be designed as such.

Driveway design is an important aspect of intersection design. Accordingly, the principles underlying intersection channelization and signalization equally apply to access drives. Signals, however, should be installed only where they meet two basic criteria: (1) the signalization must meet the bandwidth and spacing requirements for the arterial access category (access level), thereby protecting the integrity of arterial flow; and (2) the signals must meet the warrants set forth in the *Manual of Uniform Traffic Control Devices* (*2*).

Driveway Spacing

Driveway spacing should conform to the guidelines set forth in Chapter 7. These guidelines key spacing to access category (level), operating speed, and size of traffic generator. A minimum spacing of 24 ft should be adopted for single family residences, where they are exempt from access spacing requirements.

Driveways serving major activity centers should be subject to a further requirement. They should be set back from nearby signalized intersections beyond the normal queuing distances during peak periods. The approximate length of queues (with about 95 percent certainty) can be estimated as follows:

$$L = 2\,qr(1 + p)25 \qquad (2)$$

where: L = length of queue, feet per lane; q = flow rate, average vehicles per lane per second; r = effective red time (red and yellow); and p = proportion of trucks. The 25 is the effective length of a passenger car and the 2 is a random arrival factor.

This formula provides a good estimate of queue lengths, where the volume to capacity (v/c) ratio is less than 0.85 or 0.90. However, for v/c ratios greater than 0.90, some overflow queues could occur as a result of fluctuations in arrival rates. To compensate for this condition, it is suggested that one vehicle be added for each percent increase in the v/c ratio of 0.90. Accordingly, in cases where the v/c ratio ranges from 0.90 to 1.00, the following formula applies:

$$L = [2qr + \Delta x]\,[1 + p]\,[25] \qquad (3)$$

where $\Delta x = 100[v/c \text{ ratio} - 0.90]$. Thus, for a v/c ratio of 0.95, Δx would be 5 vehicles in the above formula.

Driveway Geometry

Driveway widths, turning radii, and storage requirements are determined by the number and use of lanes on the driveway, the frequencies of projected use for the location, and the operating speed limit of the roadway being accessed. Through volumes on the public street also should be taken into consideration. The width of driveways should permit vehicles to enter and exit with a minimum of interference to through traffic. Driveway widths and flare or curb radii will be based primarily on the speeds of traffic on the highway and the volume and types of vehicles using the access facilities. The effective width will also vary with the angle of the driveway. The width should be restrictive enough to discourage maneuvers that would cause conflicts. On the other hand, driveways must be wide enough so that vehicular conflicts do not occur in the driveway or on the highway. Figure 9-7 indicates the trajectory of the right front wheel of passenger cars making a right turn into a driveway having a 10-ft curb return radius and a 30-ft width.

If a vehicle is stopped in the driveway while waiting for a gap in traffic on the roadway, it will minimize the dispersement of the trajectory. At driveways with a curb return radius of less than 10 ft, drivers tend to make a wider turn using the roadway and the available throat width to compensate for the smaller radius.

The width of a driveway is measured at right angles to the centerline of the driveway and is exclusive of the flare or curb radius. The width is considered edge to edge of pavement, except where a monolithic curb, combination curb and gutter, or concrete curb is used, in which case the width will be measured from face to face of curbs. Curb return radii are established by the speed of through traffic, volume, and type of traffic accessing the driveway and frequency of occurrence. The operational efficiency of a driveway can be greatly enhanced by coordinating a driveway's geometric layout with the turning limitations of a critical design vehicle. Ideally, a vehicle should be able to turn into or out of a driveway at a reasonable speed without encroaching upon neighboring lanes. Table 9-1 gives minimum combinations of driveway entry widths and curb return radii for typical design vehicles.

A one-way driveway or a driveway separated by a median should provide at least the minimum entry width at the throat of each approach. If the environment will permit an occasional turning vehicle's encroachment into adjacent driveway lanes, the overall width may be reduced to as low as the minimum entry width.

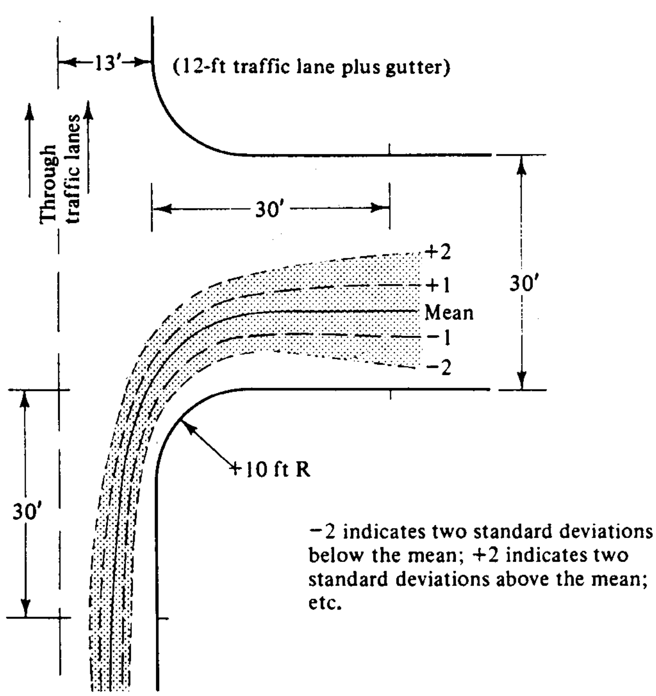


Figure 9-7. Path of right front wheel. (Source: Vergil G. Stover, "Guidelines for Spacing of Unsignalized Access to Urban Arterial Streets," Technical Bulletin No. 81-1, Texas Engineering Experiment Station, January 1981)

Table 9-1. Entry widths (feet).

CURB RADIUS (Feet)	*MINIMUM ENTRY WIDTHS FOR: P Passenger Car	SU Single Unit Truck or Bus	WB-50 Semi-Trailer Truck
5 **	16		
10	14	34	
15	14	30	
20		26	
25		22	34
30		18	30
35		16	26
40			22
45			18
50			16

* Valid for 90 degree forward entries only
** For use on low volume, local streets only

Entry Width. The entry width is the approximate width needed at the driveway throat to accommodate the swept path of the turning design vehicle. The entry widths given in Table 9-1 represent the minimums developed from design vehicles turning into a driveway from the right-most lane. The entry width will differ from the designed driveway's overall width, depending on how the driveway is expected to operate. The large entry widths associated with small radii should be considered in developing access driveway designs.

Driveway Width. All noncommercial driveways should normally have a width between 14 ft and 24 ft when the single unit (SU) vehicle volume does not exceed five vehicles in the design hour. The usable width may be increased by permissible radii to allow for smooth ingress and egress at the highway connection. Where a driveway is to be used by larger vehicles (farm equipment or trucks) at least a 20-ft width should be provided and entrances up to 30 ft wide may be permitted. Access may also be provided for common residential entrances to serve adjacent properties. These entrances should be centered on the property line and should not exceed the 24-ft maximum width.

Commercial driveway cross sections may vary from a minimum one-way in or one-way out drive 14 ft to 16 ft wide to a maximum of two inbound and three outbound lanes (each at least 11 ft wide). Where more than one inbound and outbound lane is provided, a median divider is generally desirable. This median should be at least 4 ft wide; however, widths of 10 ft to 16 ft are preferable because they improve driver maneuvering and provide opportunities for landscaping. Median widths exceeding 16 ft are generally undesirable because they create turning problems and expand the intersection.

Driveways that enter the public roadway at traffic signals should have at least two outbound lanes—one for right turns and one for left turns (22-ft minimum width) and one inbound lane (14-ft minimum width). Dual left-turn lanes into driveways and dual right-turn lanes onto public streets should be used only with traffic signal control.

Turning Radius. The preferred turning radii will depend on the type of vehicles to be accommodated, the number of pedestrians crossing the access road, and the operating speeds of the accessed roadway.

A minimum 15-ft turning radius should be provided in areas of heavy pedestrian traffic such as business districts, medical centers, and school crossings. Tighter radii (i.e., 10 ft) should only be used for serving residential drives from low-speed roadways.

A 25-ft radius is generally adequate in urban environments, although a 35-ft radius may be desirable to accommodate turning buses and single unit trucks. In most suburban settings, 25-ft to 50-ft radii are desirable. However, a 75-ft radius is desirable where turning islands or dual turning lanes are provided.

The use of large turning radii should take the increased pedestrian crossing distances into account. Pedestrians crossing a 35-ft driveway with two 50-ft radii would have to cross an opening that is over 100 ft wide. Correcting this problem would require either reducing the turning radii or introducing a pedestrian refuge island in the access drive. Larger radii may also increase exit speeds, thereby decreasing pedestrian safety across the driveways.

Guidelines. Table 9-2 presents a summary of Florida's recommended design requirements for roadway connections to various traffic generations. These representative guidelines show how connection widths, radii, driveway angles, edge clearances, and islands vary by type of generator and for urban and rural roadways.

Practical Design Considerations. For practical design, one should provide longer curb radii in situations where vehicles are exiting from higher speed facilities or when a high volume of driveway traffic is expected. This is often accomplished when designing for the critical vehicle. For example, the majority of traffic entering a commercial facility is often a passenger-type vehicle. However, by designing the commercial driveway for the occasional delivery truck or bus, one has accommodated their unrestricted entry and thereby allowed for the higher speed entry of passenger vehicles.

Justification for a width reduction is sometimes warranted for driveways abutting local streets or very low volume collector streets, where vehicles can unobstructively encroach into adjacent street lanes to enter a property. However, when driveways are located on busy arterial or collector streets, it is not practical to expect large vehicles to encroach upon neighboring lanes to enter a property. Therefore, driveways on such streets should be designed to ideal standards—to allow a design vehicle to turn into the property from the rightmost lane.

For properties expecting moderate volumes of large truck traffic, it is desirable to provide one well-designed service or truck driveway to accommodate such vehicles, allowing only passenger-type vehicles to use other appropriately designed driveways within the development. At service vehicle driveways, the most efficient design for a large vehicle's turning transition can be made by constructing a curb return with a series of compound curves or by using a simple curb radius with transitioning tapers. AASHTO's *A Policy on Geometric Design of Streets and Highways,* 1990, outlines procedures for such designs.

Driveway Storage. Adequate driveway storage space or "throat length" is necessary to (1) enable vehicles entering signalized intersections to enter at minimum headways; (2) allow for overlapping weaving movements on approach to signals; and (3) prevent spillback onto either the public roadway or the activity center's internal road system. Table 9-3 gives storage requirements for various activity centers based on application of the

Table 9-2. Summary of roadway connection design requirements—Florida. (Source: *Design Review Procedures for Access Management,* Florida Department of Maintenance, June 1990)

ELEMENT DESCRIPTION	Category I (Minimum)		Category II (Minor - Up to 1500 VPD)				Category III (Major - Over 1500 VPD)			
	URBAN SECTION	RURAL SECTION	URBAN SECTION		RURAL SECTION		URBAN SECTION		RURAL SECTION	
			1-way	2-way	1-way	2-way	1-way	2-way	1-way	2-way
CONNECTION WIDTH (W)	12' Min. 24' Max.		16' Min. 24' Max.	25' Min. 36' Max.	16' Min. 24' Max.	24' Min. 36' Max.	16' Min. 24' Max.	24' Min. 36' Max.	16' Min. 24' Max.	24' Min. 36' Max.
FLAIR (Drop Curb. Turnout Radii or Radial Curb Returns)	Drop Curb 10' Min.	Turnout Radius 15' Min 25' Std.	Drop Curb 10' Min.		Turnout Radius 25' Min. 50' Std.		Curb Return Radius 25' Min. 50' Std.		Turnout Radius 25' Min. 50' Std. (or 3-Centered Curves)	
ANGLE OF DRIVE (Y)	--	--	45°-90°	60°-90°	45°-90°	60°-90°	45°-90°	60°-90°	45°-90°	60°-90°
EDGE CLEARANCE* (E)	3' Min.	0' Min.	3' Min.		0' Min.		10' Min.		10' Min.	
ISLAND	--	--	4'-22' Wide Median		4'-22' Wide Median		4'-22' Wide Median		4'-22' Wide Median	

* EDGE CLEARANCE NOT APPLIED WHERE THERE IS JOINT DRIVEWAY USE.

Table 9-3. Suggested on-site throat length (feet).

LAND USE	SIZE	TYPE OF ROAD	
		ARTERIAL[1] Access Levels 3, 4, 5, 6	COLLECTOR[2] Access Level 7
Light Industry	100,000 sq. ft. 300,000 sq. ft. 500,000 sq. ft.	100 250[3] 400[4]	75 200[3] 300[4]
Discount Store	30,000 sq. ft. 100,000 sq. ft.	100 250[3]	75 200[3]
Supermarket	20,000 sq. ft. 50,000 sq. ft.	75 200[3]	75 150[3]
Shopping Centers	≤100,000 sq. ft. 300,000 sq. ft. 500,000 sq. ft. ≥700,000 sq. ft.	150[3] 300[4] 400[4] 500[4]	150 250[4] 350[4] 450[4]
Quality Restaurant	15,000 sq. ft. 30,000 sq. ft.	50 75	50 50
Drive-In Restaurant	2,000 sq. ft. 4,000 sq. ft.	50 75	50 50
Office Building	100,000 sq. ft. 300,000 sq. ft. 500,000 sq. ft. 700,000 sq. ft.	150[3] 300[4] 400[4] 500[4]	100 250[4] 350[4] 450[4]
Motel	150 Rooms	75	50
Apartment	100 Units 200 Units	50 75	25 50

NOTES: Throat lengths are shown for a single lane based on applying ITE trip generation rates to the formula $N=2qr$, where q = vehicles per lane per second and r = effective red time in seconds.

[1] Assumes 60 second red cycle (90 second cycle)

[2] Assumes 50 second red cycle (90 second cycle)

[3] Requires multiple lanes or access points.

[4] Requires multiple lanes and access points.

Table 9-4. Alternative guidelines for on-site driveway vehicle storage lengths. (Adapted from: DeLeuw Cather & Company in association with Barton-Aschman Associates, Inc., et al., May 1982; Dallas Thoroughfare Plan Update, City of Dallas, Subtask 1-6, Technical Memorandum *Access Control Policy;* Crommelin, Robert W., *Entrance-Exit Design and Criteria for Major Parking Facilities,* Seminar 72—Los Angeles Parking Association, Los Angeles, California)

PARKING SPACES PER EXIT LANE	STORAGE LENGTH REQUIRED Measured In Feet From Property Line			
	Multi-Family Residential	Retail	Office	Industrial
0 - 200	25	25	25	50
201 - 400	25	50	100	150
401 - 600	50	150	200	more lanes
601 - 700	100	200	more lanes	more lanes
>700	200	more lanes	more lanes	more lanes

$N = 2qr$ length of queue formula, and assuming a single driveway access lane. (The multiplier 2 reflects the effect of factors such as random arrivals.) Obviously, for larger traffic generators, multiple lanes and multiple access points are required.

Table 9-4 gives an alternative set of storage requirements based on the parking spaces per exit lane for various types of land uses.

A review of these tables suggests the following general guidelines: (1) Storage distances of at least 50 ft should be provided for "minor driveways" serving developments such as 50 to 100 apartments, retail space under 50,000 sq ft, or a small quality restaurant. (2) Storage distances of at least 150 ft with at least two exit lanes should be provided for shopping centers under 700,000 sq ft and for office complexes up to 500,000 sq ft. Storage distances of greater than 200 ft with at least two exit lanes should be provided for major multi-use activity centers, major regional shopping centers over 700,000 sq ft, and major office complexes over 500,000 sq ft.

Ideally, traffic volumes should be assigned to applicable lanes, and the highest lane volumes should govern storage requirements. Underestimating the demands may have a more negative effect on operations than overestimating the length. Storage requirements should be based on the peak highway traffic hours, or the peak hour of the generator, whichever is larger.

Driveway Profiles

The slope of a driveway can dramatically influence its operations. Usage by large vehicles can have a tremendous effect on operations if slopes are severe. The profile, or grade, of a driveway should be carefully designed to provide a comfortable and safe transition for those using the facility, and to accommodate the storm water drainage system of the roadway.

Limitations of driveway grades are imposed to ensure adequate draining of the roadway, and to accommodate mobility constraints of pedestrians and vehicles using the driveway. Figure 9-8 illustrates the treatment of driveway grades.

Initial Grade. The grade of the initial section of driveway (identified as G_1 in Figure 9-8) is controlled by speed limitations.

The minimum initial grade (G_1) for this section must be sufficient to bring the finished grade elevation of the driveway to at least 2 in. above the elevation of the top of curb. This will ensure that the roadway will drain properly. As an example of a desirable design for a typical driveway, a grade of 5 percent for G_1 will bring the finished grade of the driveway to the required minimum at approximately 14 ft from the curb line.

The maximum initial grade for G_1 is predicated upon limits providing for barrier-free sidewalk construction; the maximum grade allowable is 8 percent. Grades of 1 percent to 3 percent are preferable for major drives and 3 percent to 6 percent for minor drives.

Grades Beyond the Property Line. Figure 9-8 and Table 9-5 show the grade requirements for the section of driveway beyond the property line (G_2). The absolute minimum grade should be at least 0.5 percent for low volume driveways and a desirable minimum should be 1 percent for all driveways. The maximum grades should not exceed 8 percent to 14 percent for low volume driveways and 5 percent for high volume driveways.

At least 25 ft of consistent grade (G_2) should be profiled beyond the right-of-way line to ensure adequate replacement design. Such a grade is governed by the limitations given in Table 9-5. A further limitation on this grade specifies that the maximum change in grade without using a vertical curve in any 10 ft of distance is 12 percent. Therefore, the difference in grading, $G_1 - G_2$ must be between ± 12 percent for any design using only vertical tangent sections.

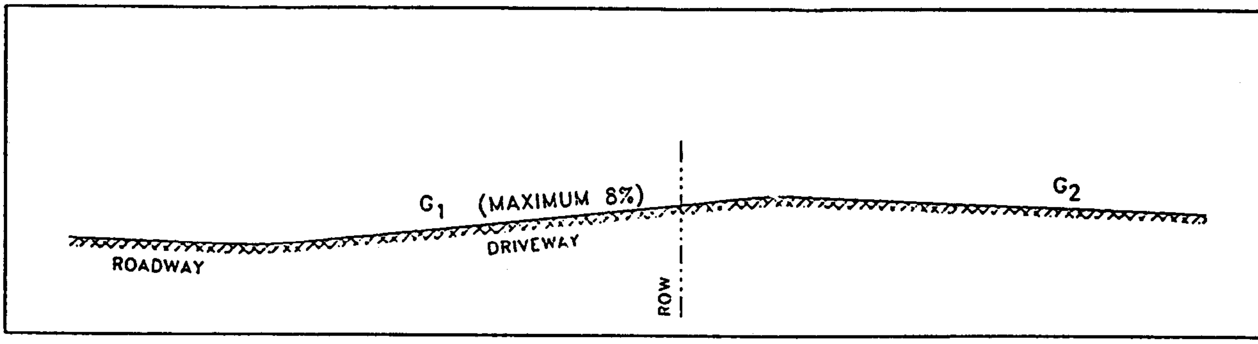


Figure 9-8. Driveway profile.

Failure to provide a longitudinal grade as well as a minimum cross slope (crown) of 1.5 percent to the driveway will move water, ice, and for nonpaved driveways, rock, dirt, and mud onto the travel way causing maintenance and safety problems.

Bituminous concrete or portland cement concrete paving should extend a minimum of 2 ft, desirably 10 ft, from the roadway edge to protect the integrity of the roadway pavement and substructure. Paving for 10 to 20 ft would reduce the tracking of mud onto the roadway.

Sight Distance

It is essential to provide sufficient sight distance for vehicles using a driveway. They should be able to enter and leave the property safely with respect to vehicles on the driveway and vehicles of the intersection roadway.

Intersection sight distance varies, depending on the design speed of the roadway to be entered, and assumes a passenger car can turn right or left into a two-lane highway and attain 85 percent of the design speed without being overtaken by an approaching vehicle that reduces speed to 85 percent of the design speed. Table 9-6 gives intersection sight distance requirements for passenger cars. Sight distances should be adjusted with cross-road grade in accordance with AASHTO policies.

In many conditions, however, variations in the vertical and horizontal alignment of the adjoining street or limited building setback lines may create situations where the sight distances given in Table 9-6 cannot be provided. Consequently, a minimum distance must be provided such that vehicles traveling on the through street can perceive, react, and stop for any potential conflict within the driveway's intersection. This minimum measure is defined by the safe stopping sight distance.

It is essential to check for stopping sight distance in cases where potential visual obstructions occur in combination with horizontal or vertical curves. Figure 9-9 shows an example where minimum stopping sight distance is not provided from either direction as a result of poor design.

To prevent hazardous situations such as this from occurring, it is necessary to check for the provision of minimum sight distance either by visually inspecting the location or by examining the site plans for potential problems. Table 9-7 provides safe stopping sight distances for various speeds and grades. A simple method of providing for such visibility is to provide an unobstructed path of sight within sight distance triangles as shown in Figure 9-10.

Table 9-5. Driveway profile standards for grades.

	Maximum Range for G_2
Low Volume Driveway* on Local Street	-8% to 14%
Low Volume Driveway* on Collector Street	- 4% to 8%
Low Volume Driveway* on Arterial Street	- 1% to 5%
High Volume Driveway** on Any Street	- 1% to 5%

* **Low Volume Driveway** -- defined as a driveway with less than 100 vehicles in the peak hour in the peak direction.

** **High Volume Driveway** -- defined as a driveway with more than 100 vehicles in the peak hour in the peak direction.

Maximum Allowable Change in Grade: G_1-G_2 = 12% for any 10 feet of distance without a vertical curve

Table 9-6. Interchange sight distance requirements for highway access. (Source: American Association of State Highway and Transportation Officials, *A Policy on Geometric Design for Highways and Streets,* 1990, Figure IX-40)

Posted Speed Limit (mph)	Distance Required (feet)
30	380
35	470
40	580
45	710
50	840
55	990

NOTES: 1. Driver's eye height shall be 3.5 feet above pavement edge.
2. Driver's eye shall be 17 feet from pavement edge.
3. Object height (approaching vehicle) shall be 4.25 feet above center of traffic lane.

The sight distance triangle can be defined by connecting a point that is along the driveway's edge of pavement or curb line and 17 ft from the edge of pavement of the roadway, with a point that is distance, *L*, along the roadway's edge of pavement. The area bounded by the above-defined triangle must be free from any visual obstruction between the heights of 2 and 8 ft above the curb line elevation; this includes parked vehicles, signs, fences, and landscaping. Table 9-8 provides clear area distances necessary to provide sufficient intersection sight distance.

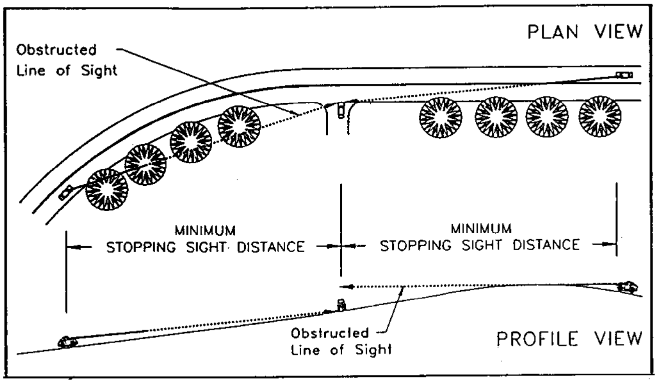


Figure 9-9. Sight distance example.

Table 9-8. Intersection sight distance triangle.

POSTED SPEED (mph)	Ll (ft.)	Lr2 (ft.)	Lr4 (ft.)
30	270	190	140
35	340	230	165
40	430	280	210
45	540	340	250
50	650	400	300
55	760	460	350

NOTE: Assumes 12 foot wide traffic lanes.
Ll = Clear distance to the left.
Lr2 = Clear distance to the right - 2-lane roadway.
Lr4 = Clear distance to the right - 4-lane roadway.

9.4 SEPARATE TURNING LANES

It may be necessary to construct turning lanes for right or left turns into an access drive for safety or capacity reasons where highway speeds or traffic volumes are high or if there are substantial turning volumes. The purpose of a separate turning lane is to expedite the movement of through traffic, increase intersection capacity, permit the controlled movement of turning traffic, and promote the safety of all traffic. This is accomplished by providing lanes that remove turning vehicles from the through-travel lanes.

The provision of left-turn lanes is essential from both capacity and safety standpoints where left turns would otherwise share the use of a through lane. Shared use of a through lane will dramatically reduce capacity, especially when opposing traffic is heavy. One left turn per signal cycle delays 40 percent of the through vehicles in the shared lane; two turns per cycle delays 60 percent (*3*). Rear-end accidents can be severe on shared lanes.

Right-turn lanes remove the speed differences in the main travel lanes, thereby reducing the frequency and severity of rear-end collisions. They also increase capacity of signalized intersections and may allow more efficient traffic signal phasing.

Table 9-7. Standard stopping sight distances. (Source: American Association of State Highway and Transportation Officials, *A Policy on Geometric Design for Highways and Streets*, 1990)

OPERATING SPEED	Stopping Sight Distances (in feet)						
	STREET GRADE IN PERCENT						
	Upgrades			Level	Downgrades		
	9%	6%	3%	0%	-3%	-6%	-9%
25 mph	140	145	150	150	155	160	165
30 mph	180	190	200	200	210	220	230
35 mph	215	225	235	240	255	270	290
40 mph	270	280	290	300	320	340	370
45 mph		340	350	365	390	420	
50 mph		410	420	440	470	510	
55 mph		460	475	500	540	590	

NOTE: For speeds greater than 35 mph, an average distance between upper and lower operations limits has been used.

Warrants

Although turning lanes may be required for some or all access locations to major activity centers, they are not always required for smaller developments. Where there are three or more through lanes in the direction of travel, the requirements for a separate right-turn lane may be dropped. Whether or not a separate turning lane is required at a specific location should be determined by a traffic engineering study. Various guidelines and warrants are suggested to guide this decision.

Left-Turn Lanes—Signalized Intersections. The 1985 "Highway Capacity Manual" recommends that an exclusive left-turn lane be provided at signalized intersections under the following conditions. (1) Where fully protected left-turn phasing is to be provided, an exclusive left-turn lane should be provided. (2) Where space permits use of a left-turn lane, it should be considered where peak-hour left-turn volumes exceed 100 vph. Left-turn lanes may be provided for lower volumes as well, based on the judged need and state or local practice. (Colorado requires by regulation that all new access connections provide a left-turn lane where the peak-hour turn volume exceeds 12 vph.) (3) Where left-turn volumes exceed 300 vph, provision of a double left-turn lane should be considered. (These lanes are essential at access points to major generators to reduce signal time requirements and spillback onto main travel lanes.)

Left-turn lanes also should be provided when delay caused by left-turning vehicles blocking through vehicles would become a problem. When the sum of left-turn and opposing volumes results in unacceptable left-turn delay, the provision of a separate turn lane would not only increase intersection capacity, but would also increase vehicle safety. The provision of left-turn

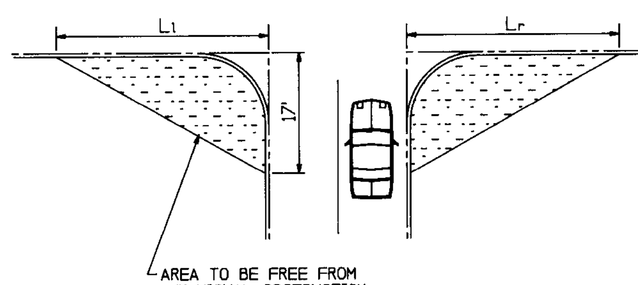


Figure 9-10. Visibility triangle for driveways.

lanes is also specified for certain access categories. In such cases, the lanes should be provided as a matter of policy. Table 9-9 can be used as an additional warrant for providing a separate left-turn lane.

Left-Turn Lanes—Unsignalized Intersection. Several studies have developed criteria for providing separate left-turn lanes at unsignalized intersections. Criteria include cases when the separate lane functions as a deceleration lane and when it becomes a storage lane. Figure 9-11 provides warrants for a left-turn lane, depending on the peak-hour volume on the intersection approach, the peak-hour volume of vehicles turning left, and the operating speed. In most cases, left-turn lanes should be provided where there are more than 12 left turns per peak hour.

Another study compares the percent of left-turning vehicles in the advancing volume against the opposing volume. Table 9-10 is a guide to traffic volumes where separate left-turn lanes should be considered.

Right-Turn Lanes. The 1985 "Highway Capacity Manual" suggests that a separate right-turn lane should be considered when the right-turn volume exceeds 300 vph and the adjacent through lanes also exceed 300 vph per lane. When calculating the adjacent through lane volume, it should be assumed that all through lanes have equal volumes.

The Colorado Department of Transportation recommends providing a separate right-turn deceleration lane, depending on the highway's single lane volume, the volume of right-turning vehicles, and the posted speed of the highway. Figure 9-12 indicates when a separate right-turn lane should be provided. When the design hour volume (DHV) of the single lane highway and the design hour volume of right turns intersect at a point on or above the curve for the posted speed, a separate right-turn lane is required.

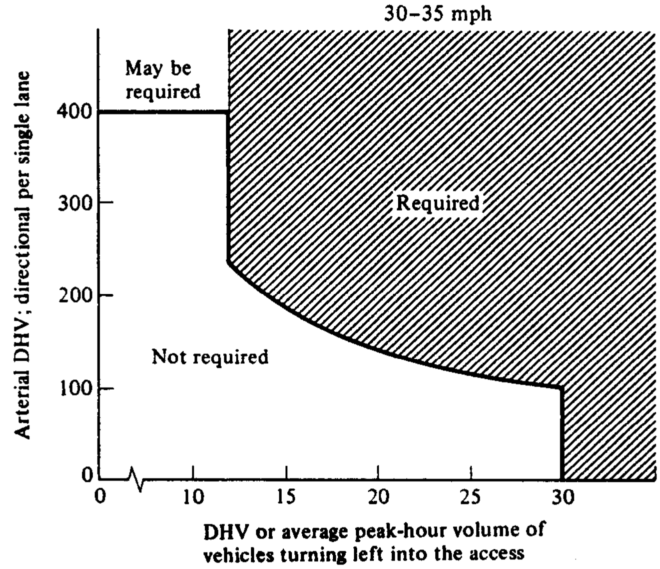
Table 9-9. Sum of left turn and opposing volumes during the peak hour necessary to create a left turn delay problem.* (Source: Kenneth R. Agent, "Warrants for Left Turn Lanes," *Transportation Quarterly,* Vol. 37, January 1983)

	Signalized Intersection (4-Lane Highway)		
	CYCLE SPLIT		
Cycle Length	70/30	60/40	50/50
120	950	800	600
90	1,000	850	700
60	1,150	1,000	850

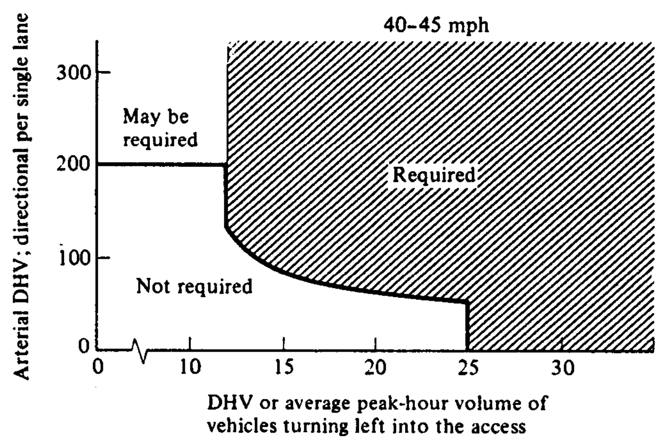
	Signalized Intersection (2-Lane Highway)		
	CYCLE SPLIT		
Cycle Length	70/30	60/40	50/50
120	650	550	400
90	700	600	500
60	750	650	550

	Non-Signalized Intersection	
Delay Criterion	4-Lane Highway	2-Lane Highway
30 Seconds	1,000	900
20 Seconds	900	800

* Assuming a minimum left turn volume such as 50 left turns in the peak hour.



30–35 MPH



40–45 MPH

Figure 9-11. Left-turn deceleration lane warrant.

Storage Lengths

The required length of vehicle storage for turning lanes depends on several factors. These include: (1) whether the lane is for left- or right-turning vehicles; (2) the type of traffic control, including the signal timing and cycle length; (3) the number of turning vehicles; and (4) the number of other vehicles on the approach.

Signalized Intersections. Where traffic is to be controlled by a traffic signal, the auxiliary lane ideally should be of sufficient length to (1) store turning vehicles or (2) clear the equivalent lane volume of all other traffic on the approach, whichever is the longest. An equivalent lane volume can be obtained by dividing the sum of other vehicles on the approach by the number of

Table 9-10. Guide for left turn lanes for 2-lane highways. (Source: American Association of State Highway and Transportation Officials, *A Policy on Geometric Design for Highways and Streets,* 1990)

Opposing Volume (Veh./Hr.)	Advancing Volume (vehicles per hour) 5% Left Turns	10% Left Turns	20% Left Turns	30% Left Turns
	40-mph Operating Speed			
800	330	240	180	160
600	410	305	225	200
400	510	380	275	245
200	640	470	350	305
100	720	515	390	340
	50-mph Operating Speed			
800	280	210	165	135
600	350	260	195	170
400	430	320	240	210
200	550	400	300	270
100	615	445	335	295
	60-mph Operating Speed			
800	230	170	125	115
600	290	210	160	140
400	365	270	200	175
200	450	330	250	215
100	505	370	275	240

available lanes. If separate turn lanes are to be provided, the turning volume is assigned to the separate lane and the remaining through or through and right- or left-turning volume is divided by the number of through lanes. This length is necessary to ensure that full use of the separate turn lane will be achieved and that the queue of other vehicles on the approach will not block vehicles from the turn lane.

1. The storage requirements for left-turn lanes should be based upon peak 15-min flow rates. The average number of left turns per cycle can then be multiplied by a factor to account for random variations in arrivals. The length of the lane can be estimated, based on the length of cars, the mix of cars, and other vehicles and arrival rate. This leads to the following formula.

$$L = VK\,25(1 + p)/N_c \qquad (4)$$

where: L = storage length, in feet; V = peak 15-min flow rate expressed in vehicles vph; K = constant to reflect random arrival of vehicles (usually 2); N_c = number of cycles per hour; p = percent of trucks or buses.

Where there are random variations in flow, a factor of 2 is normally applied to the left turns; this implies a failure rate of only 5 percent. However, where volumes increase toward saturation flow, or where movements are controlled by coordinated traffic signal systems, the random arrival factor can be decreased to 1.5.

Figure 9-13 provides a nomograph for the length of a left-turn storage lane at signalized intersections. The 95 percent probability of storing all vehicles uses a "K" value of 2 in the preceding formula. The 90 percent probability value uses a factor of 1.5.

As illustrated, with a left-turn volume of 240 vph, a 70-sec cycle and 10 percent trucks, a storage length of about 260 ft is required for desirable conditions and about 200 ft for a minimum. These storage lengths would accommodate 10 to 11 vehicles for the desirable conditions and about 8 for the minimum. The figure can be used to estimate the storage length (excluding taper) of a double left-turn bay by dividing by 1.8. Thus, for the desirable conditions, a double left-turn bay of about 145 ft (excluding taper) would be required.

2. The storage lengths for right-turn lanes can be obtained by using the "red time" formula. This formula determines the amount of storage space necessary to accommodate vehicles arriving at a signalized intersection during the red phase of the cycle. It is as follows:

$$\text{Storage Length} = \frac{(1 - G/C)\,(\text{volume})\,(1 + \%\ \text{trucks})\,(K)\,(25\ \text{ft/vehicle})}{(\#\ \text{cycles per hour})\,(\#\ \text{traffic lanes})} \qquad (5)$$

where: G = green time, C = cycle length, and K = random arrival factor. (Note that this formula is similar to Formula 3.)

A random arrival factor, K, of 2 should be used where right-turn-on-red is not permitted. Where right-turn-on-red is allowed, a factor of 1.5 could be used to determine the length of storage for right-turning vehicles.

The cycle length chosen to estimate the length of storage lanes should consider the possibility of longer cycle lengths in future years. Where the existing cycle length is less than 90 sec, storage requirements should be based on at least a 90-sec cycle. It is better practice, especially where space is not at a premium, to add an additional 50 to 100 ft to the design initially.

3. Storage lengths at unsignalized intersections can also be determined by considering the left turning volume and the opposing volume. Figure 9-14 gives guidelines for estimating lengths for various storage combinations of traffic volumes.

The nomograph (Figure 9-14) is used by reading horizontally from the opposing traffic volume, V_O, on the vertical axis and reading vertically from the left turn volume, V_L, on the horizontal axis and locating the minimum storage length, S, at the point where the horizontal and vertical lines cross. For example, 100 left-turning vehicles per hour, V_L, with an opposing through volume, V_O, of 950 vph, will require a minimum storage length of about 150 ft.

Total Length of Turn Lanes

A separate turning lane consists of a taper plus a full width auxiliary lane. The design of the turn lanes is based primarily on the speed at which drivers will turn into the lane, the speed to which drivers must reduce in order to turn into the driveway after traversing the deceleration lane, and the amount of vehicular storage that will be required. Other special considerations include the volume of trucks that will use the turning lane and the steepness of an ascending or descending grade.

Although vehicular storage is a principal factor used to establish the full length of the separate turn lane, it may not be the actual determining factor. At off-peak traffic periods on higher

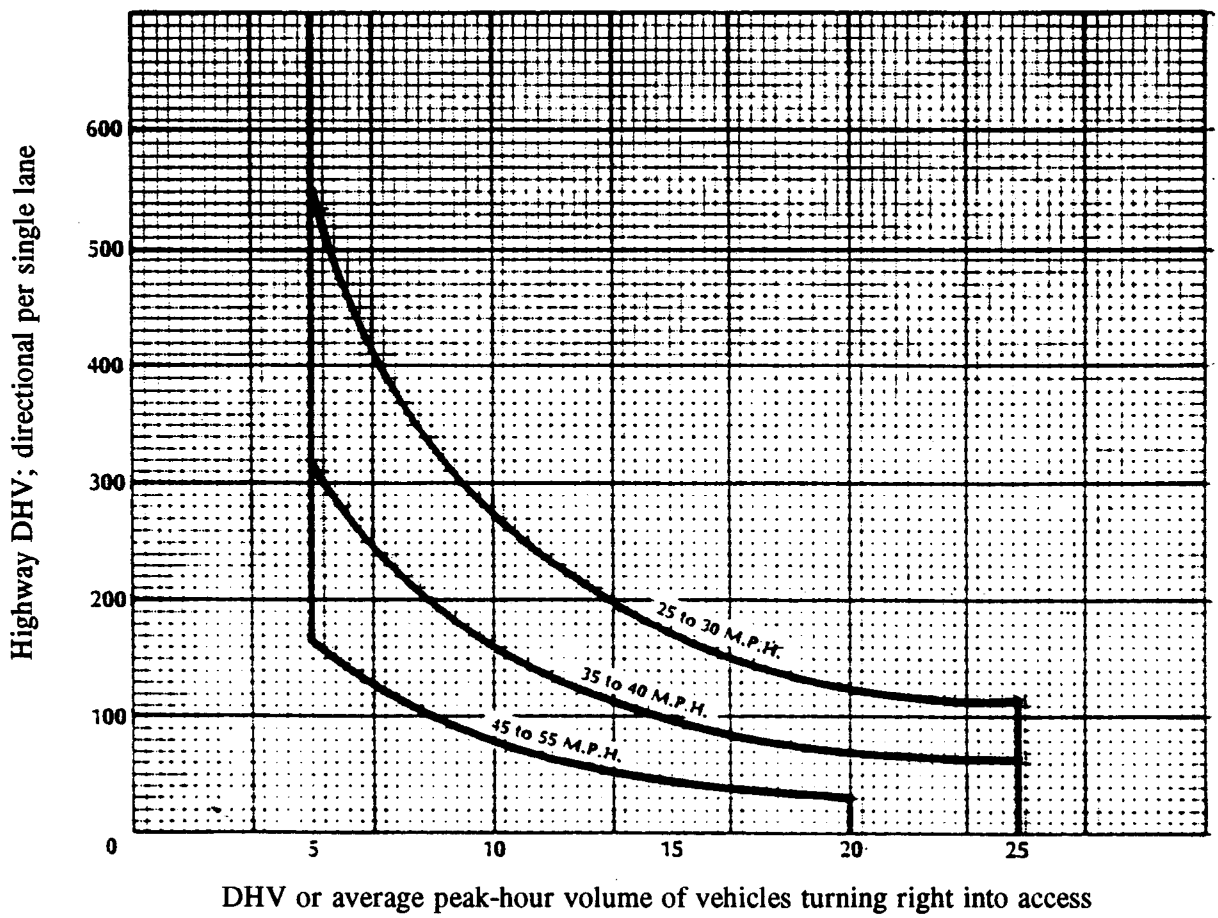


Figure 9-12. Right-turn lane warrant. (Source: Colorado Department of Transportation, State Highway Access Code, 1985)

speed roads, the lane will function as a deceleration lane.

The lengths required to come to a stop from either the design speed or an average running speed of a roadway are indicated in Table 9-11. The lengths assume the roadway is on a 2 percent or less vertical grade.

It is recommended that only the desirable length be used for left-turn lanes and that either the desirable or minimum length be used for right-turn lanes.

The total length of the separate turning lane and taper should be determined by either: (1) deceleration requirements, or (2) the combination of turn lane or through lane queue storage plus the distance necessary to maneuver or transition into the separate lane, whichever is the greatest. The minimum maneuver distance assumes that the driver is in the proper through lane and only needs to move laterally into the separate turn lane. The maneuver distance permits a turning vehicle to move laterally from the through lane while it is decelerating. Table 9-12 presents minimum maneuvering distances for various posted speed limits.

It is recommended that a 10:1 bay taper be used to provide a full width separate turning lane for all posted speed limits. If a two-lane turn lane is to be provided, it is recommended that a 7.5:1 bay taper be used to develop the dual lanes. The bay taper, which is shorter than currently being used for most roadways, will allow for additional storage during short duration surges in traffic volumes. The individual elements of separate turn lanes are shown in Figure 9-15.

It is sometimes necessary to transition through traffic lanes around left-turn lanes. In such cases, larger transition rates should be used. The transition rate for through traffic should be approximately equal to the operating speed, but never less than one in twenty. Thus, for a 40-mph operating speed and a 12-ft offset, the transition distance would be 12 × 40, or 480 ft.

Lane Width

The width of auxiliary lanes normally varies between 11 and 12 ft, with a minimum width of 10 ft. However, in low speed urban settings with restricted right-of-way, and where the lanes are only used by passenger cars, a 9-ft lane may be used.

Dual left-turn lanes, where provided, will normally require a minimum median width of 26 to 30 ft, with minimum lane widths of 11 ft. There should be 28 to 30 ft of road space available to receive the turning vehicles after they pass through the intersection.

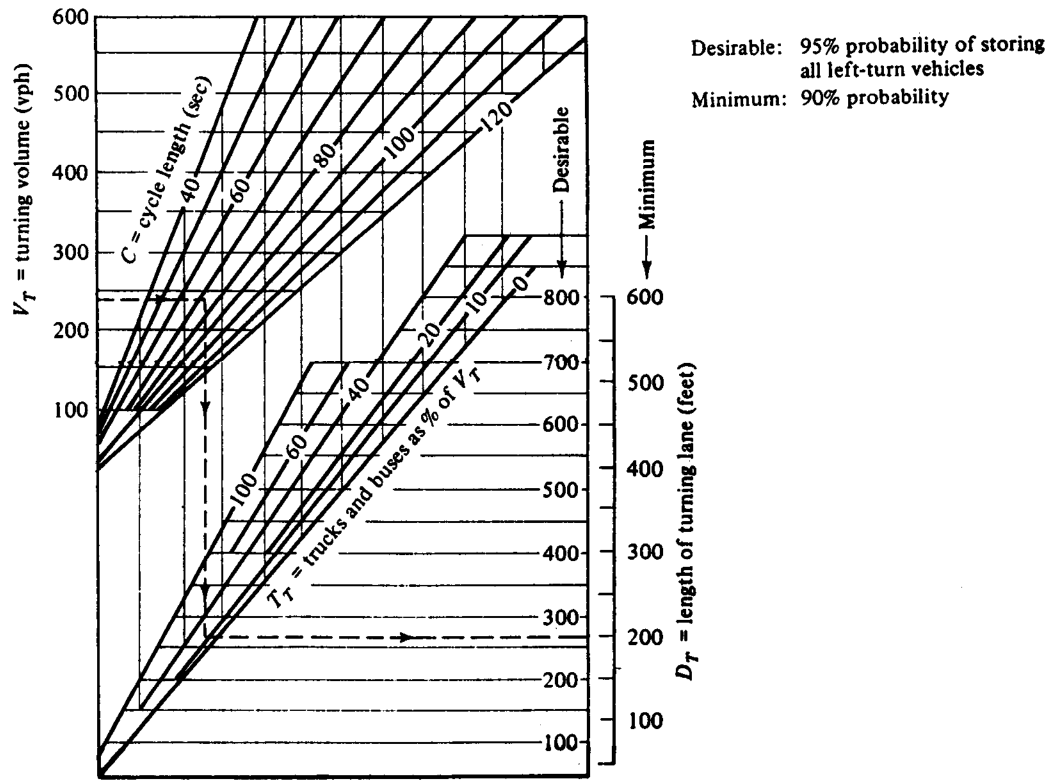


Figure 9-13. Single-lane left-turn storage at signalized intersections. (Source: Northwestern University Traffic Institute)

Design Details

A separate turn lane should be able to: (1) provide sufficient length to store turning vehicles during stop conditions; (2) provide sufficient length to permit turning vehicles to clear the queue of through vehicles and thereby enter the turn lane; (3) function as a deceleration lane during high-speed low-volume periods; (4) provide flexibility of design enabling the accommodation of peak traffic volume surges that, for short periods of time, exceed the design hour volumes; and (5) provide a lane-ending turn radius sufficiently long enough to accommodate the inside wheel turning path of the largest typical turning vehicle.

If the largest typical turning vehicle is normally a single-unit truck or possibly a fire engine, the turn radius need not be long enough to accommodate a WB-50 semi-trailer. However, the pavement area should have sufficient space to physically accommodate, with some lane encroachment, the large semi-trailer. The turning paths of all vehicles should be checked using the design vehicles indicated on Figure 9-2.

The following steps should be taken to ensure adequate design of a separate turn lane:

1. Determine turning vehicle storage length by: (a) using Formula 4 or Figure 9-13 for left turns and the "red time" Formula 5 for right turns if the intersection operates under control of traffic signals; and (b) using the nomograph shown in Figure 9-14 for unsignalized intersections.

2. Determine the probable queue length for all other vehicles on the intersection approach to a signalized intersection using the red time or queuing formula for an equivalent through lane volume (Formulas 1, 2, and 5).

3. Determine the length necessary to permit a turning vehicle to maneuver from the through traffic lane (see Table 9-12) into the turn lane plus the vehicle storage lengths (Step 1 above).

Table 9-11. Deceleration distances (feet). (Source: American Association of State Highway and Transportation Officials, *A Policy on Geometric Design for Highways and Streets,* 1990)

Design Speed (mph)	Deceleration Desirable(1)	Distance (feet) Minimum(2)
30	235	185
35	270	240
40	315	295
45	375	350
50	435	405
55	480	450

(1) Assumes stop condition
(2) Assumes 15 mph speed differential

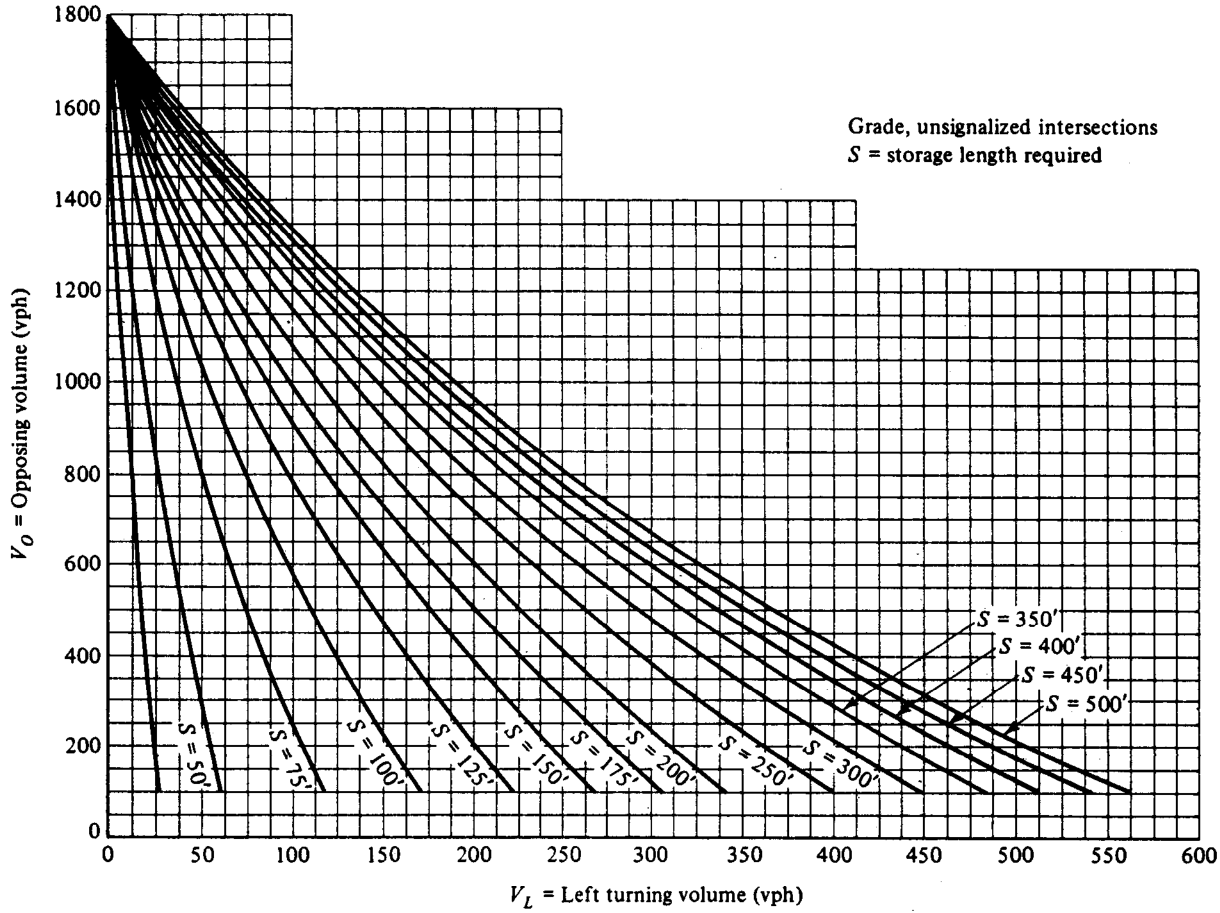


Figure 9-14. Left-turn storage at nonsignalized intersections. (Source: M.D. Harmelink, "Volume Warrants for Left-Turn Storage Lanes at Unsignalized Grade Intersection," Highway Research Record 211, 1967)

4. Determine the length necessary to decelerate from roadway design speed either to a full stop or to a 15-mph exit curve (see Table 9-11).

Whichever length or combination of lengths requires the greatest distance is the total length of turn lane that should be provided where conditions permit.

9.5 MEDIAN OPENINGS

Left-turn ingress or egress requires a median opening when traffic traveling in opposing directions is separated by a barrier median. Median widths commonly vary from 4 ft to over 30 ft. Widths ranging from 14 to 20 ft are desirable for providing separate left turn lanes.

Design elements include the median width, the spacing of median openings, and the geometrics of median noses at openings. The design of the median nose can vary from semicircular, usually for medians in the 4-ft to 10-ft range, to bullet nose design, for wider medians and for intersections that will accommodate semi-trailer trucks.

Table 9-12. Minimum maneuver distances. (Source: Adapted from V.G. Stover, Texas A & M University, College Station, TX, "Access Control Issues Related to Urban Arterial Intersection Design," unpublished paper)

SPEED (mph)	MINIMUM MANEUVER DISTANCE (feet)(1)
30	140
35	190
40	210
45	300
50	380
55	450

(1) Assumes a 4.5 fps^2 deceleration while moving laterally into turn bay at 3.0 fps^2 lateral shift and 9.0 fps^2 average deceleration thereafter.

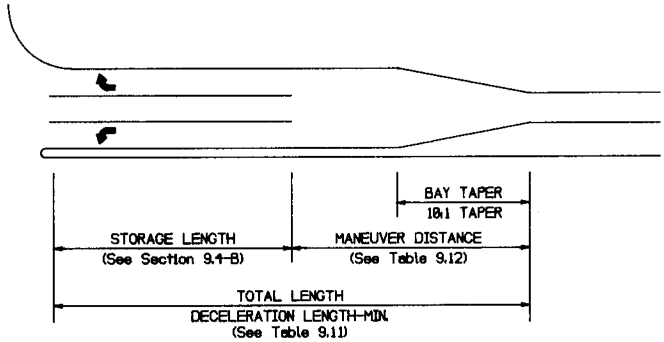


Figure 9-15. Separate turn lane.

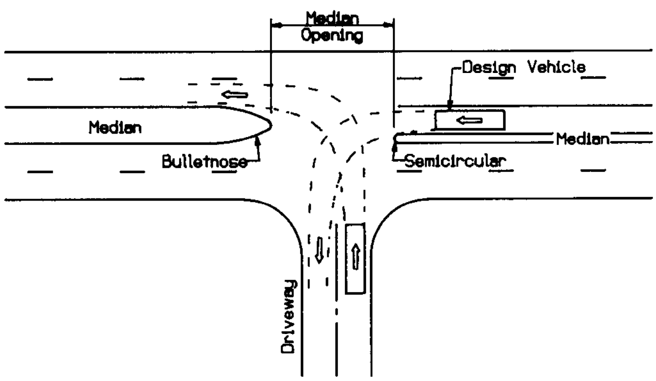


Figure 9-16. Minimum median openings.

The bullet nose is formed by two symmetrical portions of control radius arcs that are terminated by a median nose radius that is normally one-fifth the width of the median, i.e., a bullet nose design for a median opening in a 20-ft-wide median would have a small nose radius of 4 ft that could connect two 50-ft radii.

The large radii should closely fit the path of the inner rear wheel of the selected design vehicle. The advantages are that the driver of the left-turning vehicle, especially a truck, has a better guide for the maneuver. The median opening width can be kept to a minimum, and vehicle encroachment is minimized. Figure 9-16 indicates the various elements of median openings. Design control radii for various design vehicles are given in Table 9-13, and the minimum median opening for a single unit (SU) or WB-40 truck is given in Table 9-14.

9.6 APPLICATION OF CRITERIA

The design criteria provide guidelines for the design of new access and the retrofit of existing access points. The "retrofit" of existing access points is often limited by physical or fiscal constraints. Thus, minimum rather than desirable standards are commonly applied. The problem exists, and the public agency must address the restraints in the most cost-effective manner, and get the most safety and capacity benefits from its investment.

The design of new access is quite different. Here, the new access can create problems where none previously existed. Problem avoidance is best realized by applying desirable rather than minimum standards, both with regard to the provision (or denial) of access and the arrangement and design of the access itself. This is the challenge of modern access management.

Table 9-13. Median openings design controls.

CONTROL RADIUS (feet)	DESIGN VEHICLES ACCOMMODATED	
	Predominant	Occasional
40	P	SU
50	SU	WB-40
75	WB-40	WB-50

Table 9-14. Minimum median opening (feet).

MEDIAN WIDTH - ft.	SEMICIRCULAR	BULLET NOSE
4	96	96
12	88	58
18	82	47
20	80	44
30	70	40 minimum
40	60	40 minimum
50	50	
60	40 minimum	

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CHAPTER **10**

IMPLICATIONS AND DIRECTIONS

In Brief Access management extends the principle of access control to all types of streets and highways. Its goals are to preserve roadway capacity, safety, and level of traffic service while simultaneously providing access to activity centers. Programs are implemented through access management codes that include: (1) access control and spacing criteria, (2) design standards, and (3) traffic permit procedures and requirements. Land use controls and zoning ordinances are essential complements in the attempt to coordinate transportation and land development.

10.1 PROGRAM IMPLICATIONS

Several states have formalized their access management programs into codes, based on the states' police powers. Their experience indicates that the codes are upheld by the courts and they produce benefits in capacity and safety. However, their implementation can be time consuming.

Developing and adopting an access code can be a difficult task. It requires a reasonable set of policies and proposals, concerted actions by the implementing transportation agency, continued support of the top transportation officials, sustained dialogue with the development community, and substantial lead time. New Jersey, for example, has spent 3 years in moving its access management proposals from concept to acceptances.

The technical provisions that underline code and program development are straightforward. However, what appears to be lacking is a realization by many transportation agencies, of the need for, the opportunities for, and the benefits of creative approaches to protecting and enhancing their investments in streets and roads. Adopting codes in advance of major development pressures would provide the prerequisite transportation framework for future growth.

Developers and administrators of large activity centers appear receptive to the concept of access management, especially where the provision of access is enhanced through access management. For the most part, however, an important need remains with the overall development community.

10.2 RESEARCH DIRECTIONS

Several research needs emerged from the research effort. There is need for additional research on the traffic operation benefits associated with spacing criteria for unsignalized driveways. The approaches used vary, and there is wide diversity of opinion on which approach, or which factors, should be considered.

The safety impacts associated with driveway and access frequency also need additional research. Available accident analyses are several decades old, and require verification and updating. Stratification by type of road and operating speed would also prove useful.

Other areas that require documentation and research include: (1) the effects of denying access to activity centers on nearby intersections of public roads, (2) the relationship between access management and suburban traffic congestion, and (3) the traffic benefits of improved access management.

APPENDIX A

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APPENDIXES B, C, D, E, F

UNPUBLISHED MATERIAL

The appendixes contained in the research agency's final report are not published herein, but copies of that report, entitled "Access Management Guidelines for Activity Centers (Appendix)," may be obtained on loan or purchase ($15.00) by writing to the Transportation Research Board, Business Office, 2101 Constitution Avenue N.W., Washington, D.C. 20418. The available appendixes are titled as follows: Appendix B, Selected Case Studies; Appendix C, Examples of Roadway Classification; Appendix D, Access Spacing Guidelines; Appendix E, Access Management Codes; and Appendix F, Case Law Examples.

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