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A PRELIMINARY ASSESSMENT OF THE EFFECTS OF ACCESS MANAGEMENT ON PEDESTRIANS, BICYCLES AND TRANSIT

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A PRELIMINARY ASSESSMENT OF THE EFFECTS OF ACCESS MANAGEMENT ON PEDESTRIANS, BICYCLES AND TRANSIT

by
Glen D. Hodgson, P.E., Katharine Hunter-Zaworski, Ph.D.
and
Robert D. Layton, Ph.D.

Transportation Research Institute
Oregon State University
Corvallis, Oregon 97331

Transportation Northwest
(TransNow)
Department of Civil Engineering
129 More Hall
University of Washington, Box 352700
Seattle, WA 98195-2700

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16. Abstract

The project investigates the impacts of access management treatments on pedestrians and bicyclists, primarily on arterial streets. The project identifies conflicts, accident and safety issues involving pedestrians and bicycles, associated with access management treatments, impacted groups of pedestrians and bicyclists.

The project is an extension of a major access management project that is currently being conducted by Oregon Department of Transportation and the Transportation Research Institute at Oregon State University. The ODOT project is developing statutes, policies and guidelines for Access Management for the State of Oregon. The project also suggests recommendations for solution strategies to resolve or mitigate for these conflicts.

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A PRELIMINARY ASSESSMENT OF THE EFFECTS OF ACCESS MANAGEMENT ON PEDESTRIANS, BICYCLES AND TRANSIT

1. INTRODUCTION

1.1 Background

The concept known as Access Management has its roots in two basic premises of transportation engineering:

1) There is a "functional hierarchy" of streets and roadways with cul-de-sacs and local streets at one extreme, freeways at the opposite extreme and collectors and arterials between the two extremes.
2) Each class of street or roadway within this hierarchy serves both the "mobility (or movement) function" and the "access function", but each class serves these two functions to differing degrees.

Layton provides the following definitions of the mobility and access functions:

- Mobility, or the movement function, is the ease, speed, safety, comfort, and convenience of travel. Mobility is achieved through the elimination of congestion, provision of capacity, maintaining reasonable and uniform speeds, and limiting stops.
- Property access, or the access function, is the ability to reach land use activities and adjacent properties. Access to property from roads is accommodated through on-street parking, driveways, unsignalized intersections with low-volume access facilities, and at times signalized intersections. (1)

The relationships among the roadway hierarchy, the movement function and the access function are shown in simple, schematic form in Figure 1.1 and in somewhat more detail in Figure 1.2.

In order for an area, region or state to have an effective roadway system, both the movement and access functions must be provided. This is best accomplished by having "a blend and balance of road facilities where each performs its unique function, since no functional class can provide both high levels of mobility and access to property." (1)

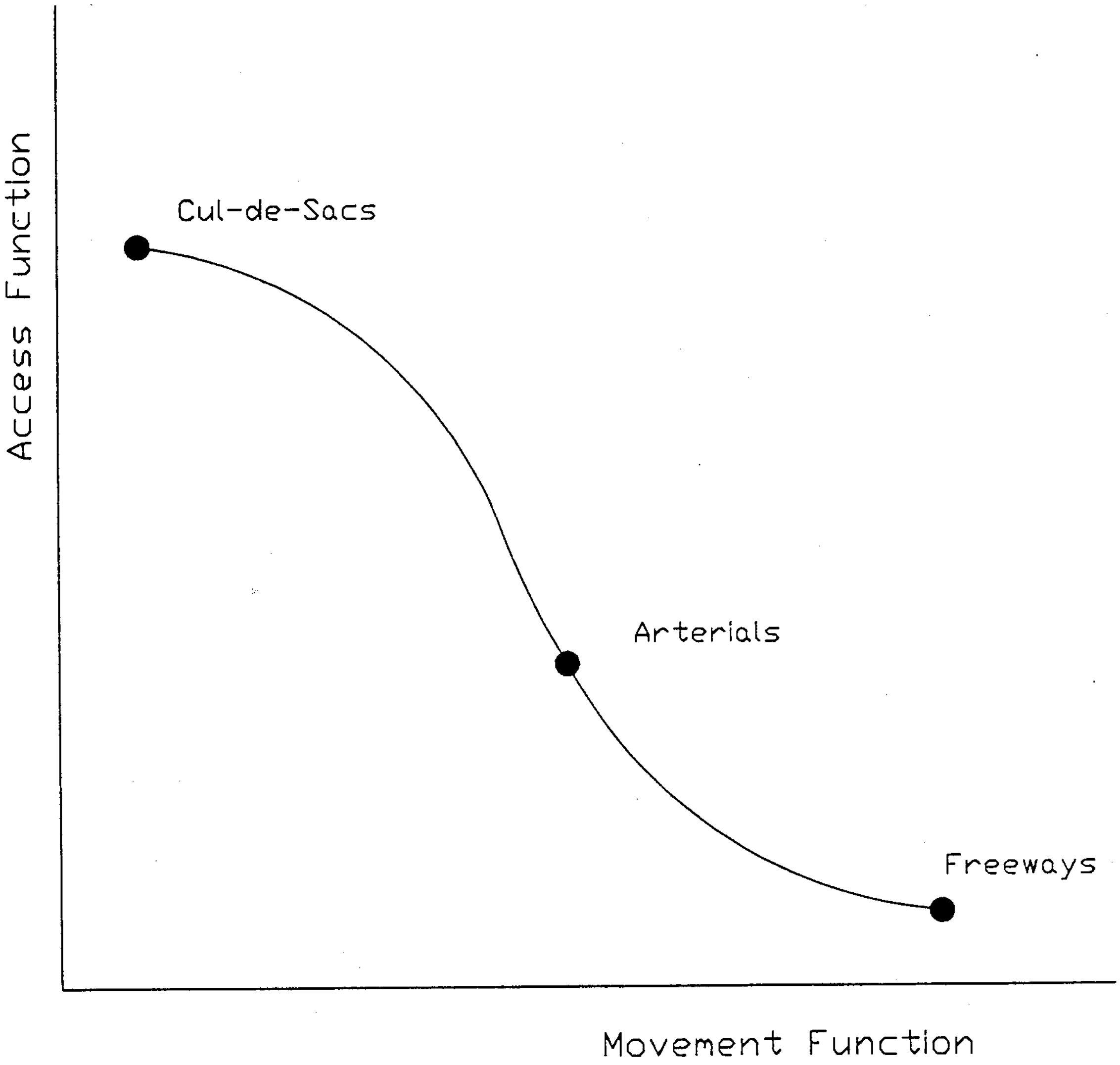
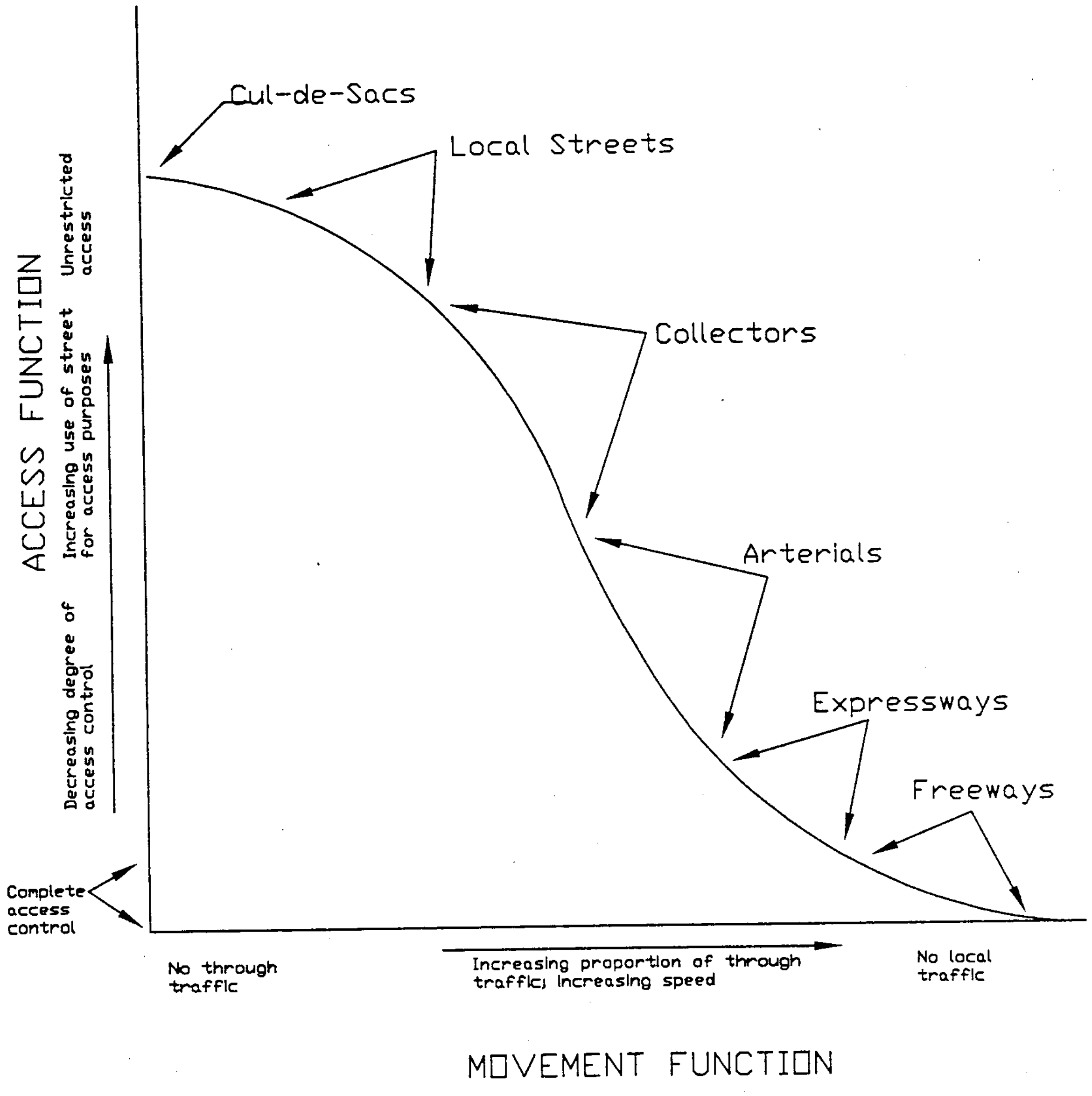


FIGURE 1.1 -- Access and Movement Functions



Source: Adapted from ITE Transportation Planning Handbook (2)

FIGURE 1.2 -- Access and Movement Functions

1.2 What is Access Management?

Access management has been defined as "a broad set of techniques that balance the need to provide efficient, safe and timely travel throughout the state, with the ability to allow access to the individual destination." (3) A slightly different definition is that "access management is an effort to maintain the effective flow of traffic and safety of all roads while accommodating the access needs of adjacent land development." (4) The Oregon Transportation Rule defines access management as "measures regulating access to streets, roads and highways from public roads and private driveways... (including) restrictions on the siting of interchanges, restrictions on the type and amount of access to roadways, and use of physical controls, such as signals and channelization including raised medians, to reduce impacts of approach road traffic on the main facility." (5)

It is clear from these definitions that access management deals with the vehicular (i.e., autos, trucks, buses, etc) mode of transportation. Therefore, within this report use of terms such as "transportation", "transportation system" and similar phrases should be interpreted to refer to the vehicular mode unless the context clearly suggests otherwise. Such references are not meant to diminish the importance of other modes in the broader transportation system but, rather, are used for the purpose of conciseness.

In a practical sense, access management most often involves measures to protect and/or enhance the mobility function of arterial streets. Arterial streets and roadways in the functional hierarchy favor the mobility function over the access function. However, since arterials typically carry high traffic volumes, these roadways are frequently pressured to provide more and more access. As access increases, mobility decreases until eventually the arterial no longer serves its intended purpose in the functional hierarchy. When one such element in the transportation system fails to perform, the entire system then begins to break down. Access management therefore promotes the effective functioning of the entire transportation system even though it is generally applied to limited components of that system. In that sense, access management can be viewed as a strategy to preserve and enhance the overall functioning of the entire transportation system.

If the "goal" of access management is to preserve and enhance the mobility function, then the main "objective" of access management that helps attain that goal is the concept of reducing conflicts within the traffic stream. Conflict reduction is achieved by :

1) Limiting the number of conflict points faced by the driver;
2) Separating the conflict points that can not be eliminated; and
3) Removing slower, turning vehicles from the traffic lanes. (3)

Various sources (1,3,4,6) discuss the potential benefits of access management. Such benefits include:

1) Fewer accidents (over 50% of the accidents on arterial roadways are access-related);
2) Increases in capacity of 25% to 35%;
3) Reductions in travel times of 40% to 60%;
4) Reductions in energy consumption of 35% to 50%;
5) Protection of the public investment in transportation infrastructure;
6) Reductions in pollution;
7) Economic savings from all of the above benefits.

1.3 Access Management Techniques

A number of techniques are being used in Oregon and elsewhere to manage access and maintain the mobility function of roadways. These techniques include:

1) Standards for the spacing and design of driveways;
2) Median use, design and openings;
3) Provision of left and right turn lanes;
4) Proper spacing of traffic signals;
5) The promotion of (off-roadway) interparcel circulation;
6) Standards for protecting the functioning of freeway interchanges;
7) Standards for protecting the functional area of intersections; and
8) Development of local road infrastructures. (3)

These individual access management techniques are not meant to be applied in isolation of one another. Rather, to be most effective, access management should take a "systems approach" that recognizes that transportation operations of public facilities, transportation operations within private developments and the operations of interfaces among facilities and developments all act as an interconnected whole. As noted by Layton: "the success of access management depends on well-integrated site design, land use planning and transportation facility design and control." (1)

1.4 The Status of Access Management in Oregon and Elsewhere

The Oregon Department of Transportation (ODOT) is the lead agency in the development of an access management program in Oregon. ODOT has assigned a program coordinator and a program staff to lead this effort. Much of the research and development work to date has been conducted by the Transportation Research Institute at Oregon State University.

A total of eleven background or discussion papers have been prepared. These papers include:

#1 – "Functional Integrity of the Highway System" (1)
#2 – "Interchange Access Management" (7)
#3 – "Variances" (8)
#4 – "Medians" (9)
#5 – "Access Management Classification and Spacing Standards" (10)
#6 – " Use of Volume/Capacity Ratio Versus Delay for Planning and Design Decisions for Signalized Intersections" (11)
#7 – "Functional Intersection Area" (12)
#8A – "Stopping Sight Distance and Decision Sight Distance" (13)
#8B – "Intersection Sight Distance" (14)
#10 – " Left-Turn Bays" (15)
#11 – "Right-Turn Lanes" (16)

These eleven papers, as well as other, on-going work will eventually lead to a full array of access management policies, standards and the documentation to support those policies and standards. ODOT maintains a site on the World Wide Web that is updated as additional work on access management is completed. The URL for that web site is: *http://www.odot.state.or.us/tdb/planning/access_management/index.html* (3)

Other state transportation agencies are also addressing access management issues. For example, the access management work plan at the Minnesota Department of Transportation is moving forward according to the following schedule:

March, 1997 to September, 1998: Research
March, 1997 to October, 1998: Draft Report
June, 1998 to October, 1998: Public Review of Draft Report
September, 1998 to January, 1999: Final Report to the Legislature (4)

2. WHY CONSIDER PEDESTRIAN, BICYCLE AND TRANSIT IMPACTS OF ACCESS MANAGEMENT?

2.1 Statewide Planning Goal 12

Since the main purpose of access management is to maintain the effective flow of vehicular traffic, one could reasonably ask why its effects on pedestrians, bicycles and transit should be considered. One answer to such a question stems from the emphasis in Oregon on multimodal transportation systems.

Statewide Planning Goal 12 (Transportation) directs that "a transportation plan shall consider all modes of transportation including mass transit … bicycle and pedestrian." (17) This goal also requires that "a transportation plan shall … avoid reliance upon any one mode of transportation." Therefore, the very basis of transportation planning (and, by extension, transportation systems and facilities) in Oregon requires that access management be pursued from a broad perspective that goes beyond a vehicular-traffic-only viewpoint.

2.2 The Transportation Planning Rule

The Oregon Land Conservation and Development Commission (LCDC) adopted the Transportation Planning Rule (TPR) to implement the Statewide Planning Goal 12. The TPR reemphasizes the need to promote a "balanced" transportation system that includes all modes.

2.3 The Oregon Transportation Plan

The TPR requires that "ODOT shall prepare, adopt and amend a state Transportation System Plan." (5) Based on this requirement, ODOT has prepared the Oregon Transportation Plan. Several goals, policies and actions specified in that plan suggest that access management impacts on transit, bicycles and pedestrians are an important consideration. Selected parts of the Oregon Transportation Plan include:

- Goal 1: " To enhance Oregon's quality of life and comparative economic advantage by the provision of a transportation system with the following characteristics: balance ... accessibility ... connectivity among places, connectivity among modes ...."
- Policy 1A: "It is the policy of the State of Oregon to provide a balanced transportation system. A balanced transportation system is one that ... reduces reliance on the single occupant automobile where other modes or choices can be made available ... and takes advantage of the inherent efficiencies of each mode."
- Action 1A.1: "Design systems and facilities that accommodate multiple modes within corridors ...."
- Action 1G.4: "Improve the safety in design, construction and maintenance of new and existing systems and facilities ... including the use of techniques to reduce conflicts between modes using the same facility or corridor."
- Action 2B.3: "Increase the availability and use of transit, walking, bicycling and ridesharing."
- Action 2D.1: "Renovating arterials and major collectors with bike lanes and walkways and designing intersections to encourage bicycling and walking for commuting and local travel." (18)

This last "action" most directly indicates that arterials and major collectors (i.e., those facilities most likely to be affected by access management) will have bicycle and pedestrian users. Any design or operational changes on these facilities will, therefore, impact those bicycle and pedestrian users. Good transportation policy and planning require an assessment of those impacts.

2.4 The Oregon Bicycle and Pedestrian Plan

This plan is an element of the Oregon Transportation Plan. The Bicycle and Pedestrian Plan lists the following benefits of bicycling and walking:

- Reduced traffic congestion

*

- Reduced air and noise pollution *
- Reduced wear and tear on roads
- Reduced consumption of petroleum *
- Reduced crashes and property damage *
- Reduced need for additional roads, travel lanes and parking *
- Improve Oregonians' health and well-being through regular exercise

Five of the seven benefits (i.e., those marked with an asterisk) are also benefits of access management. Based on this commonality among the benefits of access management, bicycling and walking, it is easily argued that the underlying objectives of access management can best be achieved if the negative impacts on bicycles and pedestrians are minimized and the positive impacts are maximized.

2.5 Pedestrian and Bicycle Safety

Another reason to consider pedestrians and bicycles when developing access management programs and projects is that the safety of pedestrians and bicycles should be an important concern for transportation professionals. In 1989, 6552 pedestrians and approximately 900 bicyclists were killed in traffic accidents in the United States (19). Access management can and should be used as a means to improve pedestrian and bicycle safety and to reduce those fatality statistics.

3. CURRENT STATUS OF RESEARCH

3.1 Field Data

The existing literature contains little or no field data on the effects of access management on transit, pedestrians and bicycles. In addition, the literature contains little or no field data on the interaction of motor vehicles with pedestrians and bicycles at roadway features that may be amenable to access management treatments.

3.2 Suggested Impacts

Many sources have suggested a variety of impacts of access management on transit, pedestrians and bicycles. By and large, those sources have been limited in scope and perspective. No known compilation of suggested impacts exists.

Suggested impacts also tend to be anecdotal in nature. Analytical, quantified descriptions of impacts are limited.

3.3 Study Scope

Because there is such a limited amount of previous research related to the impacts of access management on pedestrians, bicycles and transit, this study is only a preliminary, and somewhat exploratory, examination of those impacts. Some of the methods employed in this study yielded useful and interesting data. Other methods (particularly the data acquisition on vehicle/bicycle interactions at driveways) were less successful and served only to show that much additional work remains to be done to fully explore this aspect of access management.

4. COMPILATION OF SUGGESTED IMPACTS OF ACCESS MANAGEMENT ON PEDESTRIANS, BICYCLES AND TRANSIT

4.1 Introduction

Several references (3, 18, 20, 21, 22, 23, 24) have discussed potential or perceived impacts of access management techniques on pedestrians, bicycles and transit. These references range from a quite narrow (and sometimes proselytizing) perspective to an attempt to provide a comprehensive listing of both positive and negative impacts. This section presents a compilation of impacts suggested by the authors of the various references. Impacts indicated by the data presented in the following sections of this report are also included.

This discussion of the impacts of access management on pedestrians, bicycles and transit is organized into various "categories" of access management treatments. Categories of treatments discussed include:

Section	Type of Access Management Treatment
4.2	Standards for Spacing and Design of Driveways
4.3	Median Use, Design and Openings
4.4	Left Turn Lanes
4.5	Right Turn Lanes
4.6	Traffic Signal Spacing Standards
4.7	Interparcel and Site Circulation
4.8	Protecting the Functional Area of Freeway Interchanges
4.9	Protecting the Functional Area of Intersections
4.10	Development of Local Road Infrastructure
4.11	Combinations of More Than One Treatment

Standards for most of the various categories of access management treatments have been proposed by Layton and Stover (10). Table 4.1 reproduces those proposed standards.

State Highway Functional Class	Multi- or Two-Lane	Area	Typical Operating Speed (mph)	Typical Median Design			Typical Signal Spacing	Approaches and Driveways	
				Control Type	Opening Type	Opening Spacing		Type	Spacing
Major Arterial	Multi-Lane	Rural	55	full/partial	no break	1/2 mi	1/2 mi	rt turn	1320 ft
		Urban	45	full/partial	no break	1/4 mi	1/2 mi	rt turn	990 ft
		Fully Developed	35	none	NA	NA	1/2 mi	rt turn	660 ft
	Two-Lane	Rural	45	none	NA	NA	1/2 mi	rt turn	1320 ft
		Urban	45	none/partial	CTWLTL	NA	1/2 mi	rt turn	990 ft
		Fully Developed	35	none/partial	CTWLTL	NA	1/2 mi	rt turn	660 ft
Minor Arterial	Multi-Lane	Rural	55	partial	partial	660 ft	1/2 mi	lt/rt turns	660 ft
		Urban	45	none/partial	full/NA	330 ft/ NA	1/2 mi	lt/rt turns	660 ft
		Fully Developed	35	none	NA	NA	1/2 mi	lt/rt turns	660 ft
	Two-Lane	Rural	55	none	NA	NA	1/2 mi	lt/rt turns	660 ft
		Urban	45	none/partial	CTWLTL	NA	1/2 mi	lt/rt turns	660 ft
		Fully Developed	35	none/partial	CTWLTL	NA	1/2 mi	lt/rt turns	660 ft
Major Collector	Multi-Lane	Rural	45	none	NA	330 ft/ NA	1/2 mi	lt/rt turns	660 ft
		Urban	40	none	NA	NA	1/4 mi	lt/rt turns	330 ft
		Fully Developed	35	none	NA	NA	1/4 mi	lt/rt turns	160 ft
	Two-Lane	Rural	45	none	NA	NA	1/2 mi	lt/rt turns	660 ft
		Urban	40	none/partial	CTWLTL	NA	1/4 mi	lt/rt turns	330 ft
		Fully Developed	35	none/partial	CTWLTL	NA	1/4 mi	lt/rt turns	160 ft

Source: Adapted from (10)

Table 4.1 -- Access Management Standards
Sheet "a" (English Units)

State Highway Functional Class	Multi- or Two-Lane	Area	Typical Operating Speed (kph)	Typical Median Design			Typical Signal Spacing	Approaches and Driveways	
				Control Type	Opening Type	Opening Spacing		Type	Spacing
Major Arterial	Multi-Lane	Rural	90	full/partial	no break	800 m	800 m	rt turn	400 m
		Urban	70	full/partial	no break	400 m	800 m	rt turn	300 m
		Fully Developed	55	none	NA	NA	800 m	rt turn	200 m
	Two-Lane	Rural	70	none	NA	NA	800 m	rt turn	400 m
		Urban	70	none/partial	CTWLTL	NA	800 m	rt turn	300 m
		Fully Developed	55	none/partial	CTWLTL	NA	800 m	rt turn	200 m
Minor Arterial	Multi-Lane	Rural	90	partial	partial	200 m	800 m	lt/rt turns	200 m
		Urban	70	none/partial	full/NA	100 m/ NA	800 m	lt/rt turns	200 m
		Fully Developed	55	none	NA	NA	800 m	lt/rt turns	200 m
	Two-Lane	Rural	90	none	NA	NA	800 m	lt/rt turns	200 m
		Urban	70	none/partial	CTWLTL	NA	800 m	lt/rt turns	200 m
		Fully Developed	55	none/partial	CTWLTL	NA	800 m	lt/rt turns	200 m
Major Collector	Multi-Lane	Rural	70	none	NA	100 m/ NA	800 m	lt/rt turns	200 m
		Urban	65	none	NA	NA	400 m	lt/rt turns	100 m
		Fully Developed	55	none	NA	NA	400 m	lt/rt turns	50 m
	Two-Lane	Rural	70	none	NA	NA	800 m	lt/rt turns	200 m
		Urban	65	none/partial	CTWLTL	NA	400 m	lt/rt turns	100 m
		Fully Developed	55	none/partial	CTWLTL	NA	400 m	lt/rt turns	50 m

Source: Adapted from (10)

Note: The original source did not include these metric standards. These "standards" are converted from the initial english units and rounded.

Table 4.1 -- Access Management Standards
Sheet "b" (Metric Units)

4.2 Standards for Spacing and Design of Driveways

Perhaps the most important access management strategy related to driveways focuses on the number (or, inversely, the spacing) of driveways on a section of arterial street or roadway. Other important strategies deal with the details of the design of the driveway and the location of driveways in relation to other elements of the arterial.

In regard to the number and spacing of driveways, it is intuitively obvious that fewer driveways at larger spacings promote the goals of access management better than many driveways at short spacings. The Highway Capacity Manual provides a more analytical treatment of the effects of the number of accesses on arterial capacity. Layton and Stover describe four methods that can be used to calculate acceptable driveway spacings. Those methods include:

1) minimum stopping sight distance
2) right-turn conflict overlap
3) maximum egress capacity
4) rule-of-thumb. (10)

Driveway design details that are important in the context of access management include:

1) length of radius
2) throat width
3) throat length
4) driveway profile
5) prevention of selected movements (e.g., right-in, right-out designs)

Figure 4.1 schematically identifies these driveway design elements. Longer radii, wider and longer throat dimensions and "flatter" profiles are generally accepted as supportive of the goals of access management.

The goals of access management are also supported by locating driveways away from other potential conflict points. In order to best protect the mobility function of an arterial, drivers should not be forced to deal simultaneously with multiple conflicts. Therefore, driveways should be located a sufficient distance away from intersections (see

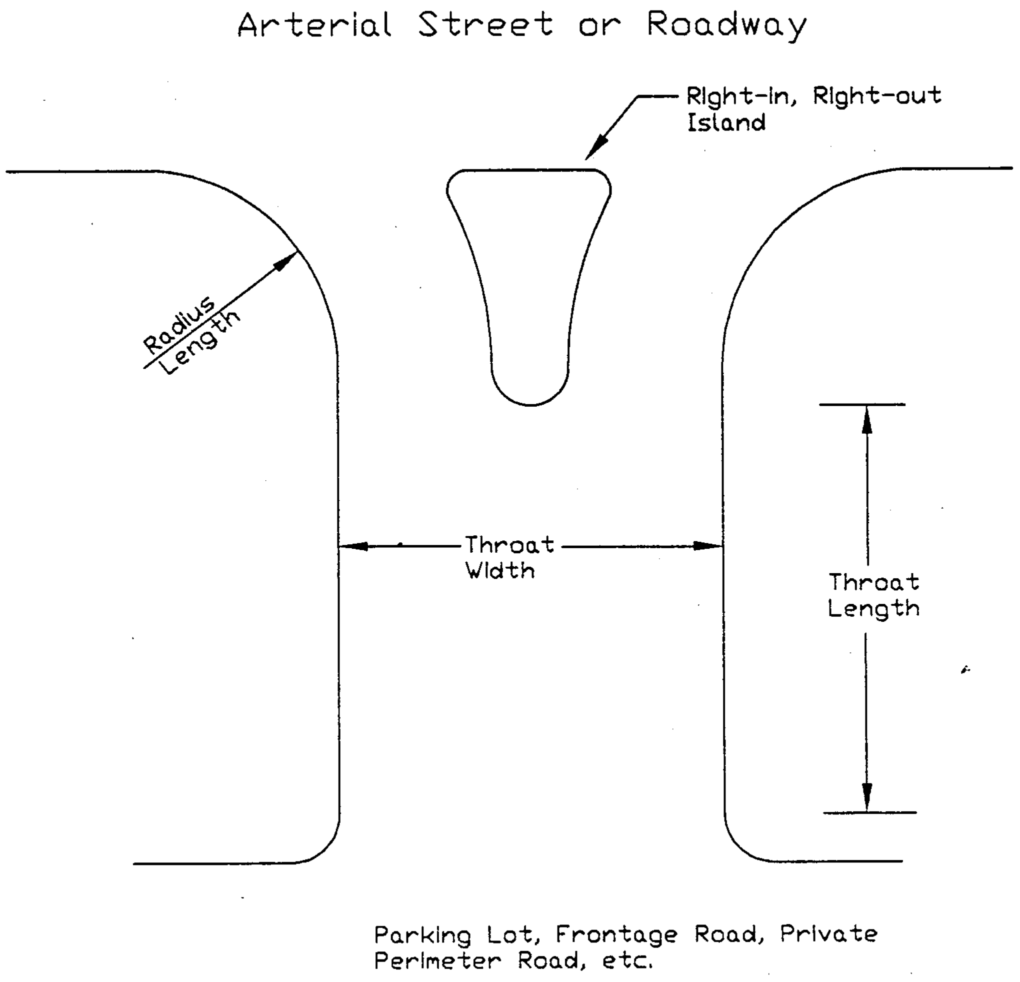


FIGURE 4.1 -- Driveway Design Elements

also Section 4.9, Protecting the Functional Area of Intersections), other driveways, weaving and lane change areas, freeway interchanges (see also Section 4.8, Protecting the Functional Area of Freeway Interchanges) and similar locations that may require complex driver decisions and maneuvers.

Various literature sources have suggested both positive and negative impacts of driveway standards. Positive effects on pedestrians include:

1) With a smaller number of driveways, pedestrians are faced with fewer conflict points where they are confronted with vehicles entering or exiting driveways.
2) With fewer driveways vehicles are directed to intersections where appropriate traffic control devices organize and control vehicular and pedestrian movements.
3) Since driveways frequently are obstacles for pedestrians with disabilities, fewer driveways along an arterial translate into fewer obstacles.

Positive impacts on bicycles are similar to the first two pedestrian impacts. That is:

1) Fewer conflict points with vehicles using driveways.
2) Vehicles are directed to intersections with appropriate traffic control

Positive impacts on transit include:

1) The improved arterial flow due to reduced access points facilitates transit vehicle operation and efficiency.
2) An arterial with fewer driveways provided greater flexibility in the placement of transit stops.
3) The positive impacts on pedestrians serve to benefit transit operations since transit users are pedestrians both before and after using the transit service.

Negative impacts on pedestrians that have been suggested in the literature include:

1) A decreased number of driveways typically results in increased vehicular traffic at the remaining driveways. Although the number of

pedestrian/vehicle conflict points may decrease, the pedestrian may be faced with more formidable conflicts at the remaining driveways.

2) Driveways that are designed to access management standards tend to be wider and have longer turning radii. Both these factors increase the total area where pedestrians are exposed to vehicles using a particular driveway.
3) The increased turning radii at driveways tend to increase the speeds of vehicles entering the driveway which creates a more serious hazard to pedestrians crossing the driveway.

Negative impacts on bicycles are similar to the negative impacts on pedestrians:

1) Increased activity at the remaining driveways.
2) Increased area of exposure at the remaining driveways.
3) Increased speeds of vehicles using the driveways.

Negative impacts on transit are the negative impacts on pedestrians since transit users are pedestrians before and after using the transit service.

4.3 Median Use, Design and Openings

Examples of access management treatments associated with median use, design and openings include:

1) Installation of a nontraversable median.
2) Replacement of a continuous two-way left-turn lane (CTWLTL) with a nontraversable median.
3) Closure or redesign of median openings along an entire section of roadway.
4) Closure of a single median opening.
5) Redesigning a median opening so as to permit a selected movement (or movements) only.
6) Adding a left turn bay at a median opening.

7) Increasing the length of an existing turn bay to provide adequate queue storage and to reduce the speed differential between turning vehicles and through traffic. (9)

These seven treatments are all supportive of one or more of the three principal strategies of median access control:

1) Separate opposing traffic streams.
2) Provide auxiliary lanes to decelerate and store left-turning vehicles.
3) Provide a pedestrian refuge area. (9)

There are four levels of median control typically used on Oregon roadways. Those four levels are:

1) Undivided roadways provide no median control. Opposing traffic lanes are immediately adjacent to each other so there is no control of nor refuge for left-turning vehicles.
2) CTWLTL's provide a single, flush, center lane that removes left turning vehicles from the through lanes and thus provide some degree of storage and refuge for these vehicles.
3) Traversable medians are any type of flush or slightly-raised median that vehicles can cross with relative ease.
4) Non-traversable medians are raised or depressed in a fashion that prevents easy crossing of the median by vehicles.

A second way to categorize median control is "no" versus "partial" versus "full" median control. Undivided roadways, CTWLTL's and traversable medians provide "no control" of left turns. A non-traversable median providing "partial median control" allows left turns only at appropriately spaced, channelized and designed breaks in the median. A non-traversable median provides "full median control" if it completely prevents left turns from or onto the roadway. (10)

Literature sources have enumerated and described positive and negative impacts of access management techniques related to median control. Positive impacts on pedestrians include the following:

1) If adequately sized and protected, a median can provide an area of refuge for pedestrians. With a median refuge area pedestrians can separate the task of crossing a street or roadway into two movements crossing one traffic stream at a time.
2) Previous studies and data have been compiled by Stover which indicate that pedestrian-vehicle crash rates are lower with increased median control. Specific conclusions suggested by Stover include:
    a) Midblock pedestrian-vehicle crash rates are much lower with restrictive (i.e., nontraversable) medians than with undivided roadways and those with CTWLTL's.
    b) For arterials in central business districts and for suburban arterials the mean pedestrian/vehicle crash rate for raised medians is much less than for streets with CTWLTL's or for undivided streets. (9)

    In the same reference Stover cites a previous study of vehicular crash rates before and after installation of a raised median which closed a number of openings at accesses and intersections. Stover concludes:

    > The fact that crash rates decreased at those intersections which remained open demonstrates that improved design and traffic control can result in lower rates in spite of the increased turning traffic at the openings.... The lower crash rate probably results from a separation of conflict areas (longer spacing between median openings) and simplified driver information workload. (9)

    Although no such data exists for pedestrian/vehicle and bicycle/vehicle crash rates, similar tendencies would not be unexpected.
3) The installation of a median can, in some circumstances, provide an increase in roadway capacity that obviates the need for added lanes. In such cases adding a median is a lesser impact on pedestrians since total street crossing width is probably less with an added median when

compared to added lanes. The lesser street width also leaves more of the right-of-way available for sidewalks and other pedestrian-friendly improvements.

4) Non-traversable medians prevent left turns into driveways thereby decreasing the number and variety of pedestrian/vehicle conflicts at driveways.

Positive impacts of median control on bicycles are similar to the impacts of median control on pedestrians:

1) Adequately-sized medians can provide a refuge area for bicycles and can separate a street crossing into two movements. (Since bicycles can cross a street in a much shorter time than pedestrians, these impacts are realized by bicycles only in unusual circumstances.)
2) The data on reduced pedestrian/vehicle and vehicle crash rates with increasing median control might suggest that a similar relationship holds for bicycle/vehicle crashes. (This topic could be the subject of additional research.)
3) If a median can provide enough extra capacity so that additional traffic lanes can be avoided, more right-of-way would be available for bicycle facilities.
4) Non-traversable medians which prevent left turns into driveways also reduce bicycle/vehicle conflicts at driveways.

Positive impacts on transit include:

1) The improved arterial flow due to medians facilitates transit vehicle operation and efficiency.
2) The positive impacts of medians on pedestrians serve to benefit transit operations since transit users are pedestrians both before and after using the transit service.

Various negative impacts of medians on pedestrians that have been suggested in the literature include:

1) High medians such as New Jersey barriers are non-traversable to all but the most nimble pedestrians. Mid-block street crossings are then prevented by such medians so that out-of-direction travel is generally increased.
2) When compared to undivided roadways, medians increase street widths thereby increasing street crossing distances for pedestrians as well as their time of exposure to vehicles.

Negative impacts of medians on bicycles include:

1) High medians such as New Jersey barriers are non-traversable to bicycles and thus prevent mid-block crossings.
2) Medians generally increase total street width and thereby increase street crossing distances and exposure times for bicycles.

Negative impacts on transit are:

1) All the negative impacts on pedestrians affect transit since transit users are pedestrians before and after using the transit service.
2) Non-traversable medians may reduce the efficacy of mid-block transit stops due to the reduced ease of mid-block crossings by transit users coming to or departing from the transit stop.

4.4 Left Turn Lanes

Examples of access management treatments associated with left turn lanes are:

1) The addition of a left turn lane at a median opening for either a driveway or an intersection.
2) Increasing the length of an existing left turn lane to provide queue storage space or to provide a deceleration lane for left-turning vehicles as they exit the through lane.

The provision of a left turn lane promotes the goals of access management by reducing the need for left-turning vehicles to decelerate in the through lanes and, thereby, reducing the speed differential of vehicles in the through lanes. Reducing that speed differential will reduce crash rates and will reduce shock waves and loss of capacity caused by the forced deceleration of through vehicles.

Proper design of a left turn lane will account for the four elements of a left-turning maneuver as depicted in Figure 4.2.

Potential positive impacts of left turn lanes on pedestrians are:

1) The separation of vehicular turning and through movements "organizes" the traffic that the pedestrian must cross, so the pedestrian will experience fewer unexpected vehicle operations.
2) According to a 1996 study there was a decrease in pedestrian accidents after left-turn bays were added to a four-mile section of street in Denver. (9)

Potential positive impacts of left-turn lanes on bicycles are:

1) The lane provides separation and protection (from through vehicles) for left-turning bicycles.
2) As with pedestrians, the separation of left-turning and through vehicles "organizes" the traffic to which the bicyclist is exposed.

Potential positive impacts on transit are:

1) The improved arterial flow due to removing left turning traffic from the through lanes facilitates transit vehicle operation and efficiency.
2) The positive impacts on pedestrians serve to benefit transit operations since transit users are pedestrians both before and after using the transit service.

A negative impact of left turn lanes on pedestrians is that the added lane increases street crossing distances and exposure times for pedestrians.

The suggested negative impacts of left turn lanes on bicycles include:

1) The added lane increases street crossing distances and exposure times.
2) Bicycles traveling along the arterial must cross the through lanes to reach the left turn lane.

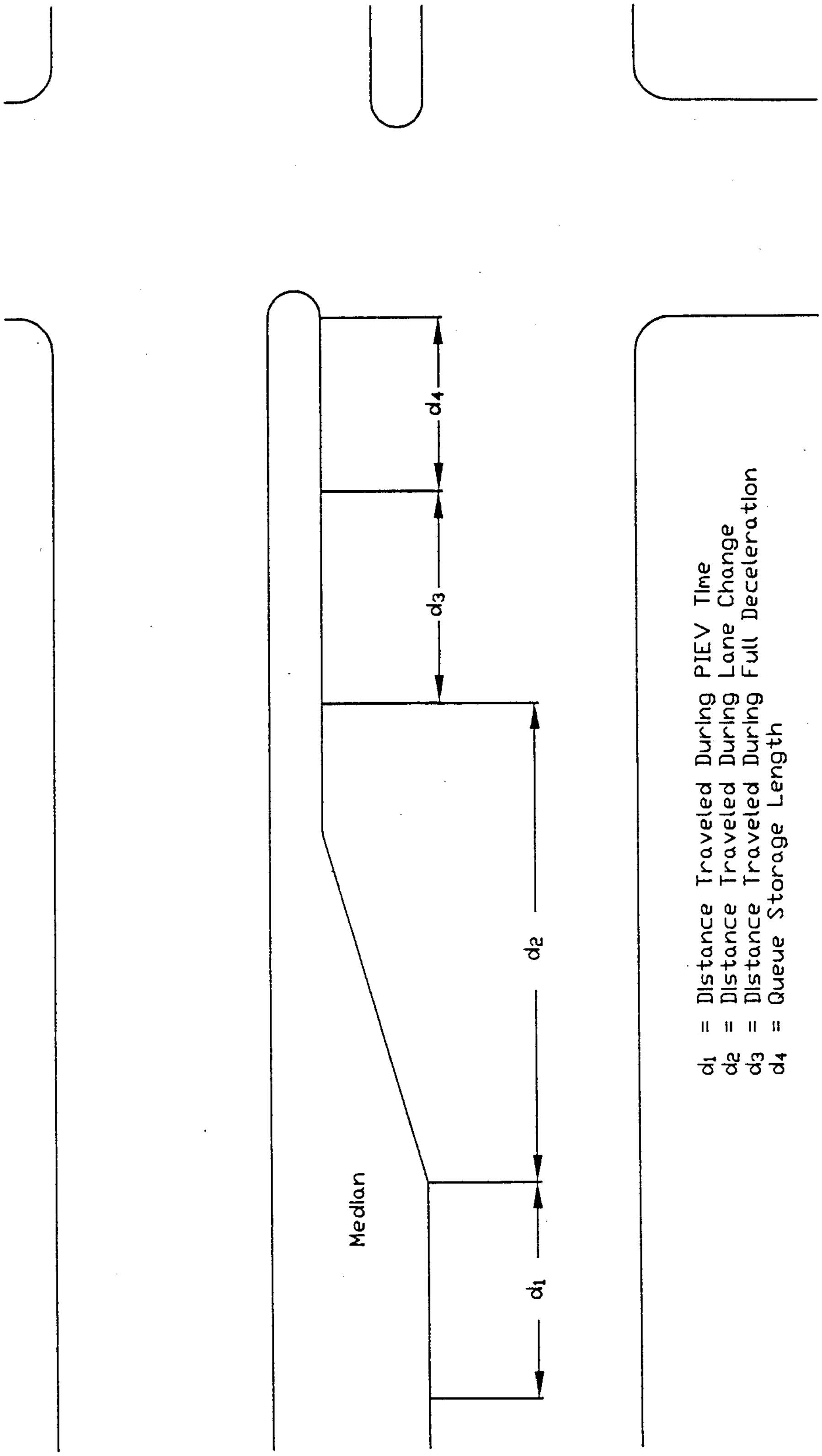


FIGURE 4.2 -- Elements of a Left Turn Maneuver

The negative impact on pedestrians is also a negative impact on transit since transit users are pedestrians both before and after using the transit service.

4.5 Right Turn Lanes

As with left turn lanes, right turn lanes are used as access management treatments at driveways and intersections to remove decelerating traffic (i.e., the turning vehicles) from the through lanes on an arterial. The effects of right-turning vehicles which are forced to decelerate in the through lane are increased crash rates and decreased capacity on the arterial.

Stover presents data on crash rates that quantifies the impacts on traffic safety caused by decelerated vehicles on at-grade arterials (16):

Speed Differential (mph)	0	-10	-20	-30	-35
Speed Differential (kph)	0	-16	-32	-48	-56
Relative accident rate (no units)	110	220	720	5,000	20,000

Proper design of a right turn lane will account for the four elements of a right-turning maneuver as depicted in Figure 4.3.

Potential positive impacts of right turn lanes on pedestrians are:

1) The separation of vehicular turning and through movements "organizes" the traffic that the pedestrian must cross, so the pedestrian will experience fewer unexpected vehicle operations.
2) Field data collected during this study suggests that right turn lanes at driveways reduce the speeds of vehicles entering the driveway.
3) Right turn lanes provide some separation between the pedestrian sidewalk and the higher-speed through traffic lanes.

A potential positive impact of right turn lanes on bicycles is the organization of the traffic to which the bicyclist is exposed.

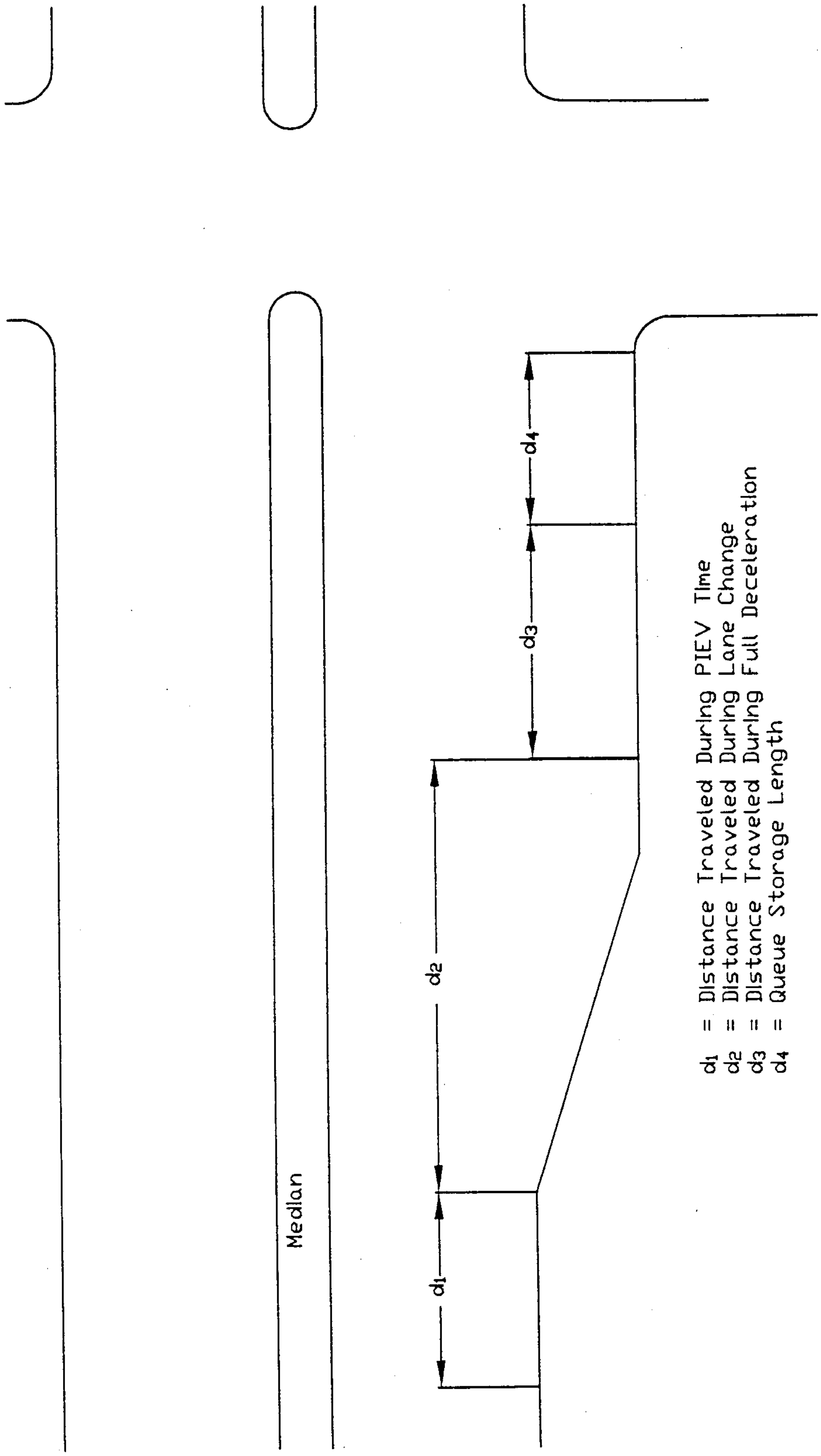


FIGURE 4.3 -- Elements of a Right Turn Maneuver

Positive impacts of right turn lanes on transit are:

1) The improved arterial flow due to removal of right-turning traffic from the through lanes facilitates transit vehicle operation and efficiency.
2) The right turn lane can serve a secondary function of providing a transit stop pull-out.
3) The positive impacts on pedestrians serve to benefit transit operations since transit users are pedestrians both before and after using the transit service.

A negative impact of right turn lanes is that the added lane increases street crossing distances and exposure times for pedestrians.

Potential negative impacts of right turn lanes on bicycles include:

1) The added lane increases street crossing distances and exposure times.
2) Weaving-type conflicts with vehicles occur in the area where vehicles cross the bike lane to enter the right turn lane.

The negative impact of right turn lanes on pedestrians is also a negative impact on transit since transit users are pedestrians both before and after using the transit service.

4.6 Traffic Signal Spacing Standards

Traffic signal spacing along an arterial can have a significant impact on the progression of traffic flow and, therefore, on the capacity of the arterial. With larger signal spacings there is a lower probability that traffic progression will be interrupted by the red phase of a traffic signal. Conversely, with shorter signal spacing the task of coordinating signals along the arterial becomes more complex.

It is also important to realize that effective traffic signal coordination (which is a function of spacing and other variables) is a necessary prerequisite for an arterial to provide the mobility function. Inadequate traffic signal coordination will prevent the progressive flow of traffic on an arterial. In such cases the application of other access management treatments will be completely ineffective and will not overcome the degradation in mobility caused by poor signal coordination.

Factors that influence the proper spacing of traffic signals include operational speed on the arterial, signal cycle length and traffic volumes. With typical values of speed and cycle length, Layton and Stover suggest that "in general, the most appropriate signal spacing for rural, suburban and urban arterials is 1/2 mile (approximately 800 m)." (10)

No positive impacts of signal spacing on pedestrians have been identified. A positive impact on bicycles of signal spacing is that bicycles are faced with fewer stops and starts while traveling on the arterial. A positive effect on transit is that the improved arterial flow facilitates transit vehicle operation and efficiency.

A negative impact on both pedestrians and bicycles that are traveling across the arterial is that the increased signal spacing increases the distance between protected crossings thus increasing travel distances and times. This same impact applies to transit since transit users are pedestrians before and after using the transit service. Distances between protected crossings can be lessened by the placement of secondary signals at closer spacings. In this sense, "secondary signals" are those that are controlled to avoid interruptions to traffic progression.

4.7 Interparcel and Site Circulation

Transportation and traffic design and operations on private developments can greatly influence the success of access management efforts on public roadways. When private, on-site transportation facilities are developed without thoughtful consideration of the interfaces with public facilities, access management efforts on those public facilities can be severely impaired.

Conversely, site circulation design and operations can be an important component of access management if the arterial roadway, the accesses to the roadway and the circulation of traffic on adjacent land parcels are treated as interdependent components of a system. For the arterial designer that means analyzing the traffic generated by existing and/or proposed land uses as well as the on-site traffic flow needs of those land uses. For the site designer and developer that means providing a traffic circulation pattern on-site and between sites which does not create access demands that are unduly disruptive to the mobility function of the arterial.

Because on-site traffic considerations are widely variable, there are few, if any, design tactics that are applicable to all sites. However, the following examples are indicative of the types of elements that designers of on-site facilities should consider:

1) consolidation of driveways
2) provision of private frontage roads
3) parking lot design which does not create conflicts between parking maneuvers and vehicles exiting the arterial
4) off-roadway vehicular routes connecting adjacent parcels of property
5) integrating transit stops into the on-site facilities.

A number of positive impacts on both pedestrians and bicycles can be realized by the thoughtful design of interparcel and site circulation facilities. Such impacts include the following:

1) On-site and interparcel facilities can provide alternate, and frequently shorter, travel routes that separate pedestrians and bicycle movements from the higher volumes and speeds on the arterial.
2) Pedestrian and bicycle-friendly designs can be readily incorporated into interparcel and site circulation routes.
3) Effective on-site and interparcel traffic circulation can reduce the traffic volumes using driveways and other accesses, thereby reducing the number of pedestrian/vehicle and bicycle/vehicle conflicts at those points.

Positive impacts on transit include:

1) On-site transit stops can provide better integration and coordination of transit facilities and pedestrian travel routes.
2) The improved arterial flow facilitates transit vehicle operation and efficiency.

3) The positive impacts on pedestrians serve to help transit since transit users are pedestrians before and after using the transit service.

A potential negative effect of interparcel circulation routes on pedestrians, bicycles and transit is that use of those routes generally places the pedestrian and bicycle further away from transit routes. This negative impact can be at least partially offset by developing on-site transit stops.

4.8 Protecting the Functional Area of Freeway Interchanges

A broad definition of this access management strategy is that protecting the functional area of freeway interchanges involves controls on the design and operation of crossroads that limit conflicts between crossroad traffic and interchange ramp operations. Specific techniques that have been suggested by Layton include:

1. Maintaining a minimum distance between the end of an off ramp and:
    - a) the first signalized intersection on the crossroad (1320 feet [approximately 800 meters] has been suggested);
    - b) the first driveway or minor street intersection on the crossroad (660 feet [approximately 200 meters] has been suggested);
    - c) the first median opening or the first driveway to the left (roughly 1/4 mile [approximately 400 meters] has been suggested.)
2. Development (in the vicinity of the interchange) of a system of local streets that effectively moves traffic to and away from the interchange.
3. Land use controls such as siting uses with low trip generation rates near freeway interchanges.
4. Maintaining a minimum distance between the end of an on ramp and the nearest access or driveway. (1,000 feet [approximately 300 meters] has been suggested.) (7)

These techniques to protect the functional area of freeway interchanges result in no identified or suggested positive impacts on pedestrians and bicycles. Potential positive impacts on transit are:

1) These techniques may promote the development and use of intermodal facilities such as park-and-ride stations.
2) Improved arterial flow due to protection of the functional area of freeway interchanges facilitates transit vehicle operation and efficiency.

A negative impact that potentially affects pedestrians and bicycles is that several of the techniques may increase travel distances and times by forcing out-of-direction travel. This negative impact also translates through to transit since transit users are also pedestrians.

4.9 Protecting the Functional Area of Intersections

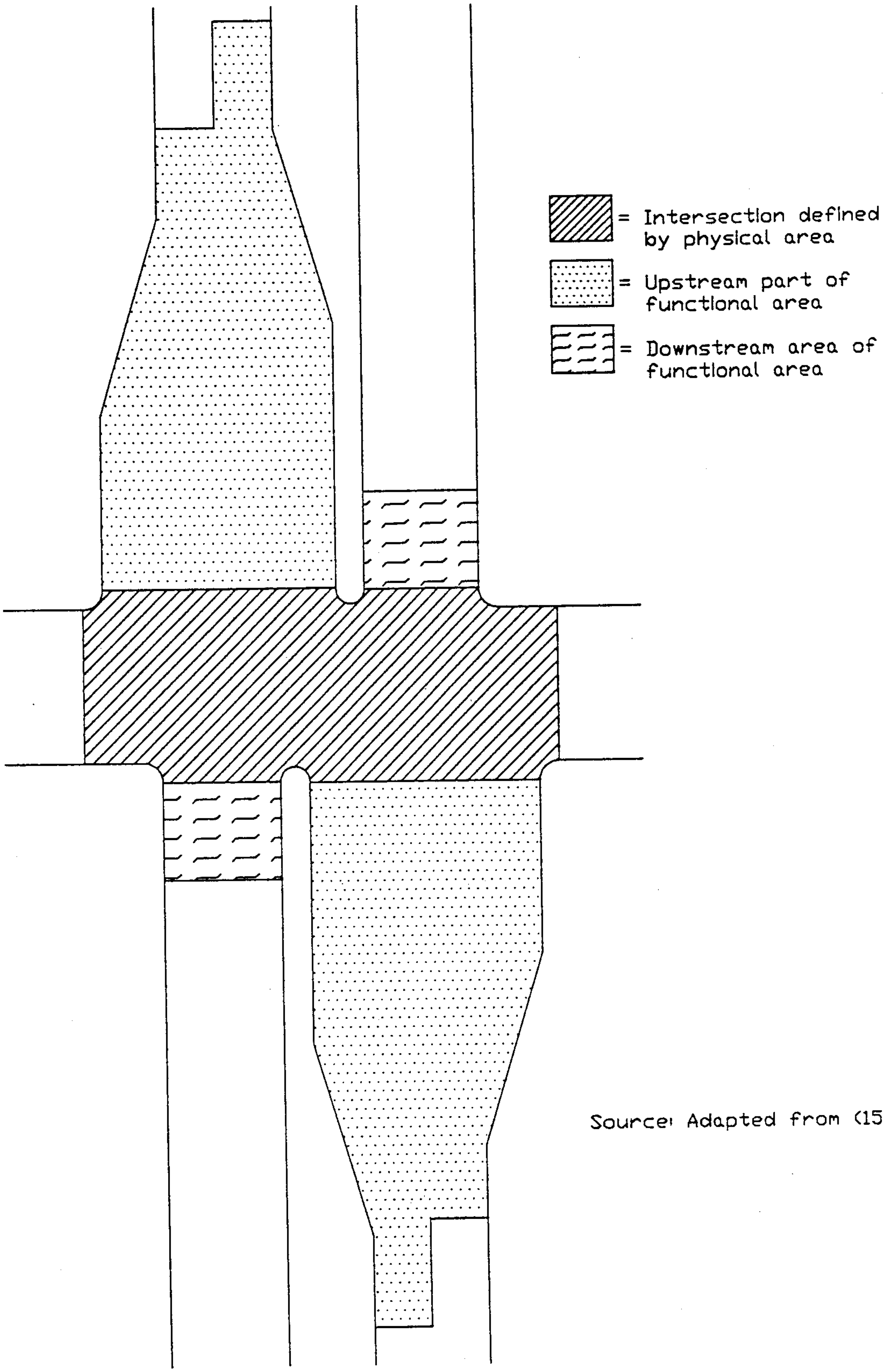
The functional area of an intersection consists of three parts:

1) the physical limits of the intersection;
2) an upstream area in which traffic operations are directly impacted by the intersection; and
3) a downstream area in which traffic operations are directly impacted by the intersection.

These three parts are shown graphically in Figure 4.4. The concept of "protecting the functional area of intersections" implies that no features (e.g., driveways, pedestrian crossings, other intersections, etc.) that adversely affect intersection operations would be permitted in the functional area.

The length of the upstream functional area is the sum of four parts:

1) The distance traveled by a vehicle during the perception-reaction (PIEV) time of the driver. This distance is denoted "d_1" in Figures 4.2 and 4.3 for left and right turns, respectively.



Source: Adapted from (15)

FIGURE 4.4 -- Functional Area of an Intersection

2) The distance traveled during the combined operations of partial braking and lane shifting ("d_2" in Figures 4.2 and 4.3.)
3) The distance traveled during full deceleration after the lane shift is completed ("d_3".)
4) The distance required for queue storage ("d_4".)

As implied by Figure 4.4, the sums of $d_1 + d_2 + d_3 + d_4$ for left and right turns at an intersection are not necessarily equal.

Typical lengths of the upstream functional area including d_1, d_2, and d_3 but excluding d_4 are given by Stover for various operating speeds:

	Lengths in Feet of Upstream Functional Area (less queue storage) (12)	
Speed (mph)	Desirable	Minimum
30	315	215
40	490	335
50	710	485
60	960	605

	Lengths in Meters of Upstream Functional Area (less queue storage) (12)	
Speed (kph)	Desirable	Minimum
40	70	45
60	140	85
80	210	140
100	305	205

The downstream functional area of an intersection "extends some distance downstream from the crosswalk location because of the need to (re)establish guidance and tracking after having passed through the (physical area of the intersection) in which there are no lane lines." (12) Unlike the rather straightforward method of determining the length of the upstream area, a single, accepted procedure for establishing the downstream length is not available. Stover suggests three procedures for defining the downstream distance and compares the distances suggested by each procedure:

Lengths in Feet of Downstream Functional Area by Three Procedures (12)

Speed (mph)	Stopping Sight Distance	Conflict Overlap	Left-turn Task
20	145	--	90
30	275	100	90
40	435	200	90
50	640	--	90
60	870	--	90

Lengths in Meters of Downstream Functional Area by Three Procedures (12)

Speed (kph)	Stopping Sight Distance	Conflict Overlap	Left-turn Task
30	40	--	30
40	70	--	30
60	120	70	30
80	190	--	30
100	280	--	30

The primary positive impact on pedestrians and bicycles is that protecting the functional area simplifies the driver's task at the intersection. The simplified driver's task allows the driver to focus more attention on any pedestrians and/or bicycle movements in the intersection area. The simplified driving task also tends to organize traffic flow so that pedestrians and bicycles are confronted with fewer unexpected vehicular actions.

Positive impacts on transit include:

1) The improved arterial flow due to protection of intersection functional areas facilitates transit vehicle operation and efficiency.

2) The positive impact on pedestrians served to benefit transit operations since transit users are pedestrians both before and after using the transit service.

A negative effect on pedestrians, bicycles and transit is that the protection of the functional area of intersections may increase travel distances, travel times and out-of-direction travel for those pedestrians and bicycles that are crossing the arterial.

4.10 Development of Local Road Infrastructure

The access management strategies associated with the development of local road infrastructure are similar to, but generally on a larger scale than, the strategies for interparcel and site circulation. Due to the variety of local road infrastructure layouts, the variability of local land use patterns and the almost endless combinations of local roads and land uses, there is also a nearly endless variety of specific treatments appropriate to specific local circumstances. It can be said though that those specific treatments generally fall into one or more of the following categories:

1) Providing a local roadway or network of roadways that effectively moves traffic away from the arterial after that traffic exits the arterial.
2) Providing a local roadway or network of roadways that effectively delivers vehicles to the arterial at locations where the vehicles can readily merge into the traffic flow without seriously disrupting operations on the arterial.
3) Providing alternate routes for local traffic moving within the corridor served by the arterial.

A number of positive impacts on both pedestrians and bicycles can be realized by the development of a local road infrastructure. Such impacts include:

1) The local road network can provide alternate routes that may be more pedestrian and bicycle-friendly.

2) An effective local road network can reduce the number of vehicles at accesses on the arterial thereby decreasing the frequency of pedestrian/vehicle and bicycle/vehicle conflicts at those accesses.
3) By removing local traffic from the arterial, the local road network can make the arterial less intimidating to pedestrians and bicycles.

The positive impacts on transit include:

1) The local road network can provide alternate routes for smaller transit vehicles.
2) Improved arterial flow due to an effective local road network facilitates transit vehicle operation and efficiency.
3) The positive impacts on pedestrians serve to help transit since transit users are pedestrians before and after using the transit service.

A potential negative effect on pedestrians, bicycles and transit of developing a local road infrastructure is that use of the local network generally places the pedestrian and bicycle further away from transit routes.

4.11 Combinations of More Than One Treatment

Sections 4.2 through 4.10 discuss impacts of various individual aspects of access management including such elements as driveways, medians, turn lanes, intersection areas and others. These discussions, in the context of a single access management feature, are valid and illustrative, but it is equally important to recognize that access management is typically applied as a system rather than as a set of independent treatments. Therefore, an examination of the impacts of the entire access management system is also necessary.

A positive impact of access management on pedestrians is that the reduced need for road widening leaves more room in the right-of-way for pedestrian facilities and more transportation funds to develop such facilities. An analogous impact benefits both bicycles and transit.

Other positive impacts on transit are:

1) Improved arterial flow due to access management as a whole facilitates transit vehicle operation and efficiency.
2) The positive impact on pedestrians serves to help transit since transit users are pedestrians before and after using the transit service.

Several negative impacts of the access management system have been suggested in the literature. These impacts affect pedestrians as well as bicycles. Transit is also negatively impacted due to the link between transit and pedestrian travel to and from the transit service. The suggested negative impacts include:

1) Access management as a whole may increase (in fact, it is designed to increase) traffic speeds and volumes on arterials.
2) Providing fewer local street crossings of arterials reduces pedestrian and bicycle travel choices and may increase out-of-direction travel.
3) Reduced access to roadside land uses may require out-of-direction travel.
4) Removal of on-street parking eliminates a buffer between vehicular lanes and pedestrian sidewalks.
5) Removal of local street connections to arterials decreases street "connectivity" and thereby increases pedestrian and bicycle travel distances and times. (This impact can be reduced by providing pedestrian and bicycle easements as shown in Figure 4.5.)

4.12 Summary of Suggested Impacts of Access Management

Tables 4.2 and 4.3, respectively, summarize the positive and negative impacts of access management on pedestrians, bicycles and transit.

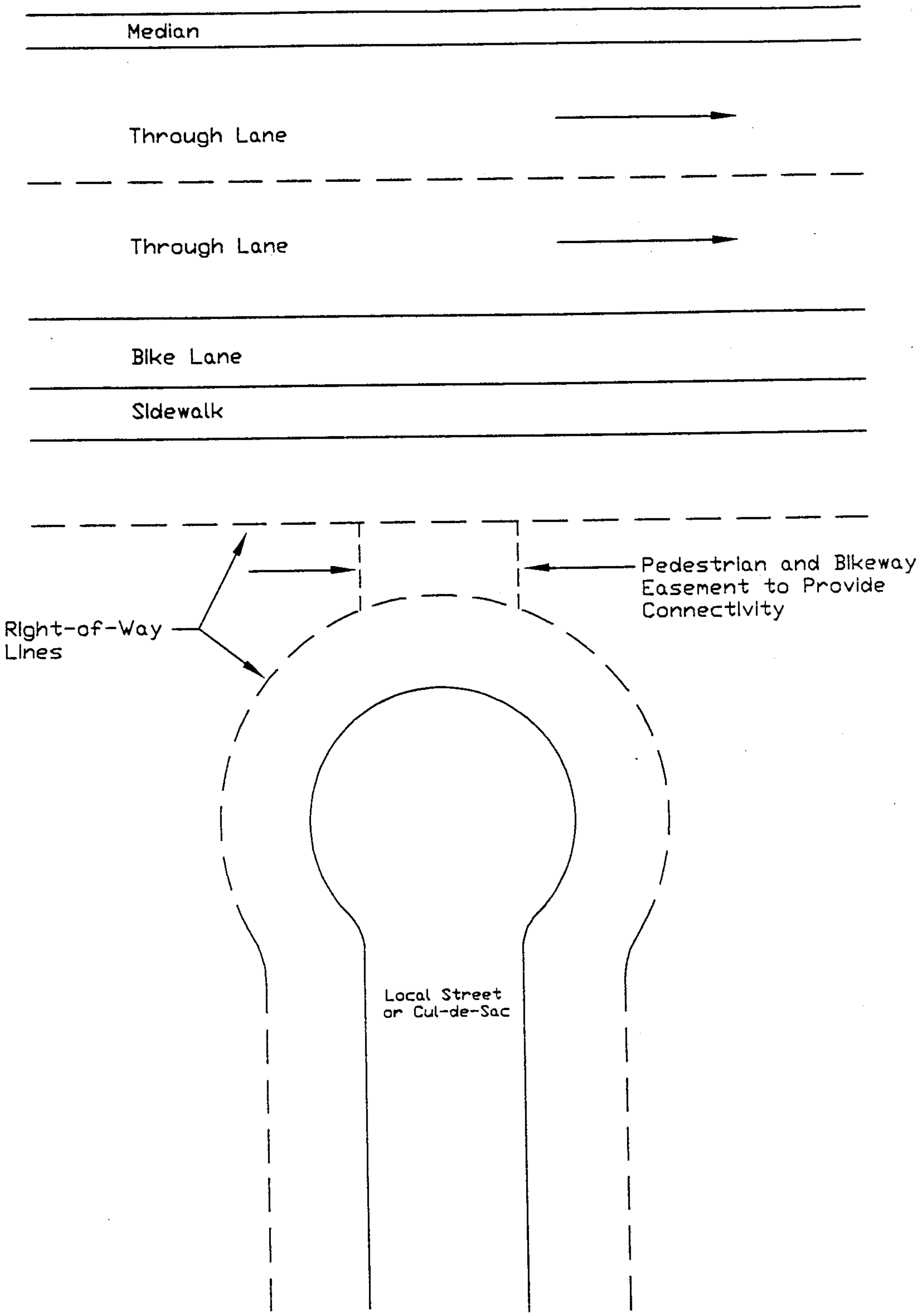


FIGURE 4.5 -- CONNECTIVITY THROUGH AN EASEMENT

	Pedestrians	Bicycles	Transit
Driveway Standards	*Fewer conflict points *Vehicles directed to intersections *Fewer obstacles to pedestrians with disabilities	*Fewer conflict points *Vehicles directed to intersections	*Improved arterial flow *Greater flexibility in placement of stops *Benefits to pedestrians who are transit users
Medians	*Provide refuge area *Separates street crossing into two movements	*Provide refuge area *Separates street crossing into two movements	*Improved arterial flow *Benefits to pedestrians who are transit users
Left Turn Lanes	*Traffic organized better at intersections *Reduced accident rate	*Left turn separation and protection *Traffic organized better at intersections	*Improved arterial flow *Benefits to pedestrians who are transit users
Right Turn Lanes	*Traffic organized better at intersections *Reduced vehicle speeds at driveways *Separation from through traffic	*Traffic organized better at intersections	*Improved arterial flow *Benefits to pedestrians who are transit users *Also serve as transit stop pull-out
Signal Spacing	N/A	*Fewer stops along arterial	*Improved arterial flow
Site Circulation	*Provides alternate travel route *Provides pedestrian-friendly designs *Reduces vehicular volumes at driveways	*Provides alternate travel route *Provides bike-friendly designs *Reduces vehicular volumes at driveways	*Improved arterial flow *Benefits to pedestrians who are transit users *On-site transit stops
Protection of Interchanges	N/A	N/A	*Improve arterial flow *Promotes intermodal facilities
Protection of Intersections	*Simplifies driver's task at intersections *Organizes traffic at intersections	*Simplifies driver's task at intersections *Organizes traffic at intersections	*Improve arterial flow *Benefits to pedestrians who are transit users
Local Road Infrastructure	*Alternate routes *Pedestrian-friendly routes *Reduces vehicular volumes at driveways *Reduces vehicular volumes on arterial	*Alternate routes *Bike-friendly routes *Reduces vehicular volumes at driveways *Reduces vehicular volumes on arterial	*Alternate routes for smaller transit vehicles *Improve arterial flow *Benefits to pedestrians who are transit users
Miscellaneous Impacts	*More room and funds for pedestrian facilities	*More room and funds for bike facilities	*More room and funds for transit facilities

TABLE 4.2 -- POSITIVE IMPACTS OF ACCESS MANAGEMENT TREATMENTS

	Pedestrians	**Bicycles**	**Transit**
Driveway Standards	*Increased activity at remaining driveways *Increased exposure area at driveways *Increased vehicular speeds at driveways	*Increased activity at remaining driveways *Increased exposure area at driveways *Increased vehicular speeds at driveways	*Detriments to pedestrians who are transit users
Medians	*May be non-traversable to pedestrians *Increased street crossing width	*May be non-traversable to bikes *Increased street crossing width	*Detriments to pedestrians who are transit users *Can reduce efficacy of midblock stops
Left Turn Lanes	*Increased street crossing width	*Increased street crossing width *Must cross traffic lanes to reach left turn lane	*Detriments to pedestrians who are transit users
Right Turn Lanes	*Increased street crossing width	*Increased street crossing width *Weaving conflicts with vehicles entering turn lane	*Detriments to pedestrians who are transit users
Signal Spacing	*Increased distance between protected crossings	*Increased distance between protected crossings	*Detriments to pedestrians who are transit users
Site Circulation	*Can place pedestrians further from transit stops	*Can place bikes further from transit stops	*Detriments to pedestrians who are transit users
Protection of Interchanges	*May force out-of-direction travel	*May force out-of-direction travel	*Detriments to pedestrians who are transit users
Protection of Intersections	*May force out-of-direction travel	*May force out-of-direction travel	*Detriments to pedestrians who are transit users
Local Road Infrastructure	*Can place pedestrians further from transit stops	*Can place bikes further from transit stops	*Detriments to pedestrians who are transit users
Miscellaneous Impacts	*Increased vehicular volumes and speeds *Reduced travel route choices *Increased out-of-direction travel *Removes buffer of on-street parking *Reduces street connectivity	*Increased vehicular volumes and speeds *Reduced travel route choices *Increased out-of-direction travel *Removes buffer of on-street parking *Reduces street connectivity	*Detriments to pedestrians who are transit users

TABLE 4.3 -- NEGATIVE IMPACTS OF ACCESS MANAGEMENT TREATMENTS

5. FIELD DATA COLLECTION METHODOLOGY

5.1 Speed Measurements

One of the major data collection efforts of this study involves the measurement of vehicular speeds. All speed data collected were obtained using a Decatur Electronics Range Master Model No. RM715 radar gun. To verify the accuracy of the radar gun, its calibration was checked for vehicle speeds of less than 25 miles per hour (40 kilometers per hour). The calibration procedure used english units and the following steps:

1) A 100-foot long segment within a flat, straight section of roadway was measured and marked.
2) A vehicle was driven over the 100-foot segment at a constant speed. In all trials, the vehicle began far enough upstream of the 100-foot segment so that all acceleration or deceleration was accomplished prior to the 100-foot segment. The driver of the vehicle was given a sequence of target speeds for all trials. The target speeds were randomly selected from 1 to 25 miles per hour. ,
3). The speed of the vehicle was measured with the radar gun at approximately the midpoint of the 100-foot segment.
4) The travel time of the vehicle over the 100-foot segment was measured using a Synchrotimer X-3000 stopwatch.
5) For all trials vehicular speed as measured by the radar gun was compared to vehicular speed as calculated from travel times.

A plot of "gun speed" (measured by the radar gun) versus "timed speed" is shown in Figure 5.1. A linear regression analysis of the data with the intercept held at zero was computed and is also shown in the figure. According to this computation, the radar gun measurements are within 1.8% of the time measurements. For the linear regression $R^2 = 0.9858$.

Based on the results of the calibration procedure, speed measurements obtained with this radar gun can be used with confidence.

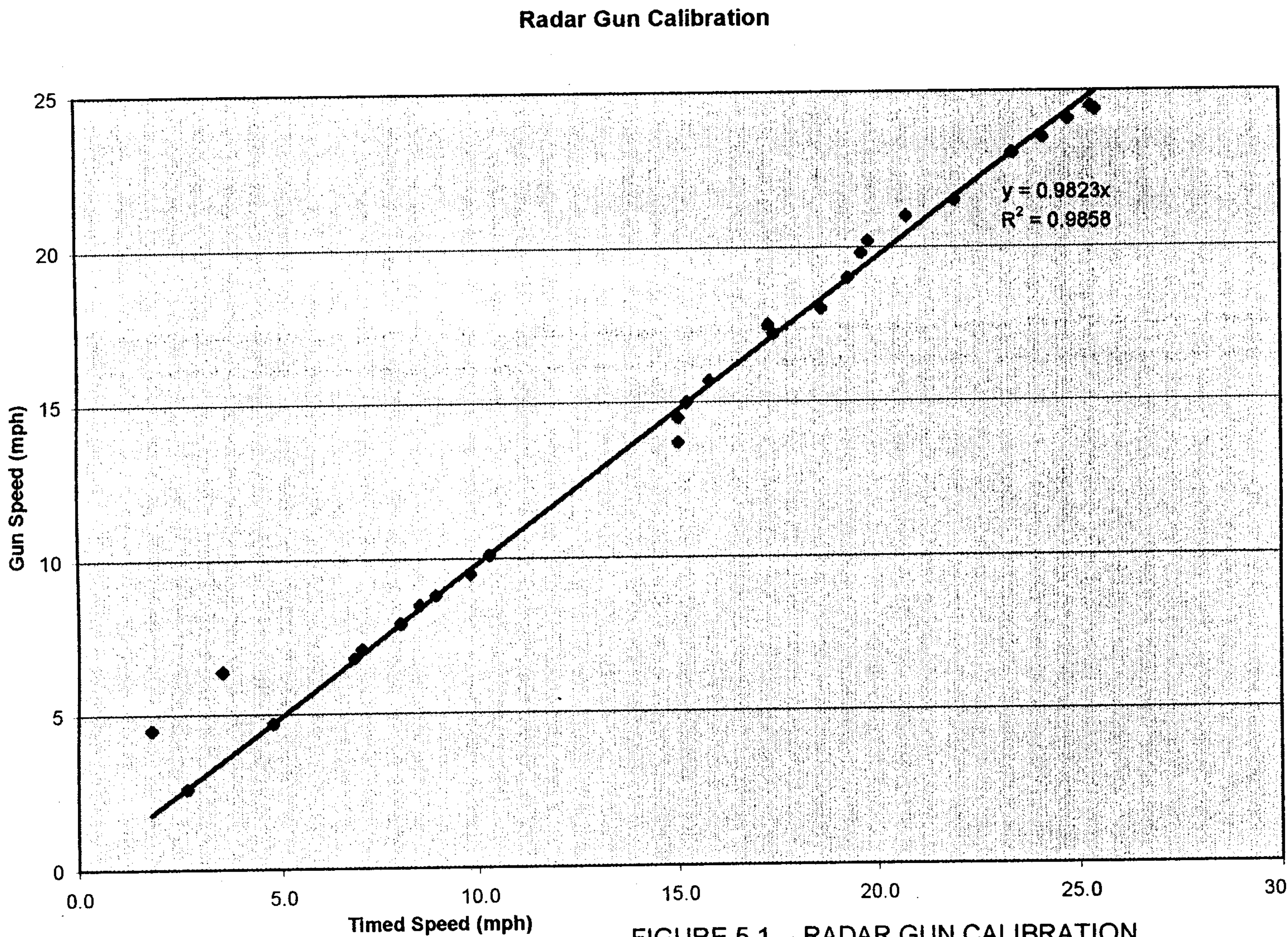


FIGURE 5.1 -- RADAR GUN CALIBRATION

5.2 Pedestrian Location Terminology

Section 6 presents field data on observed vehicular speeds at driveways at eight different locations. At the various sites the data consist of speeds for both left and right turns into the driveways. Speeds were measured with no pedestrian present, with a "near side" pedestrian present and/or with a "far side" pedestrian present. Figure 5.2 explains the meaning of "near side" and far side" pedestrian locations.

5.3 "Real" Versus "Planted" Pedestrians and Bicycles

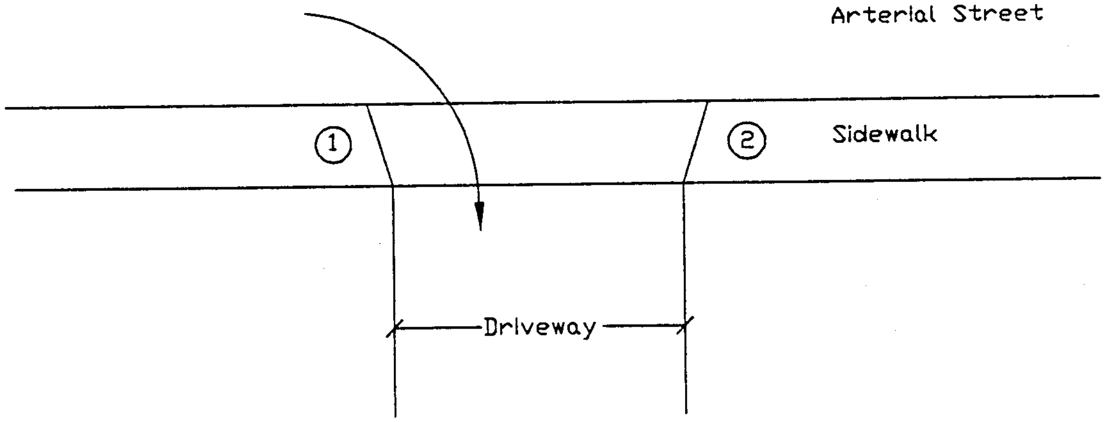
In order to reduce the possibility of researcher bias, it would be preferred to collect data using pedestrians and bicycles that randomly arrive at the locations under observation. However, at the locations studied such "real" pedestrians and bicycles are quite rare.

Driveway operations were videotaped at four of the eight sites described in Section 6. Pedestrian and bicycle activity at these four driveways is summarized below:

Site #	Hours of Videotape	# of Pedestrians	# of Bicycles
1	1.97	5	5
2	0.89	1	2
4	0.50	3	2
6	0.50	1	3
Totals	3.86	10	12

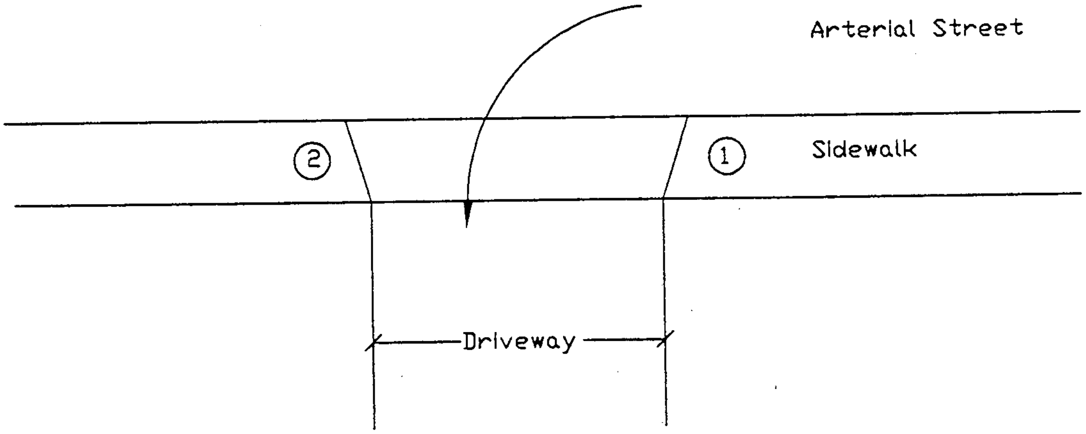
For these four sites (covering 3 of the 4 cities where pedestrian data were collected) the average rates at which "real" pedestrians and "real" bicycles appeared were 2.6 pedestrians per hour and 3.1 bicycles per hour. None of the 10 "real" pedestrians resulted in an observable pedestrian-vehicle interaction. A very optimistic estimate of useable interactions might then be one observation for each 5 "real" pedestrians. One would then expect to obtain a useable pedestrian data point every 1.92 hours.

TYPICAL TURNING MOVEMENTS
AND PEDESTRIAN LOCATION TERMINOLOGY



① This pedestrian location is 'near side'
② This pedestrian location is 'far side'

TYPICAL RIGHT TURN



① This pedestrian location is 'near side'
② This pedestrian location is 'far side'

TYPICAL LEFT TURN

FIGURE 5.2 -- Pedestrian Location Terminology

At sites 1 through 8 data from a total of 310 pedestrian-vehicle interactions at driveways was recorded. If only "real" pedestrians were used, an estimate of the time to collect the data at sites 1 through 8 is therefore 595 hours or nearly 15 weeks at 40 hours per week.

Such an investment of time for collection of this data is not feasible, so the use of "planted" pedestrians is warranted. A similar argument justifies the use of "planted" bicycles. Therefore, to expedite this study, various researchers assumed the role of pedestrians and bicycles at the locations studied.

6. FIELD DATA ON PEDESTRIAN AND VEHICLE INTERACTIONS AT DRIVEWAYS

6.1 Introduction

Data were collected at eight sites in four different cities in the Willamette Valley of Oregon. The data consist of the measured speeds of vehicles as they entered the driveways at the eight sites. Unless noted otherwise, speeds were measured when the vehicle was approximately halfway through the turning maneuver. That is, speeds were measured when the vehicles were at an angle of approximately 45 degrees from the alignment of the street.

The eight sites where speed data were collected are:

Site #	City	Street	Approximate Location
1	Corvallis	Circle Boulevard	1140’ (350 m) west of 9th Street
2	Salem	Lancaster Drive	at D-Street
3	Salem	Lancaster Drive	390’ (120 m) south of Market Street
4	Salem	Lancaster Drive	at Glendale Street
5	Salem	Lancaster Drive	435’ (135 m) north of Center Street
6	Eugene	Coburg Road	420’ (130 m) north of Cal Young Road
7	Albany	Clay Street	450’ (135 m) north of 14th Avenue
8	Albany	Geary Street	390’ (120 m) north of 14th Avenue

6.2 Site Layouts

Figures 6.1 through 6.8 show in schematic form the geometric layouts of the eight driveway sites. Each figure includes:

1) A plan view showing relationships between the driveway, sidewalks and traffic lanes on the street.
2) A profile of the driveway showing the change in vertical grade encountered by a vehicle as it travels from the crowned street to the sloped driveway.
3) A depiction of the turning movement(s) for which data were collected at each site.

6.3 Data at Each Site

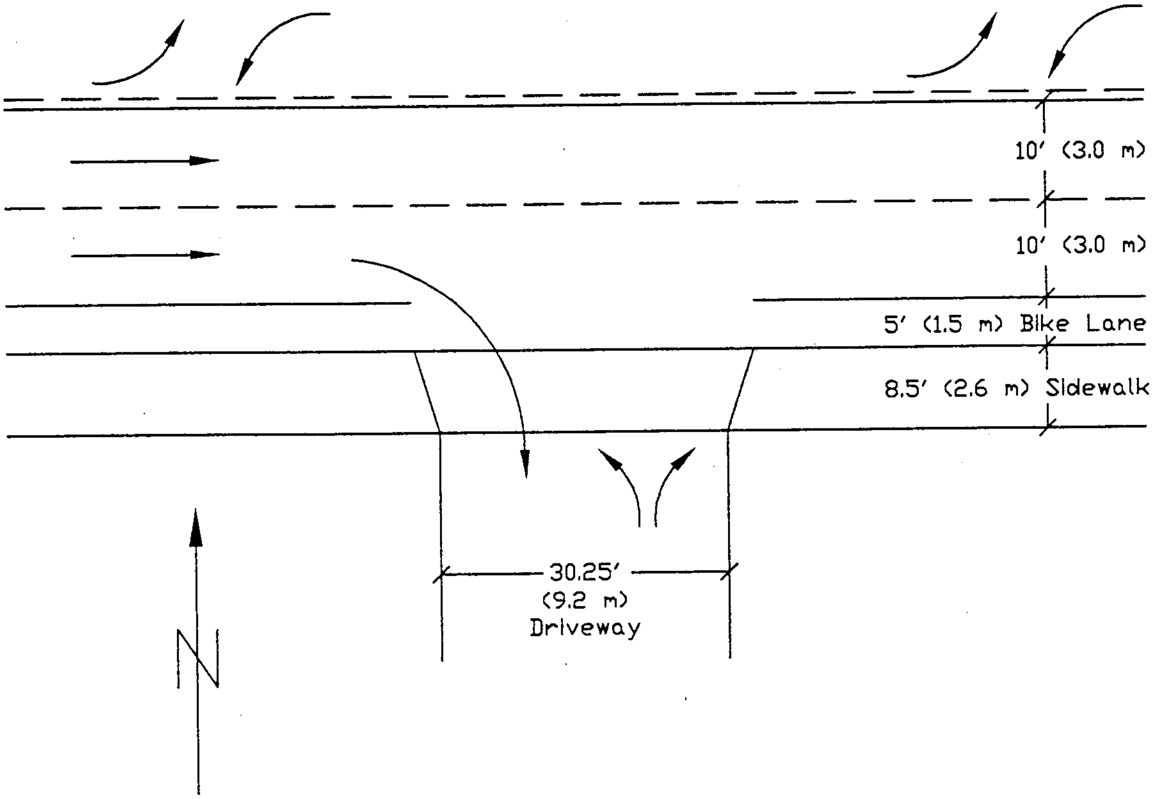
Tables 6.1 through 6.8 summarize the data and provide summaries of statistical findings. Statistical analysis consisted of comparing average vehicular speeds with and without a pedestrian present. For each site and each turning movement analyzed, the statistical analysis addressed the following, general "Null Hypothesis":

> H_0: There is no difference in the average speeds of vehicles entering the driveway when a pedestrian is present as compared to when no pedestrian is present.

The p-values that are reported in the tables represent the probability that, assuming the Null Hypothesis is true, the observed differences in average speeds are the result of random sampling error.

Site 1
Corvallis, OR on Circle Blvd.
Approximately 1140′ (350 m) west of 9th Street
EB Vehicles Turning Right Into Driveway

Plan View



Driveway Profile

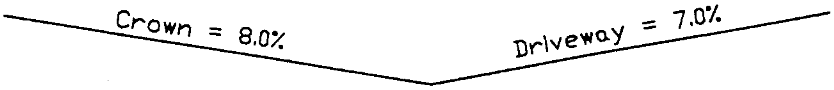


FIGURE 6.1 -- Site 1 Layout

Site 1
Corvallis, OR
Circle Boulevard
1140' (350 m) West of 9th Street

Driveway Type:	Dustpan
EB Through Traffic:	340 vehicles per hour
EB Right Turns:	76 vehicles per hour
Posted Speed Limit:	35 miles per hour (56 kph)

Speed data for EB vehicles turning right into the driveway:

	English Units		
Pedestrian Location:	None	Far Side	Near Side
Data Points	25	20	23
Minimum Observed Speed (mph)	5.8	1.0	4.1
Maximum Observed Speed (mph)	13.3	11.8	13.7
Average Observed Speed (mph)	9.4	8.6	10.2
Standard Deviation (mph)	1.68	2.65	2.70
Standard Error of the Average (mph)	0.34	0.59	0.56

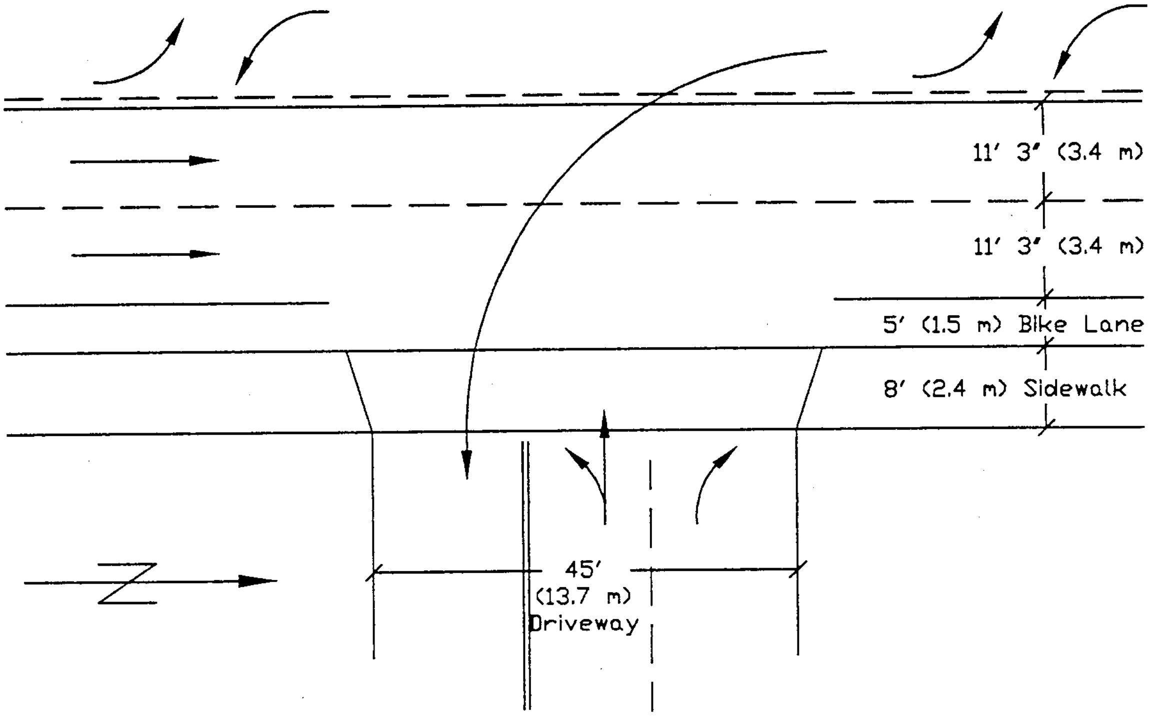
	Metric Units		
Pedestrian Location:	None	Far Side	Near Side
Data Points	25	20	23
Minimum Observed Speed (kph)	9.3	1.6	6.6
Maximum Observed Speed (kph)	21.4	19.0	22.0
Average Observed Speed (kph)	15.1	13.8	16.4
Standard Deviation (kph)	2.70	4.26	4.35
Standard Error of the Average (kph)	0.55	0.95	0.90

Summary of Statistical Findings: These data provide no evidence of a difference in average speeds for the "no pedestrian" versus the "far-side pedestrian" cases (2-sided p-value for a test of difference in means = 0.26). These data provide no evidence of a difference in average speeds for the "no pedestrian" versus the "near-side pedestrian" cases (2-sided p-value = 0.24).

Table 6.1 – Site 1 Data

Site 2
Salem, OR on Lancaster Drive
(at D-Street)
SB Vehicles Turning Left into Driveway

Plan View



Driveway Profile

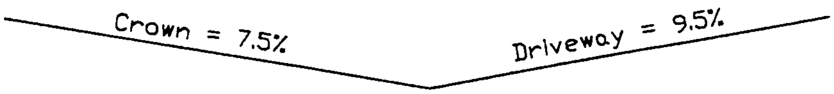


FIGURE 6.2 -- Site 2 Layout

Site 2
Salem, OR
Lancaster Drive
(at D-Street)

Driveway Type:	Dustpan
SB Through Traffic:	1156 vehicles per hour
SB Left Turns:	28 vehicles per hour
Posted Speed Limit:	35 miles per hour (56 kph)

Speed data for SB vehicles turning left into the driveway:

	English Units	
Pedestrian Location:	None	Far Side
Data Points	18	18
Minimum Observed Speed (mph)	3.9	6.3
Maximum Observed Speed (mph)	11.3	13.4
Average Observed Speed (mph)	6.8	9.1
Standard Deviation (mph)	2.15	2.18
Standard Error of the Average (mph)	0.51	0.51

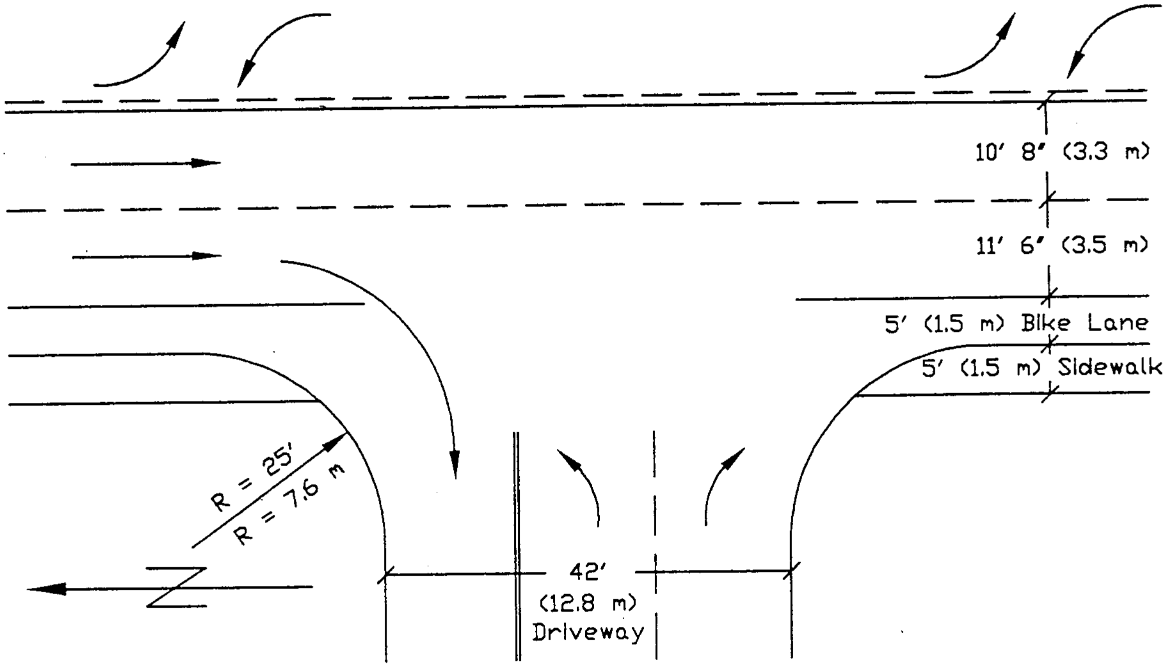
	Metric Units	
Pedestrian Location:	None	Far Side
Data Points	18	18
Minimum Observed Speed (kph)	6.3	10.1
Maximum Observed Speed (kph)	18.2	21.6
Average Observed Speed (kph)	10.9	14.6
Standard Deviation (kph)	3.46	3.51
Standard Error of the Average (kph)	0.82	0.82

Summary of Statistical Findings: These data provide strong evidence of a difference in average speeds for the "no pedestrian" versus the "far-side pedestrian" cases (2-sided p-value for a test of difference in means = 0.003). The 95% confidence interval for the difference in average speeds is 0.8 mph (1.3 kph) to 3.8 mph (6.1 kph) faster with a far-side pedestrian present.

Table 6.2 – Site 2 Data

Site 3
Salem, OR on Lancaster Drive
Approximately 390' (120 m) south of Market Street
SB Vehicles Turning Right Into Driveway

Plan View



Driveway Profile

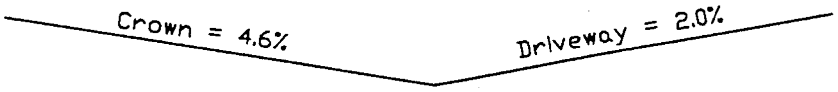


FIGURE 6.3 -- Site 3 Layout

Site 3
Salem, OR
Lancaster Drive
390' (120 m) South of Market Street

Driveway Type:	Curb Return
SB Through Traffic:	Not Measured
SB Right Turns:	93 vehicles per hour
Posted Speed Limit:	35 miles per hour (56 kph)

Speed data for SB vehicles turning right into the driveway:

	English Units	
Pedestrian Location:	None	Near Side
Data Points	21	20
Minimum Observed Speed (mph)	9.9	7.4
Maximum Observed Speed (mph)	14.8	15.1
Average Observed Speed (mph)	12.8	11.4
Standard Deviation (mph)	1.36	2.34
Standard Error of the Average (mph)	0.30	0.52

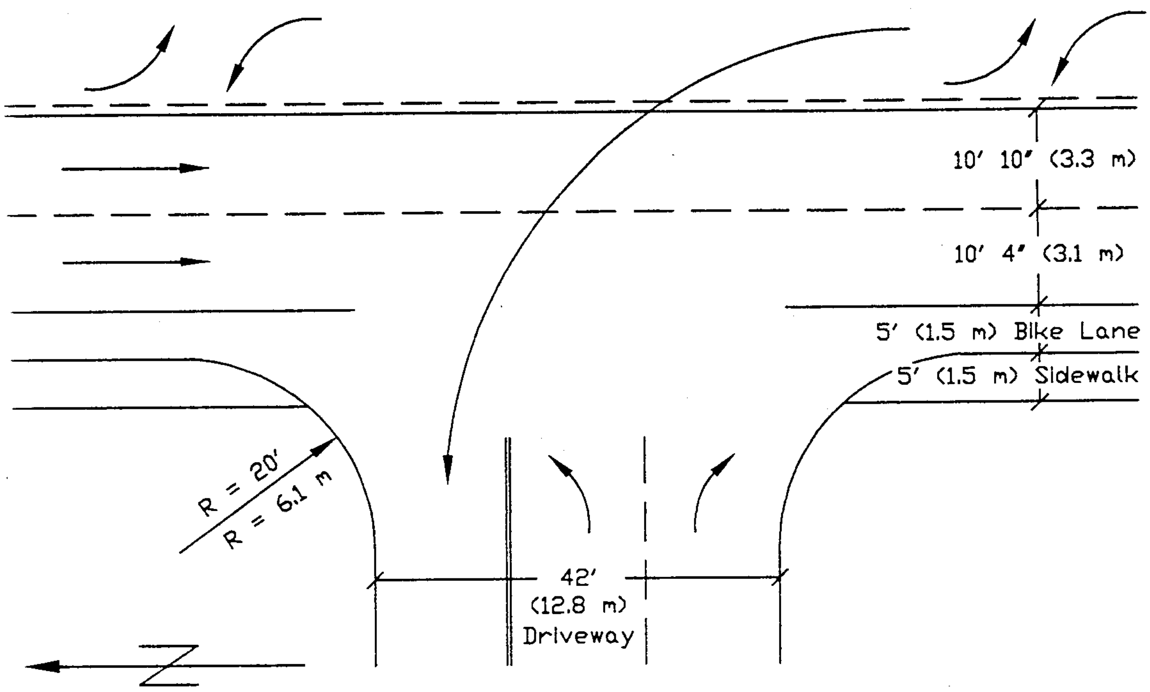
	Metric Units	
Pedestrian Location:	None	Near Side
Data Points	21	20
Minimum Observed Speed (kph)	15.9	11.9
Maximum Observed Speed (kph)	23.8	24.3
Average Observed Speed (kph)	20.6	18.3
Standard Deviation (kph)	2.19	3.77
Standard Error of the Average (kph)	0.48	0.84

Summary of Statistical Findings: These data provide suggestive evidence of a difference in average speeds for the "no pedestrian" versus the "near-side pedestrian" cases (2-sided p-value for a test of difference in means = 0.024). The 95% confidence interval for the difference in average speeds is 0.2 mph (0.3 kph) to 2.6 mph (4.2 kph) slower with a near-side pedestrian present.

Table 6.3 – Site 3 Data

Site 4
Salem, OR on Lancaster Drive
(at Glendale Street)
NB Vehicles Turning Left Into Driveway

Plan View



Driveway Profile

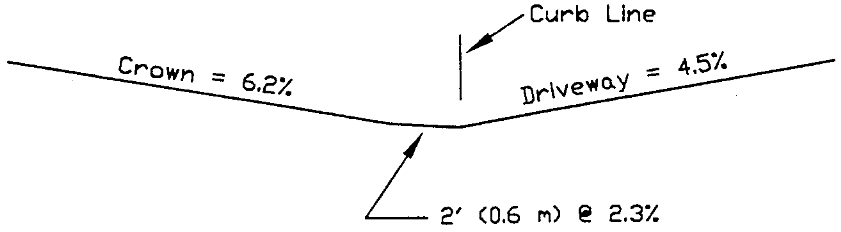


FIGURE 6.4 -- Site 4 Layout

Site 4
Salem, OR
Lancaster Drive
(at Glendale Street)

Driveway Type:	Curb Return
NB Through Traffic:	1020 vehicles per hour
NB Right Turns:	88 vehicles per hour
Posted Speed Limit:	35 miles per hour (56 kph)

Speed data for NB vehicles turning left into the driveway:

	English Units		
Pedestrian Location:	None	Far Side	Near Side
Data Points	22	20	24
Minimum Observed Speed (mph)	7.1	8.3	7.6
Maximum Observed Speed (mph)	14.7	13.9	16.4
Average Observed Speed (mph)	11.9	11.4	12.1
Standard Deviation (mph)	2.14	1.49	1.90
Standard Error of the Average (mph)	0.46	0.33	0.39

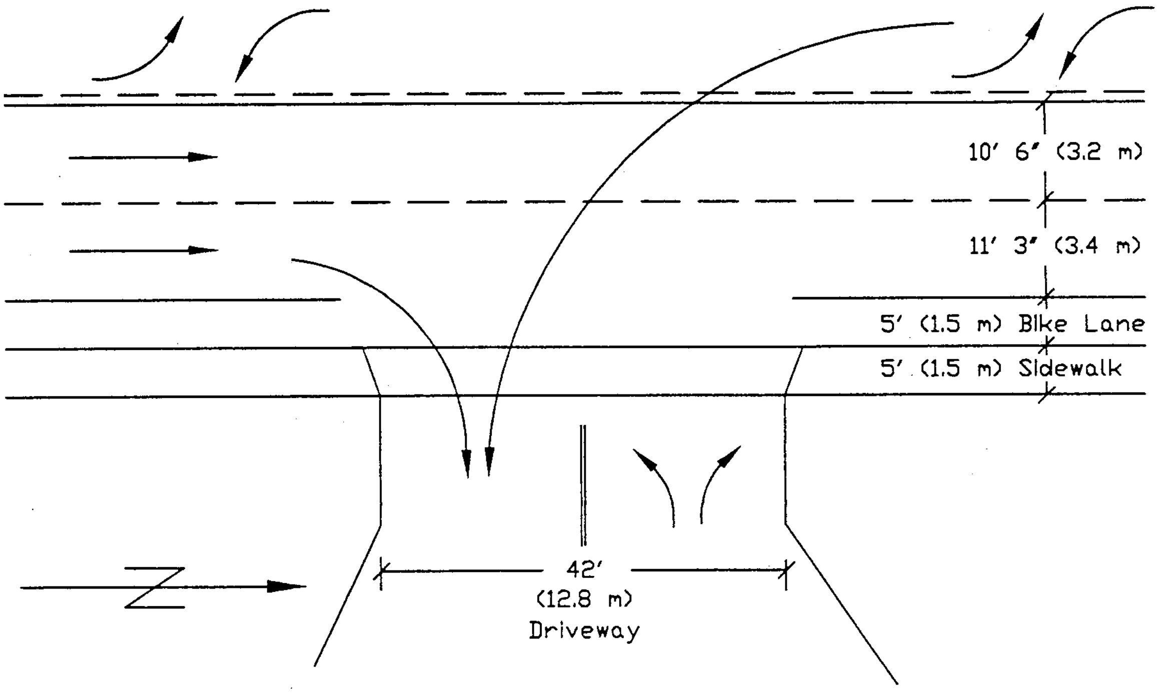
	Metric Units		
Pedestrian Location:	None	Far Side	Near Side
Data Points	22	20	24
Minimum Observed Speed (kph)	11.4	13.4	12.2
Maximum Observed Speed (kph)	23.7	22.4	26.4
Average Observed Speed (kph)	19.2	18.3	19.5
Standard Deviation (kph)	3.44	2.40	3.06
Standard Error of the Average (kph)	0.74	0.53	0.63

Summary of Statistical Findings: These data provide no evidence of a difference in average speeds for the “no pedestrian” versus the “far-side pedestrian” cases (2-sided p-value for a test of difference in means = 0.39). These data provide no evidence of a difference in average speeds for the “no pedestrian” versus the “near-side pedestrian” cases (2-sided p-value = 0.72).

Table 6.4 – Site 4 Data

Site 5
Salem, OR on Lancaster Drive
Approximately 435′ (135 m) north of Center Street
NB Vehicles Turning Right Into Driveway
SB Vehicles Turning Left Into Driveway

Plan View



Driveway Profile

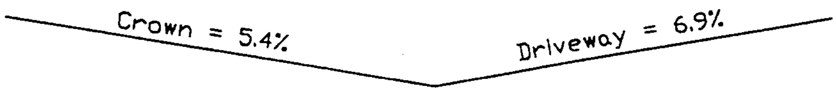


FIGURE 6.5 -- Site 5 Layout

Site 5
Salem, OR
Lancaster Drive
435' (135 m) North of Center Street

Driveway Type:	Dustpan
NB Through Traffic:	Not Measured
NB Right Turns:	64 vehicles per hour
Posted Speed Limit:	35 miles per hour (56 kph)

Speed data for NB vehicles turning right into the driveway:

		English Units	
Pedestrian Location:	None	Far Side	Near Side
Data Points	23	25	26
Minimum Observed Speed (mph)	5.0	4.3	5.0
Maximum Observed Speed (mph)	10.7	8.2	9.7
Average Observed Speed (mph)	7.0	6.6	6.7
Standard Deviation (mph)	1.44	0.94	1.16
Standard Error of the Average (mph)	0.30	0.19	0.23

		Metric Units	
Pedestrian Location:	None	Far Side	Near Side
Data Points	23	25	26
Minimum Observed Speed (kph)	8.0	6.9	8.0
Maximum Observed Speed (kph)	17.2	13.2	15.6
Average Observed Speed (kph)	11.3	10.6	10.8
Standard Deviation (kph)	2.32	1.51	1.87
Standard Error of the Average (kph)	0.48	0.31	0.37

Summary of Statistical Findings: These data provide no evidence of a difference in average speeds for the "no pedestrian" versus the "far-side pedestrian" cases (2-sided p-value for a test of difference in means = 0.25). These data provide no evidence of a difference in average speeds for the "no pedestrian" versus the "near-side pedestrian" cases (2-sided p-value = 0.38).

Table 6.5a – Site 5 Data

Site 5
Salem, OR
Lancaster Drive
435' (135 m) north of Center Street

Driveway Type:	Dustpan
SB Through Traffic:	Not Measured
SB Left Turns:	36 vehicles per hour
Posted Speed Limit:	35 miles per hour (56 kph)

Speed data for SB vehicles turning left into the driveway:

	English Units		
Pedestrian Location:	None	Far Side	Near Side
Data Points	16	15	14
Minimum Observed Speed (mph)	4.9	4.4	5.1
Maximum Observed Speed (mph)	9.9	10.0	9.7
Average Observed Speed (mph)	7.2	7.9	8.0
Standard Deviation (mph)	1.72	1.56	1.29
Standard Error of the Average (mph)	0.43	0.40	0.34

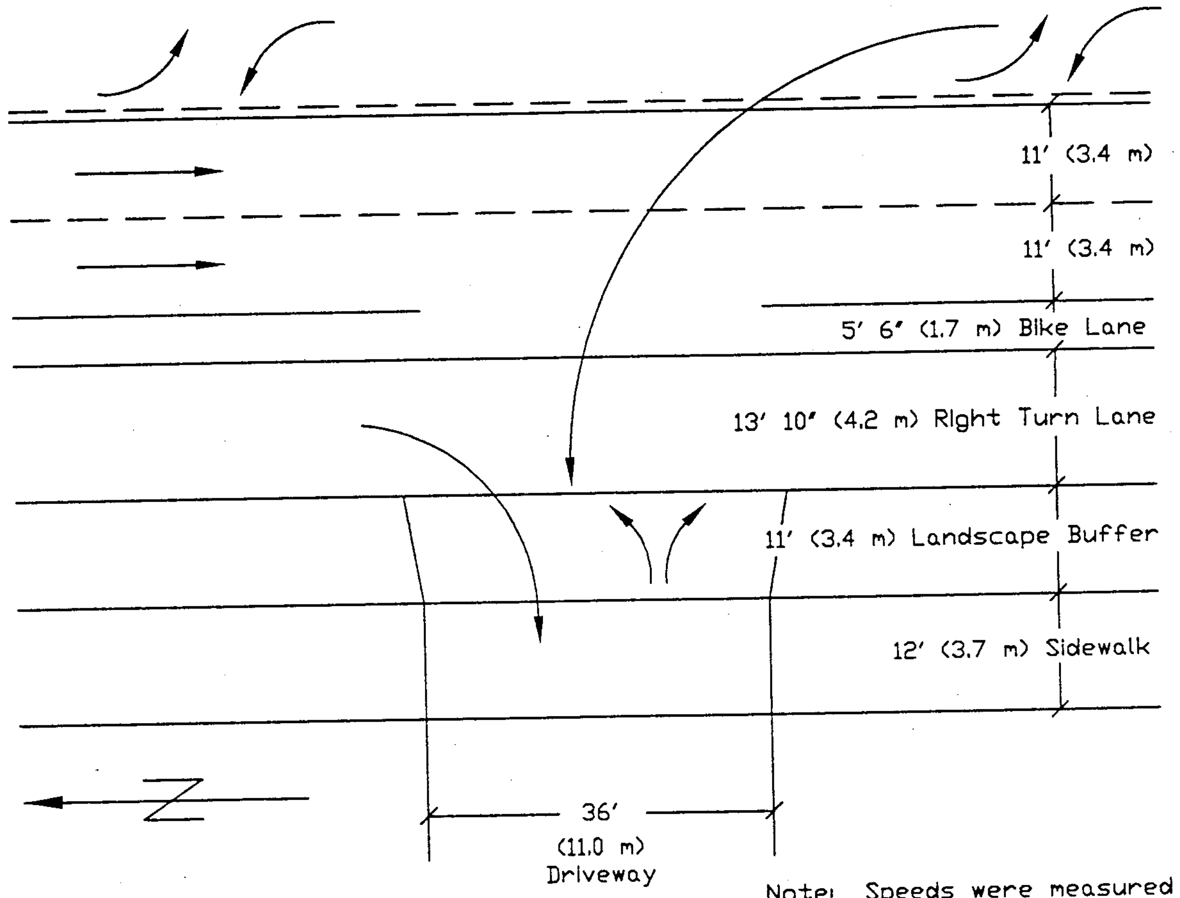
	Metric Units		
Pedestrian Location:	None	Far Side	Near Side
Data Points	16	15	14
Minimum Observed Speed (kph)	7.9	7.1	8.2
Maximum Observed Speed (kph)	15.9	16.1	15.6
Average Observed Speed (kph)	11.6	12.7	12.9
Standard Deviation (kph)	2.77	2.51	2.08
Standard Error of the Average (kph)	0.69	0.64	0.55

Summary of Statistical Findings: These data provide no evidence of a difference in average speeds for the "no pedestrian" versus the "far-side pedestrian" cases (2-sided p-value for a test of difference in means = 0.21). These data provide no evidence of a difference in average speeds for the "no pedestrian" versus the "near-side pedestrian" cases (2-sided p-value = 0.16).

Table 6.5b – Site 5 Data

Site 6
Eugene, OR on Coburg Road
Approximately 420' (130 m) north of Cal Young Road
SB Vehicles Turning Right Into Driveway and
NB Vehicles Turning Left Into Driveway

Plan View



Note: Speeds were measured as the vehicles crossed the sidewalk.

Driveway Profile

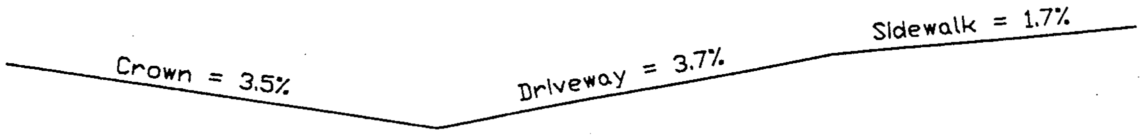


FIGURE 6.6 -- Site 6 Layout

Site 6
Eugene, OR
Coburg Road
420' (130 m) north of Cal Young Road

Driveway Type:	Dustpan
SB Through Traffic:	696 vehicles per hour
SB Right Turns:	40 vehicles per hour
Posted Speed Limit:	35 miles per hour (56 kph)

Speed data for SB vehicles turning right into the driveway:

	English Units	
Pedestrian Location:	None	Near Side
Data Points	24	29
Minimum Observed Speed (mph)	4.1	3.6
Maximum Observed Speed (mph)	13.2	12.0
Average Observed Speed (mph)	7.2	6.8
Standard Deviation (mph)	1.97	1.51
Standard Error of the Average (mph)	0.40	0.28

	Metric Units	
Pedestrian Location:	None	Near Side
Data Points	24	29
Minimum Observed Speed (kph)	6.6	5.8
Maximum Observed Speed (kph)	21.2	19.3
Average Observed Speed (kph)	11.6	10.9
Standard Deviation (kph)	3.17	2.43
Standard Error of the Average (kph)	0.64	0.45

Summary of Statistical Findings: These data provide no evidence of a difference in average speeds for the "no pedestrian" versus the "near-side pedestrian" cases (2-sided p-value for a test of difference in means = 0.41).

Table 6.6a – Site 6 Data

Site 6
Eugene, OR
Coburg Road
420' (130 m) north of Cal Young Road

Driveway Type:	Dustpan
NB Through Traffic:	784 vehicles per hour
NB Left Turns:	20 vehicles per hour
Posted Speed Limit:	35 miles per hour (56 kph)

Speed data for NB vehicles turning left into the driveway:

	English Units	
Pedestrian Location:	None	Far Side
Data Points	27	25
Minimum Observed Speed (mph)	6.7	5.5
Maximum Observed Speed (mph)	16.9	13.8
Average Observed Speed (mph)	10.6	10.0
Standard Deviation (mph)	2.36	2.37
Standard Error of the Average (mph)	0.45	0.47

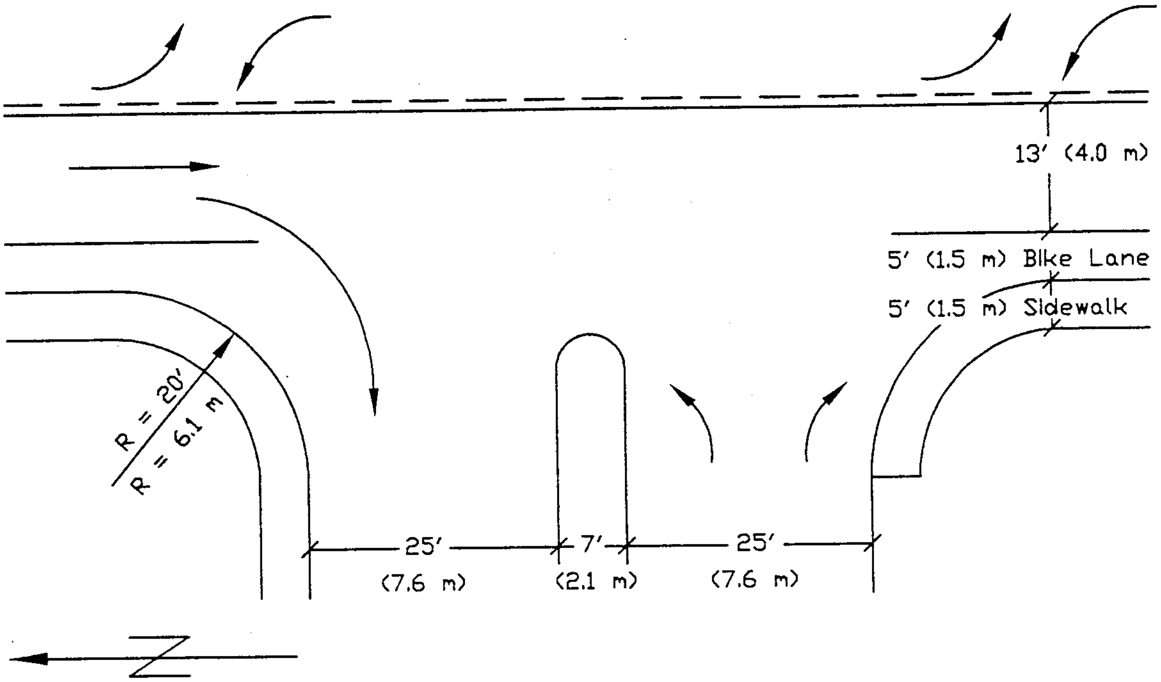
	Metric Units	
Pedestrian Location:	None	Far Side
Data Points	27	25
Minimum Observed Speed (kph)	10.8	8.9
Maximum Observed Speed (kph)	27.2	22.2
Average Observed Speed (kph)	17.1	16.1
Standard Deviation (kph)	3.80	3.81
Standard Error of the Average (kph)	0.72	0.76

Summary of Statistical Findings: These data provide no evidence of a difference in average speeds for the "no pedestrian" versus the "far-side pedestrian" cases (2-sided p-value for a test of difference in means = 0.37).

Table 6.6b – Site 6 Data

Site 7
Albany, OR on Clay Street
Approximately 450′ (135 m) north of 14th Avenue
SB Vehicles Turning Right Into Driveway

Plan View



Driveway Profile

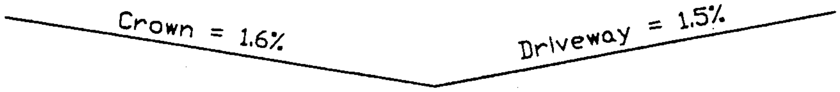


FIGURE 6.7 -- Site 7 Layout

Site 7
Albany, OR
Clay Street
450' (135 m) North of 14th Avenue

Driveway Type:	Curb Return
SB Through Traffic:	308 vehicles per hour
SB Right Turns:	140 vehicles per hour
Posted Speed Limit:	35 miles per hour (56 kph)

Speed data for SB vehicles turning right into the driveway:

	English Units	
Pedestrian Location:	None	Near Side
Data Points	36	30
Minimum Observed Speed (mph)	7.7	6.3
Maximum Observed Speed (mph)	16.9	15.3
Average Observed Speed (mph)	11.1	10.7
Standard Deviation (mph)	1.89	1.69
Standard Error of the Average (mph)	0.32	0.31

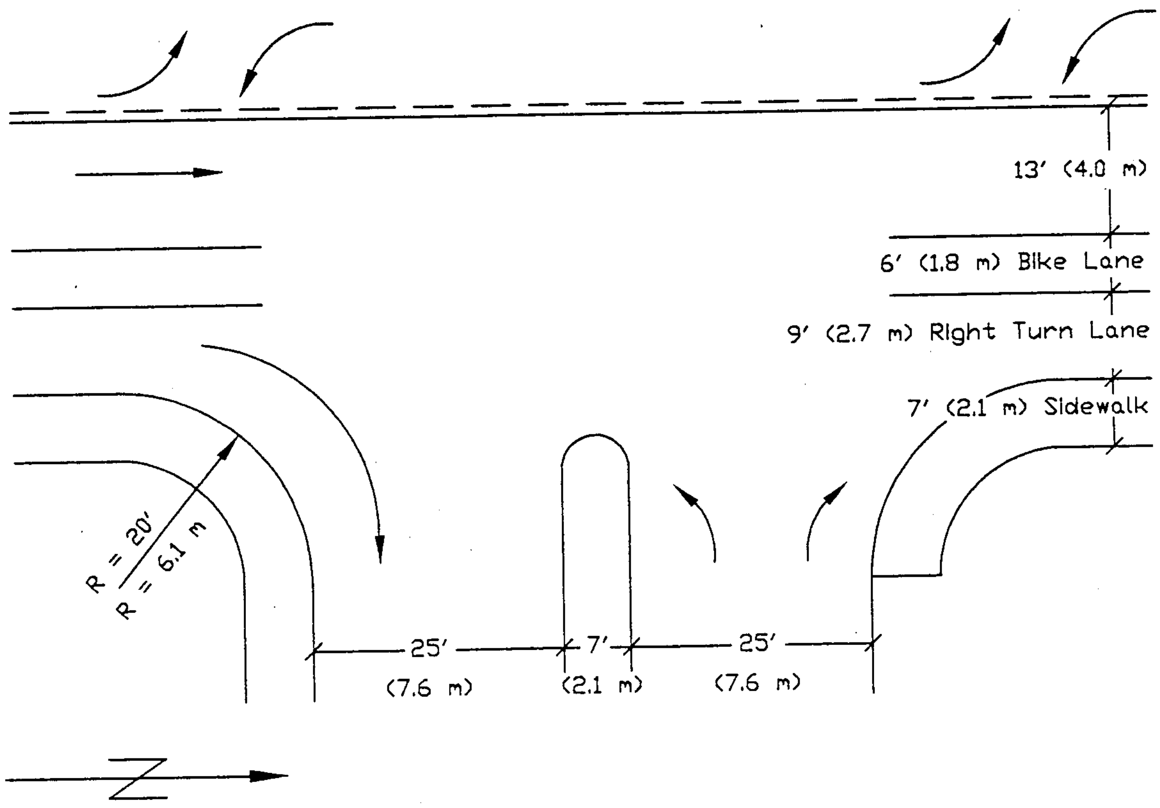
	Metric Units	
Pedestrian Location:	None	Near Side
Data Points	36	30
Minimum Observed Speed (kph)	12.4	10.1
Maximum Observed Speed (kph)	27.2	24.6
Average Observed Speed (kph)	17.9	17.2
Standard Deviation (kph)	3.04	2.72
Standard Error of the Average (kph)	0.51	0.50

Summary of Statistical Findings: These data provide no evidence of a difference in average speeds for the "no pedestrian" versus the "near-side pedestrian" cases (2-sided p-value for a test of difference in means = 0.36).

Table 6.7 – Site 7 Data

Site 8
Albany, OR on Geary Street
Approximately 390′ (120 m) north of 14th Avenue
NB Vehicles Turning Right Into Driveway

Plan View



Driveway Profile

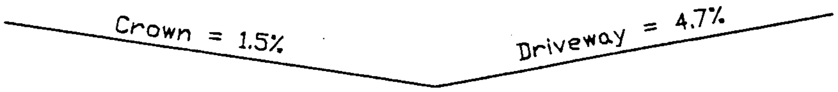


FIGURE 6.8 -- Site 8 Layout

Site 8
Albany, OR
Geary Street
390' (120 m) North of 14th Avenue

Driveway Type:	Curb Return
NB Through Traffic:	256 vehicles per hour
NB Right Turns:	16 vehicles per hour
Posted Speed Limit:	35 miles per hour (56 kph)

Speed data for NB vehicles turning right into the driveway:

	English Units	
Pedestrian Location:	None	Near Side
Data Points	18	21
Minimum Observed Speed (mph)	6.9	5.9
Maximum Observed Speed (mph)	13.0	15.1
Average Observed Speed (mph)	9.6	9.5
Standard Deviation (mph)	1.72	2.48
Standard Error of the Average (mph)	0.40	0.54

	Metric Units	
Pedestrian Location:	None	Near Side
Data Points	18	21
Minimum Observed Speed (kph)	11.1	9.5
Maximum Observed Speed (kph)	20.9	24.3
Average Observed Speed (kph)	15.4	15.3
Standard Deviation (kph)	2.77	3.99
Standard Error of the Average (kph)	0.64	0.87

Summary of Statistical Findings: These data provide no evidence of a difference in average speeds for the "no pedestrian" versus the "near-side pedestrian" cases (2-sided p-value for a test of difference in means = 0.88).

Table 6.8 – Site 8 Data

6.4 Summary of the Data

Table 6.9 summarizes the data from all eight sites. Fourteen comparisons of vehicular speeds with a pedestrian present versus with no pedestrian present were made.

Assuming a "critical p-value" of 0.05, only two of the fourteen comparisons show a statistically significant difference in speeds. At Site 2 the average vehicular speed with a pedestrian present was observed to be 2.3 miles per hour (3.7 kph) faster than the average vehicular speed with no pedestrian. At Site 3 the average vehicular speed with a pedestrian present was observed to be 1.4 miles per hour (2.3 kph) slower than the average speed without a pedestrian.

Nine of the comparisons show a lower speed with a pedestrian present. Five of the comparisons show a higher speed with a pedestrian present. With the above-stated Null Hypothesis, the 2-sided p-value for observing a combination as or more extreme as "nine lower, five higher" is 0.42. Thus, taken as a whole, the data do not provide any evidence that the null hypothesis is false.

6.5 Conclusions

The conclusion drawn from these data is that the presence of a pedestrian does not alter the behavior (as measured by average vehicular speeds) of vehicles entering driveways.

SUMMARY OF FIELD DATA -- Sites 1 Through 8

						Speed		w/ Ped difference		
Site	City	Location	D/W Type	Turn	Ped Location	MPH	KPH	MPH	KPH	p-value
1	Corvallis	Circle Blvd	Dustpan	EB to SB right	None	9.4	15.1			
					Far Side	8.6	13.8	-0.8	-1.3	0.26
					Near Side	10.2	16.4	0.8	1.3	0.24
2	Salem	Lancaster Dr.	Curb Return	SB to EB left	None	6.8	10.9			
					Far Side	9.1	14.6	2.3	3.7	0.003
3	Salem	Lancaster Dr.	Curb Return	SB to WB right	None	12.8	20.6			
					Near Side	11.4	18.3	-1.4	-2.3	0.024
4	Salem	Lancaster Dr.	Curb Return	NB to WB left	None	11.9	19.2			
					Far Side	11.4	18.3	-0.5	-0.9	0.39
					Near Side	12.1	19.5	0.2	0.3	0.72
5	Salem	Lancaster Dr.	Dustpan	NB to EB right	None	7.0	11.3			
					Far Side	6.6	10.6	-0.4	-0.7	0.25
					Near Side	6.7	10.8	-0.3	-0.5	0.38
				SB to EB left	None	7.2	11.6			
					Far Side	7.9	12.7	0.7	1.1	0.21
					Near Side	8.0	12.9	0.8	1.3	0.16
6	Eugene	Coburg Rd.	Dustpan	SB to WB right	None	7.2	11.6			
					Near Side	6.8	10.9	-0.4	-0.7	0.41
				NB to WB left	None	10.6	17.1			
					Far Side	10.0	16.1	-0.6	-1.0	0.37
7	Albany	Clay St.	Curb return	SB to WB right	None	11.1	17.9			
					Near Side	10.7	17.2	-0.4	-0.7	0.36
8	Albany	Geary St.	Curb return	NB to EB right	None	9.6	15.4			
					Near Side	9.5	15.3	-0.1	-0.1	0.88

Table 6.9 -- Data Summary

7. FIELD DATA ON THE EFFECTS OF A RIGHT-TURN LANE AT A DRIVEWAY

7.1 Introduction

In order to investigate the effects of right-turn lanes at driveways, the researchers attempted to find pairs of driveways with similar geometry's except for the presence or absence of a right-turn lane on the street which the driveway(s) accessed. Two such pairs of driveways were located.

The first driveway pair involves the following two driveways:

Site #	City	Street	Approximate Location
7	Albany	Clay Street	450' (135 m) north of 14th Avenue
8	Albany	Geary Street	390' (120 m) north of 14th Avenue

The second driveway pair involves the following two driveways:

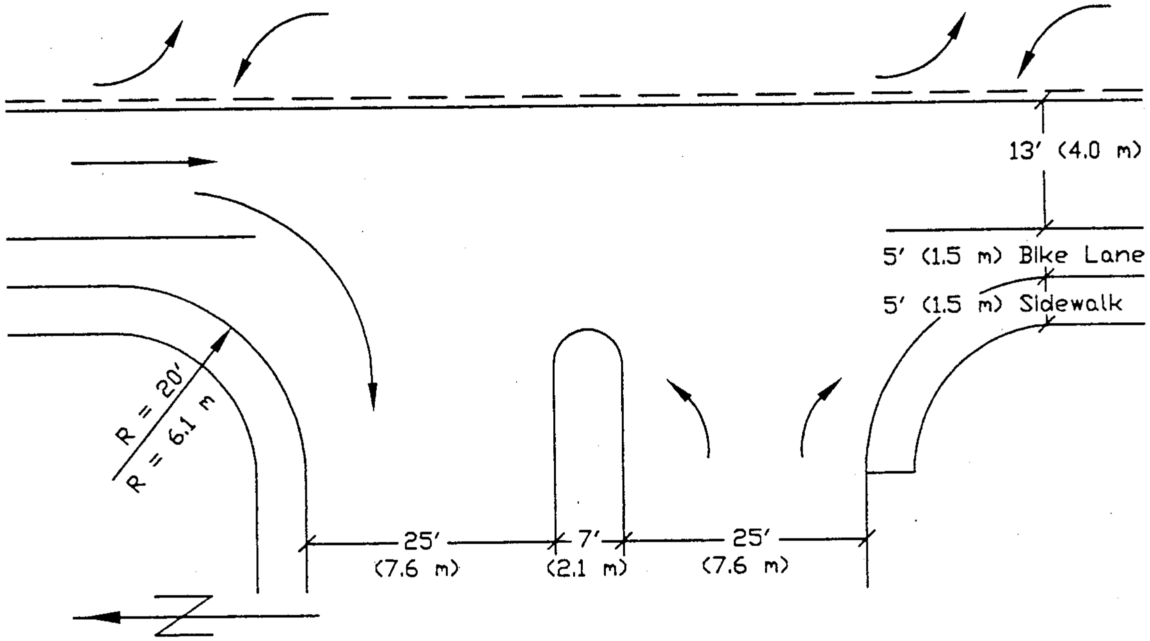
Site #	City	Street	Approximate Location
6	Eugene	Coburg Road	420' (130 m) north of Cal Young Road
9	Eugene	Coburg Road	700' (210 m) north of Cal Young Road

7.2 Site Layouts

Figures 7.1 through 7.4 show in schematic form the geometric layouts of the four driveways. Figures 7.1, 7.2 and 7.3 are adapted from the layouts in Section 6 for the relevant driveways. Figure 7.4 depicts an additional driveway that was selected because it is similar (except for the right-turn lane) to the driveway at Site 6.

Site 7
Albany, OR on Clay Street
Approximately 450′ (135 m) north of 14th Avenue
SB Vehicles Turning Right Into Driveway

Plan View



Driveway Profile

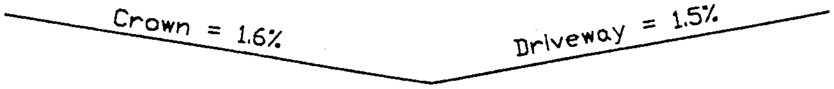
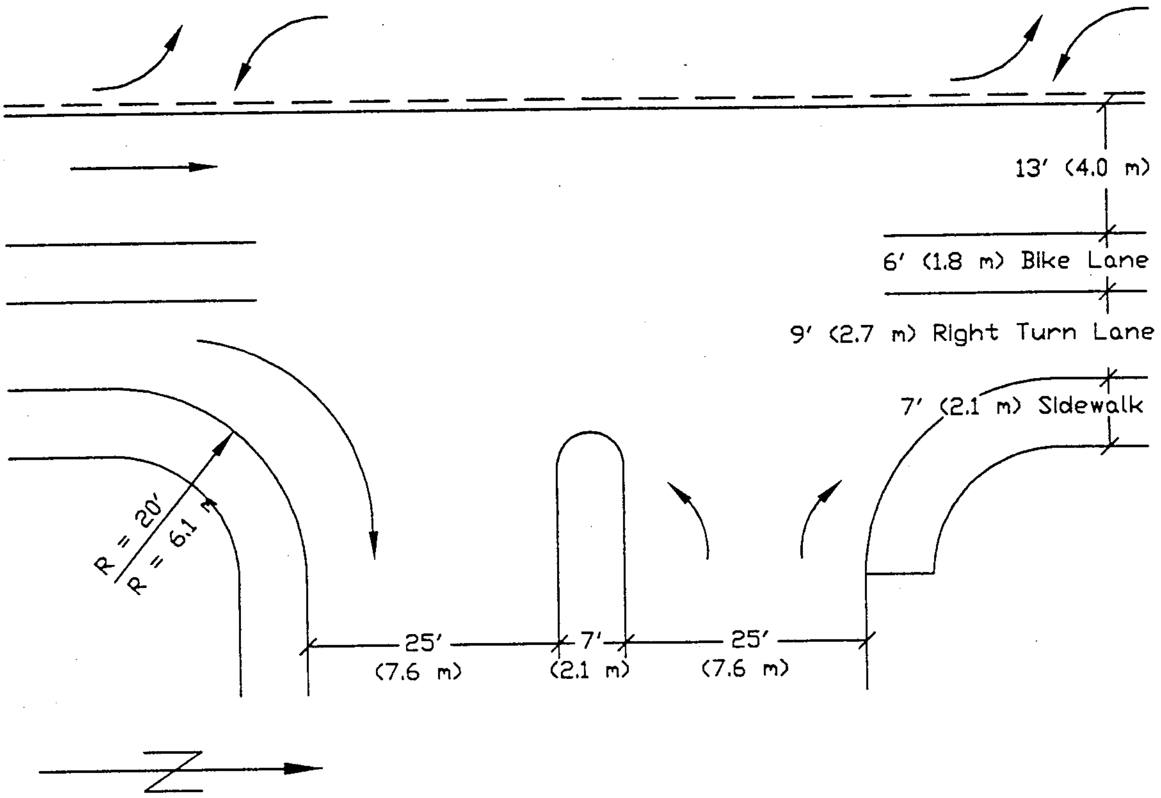


FIGURE 7.1 -- Site 7 Layout

Site 8
Albany, OR on Geary Street
Approximately 390′ (120 m) north of 14th Avenue
NB Vehicles Turning Right Into Driveway

Plan View



Driveway Profile

FIGURE 7.2 -- Site 8 Layout

Site 6
Eugene, OR on Coburg Road
Approximately 420' (130 m) north of Cal Young Road
SB Vehicles Turning Right Into Driveway

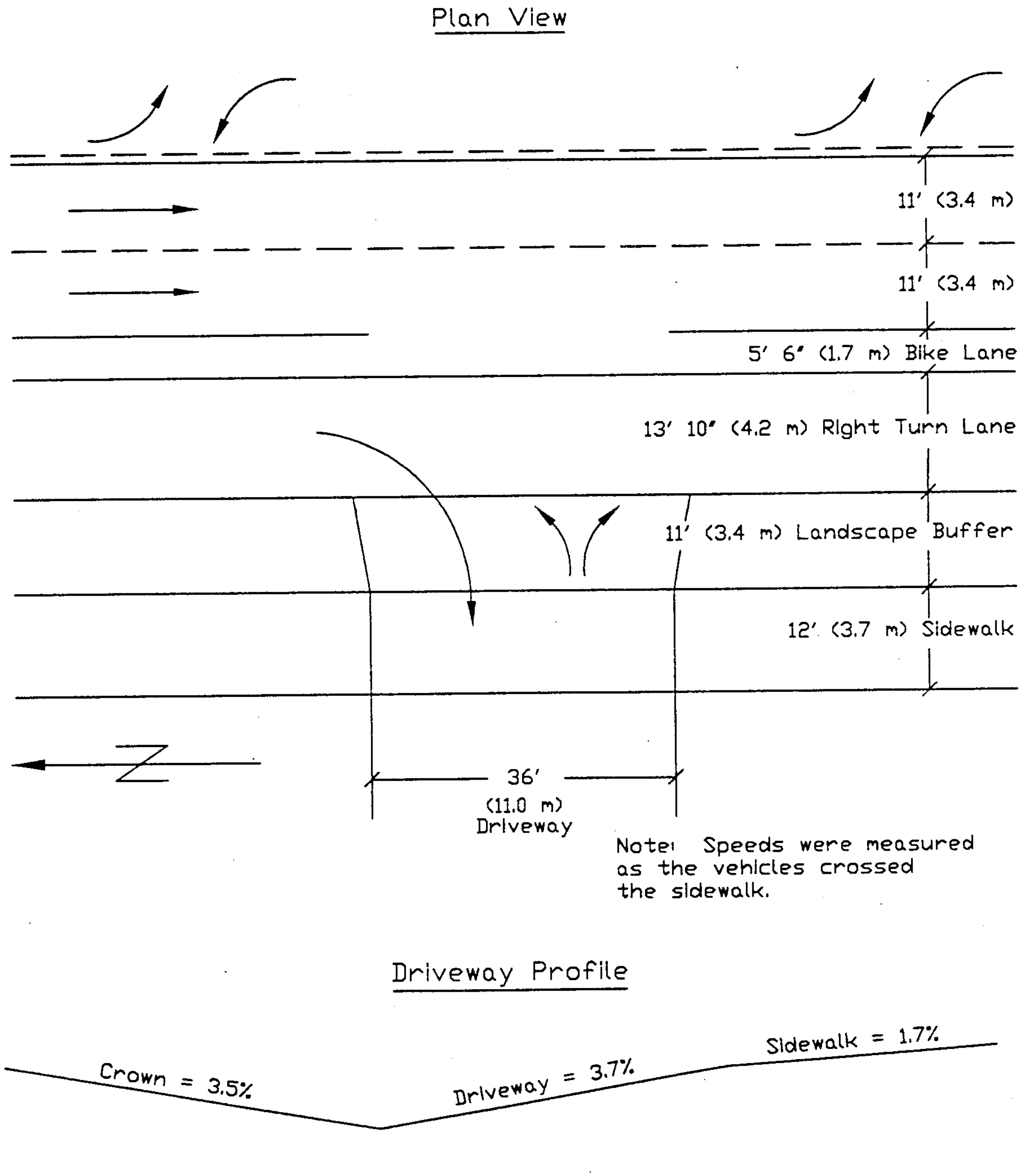
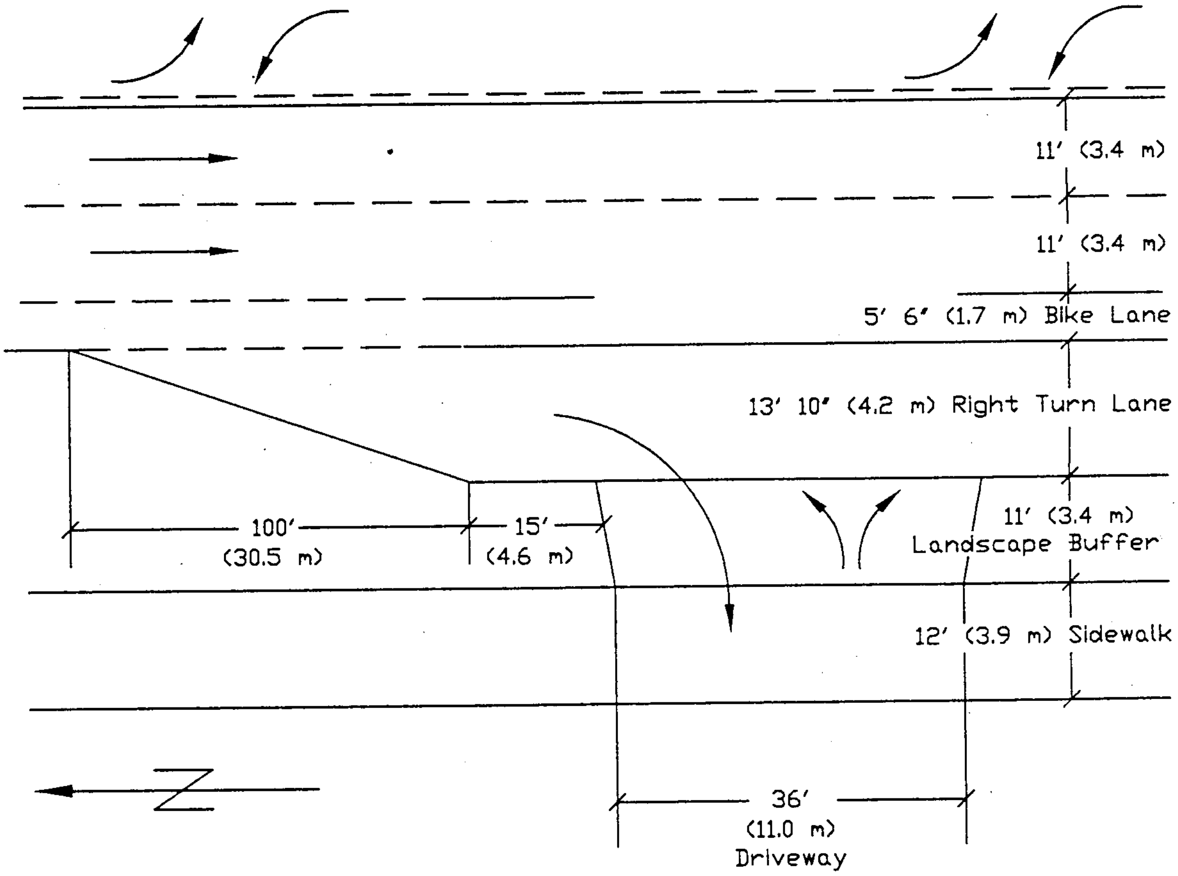


FIGURE 7.3 -- Site 6 Layout

Site 9
Eugene, OR on Coburg Road
Approximately 700' north of Cal Young Road
SB Vehicles Turning Right Into Driveway

Plan View



Note: Speeds were measured as the vehicles crossed the sidewalk.

Driveway Profile

FIGURE 7.4 -- Site 9 Layout

7.3 Data for Each Driveway Pair

Tables 7.1 and 7.2 present the data and provide summaries of statistical findings for the two comparisons of driveways with and without right-turn lanes. In both pairs of driveways, data for the "no pedestrian" cases were used. For each driveway pair, the statistical analysis addressed the following Null Hypothesis:

> H_0: There is no difference in the average speed of vehicles entering the driveway from a street with a right-turn lane as compared to the average speed of vehicles entering the driveway from a street without a right-turn lane.

The p-values that are reported in the tables represent the probability that, assuming the Null Hypothesis is true, the observed differences in average speeds are the result of random sampling error.

7.4 Summary of the Data

At Sites 7 and 8, the driveway with the right-turn lane had an average speed that was 1.5 mph (2.5 kph) lower than the driveway without the right turn lane. At Sites 6 and 9, the driveway with the right-turn lane had an average speed that was 3.3 mph (5.3 kph) lower than the driveway without the right turn lane. Both differences are statistically significant based on a critical p-value of 0.05.

Average speeds with a right-turn lane were 14% and 31% slower at Sites 7/8 and Sites 6/9, respectively.

7.5 Conclusions

The conclusion drawn from these data is that the presence of a right-turn lane decreased the average speed of vehicles entering the driveways <u>at the tested locations.</u> However, it would be premature to extend this conclusion to other locations. Additional research of similar pairs of driveways should be undertaken.

Sites 7 and 8
Albany, OR
Clay and Geary Streets
450' (135 m) and 390' (120 m) North of 14th Avenue

Speed data for vehicles turning right into the driveway:

	English Units	
Location:	Site 7	Site 8
Data Points	36	18
Minimum Observed Speed (mph)	7.7	6.9
Maximum Observed Speed (mph)	16.9	13.0
Average Observed Speed (mph)	11.1	9.6
Standard Deviation (mph)	1.89	1.72
Standard Error of the Average (mph)	0.32	0.40

	Metric Units	
Location:	Site 7	Site 8
Data Points	36	18
Minimum Observed Speed (kph)	12.4	11.1
Maximum Observed Speed (kph)	27.2	20.9
Average Observed Speed (kph)	17.9	15.4
Standard Deviation (kph)	3.04	2.77
Standard Error of the Average (kph)	0.51	0.64

Summary of Statistical Findings: These data provide strong evidence of a difference in average speeds for Site 7 versus Site 8 (2-sided p-value for a test of difference in means =0.007). It is estimated that the average speed of right turns into the driveway at Site 7 (no right-turn lane) is 1.5 mph (2.5 kph) higher than the average speed of right-turns into the driveway at Site 8 (fully-developed right-turn lane). The 95% confidence interval for this difference is from 0.4 mph (0.6 kph) to 2.6 mph (4.2 kph).

Table 7.1 – Sites 7 and 8 Data

Sites 6 and 9
Eugene, OR
Coburg Road
420' (130 m) and 700' (210 m) north of Cal Young Road

Speed data for SB vehicles turning right into the driveways:

	English Units	
Location:	Site 6	Site 9
Data Points	24	31
Minimum Observed Speed (mph)	4.1	6.5
Maximum Observed Speed (mph)	13.2	12.9
Average Observed Speed (mph)	7.2	10.5
Standard Deviation (mph)	1.97	1.78
Standard Error of the Average (mph)	0.40	0.32

	Metric Units	
Location:	Site 6	Site 9
Data Points	24	31
Minimum Observed Speed (kph)	6.6	10.5
Maximum Observed Speed (kph)	21.2	20.8
Average Observed Speed (kph)	11.6	16.9
Standard Deviation (kph)	3.17	2.86
Standard Error of the Average (kph)	0.64	0.51

Summary of Statistical Findings: These data provide convincing evidence of a difference in average speeds for Site 6 versus Site 9 (2-sided p-value for a test of difference in means <0.001). It is estimated that the average speed of right turns into the driveway at Site 9 (limited right-turn lane) is 3.3 mph (5.3 kph) higher than the average speed of right-turns into the driveway at Site 6 (fully-developed right-turn lane). The 95% confidence interval for this difference is from 2.3 mph (3.7 kph) to 4.3 mph (6.9 kph).

Table 7.2 – Sites 6 and 9 Data

8. FIELD DATA COMPARING RIGHT AND LEFT TURNS INTO THE SAME DRIVEWAY

8.1 Introduction

Vehicles making a right turn into a driveway frequently follow a different turning radius than vehicles making a left turn into that same driveway. These unequal radii could result in unequal speeds as the turning vehicles enter the driveway. Since different vehicular speeds have different impacts on pedestrians, a comparison of right-turning versus left-turning speeds is appropriate.

8.2 Site Layouts

At three of the previously described driveways, vehicular speed for both left and right turns were measured. Those three driveways are:

Site #	City	Street	Approximate Location
2	Salem	Lancaster	at D-Street
5	Salem	Lancaster	435' (135 m) north of Center Street
6	Eugene	Coburg Road	420' (130 m) north of Cal Young Road

Figures 8.1 through 8.3 show the geometric layouts of these three driveways.

8.3 Left and Right Turn Data

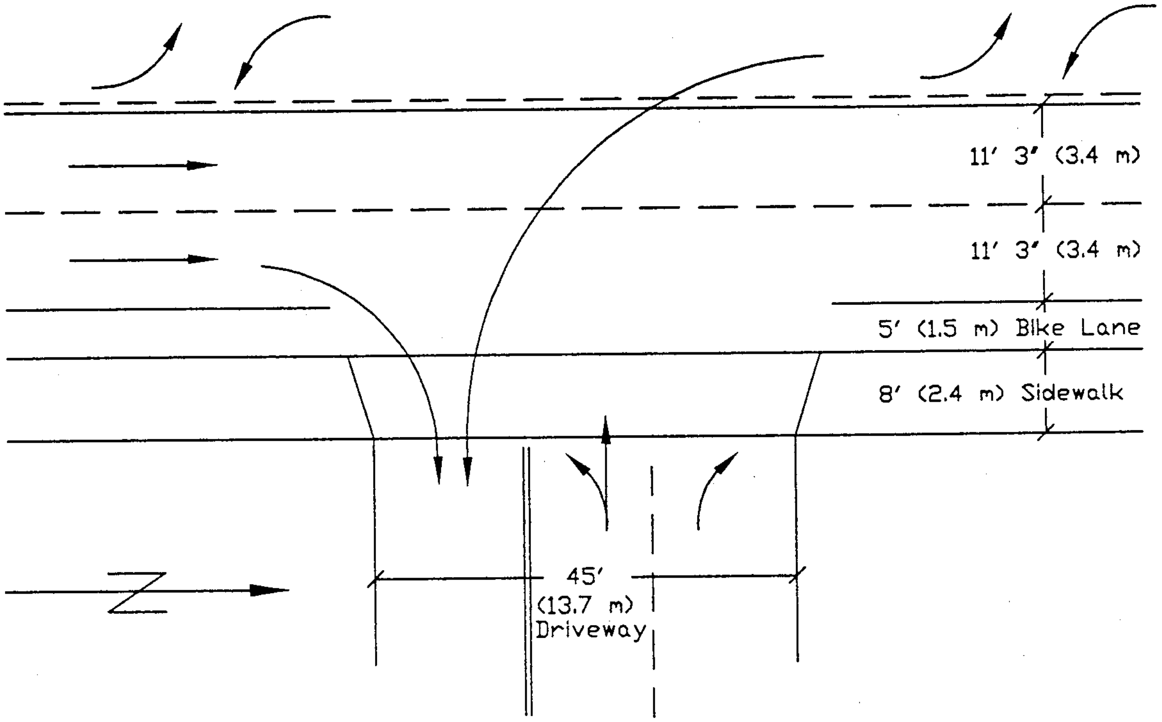
Tables 8.1 through 8.3 present the data and provide summaries of statistical findings for the three comparisons of right and left turns. At all three driveways, data for the "no pedestrian" cases were used. For each driveway, the statistical analysis addressed the following Null Hypothesis:

H_0: There is no difference in the average speed of vehicles executing a right turn into the driveway as compared to the average speed of vehicles executing a left turn into the driveway.

The p-values that are reported in the tables represent the probability that, assuming the Null Hypothesis is true, the observed differences in average speeds are the result of random sampling error.

Site 2
Salem, OR on Lancaster Drive (at D-Street)
SB Vehicles Turning Left into Driveway and NB Vehicles Turning Right into Driveway

Plan View



Driveway Profile

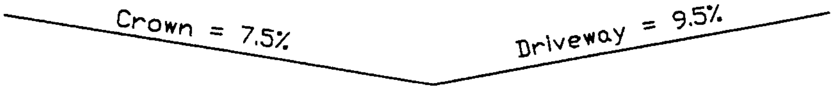


FIGURE 8.1 -- Site 2 Layout

Site 2
Salem, OR
Lancaster Drive
(at D-Street)

Driveway Type:	Dustpan
Posted Speed Limit:	35 miles per hour (56 kph)
Change in Profile Grade at Gutter Line:	17.0%

Speed data for NB vehicles turning right and SB vehicles turning left into the driveway:

	English Units	
Turn:	Right	Left
Data Points	10	18
Minimum Observed Speed (mph)	4.6	3.9
Maximum Observed Speed (mph)	9.3	11.3
Average Observed Speed (mph)	7.4	6.8
Standard Deviation (mph)	1.64	2.15
Standard Error of the Average (mph)	0.52	0.51

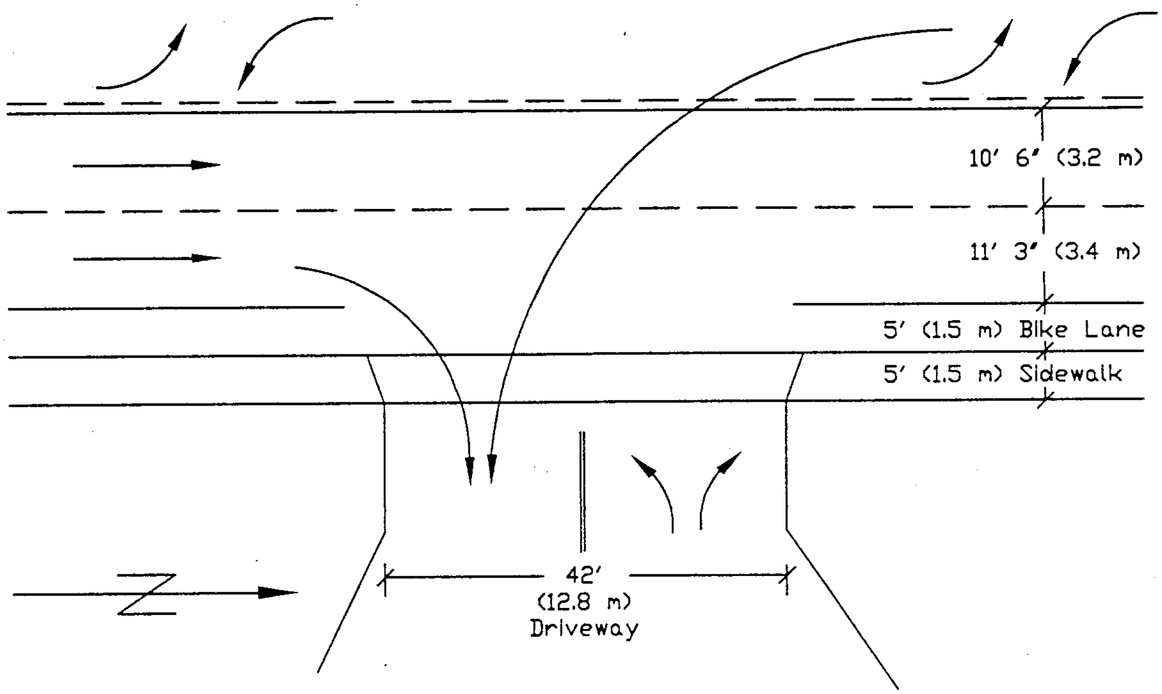
	Metric Units	
Turn:	Right	Left
Data Points	10	18
Minimum Observed Speed (kph)	7.4	6.3
Maximum Observed Speed (kph)	15.0	18.2
Average Observed Speed (kph)	11.9	10.9
Standard Deviation (kph)	2.64	3.46
Standard Error of the Average (kph)	0.84	0.82

Summary of Statistical Findings: These data provide no evidence of a difference in average speed of right-turning vehicles as compared to the average speed of left-turning vehicles at this driveway (2-sided p-value for a test of difference in means = 0.45).

Table 8.1 – Site 2 Data

Site 5
Salem, OR on Lancaster Drive
Approximately 435' (135 m) north of Center Street
NB Vehicles Turning Right Into Driveway
SB Vehicles Turning Left Into Driveway

Plan View



Driveway Profile

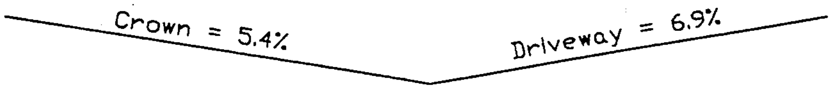


FIGURE 8.2 -- Site 5 Layout

Site 5
Salem, OR
Lancaster Drive
435' (135 m) North of Center Street

Driveway Type:	Dustpan
Posted Speed Limit:	35 miles per hour (56 kph)
Change in Profile Grade at Gutter Line:	12.3%

Speed data for NB vehicles turning right and SB vehicles turning left into the driveway:

	English Units	
Turn:	Right	Left
Data Points	23	19
Minimum Observed Speed (mph)	5.0	4.9
Maximum Observed Speed (mph)	10.7	9.9
Average Observed Speed (mph)	7.0	7.2
Standard Deviation (mph)	1.44	1.72
Standard Error of the Average (mph)	0.30	0.43

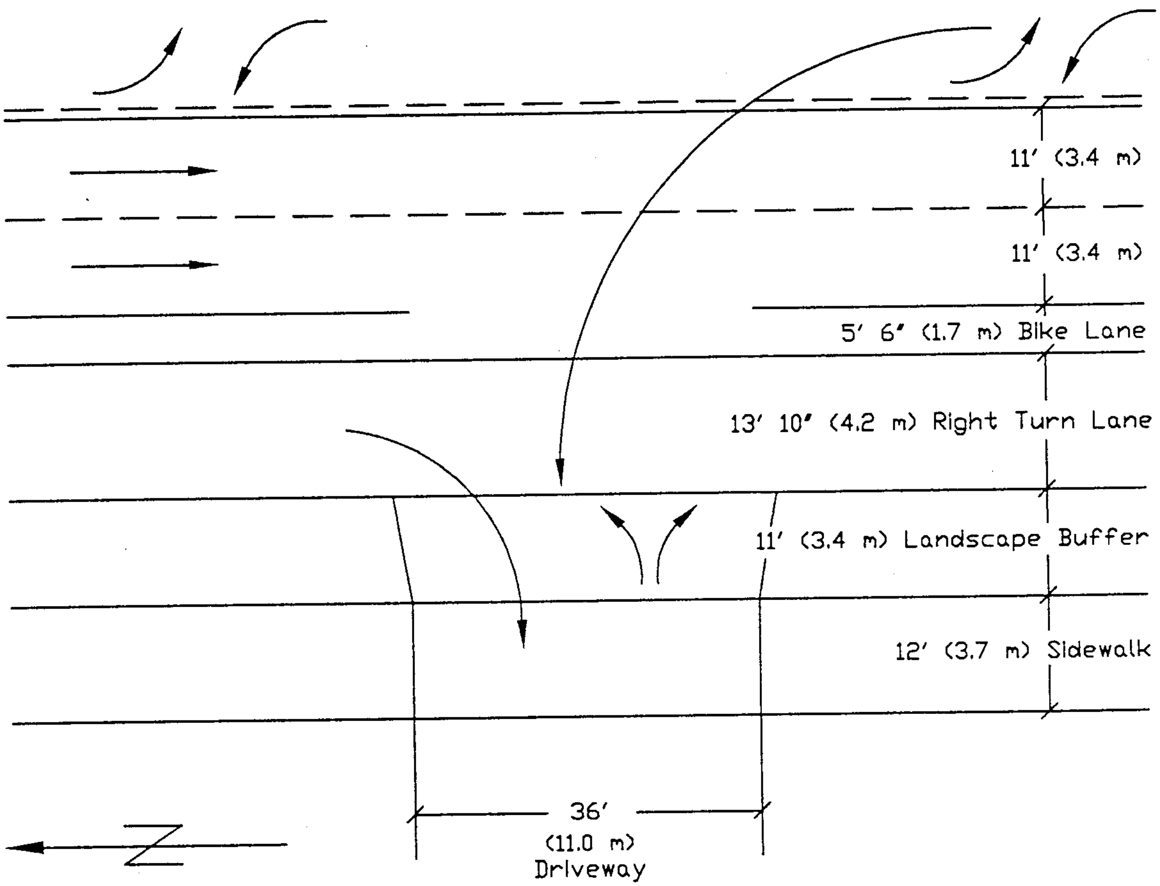
	Metric Units	
Turn:	Right	Left
Data Points	23	19
Minimum Observed Speed (kph)	8.0	7.9
Maximum Observed Speed (kph)	17.2	15.9
Average Observed Speed (kph)	11.3	11.6
Standard Deviation (kph)	2.32	2.77
Standard Error of the Average (kph)	0.48	0.69

Summary of Statistical Findings: These data provide no evidence of a difference in average speed of right-turning vehicles as compared to the average speed of left-turning vehicles at this driveway (2-sided p-value for a test of difference in means = 0.70).

Table 8.2 – Site 5 Data

Site 6
Eugene, OR on Coburg Road
Approximately 420′ (130 m) north of Cal Young Road
SB Vehicles Turning Right Into Driveway and
NB Vehicles Turning Left Into Driveway

Plan View



Note: Speeds were measured as the vehicles crossed the sidewalk.

Driveway Profile

FIGURE 8.3 -- Site 6 Layout

Site 6
Eugene, OR
Coburg Road
420' (130 m) north of Cal Young Road

Driveway Type:	Dustpan
Posted Speed Limit:	35 miles per hour (56 kph)
Change in Profile Grade at Gutter Line:	7.2%

Speed data for SB vehicles turning right and NB vehicles turning left into the driveway:

	English Units	
Turn:	Right	Left
Data Points	24	27
Minimum Observed Speed (mph)	4.1	6.7
Maximum Observed Speed (mph)	13.2	16.9
Average Observed Speed (mph)	7.2	10.6
Standard Deviation (mph)	1.97	2.36
Standard Error of the Average (mph)	0.40	0.45

	Metric Units	
Turn:	Right	Left
Data Points	24	27
Minimum Observed Speed (kph)	6.6	10.8
Maximum Observed Speed (kph)	21.2	27.2
Average Observed Speed (kph)	11.6	17.1
Standard Deviation (kph)	3.17	3.80
Standard Error of the Average (kph)	0.64	0.72

Summary of Statistical Findings: These data provide convincing evidence of a difference in average speeds for right-turning versus left-turning vehicles at this driveway (2-sided p-value for a test of difference in means <0.0001). It is estimated that at this driveway the average speed of right turning traffic is 3.4 mph (5.5 kph) or 32% slower than that of left-turning traffic. The 95% confidence interval for the difference in average speeds is 2.2 mph (3.5 kph) to 4.7 mph (7.6 kph) slower for right turning traffic.

Table 8.3 – Site 6 Data

8.4 Summary of the Data

The data give mixed results. At two locations there were no significant differences in the average speeds of right and left-turning vehicles, while at the third location there was a substantial and statistically significant difference.

One possible confounding variable may be the change in grade of the driveway profiles at the gutter line at each driveway. In the two cases with no significant difference between right and left turns, the change in grade is large (i.e., 17.0% and 12.3%). In the case where a statistically significant difference was observed, the change in grade is much smaller (i.e., 7.2%). Many roadway designers use 12% as a rule-of-thumb for the maximum, desirable change in grade at a driveway. Thus, the two locations without a turning speed difference both have unusually large grade changes. It is quite possible that the grade change at these driveways was an overriding factor in limiting turning speeds. On the other hand, the driveway with a "normal" grade change showed a 32% difference in speeds of right versus left-turning vehicles.

8.5 Conclusions

No conclusions should be drawn from this limited amount of data. Additional research to explore the differences in speeds of right turns versus left turns at driveways should be conducted. This research should take into account the effects of varying changes in grade in the driveway profiles.

9. FIELD DATA ON BICYCLE AND VEHICLE INTERACTIONS AT DRIVEWAYS

9.1 Introduction

As discussed earlier in this report, the literature contains little or no data describing the interaction between bicycles and vehicles at driveways or other roadway elements. Therefore, one initial goal for this study was to begin to gather such data.

The researchers decided to first gather data on the interaction of bicycles and vehicles entering driveways. Figure 9.1 shows a schematic drawing of the type of situation and data that was desired.

9.2 Site Layouts

Figure 9.2 shows in schematic form the geometric layout of the single driveway where data were collected. The driveway is the same one identified in Part 6 as "Site 1."

9.3 Data Collected

Table 9.1 presents the limited data that was collected during this effort. Unfortunately, the collection of useful observations was very much slower than expected. Even using a "planted" bicycle, the twenty data points obtained represent very nearly a full day's work for two researchers.

Because of the large time expenditure that would be necessary to gather a statistically valid sample at even this single driveway (not to mention an assortment of driveways with different characteristics) and because of the limited resources available for this study, the researchers decided to cease these data collection efforts. The researchers also concluded that additional preparatory work should be done to develop an experimental procedure that will be more efficient in capturing useful data. This may involve the use of multiple "planted" bicycles, recording the bicycle/vehicle interactions on videotape, studying locations with higher driveway turning movements or some combination of these and other approaches.

Idealized Site
Data Acquisition for
Bicycle/Vehicle Interactions
at Driveways

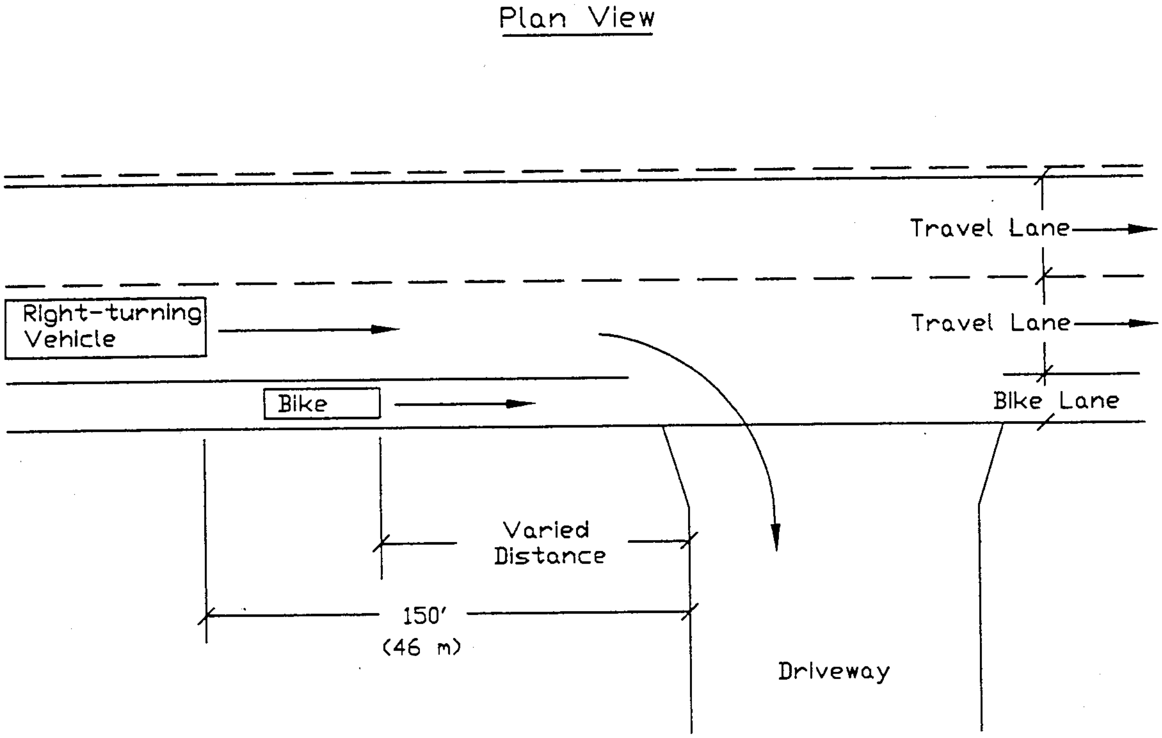
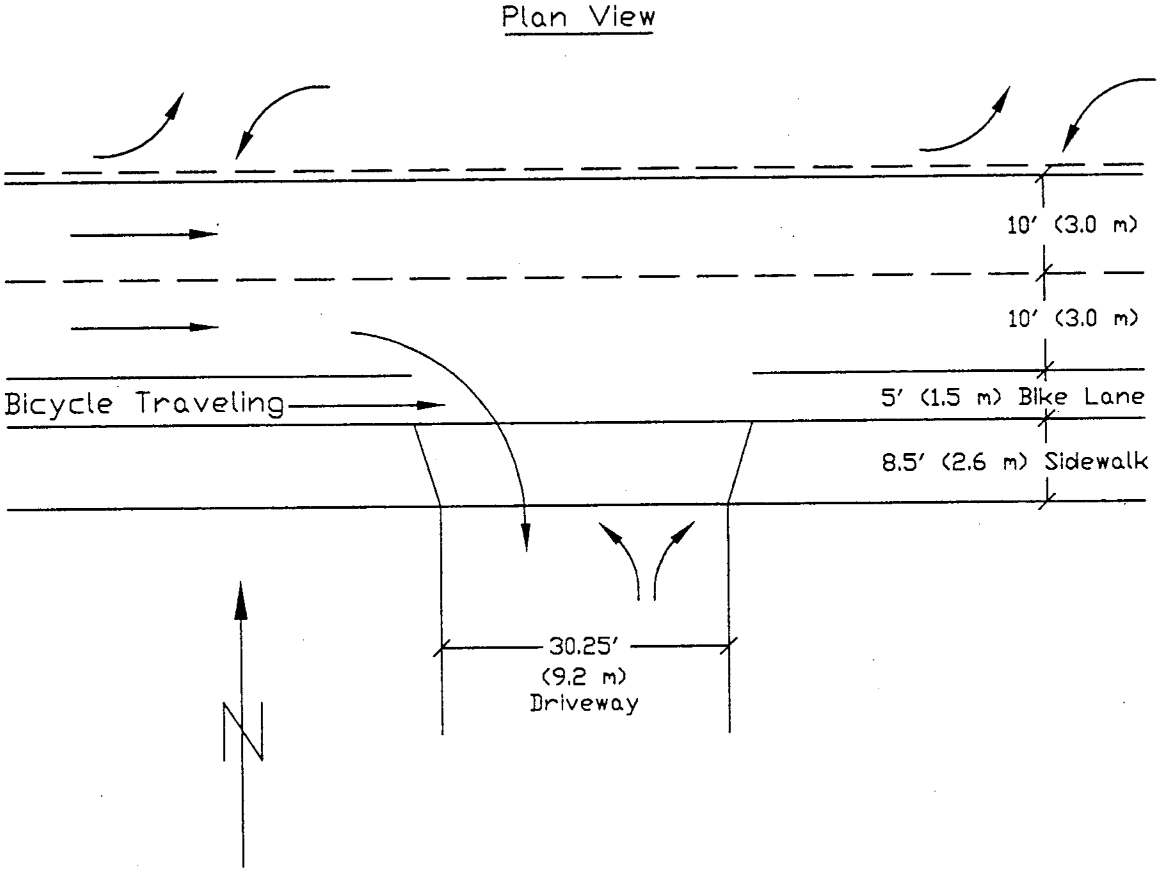


FIGURE 9.1 -- Bicycle/Vehicle Interaction

Site 1
Corvallis, OR on Circle Blvd.
Approximately 1140′ (350 m) west of 9th Street
EB Vehicles Turning Right Into Driveway
With an EB Bicycle Present



Note: Each observation consisted of noting:

1) How far upstream from the driveway the bicycle was when an oncoming, turning vehicle was 150′ (46 m) upstream from the driveway; and
2) If the turning vehicle yielded to the bicycle (i.e., allowed the bicycle to pass through the driveway before the vehicle turned into the driveway.)

FIGURE 9.2 -- Site 1 Layout

Site 1
Corvallis, OR
Circle Boulevard
1140’ (350 m) West of 9th Street

Driveway Type:	Dustpan
EB Through Traffic:	340 vehicles per hour
EB Right Turns:	76 vehicles per hour
Posted Speed Limit:	35 miles per hour (56 kph)

Data on number of vehicles yielding to the bicycle at the driveway:

		Turning Vehicle Yields to Bike?	
Bike Location		No	Yes
0’-25’	(0-8 m)	0	1
26’-50’	(8-15 m)	0	3
51’-75’	(15-23 m)	0	2
76’-100’	(23-30 m)	0	4
101’-125’	(30-38 m)	1	3
126’-150’	(38-46 m)	3	1
151’+	(46 m +)	2	0

Note: “Bike location” is the bike’s distance upstream from the driveway when the vehicle is 150’ (46 m) upstream of the driveway.

Table 9.1 – Site 1 Bike Data

9.4 Summary of the Data

Due to the small amount of data collected, no summary statements are warranted.

9.5 Conclusions

The conclusion drawn from these efforts is that the collection of a statistically useful amount of data on bicycle/vehicle interactions will take a more substantial time and resource commitment than is available for this study.

10. QUANTITATIVE ANALYSIS OF IMPACTS ON PEDESTRIANS

10.1 Introduction

Section 4 presented a qualitative listing of the suggested impacts of access management on pedestrians, bicycles and transit. This Section 10 presents a quantitative discussion of three of the suggested impacts on pedestrians. The three impacts included in this discussion are:

Section	Impact
10.2	Conflict area at driveways
10.3	Probabilities of pedestrian/vehicle conflicts
10.4	Pedestrian travel times.

The nomenclature that is used throughout this Section includes the following terms:

1) *normal driveway:* a driveway that is designed and constructed without consideration of access management standards.
2) *access management driveway:* a driveway that has been designed and constructed according to access management standards including consolidation of one or more "normal driveways" into a single "access management driveway."
3) *N:* the number of normal driveways on a block of arterial street under consideration and/or the number of "normal driveways" consolidated into a single "access management driveway."
4) *q:* the hourly flow rate of vehicles entering a "normal driveway."
5) *q':* the hourly flow rate of vehicles entering an "access management driveway." (Note that $q' = N * q$.)

10.2 Total Area of Potential Conflict Between a Pedestrian and a Vehicle at a Driveway

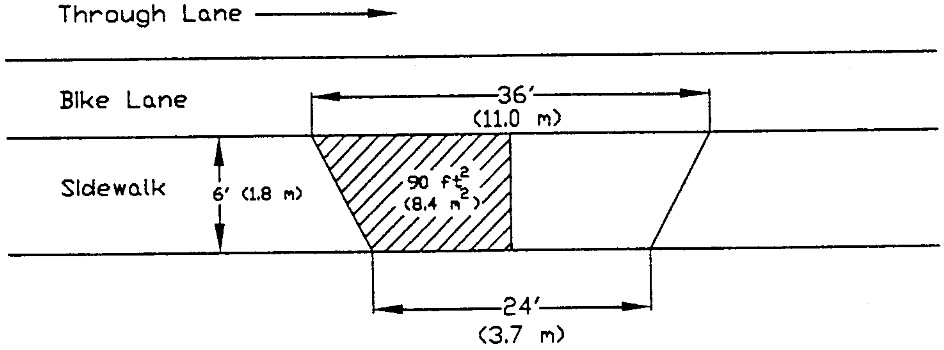
As pointed out in Section 4.2 the total area where pedestrians are exposed to vehicles is generally greater for access management driveways than for normal driveways. It is a simple matter to quantify this effect.

Figure 10.1 depicts a typical normal driveway and a typical driveway with geometrics that promote the objectives of access management. For each driveway, the area of potential conflict between a pedestrian and vehicles that enter the driveway is hatched. (Since vehicles exiting the driveway typically face a stop condition, the potential conflict between pedestrians and exiting vehicles is less severe than the potential conflict between pedestrians and entering vehicles.) Given these driveway dimensions, the pedestrian/vehicle conflict area is 90 square feet (8.4 m^2) for the normal driveway and 178 square feet (16.5 m^2) for the access management driveway.

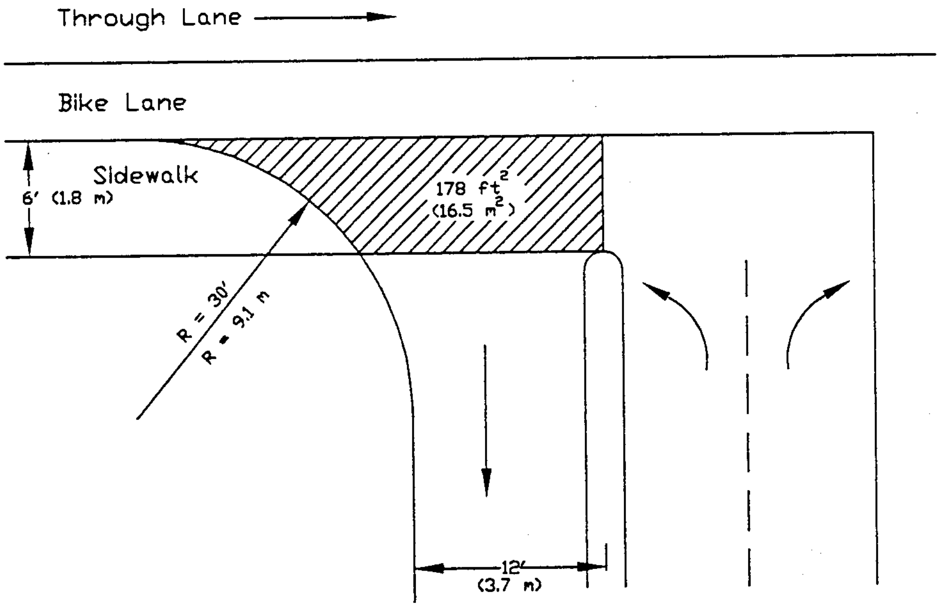
This comparison of conflict areas at driveways can be extended to take into account the practice of consolidating one or more normal driveways into a single access management driveway:

# of normal d/w's consolidated	total area-normal d/w's	total area-access management d/w's
1	90 ft^2 (8.4 m^2)	178 ft^2 (16.5 m^2)
2	180 ft^2 (16.7 m^2)	178 ft^2 (16.5 m^2)
3	270 ft^2 (25.1 m^2)	178 ft^2 (16.5 m^2)
4	360 ft^2 (33.4 m^2)	178 ft^2 (16.5 m^2)
5	450 ft^2 (41.8 m^2)	178 ft^2 (16.5 m^2)

Thus, if three or more normal driveways are consolidated into a single access management driveway, the total conflict area that is faced by a pedestrian decreases.

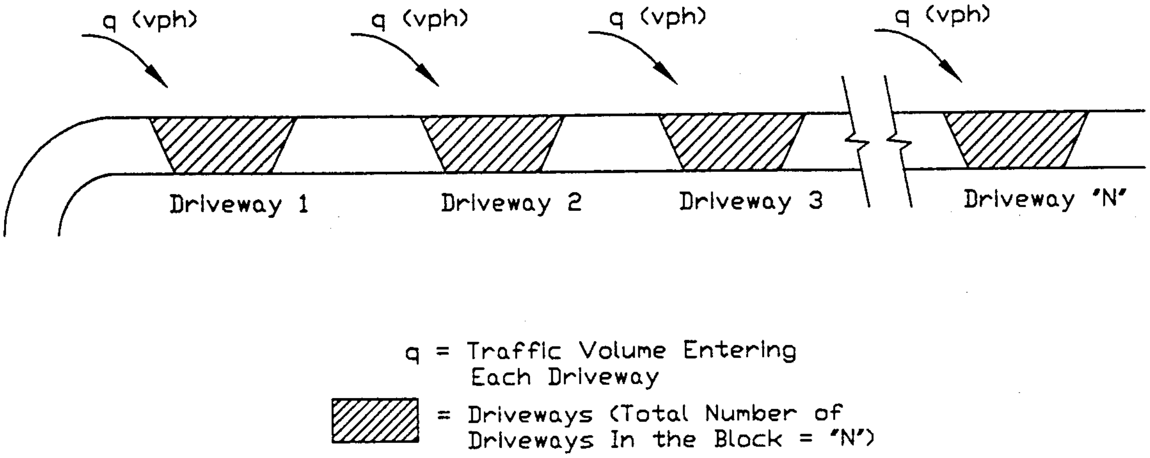


NORMAL DRIVEWAY

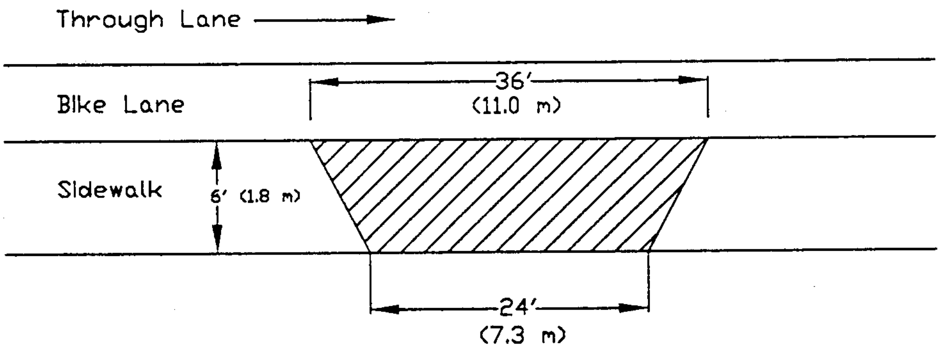


ACCESS MANAGEMENT DRIVEWAY

FIGURE 10.1 -- NORMAL AND ACCESS MANAGMENT DRIVEWAYS



DRIVEWAYS ALONG THE BLOCK



TYPICAL DRIVEWAY DETAIL

FIGURE 10.2 -- TYPICAL BLOCK WITH NORMAL DRIVEWAYS

10.3 The Probability of a Conflict Between a Pedestrian and a Vehicle at a Driveway

Section 10.2 compared normal and access management driveways in regard to the area in which pedestrians are exposed to entering vehicles at driveways. Another approach to the quantification of the impacts on pedestrians of access management standards for driveways is to compare the probability that a pedestrian at a driveway will experience a conflict with a vehicle.

Figure 10.2 depicts a typical block on an arterial street where the driveways have not been constructed in accordance with access management standards. Assuming a pedestrian is walking along the centerline of the sidewalk at a speed of 4 feet per second (1.22 mps) and crosses a normal driveway on this block, that pedestrian is exposed in the entry half of this driveway for a distance of 15 feet (4.57 m) and a time of 3.75 seconds. If a turning vehicle arrives at the driveway during that 3.75 seconds, then a conflict between the pedestrian and the vehicle can be assumed to occur. If a vehicle does not arrive, then no conflict occurs.

The probability that a vehicle does not arrive while the pedestrian is exposed can be estimated using the Poisson distribution. When used to describe random traffic events (for this calculation the assumption is that vehicles arrive randomly at the driveway) the Poisson distribution takes the following form:

$$P(x)_t = (e^{-z} * z^x) / x!$$

where: $P(x)_t$ = Probability that "x" events occur in the time period "t"

z = the mean number of events expected to occur in time "t"

$z = q*t/3600$

q = vehicles per hour

t = time in seconds

In the case of the normal driveway the probability that no vehicles arrive (i.e., no pedestrian/vehicle conflict occurs) during the time a pedestrian is exposed can be calculated as follows:

$$z = q*3.75/3600$$

$x = 0$

$x! = 1$

$z^x = 1$

so: $P(0) = e^{-z} = e^{-3.75q/3600}$

Therefore, at various hourly volumes of vehicles entering the typical, normal driveway, the probabilities that any single pedestrian does not experience a conflict are as follows:

q(vph)	P(0)
20	0.98
40	0.96
60	0.94
80	0.92
100	0.90

These driveway flow rates are representative of commerical land uses. All 8 accesses described in Section 6 are for commercial establishments and generally had entering volumes within the range analyzed above.

These probabilities are for a <u>single</u> driveway. If "N" driveways exist on an arterial block and if all those driveways have an hourly entering volume of "q", then the probability that a single pedestrian will experience no conflicts in the entire block is:

$$P(0,N) = [P(0)]^N$$

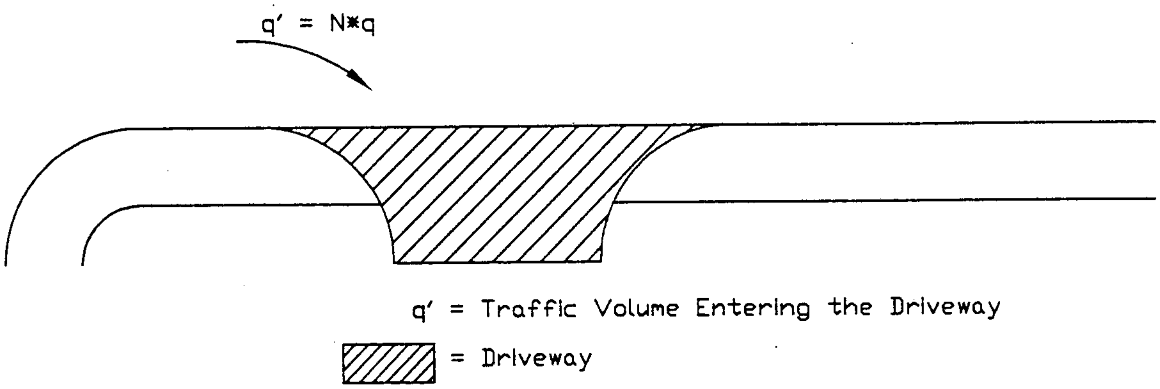
Table 10.1 provides P(0,N) for various values of q and N.

The above analysis applies to a block with normal driveways. A similar analysis can be completed for a block of arterial street that was designed with access management in mind. That is, all "N" driveways have been consolidated into a single driveway, and that driveway meets access management dimensional standards. Figure 10.3 depicts such a block and driveway. With this driveway layout a pedestrian that is walking along the sidewalk centerline at 4 fps (1.22 mps) will be exposed to entering vehicles for a distance of 28.9 feet (8.81 m) and a time of 7.23 seconds.

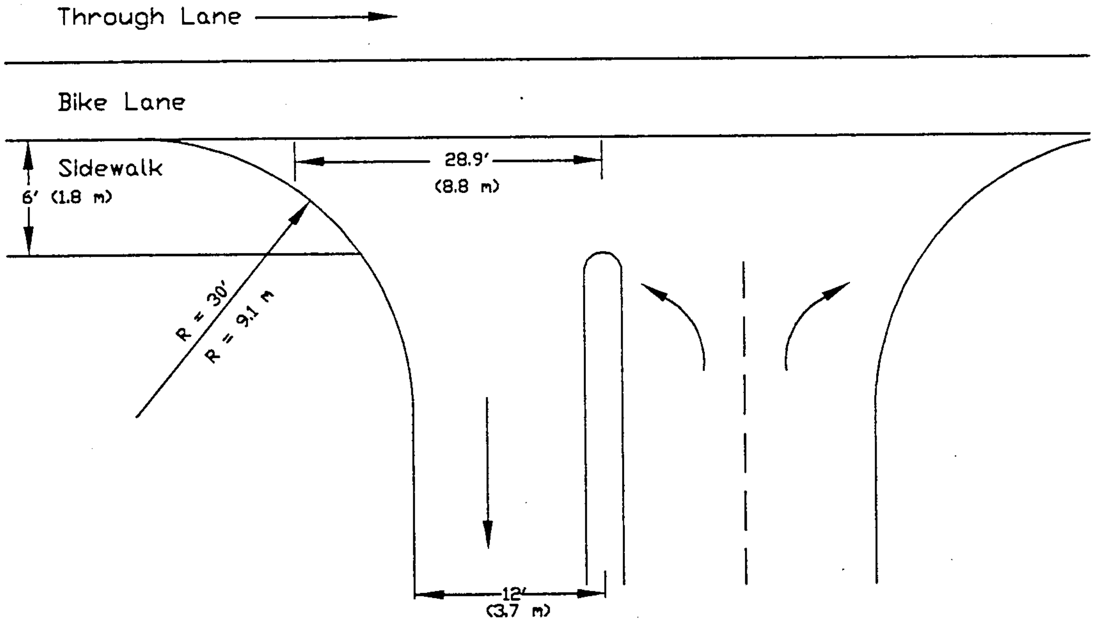
	"N" = number of driveways				
q(vph)	1	2	3	4	5
20	0.98	0.96	0.94	0.92	0.90
40	0.96	0.92	0.88	0.85	0.81
60	0.94	0.88	0.83	0.78	0.73
80	0.92	0.85	0.78	0.72	0.66
100	0.90	0.81	0.73	0.66	0.59

Probabilities That a Single Pedestrian Will Face No Vehicular Conflicts Over "N" Normal Driveways Each With An Entering Volumes of "q" Vehicles per Hour

TABLE 10.1 -- CONFLICT PROBABILITIES (NORMAL DRIVEWAYS)



NORMAL DRIVEWAY



TYPICAL DRIVEWAY DETAIL

FIGURE 10.3 -- TYPICAL BLOCK WITH ACCESS MANAGEMENT DRIVEWAYS

The probability that no pedestrian/vehicle conflicts will occur is again calculated with the Poisson distribution. Table 10.2 provides values for P'(0,N) for various values of q and N as calculated using the following equation:

$$P'(0,N) = e^{-7.23*q'/3600}$$

Where: q' = the arrival rate of the consolidated traffic entering the driveway

$q' = n*q.$

Table 10.3 is a combination of Tables 10.1 and 10.2 and provides a convenient means for comparing the relative "risk" of vehicle/pedestrian conflicts at driveways on streets with and without access management treatments applies to driveways. This table indicates that access management driveways put pedestrians at a greater risk of a pedestrian/vehicle conflict when compared to normal driveways. Furthermore, this risk increases with the hourly flow rate of vehicles entering a driveway (or driveways) and with the number of normal driveways that are consolidated into a single access management driveway. In the worst case considered in this table (q=100 vph, N=5 driveways) the access management driveway has a 62% higher risk to a pedestrian than the unconsolidated, five normal driveways.

10.4 Access Management Impacts on Pedestrian Travel Time Along an Arterial

Figures 10.2 and 10.3 schematically depict arterial streets with normal and access management driveways. Travel time for an individual pedestrian passing along a block of these arterials consists of three components:

1) The time (t_1) required to travel the block length assuming that no driveways exist to impede the steady progress of the pedestrian.
2) Total, combined PIEV time (t_2) at the driveway(s) during which the pedestrian decides if an acceptable gap exists in the driveway traffic stream.
3) Total, combined delay (t_3) at the driveway(s) while the pedestrian waits for an acceptable gap.

	"N" = number of driveways									
	1		2		3		4		5	
q(vph)	q'	P'(0,N)	q'	P'(0,N)	q'	P'(0,N)	q'	P'(0,N)	q'	P'(0,N)
20	20	0.96	40	0.92	60	0.89	80	0.85	100	0.82
40	40	0.92	80	0.85	120	0.79	160	0.73	200	0.67
60	60	0.89	120	0.79	180	0.70	240	0.62	300	0.55
80	80	0.85	160	0.73	240	0.62	320	0.53	400	0.45
100	100	0.82	200	0.67	300	0.55	400	0.45	500	0.37

Probabilities That a Single Pedestrian Will Face No Vehicular Conflicts at an "Access-Management Driveway with Consolidated Traffic from "N" Normal Driveways

TABLE 10.2 -- CONFLICT PROBABILITIES (ACCESS MANAGEMENT DRIVEWAYS)

q(vph)		"N"=number of driveways				
		1	2	3	4	5
20	P(0,N)	0.98	0.96	0.94	0.92	0.90
	P'(0,N)	0.96	0.92	0.89	0.85	0.82
	R(P/P')	**1.02**	**1.04**	**1.06**	**1.08**	**1.10**
40	P(0,N)	0.96	0.92	0.88	0.85	0.81
	P'(0,N)	0.92	0.85	0.79	0.73	0.67
	R(P/P')	**1.04**	**1.08**	**1.12**	**1.17**	**1.21**
60	P(0,N)	0.94	0.88	0.83	0.78	0.73
	P'(0,N)	0.89	0.79	0.70	0.62	0.55
	R(P/P')	**1.06**	**1.12**	**1.19**	**1.26**	**1.34**
80	P(0,N)	0.92	0.85	0.78	0.72	0.66
	P'(0,N)	0.85	0.73	0.62	0.53	0.45
	R(P/P')	**1.08**	**1.17**	**1.26**	**1.36**	**1.47**
100	P(0,N)	0.90	0.81	0.73	0.66	0.59
	P'(0,N)	0.82	0.67	0.55	0.45	0.37
	R(P/P')	**1.10**	**1.21**	**1.34**	**1.47**	**1.62**

P(0,N) = Conflict probability -- normal driveway
P'(0,N) = Conflict probability -- access management driveway
R(P/P') = Relative risk of access management driveway as compared to normal driveway

TABLE 10.3 -- RELATIVE RISK OF CONFLICTS AT DRIVEWAYS

The calculation of t_1 is trivial:

t_1 = block length/walking speed.

The magnitude of t_2 is dependent on the number of driveways (N) in the block and the assumed PIEV time at each driveway:

$t_2 = N * PIEV$.

The determination of t_3 is much less straightforward but can be accomplished using the mathematics of gap acceptance. Section 10.3 used the Poisson distribution in a theoretical analysis of the probability of a pedestrian/vehicle conflict at a driveway. The Poisson distribution also describes the probability of a pedestrian encountering different sizes of gaps in a traffic stream. The probability of occurrence of a particular size gap is given by the following equations:

$P(g>t) = e^{-qt/3600}$ and

$P(g<t) = 1 - e^{-qt/3600}$

Where: g = length of gap in seconds

q = driveway traffic volume in vehicles per hour

t = selected time in seconds.

A pedestrian will experience a delay in crossing a driveway if the gap in the traffic stream entering that driveway is shorter than some "critical gap length." This critical gap length is primarily dependent on the width of the driveway. If this gap length is denoted as "t_c", then the probability that a pedestrian will be delayed is:

$P(delay) = P(g< t_c) = 1 - e^{-qtc/3600}$

Values of "t_c" for a normal and an access management driveway can be estimated using the times (see Section 10.3) required for crossing the entry lane of the driveway. If a typical pedestrian accepts a gap in the traffic flow into the driveway that is 25% larger than the required crossing time, then:

t_c (normal driveway) = 125% * 3.75 seconds = 4.7 seconds

t_c (access management driveway) = 125% * 7.23 seconds = 9.0 seconds.

The likelihood that a pedestrian will be delayed at a driveway is then dependent only on the entering flow rate. Using the nomenclature of Section 10.1, the flow rates for normal and access management driveways are *q* and *q'*, respectively. Therefore, the probabilities of delay are:

$$\text{Normal driveway: } P(\text{delay}) = P(g<4.7 \text{ seconds}) = 1 - e^{-q(4.7)/3600} = 1 - e^{-0.001306\,q}$$

$$\text{Access management driveway: } P(\text{delay}) = P(g<9.0 \text{ seconds}) = 1 - e^{-q'(9.0)/3600} = 1 - e^{-0.00250\,q'}$$

If there are "N" normal driveways in a block, then the probability that a pedestrian will be delayed at one or more driveways in the block is:

$$P(\text{delay over "N" driveways}) = 1 - [e^{-0.001306\,q}]^{N}$$

Table 10.4 compares the probabilities of a pedestrian being delayed on a "normal block" and an "access management block" for various values of "N" and "q". For the range of values considered, it is much more likely that a pedestrian will be delayed at a driveway on an access management block as compared to a normal block. That increased likelihood ranges from 49% to 89% more likely to be delayed on an access management block.

The probabilities listed in Table 10.4 are interesting but not particularly relevant to this discussion of pedestrian travel times. The more important statistic is the magnitude of delays that a pedestrian must endure at the two types of driveways.

Figure 10.4 plots the probability that a gap in the driveway traffic flow will be less than some time span, "t". If a gap in the traffic stream is smaller than the critical gap (t_c), then the pedestrian will not cross the driveway and, thus, will be delayed. Conversely, if a gap is larger than t_c, the pedestrian will accept the gap, cross the driveway and suffer no delay.

Furthermore, if a gap is smaller than t_c, the magnitude of the delay to the pedestrian is equal to the gap size (in seconds.) The average delay to a pedestrian for a particular combination of t_c and q (or q' in the case of an access management driveway) can thus be calculated. The notation shown in Figure 10.5 depicts an approximate method of completing such a calculation. In Figure 10.5, the probability that a gap size will be

		q (vph)				
		20	40	60	80	100
N						
1	q' (n*q)	20	40	60	80	100
	P(delay)					
	Normal driveway	2.6%	5.1%	7.5%	9.9%	12.2%
	Access management d/w	4.9%	9.5%	13.9%	18.1%	22.1%
	Ratio	**1.89**	**1.87**	**1.85**	**1.83**	**1.81**
2	q' (n*q)	40	80	120	160	200
	P(delay)					
	Normal driveway	5.1%	9.9%	14.5%	18.9%	23.0%
	Access management d/w	9.5%	18.1%	25.9%	33.0%	39.3%
	Ratio	**1.87**	**1.83**	**1.79**	**1.75**	**1.71**
3	q' (n*q)	60	120	180	240	300
	P(delay)					
	Normal driveway	7.5%	14.5%	20.9%	26.9%	32.4%
	Access management d/w	13.9%	25.9%	36.2%	45.1%	52.8%
	Ratio	**1.85**	**1.79**	**1.73**	**1.68**	**1.63**
4	q' (n*q)	80	160	240	320	400
	P(delay)					
	Normal driveway	9.9%	18.9%	26.9%	34.2%	40.7%
	Access management d/w	18.1%	33.0%	45.1%	55.1%	63.2%
	Ratio	**1.83**	**1.75**	**1.68**	**1.61**	**1.55**
5	q' (n*q)	100	200	300	400	500
	P(delay)					
	Normal driveway	12.2%	23.0%	32.4%	40.7%	48.0%
	Access management d/w	22.1%	39.3%	52.8%	63.2%	71.3%
	Ratio	**1.81**	**1.71**	**1.63**	**1.55**	**1.49**

TABLE 10.4 -- PROBABILITIES OF PEDESTRIAN DELAYS AT DRIVEWAYS

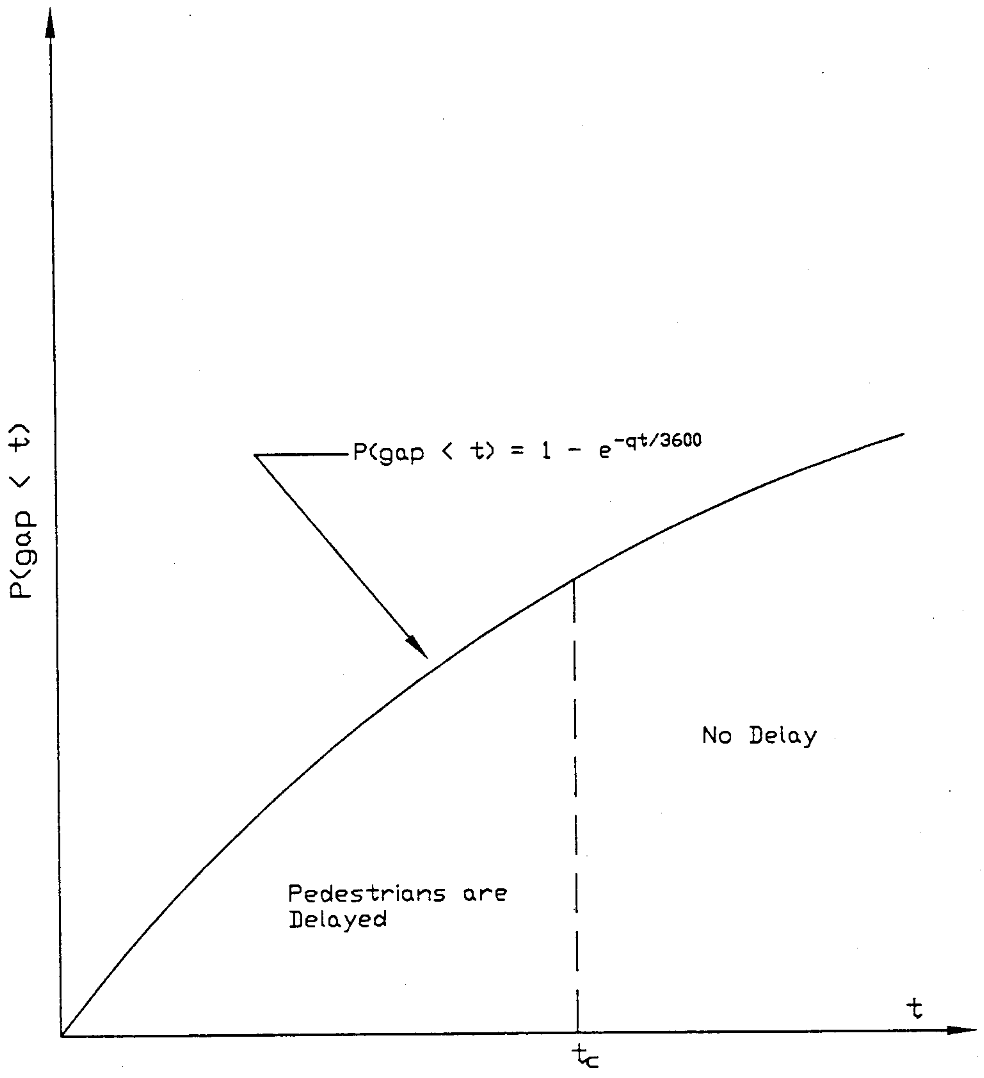


FIGURE 10.4 -- PROBABILITY OF GAPS IN TRAFFIC FLOW

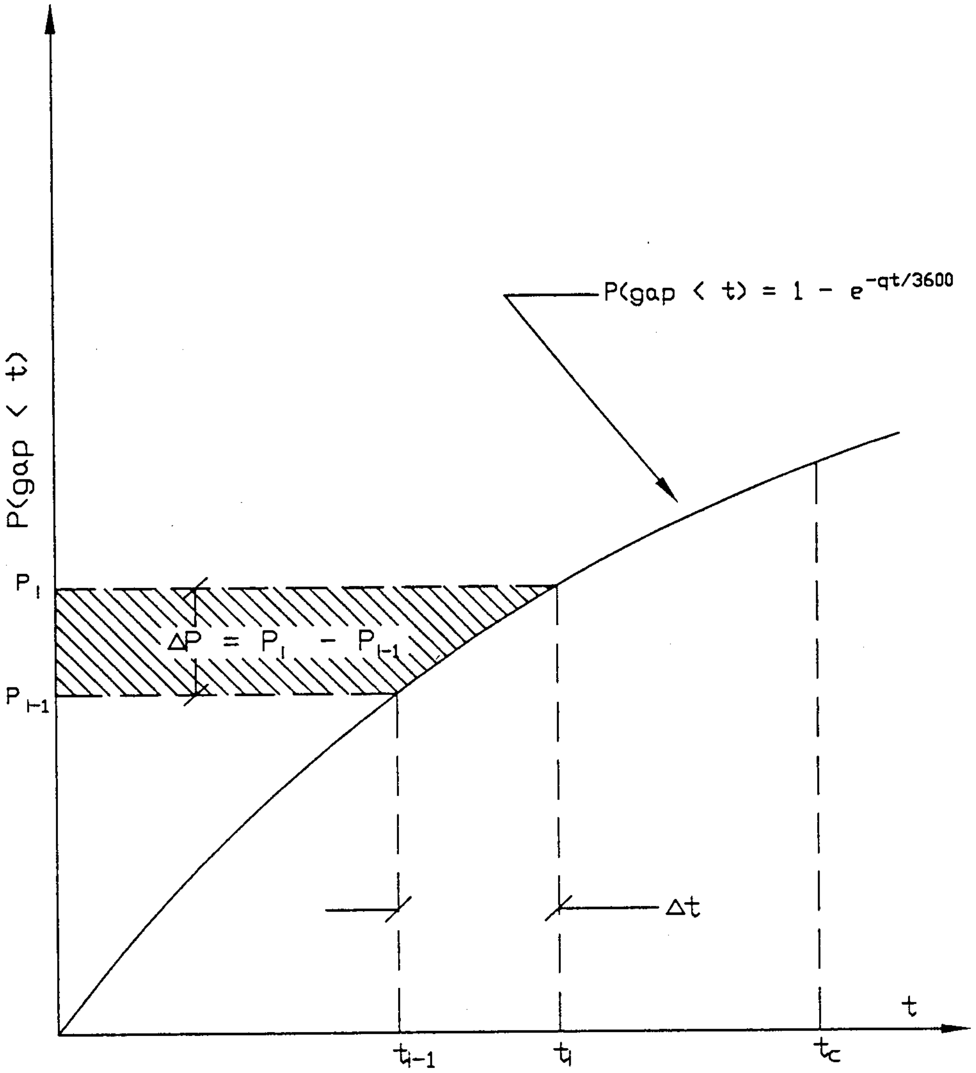


FIGURE 10.5 -- NUMERICAL APPROXIMATION OF AVERAGE DELAY

between t_{i-1} and t_i is equal to $\Delta P = P_i - P_{i-1}$. If the time interval from 0 to t_c is divided into "m" equal time increments of Δt, then the average delay to a pedestrian is:

$$\text{Average delay} = \sum_{i=1}^{m} (P_i - P_{i-1}) * (0.5 * [t_{i-1} + t_i])$$

Table 10.5 (sheets "a" through "e") calculate the average delay for various traffic flow rates to a pedestrian at a normal driveway using the equation:

$$P(\text{delay}) = 1 - e^{-qt/3600} \text{ for } 0 < t < 4.7 \text{ seconds.}$$

The average pedestrian delay at normal driveways is therefore:

q (vph)	delay (per gap)
20	0.06 seconds
40	0.12 seconds
60	0.17 seconds
80	0.23 seconds
100	0.28 seconds

It is important to realize that these delays are "per gap" and that varying percentages of pedestrians will be delayed for zero, one, two or more gaps. For example, Table 10.4 shows that 12.2% of pedestrians will be delayed during the first gap at a normal driveway with q=100 vph. 12.2% of the delayed pedestrians will be delayed for a second gap. 12.2% of the twice-delayed pedestrians will be delayed for a third gap and so on. Table 10.6 calculates the pedestrian delays at a single, normal driveway through 5 gaps. (The calculation was performed through 5 gaps because the percentage of pedestrians delayed for over 5 gaps is insignificant.) Thus, the total delays that a pedestrian can expect at a normal driveway at various flow rates are:

q (vph)	total delay
20	0.06 seconds
40	0.13 seconds
60	0.18 seconds
80	0.26 seconds
100	0.32 seconds

q = 20

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0	0.000				
0.1	0.001	0.001	0.050	0.000	0.000
0.2	0.001	0.001	0.150	0.000	0.000
0.3	0.002	0.001	0.250	0.000	0.000
0.4	0.002	0.001	0.350	0.000	0.000
0.5	0.003	0.001	0.450	0.000	0.001
0.6	0.003	0.001	0.550	0.000	0.001
0.7	0.004	0.001	0.650	0.000	0.001
0.8	0.004	0.001	0.750	0.000	0.002
0.9	0.005	0.001	0.850	0.000	0.002
1	0.006	0.001	0.950	0.001	0.003
1.1	0.006	0.001	1.050	0.001	0.003
1.2	0.007	0.001	1.150	0.001	0.004
1.3	0.007	0.001	1.250	0.001	0.005
1.4	0.008	0.001	1.350	0.001	0.005
1.5	0.008	0.001	1.450	0.001	0.006
1.6	0.009	0.001	1.550	0.001	0.007
1.7	0.009	0.001	1.650	0.001	0.008
1.8	0.010	0.001	1.750	0.001	0.009
1.9	0.011	0.001	1.850	0.001	0.010
2	0.011	0.001	1.950	0.001	0.011
2.1	0.012	0.001	2.050	0.001	0.012
2.2	0.012	0.001	2.150	0.001	0.013
2.3	0.013	0.001	2.250	0.001	0.015
2.4	0.013	0.001	2.350	0.001	0.016
2.5	0.014	0.001	2.450	0.001	0.017
2.6	0.014	0.001	2.550	0.001	0.019
2.7	0.015	0.001	2.650	0.001	0.020
2.8	0.015	0.001	2.750	0.002	0.022
2.9	0.016	0.001	2.850	0.002	0.023
3	0.017	0.001	2.950	0.002	0.025
3.1	0.017	0.001	3.050	0.002	0.026
3.2	0.018	0.001	3.150	0.002	0.028
3.3	0.018	0.001	3.250	0.002	0.030
3.4	0.019	0.001	3.350	0.002	0.032
3.5	0.019	0.001	3.450	0.002	0.034
3.6	0.020	0.001	3.550	0.002	0.036
3.7	0.020	0.001	3.650	0.002	0.038
3.8	0.021	0.001	3.750	0.002	0.040
3.9	0.021	0.001	3.850	0.002	0.042
4	0.022	0.001	3.950	0.002	0.044
4.1	0.023	0.001	4.050	0.002	0.046
4.2	0.023	0.001	4.150	0.002	0.048
4.3	0.024	0.001	4.250	0.002	0.051
4.4	0.024	0.001	4.350	0.002	0.053
4.5	0.025	0.001	4.450	0.002	0.055
4.6	0.025	0.001	4.550	0.002	0.058
4.7	0.026	0.001	4.650	0.003	0.060

AVERAGE PEDESTRIAN DELAY = 0.06 seconds

TABLE 10.5 – PEDESTRIAN DELAYS (NORMAL DRIVEWAYS)

Sheet: a

q = 40

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0	0.000				
0.1	0.001	0.001	0.050	0.000	0.000
0.2	0.002	0.001	0.150	0.000	0.000
0.3	0.003	0.001	0.250	0.000	0.000
0.4	0.004	0.001	0.350	0.000	0.001
0.5	0.006	0.001	0.450	0.000	0.001
0.6	0.007	0.001	0.550	0.001	0.002
0.7	0.008	0.001	0.650	0.001	0.003
0.8	0.009	0.001	0.750	0.001	0.004
0.9	0.010	0.001	0.850	0.001	0.004
1	0.011	0.001	0.950	0.001	0.006
1.1	0.012	0.001	1.050	0.001	0.007
1.2	0.013	0.001	1.150	0.001	0.008
1.3	0.014	0.001	1.250	0.001	0.009
1.4	0.015	0.001	1.350	0.001	0.011
1.5	0.017	0.001	1.450	0.002	0.012
1.6	0.018	0.001	1.550	0.002	0.014
1.7	0.019	0.001	1.650	0.002	0.016
1.8	0.020	0.001	1.750	0.002	0.018
1.9	0.021	0.001	1.850	0.002	0.020
2	0.022	0.001	1.950	0.002	0.022
2.1	0.023	0.001	2.050	0.002	0.024
2.2	0.024	0.001	2.150	0.002	0.026
2.3	0.025	0.001	2.250	0.002	0.029
2.4	0.026	0.001	2.350	0.003	0.031
2.5	0.027	0.001	2.450	0.003	0.034
2.6	0.028	0.001	2.550	0.003	0.037
2.7	0.030	0.001	2.650	0.003	0.040
2.8	0.031	0.001	2.750	0.003	0.043
2.9	0.032	0.001	2.850	0.003	0.046
3	0.033	0.001	2.950	0.003	0.049
3.1	0.034	0.001	3.050	0.003	0.052
3.2	0.035	0.001	3.150	0.003	0.056
3.3	0.036	0.001	3.250	0.003	0.059
3.4	0.037	0.001	3.350	0.004	0.063
3.5	0.038	0.001	3.450	0.004	0.066
3.6	0.039	0.001	3.550	0.004	0.070
3.7	0.040	0.001	3.650	0.004	0.074
3.8	0.041	0.001	3.750	0.004	0.078
3.9	0.042	0.001	3.850	0.004	0.082
4	0.043	0.001	3.950	0.004	0.086
4.1	0.045	0.001	4.050	0.004	0.091
4.2	0.046	0.001	4.150	0.004	0.095
4.3	0.047	0.001	4.250	0.005	0.100
4.4	0.048	0.001	4.350	0.005	0.104
4.5	0.049	0.001	4.450	0.005	0.109
4.6	0.050	0.001	4.550	0.005	0.114
4.7	0.051	0.001	4.650	0.005	0.119
	AVERAGE PEDESTRIAN DELAY =				**0.12 seconds**

TABLE 10.5 -- PEDESTRIAN DELAYS (NORMAL DRIVEWAYS)

Sheet: b

q = 60

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0	0.000				
0.1	0.002	0.002	0.050	0.000	0.000
0.2	0.003	0.002	0.150	0.000	0.000
0.3	0.005	0.002	0.250	0.000	0.001
0.4	0.007	0.002	0.350	0.001	0.001
0.5	0.008	0.002	0.450	0.001	0.002
0.6	0.010	0.002	0.550	0.001	0.003
0.7	0.012	0.002	0.650	0.001	0.004
0.8	0.013	0.002	0.750	0.001	0.005
0.9	0.015	0.002	0.850	0.001	0.007
1	0.017	0.002	0.950	0.002	0.008
1.1	0.018	0.002	1.050	0.002	0.010
1.2	0.020	0.002	1.150	0.002	0.012
1.3	0.021	0.002	1.250	0.002	0.014
1.4	0.023	0.002	1.350	0.002	0.016
1.5	0.025	0.002	1.450	0.002	0.018
1.6	0.026	0.002	1.550	0.003	0.021
1.7	0.028	0.002	1.650	0.003	0.024
1.8	0.030	0.002	1.750	0.003	0.026
1.9	0.031	0.002	1.850	0.003	0.029
2	0.033	0.002	1.950	0.003	0.033
2.1	0.034	0.002	2.050	0.003	0.036
2.2	0.036	0.002	2.150	0.003	0.039
2.3	0.038	0.002	2.250	0.004	0.043
2.4	0.039	0.002	2.350	0.004	0.047
2.5	0.041	0.002	2.450	0.004	0.051
2.6	0.042	0.002	2.550	0.004	0.055
2.7	0.044	0.002	2.650	0.004	0.059
2.8	0.046	0.002	2.750	0.004	0.063
2.9	0.047	0.002	2.850	0.005	0.068
3	0.049	0.002	2.950	0.005	0.073
3.1	0.050	0.002	3.050	0.005	0.077
3.2	0.052	0.002	3.150	0.005	0.082
3.3	0.054	0.002	3.250	0.005	0.087
3.4	0.055	0.002	3.350	0.005	0.093
3.5	0.057	0.002	3.450	0.005	0.098
3.6	0.058	0.002	3.550	0.006	0.104
3.7	0.060	0.002	3.650	0.006	0.110
3.8	0.061	0.002	3.750	0.006	0.115
3.9	0.063	0.002	3.850	0.006	0.121
4	0.064	0.002	3.950	0.006	0.128
4.1	0.066	0.002	4.050	0.006	0.134
4.2	0.068	0.002	4.150	0.006	0.140
4.3	0.069	0.002	4.250	0.007	0.147
4.4	0.071	0.002	4.350	0.007	0.154
4.5	0.072	0.002	4.450	0.007	0.161
4.6	0.074	0.002	4.550	0.007	0.168
4.7	0.075	0.002	4.650	0.007	0.175

AVERAGE PEDESTRIAN DELAY = 0.17 seconds

TABLE 10.5 – PEDESTRIAN DELAYS (NORMAL DRIVEWAYS)

Sheet: c

q = 80

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0	0.000				
0.1	0.002	0.002	0.050	0.000	0.000
0.2	0.004	0.002	0.150	0.000	0.000
0.3	0.007	0.002	0.250	0.001	0.001
0.4	0.009	0.002	0.350	0.001	0.002
0.5	0.011	0.002	0.450	0.001	0.003
0.6	0.013	0.002	0.550	0.001	0.004
0.7	0.015	0.002	0.650	0.001	0.005
0.8	0.018	0.002	0.750	0.002	0.007
0.9	0.020	0.002	0.850	0.002	0.009
1	0.022	0.002	0.950	0.002	0.011
1.1	0.024	0.002	1.050	0.002	0.013
1.2	0.026	0.002	1.150	0.002	0.016
1.3	0.028	0.002	1.250	0.003	0.018
1.4	0.031	0.002	1.350	0.003	0.021
1.5	0.033	0.002	1.450	0.003	0.024
1.6	0.035	0.002	1.550	0.003	0.028
1.7	0.037	0.002	1.650	0.004	0.031
1.8	0.039	0.002	1.750	0.004	0.035
1.9	0.041	0.002	1.850	0.004	0.039
2	0.043	0.002	1.950	0.004	0.043
2.1	0.046	0.002	2.050	0.004	0.048
2.2	0.048	0.002	2.150	0.005	0.052
2.3	0.050	0.002	2.250	0.005	0.057
2.4	0.052	0.002	2.350	0.005	0.062
2.5	0.054	0.002	2.450	0.005	0.067
2.6	0.056	0.002	2.550	0.005	0.072
2.7	0.058	0.002	2.650	0.006	0.078
2.8	0.060	0.002	2.750	0.006	0.084
2.9	0.062	0.002	2.850	0.006	0.090
3	0.064	0.002	2.950	0.006	0.096
3.1	0.067	0.002	3.050	0.006	0.102
3.2	0.069	0.002	3.150	0.007	0.109
3.3	0.071	0.002	3.250	0.007	0.115
3.4	0.073	0.002	3.350	0.007	0.122
3.5	0.075	0.002	3.450	0.007	0.129
3.6	0.077	0.002	3.550	0.007	0.137
3.7	0.079	0.002	3.650	0.007	0.144
3.8	0.081	0.002	3.750	0.008	0.152
3.9	0.083	0.002	3.850	0.008	0.160
4	0.085	0.002	3.950	0.008	0.168
4.1	0.087	0.002	4.050	0.008	0.176
4.2	0.089	0.002	4.150	0.008	0.184
4.3	0.091	0.002	4.250	0.009	0.193
4.4	0.093	0.002	4.350	0.009	0.202
4.5	0.095	0.002	4.450	0.009	0.211
4.6	0.097	0.002	4.550	0.009	0.220
4.7	0.099	0.002	4.650	0.009	0.229

AVERAGE PEDESTRIAN DELAY = 0.23 seconds

TABLE 10.5 – PEDESTRIAN DELAYS (NORMAL DRIVEWAYS)

Sheet: d

						q =	**100**
	ti	P(t)	delta P	t (ave)	Product	Accumulated Product	
	0	0.000					
	0.1	0.003	0.003	0.050	0.000	0.000	
	0.2	0.006	0.003	0.150	0.000	0.001	
	0.3	0.008	0.003	0.250	0.001	0.001	
	0.4	0.011	0.003	0.350	0.001	0.002	
	0.5	0.014	0.003	0.450	0.001	0.003	
	0.6	0.017	0.003	0.550	0.002	0.005	
	0.7	0.019	0.003	0.650	0.002	0.007	
	0.8	0.022	0.003	0.750	0.002	0.009	
	0.9	0.025	0.003	0.850	0.002	0.011	
	1	0.027	0.003	0.950	0.003	0.014	
	1.1	0.030	0.003	1.050	0.003	0.016	
	1.2	0.033	0.003	1.150	0.003	0.020	
	1.3	0.035	0.003	1.250	0.003	0.023	
	1.4	0.038	0.003	1.350	0.004	0.027	
	1.5	0.041	0.003	1.450	0.004	0.030	
	1.6	0.043	0.003	1.550	0.004	0.035	
	1.7	0.046	0.003	1.650	0.004	0.039	
	1.8	0.049	0.003	1.750	0.005	0.044	
	1.9	0.051	0.003	1.850	0.005	0.048	
	2	0.054	0.003	1.950	0.005	0.054	
	2.1	0.057	0.003	2.050	0.005	0.059	
	2.2	0.059	0.003	2.150	0.006	0.065	
	2.3	0.062	0.003	2.250	0.006	0.070	
	2.4	0.064	0.003	2.350	0.006	0.077	
	2.5	0.067	0.003	2.450	0.006	0.083	
	2.6	0.070	0.003	2.550	0.007	0.089	
	2.7	0.072	0.003	2.650	0.007	0.096	
	2.8	0.075	0.003	2.750	0.007	0.103	
	2.9	0.077	0.003	2.850	0.007	0.111	
	3	0.080	0.003	2.950	0.008	0.118	
	3.1	0.083	0.003	3.050	0.008	0.126	
	3.2	0.085	0.003	3.150	0.008	0.134	
	3.3	0.088	0.003	3.250	0.008	0.142	
	3.4	0.090	0.003	3.350	0.008	0.151	
	3.5	0.093	0.003	3.450	0.009	0.160	
	3.6	0.095	0.003	3.550	0.009	0.168	
	3.7	0.098	0.003	3.650	0.009	0.178	
	3.8	0.100	0.003	3.750	0.009	0.187	
	3.9	0.103	0.002	3.850	0.010	0.197	
	4	0.105	0.002	3.950	0.010	0.206	
	4.1	0.108	0.002	4.050	0.010	0.216	
	4.2	0.110	0.002	4.150	0.010	0.227	
	4.3	0.113	0.002	4.250	0.010	0.237	
	4.4	0.115	0.002	4.350	0.011	0.248	
	4.5	0.118	0.002	4.450	0.011	0.259	
	4.6	0.120	0.002	4.550	0.011	0.270	
	4.7	0.122	0.002	4.650	0.011	0.281	
		AVERAGE PEDESTRIAN DELAY =				**0.28**	**seconds**

TABLE 10.5 – PEDESTRIAN DELAYS (NORMAL DRIVEWAYS)

Sheet: e

		q (vph)					
Gap		20	40	60	80	100	
1	% of pedestrians	100%	100%	100%	100%	100%	
	Ave delay per gap	0.06	0.12	0.17	0.23	0.28	
2	% of pedestrians	2.6%	5.1%	7.5%	9.9%	12.2%	(a)
	Ave delay per gap	0.06	0.12	0.17	0.23	0.28	
3	% of pedestrians	0.1%	0.3%	0.6%	1.0%	1.5%	(b)
	Ave delay per gap	0.06	0.12	0.17	0.23	0.28	
4	% of pedestrians	0.0%	0.0%	0.0%	0.1%	0.2%	(c)
	Ave delay per gap	0.06	0.12	0.17	0.23	0.28	
5	% of pedestrians	0.0%	0.0%	0.0%	0.0%	0.0%	(d)
	Ave delay per gap	0.06	0.12	0.17	0.23	0.28	
	Average delay through 5 gaps (seconds)	**0.06**	**0.13**	**0.18**	**0.26**	**0.32**	(e)

(a): From Table 10.4
(b): Value of row (a) squared
(c): (a) cubed
(d): (a) ^ 4
(e): [1 + (a) + (b) + (c) + (d)] * Ave delay per gap

TABLE 10.6 -- PED DELAYS AT A SINGLE NORMAL DRIVEWAY

Total pedestrian travel time along a block of arterial street with normal driveways can now be calculated as:

Travel time (T) = $t_1 + t_2 + N^*t_d$

Where: t_1 and t_2 are as defined above

N = the number of driveways in the block

t_d = overall average delay at a driveway while waiting for an acceptable gap (row "e" in Table 10.6).

Table 10.7 calculates pedestrian travel times for various values of "q" and "N" for an arterial block with normal driveways.

Total pedestrian travel time along a block of arterial street where all "N" driveways have been consolidated into a single access management driveway can be calculated in a similar fashion. Figure 10.3 shows the block and driveway layout in the access management case.

At a pedestrian walking speed of 4 fps, the pedestrian requires 7.23 seconds to traverse the entry lane of the driveway. Assuming that the critical gap is again 25% longer than the crossing time, t_c will be 9.0 seconds for the access management driveway.

Using the nomenclature of Figure 10.5, the average delay at an access management driveway is again:

$$\text{Average delay} = \sum_{i=1}^{m} (P_i - P_{i-1}) * (0.5 * [t_{i-1} + t_i])$$

Table 10.8 (sheets "a" through "y") calculate the average delays to a pedestrian at an access management driveway for various values of "N" (the number of normal driveways consolidated into the single access management driveway) and "q" (the traffic flow rate into each of the consolidated normal driveways.) Table 10.9 summarizes the calculated average delays at the access management driveway. It should be noted again that these delays are "per gap" and varying percentages of pedestrians will be delayed by zero, one, two or more gaps.

Table 10.10 (sheets "a" through "e") calculate the pedestrian delays at an access management driveway through 20 gaps for varying "q" and "N". Table 10.11

consolidates these calculated delays. Table 10.12 calculates pedestrian travel times for various values of "q" and "N" for an arterial block with an access management driveway.

Finally, Table 10.13 compares these travel times to those calculated in Table 10.7 for a block with normal driveways. This table shows that pedestrian travel times are generally shorter along blocks where driveways have been consolidated as compared to blocks with normal driveways. However, the reductions in travel times are generally rather small and may, in fact, not be discernible to the average pedestrian. (It should also be noted that the shorter travel times on access management blocks are the result of normal blocks requiring more PIEV time. If the assumed PIEV time at each driveway were changed, the resulting comparative travel times would also change.)

	Block length =	400	feet	(122 m)		
	Walking speed =	4	fps	(1.22 mps)		
	PIEV time =	2.5	seconds			
	q (vph)	**20**	**40**	**60**	**80**	**100**
	td (sec)	0.06	0.13	0.18	0.26	0.32
N = # of driveways						
1	t1	100.0	100.0	100.0	100.0	100.0
	t2	2.5	2.5	2.5	2.5	2.5
	t3	0.1	0.1	0.2	0.3	0.3
	T	**102.6**	**102.6**	**102.7**	**102.8**	**102.8**
2	t1	100.0	100.0	100.0	100.0	100.0
	t2	5.0	5.0	5.0	5.0	5.0
	t3	0.1	0.3	0.4	0.5	0.6
	T	**105.1**	**105.3**	**105.4**	**105.5**	**105.6**
3	t1	100.0	100.0	100.0	100.0	100.0
	t2	7.5	7.5	7.5	7.5	7.5
	t3	0.2	0.4	0.5	0.8	1.0
	T	**107.7**	**107.9**	**108.0**	**108.3**	**108.5**
4	t1	100.0	100.0	100.0	100.0	100.0
	t2	10.0	10.0	10.0	10.0	10.0
	t3	0.2	0.5	0.7	1.0	1.3
	T	**110.2**	**110.5**	**110.7**	**111.0**	**111.3**
5	t1	100.0	100.0	100.0	100.0	100.0
	t2	12.5	12.5	12.5	12.5	12.5
	t3	0.3	0.7	0.9	1.3	1.6
	T	**112.8**	**113.2**	**113.4**	**113.8**	**114.1**

TABLE 10.7 -- PED TRAVEL TIMES (NORMAL DRIVEWAYS)

AVERAGE PEDESTRIAN DELAY					q =	20
					N=	1
					q'=	20
ti	P(t)	delta P	t (ave)	Product	Accumulated Product	
0.0	0.000					
0.2	0.001	0.001	0.100	0.000	0.000	
0.4	0.002	0.001	0.300	0.000	0.000	
0.6	0.003	0.001	0.500	0.001	0.001	
0.8	0.004	0.001	0.700	0.001	0.002	
1.0	0.006	0.001	0.900	0.001	0.003	
1.2	0.007	0.001	1.100	0.001	0.004	
1.4	0.008	0.001	1.300	0.001	0.005	
1.6	0.009	0.001	1.500	0.002	0.007	
1.8	0.010	0.001	1.700	0.002	0.009	
2.0	0.011	0.001	1.900	0.002	0.011	
2.2	0.012	0.001	2.100	0.002	0.013	
2.4	0.013	0.001	2.300	0.003	0.016	
2.6	0.014	0.001	2.500	0.003	0.019	
2.8	0.015	0.001	2.700	0.003	0.022	
3.0	0.017	0.001	2.900	0.003	0.025	
3.2	0.018	0.001	3.100	0.003	0.028	
3.4	0.019	0.001	3.300	0.004	0.032	
3.6	0.020	0.001	3.500	0.004	0.036	
3.8	0.021	0.001	3.700	0.004	0.040	
4.0	0.022	0.001	3.900	0.004	0.044	
4.2	0.023	0.001	4.100	0.004	0.048	
4.4	0.024	0.001	4.300	0.005	0.053	
4.6	0.025	0.001	4.500	0.005	0.058	
4.8	0.026	0.001	4.700	0.005	0.063	
5.0	0.027	0.001	4.900	0.005	0.068	
5.2	0.028	0.001	5.100	0.006	0.074	
5.4	0.030	0.001	5.300	0.006	0.079	
5.6	0.031	0.001	5.500	0.006	0.085	
5.8	0.032	0.001	5.700	0.006	0.091	
6.0	0.033	0.001	5.900	0.006	0.098	
6.2	0.034	0.001	6.100	0.007	0.104	
6.4	0.035	0.001	6.300	0.007	0.111	
6.6	0.036	0.001	6.500	0.007	0.118	
6.8	0.037	0.001	6.700	0.007	0.125	
7.0	0.038	0.001	6.900	0.007	0.133	
7.2	0.039	0.001	7.100	0.008	0.140	
7.4	0.040	0.001	7.300	0.008	0.148	
7.6	0.041	0.001	7.500	0.008	0.156	
7.8	0.042	0.001	7.700	0.008	0.164	
8.0	0.043	0.001	7.900	0.008	0.173	
8.2	0.045	0.001	8.100	0.009	0.181	
8.4	0.046	0.001	8.300	0.009	0.190	
8.6	0.047	0.001	8.500	0.009	0.199	
8.8	0.048	0.001	8.700	0.009	0.208	
9.0	0.049	0.001	8.900	0.009	0.218	
	AVERAGE PEDESTRIAN DELAY =				0.22	seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet a

AVERAGE PEDESTRIAN DELAY

q = 20
N= 2
q'= 40

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.002	0.002	0.100	0.000	0.000
0.4	0.004	0.002	0.300	0.001	0.001
0.6	0.007	0.002	0.500	0.001	0.002
0.8	0.009	0.002	0.700	0.002	0.004
1.0	0.011	0.002	0.900	0.002	0.006
1.2	0.013	0.002	1.100	0.002	0.008
1.4	0.015	0.002	1.300	0.003	0.011
1.6	0.018	0.002	1.500	0.003	0.014
1.8	0.020	0.002	1.700	0.004	0.018
2.0	0.022	0.002	1.900	0.004	0.022
2.2	0.024	0.002	2.100	0.005	0.026
2.4	0.026	0.002	2.300	0.005	0.031
2.6	0.028	0.002	2.500	0.005	0.037
2.8	0.031	0.002	2.700	0.006	0.043
3.0	0.033	0.002	2.900	0.006	0.049
3.2	0.035	0.002	3.100	0.007	0.056
3.4	0.037	0.002	3.300	0.007	0.063
3.6	0.039	0.002	3.500	0.007	0.070
3.8	0.041	0.002	3.700	0.008	0.078
4.0	0.043	0.002	3.900	0.008	0.086
4.2	0.046	0.002	4.100	0.009	0.095
4.4	0.048	0.002	4.300	0.009	0.104
4.6	0.050	0.002	4.500	0.010	0.114
4.8	0.052	0.002	4.700	0.010	0.124
5.0	0.054	0.002	4.900	0.010	0.134
5.2	0.056	0.002	5.100	0.011	0.145
5.4	0.058	0.002	5.300	0.011	0.156
5.6	0.060	0.002	5.500	0.011	0.167
5.8	0.062	0.002	5.700	0.012	0.179
6.0	0.064	0.002	5.900	0.012	0.191
6.2	0.067	0.002	6.100	0.013	0.204
6.4	0.069	0.002	6.300	0.013	0.217
6.6	0.071	0.002	6.500	0.013	0.230
6.8	0.073	0.002	6.700	0.014	0.244
7.0	0.075	0.002	6.900	0.014	0.259
7.2	0.077	0.002	7.100	0.015	0.273
7.4	0.079	0.002	7.300	0.015	0.288
7.6	0.081	0.002	7.500	0.015	0.303
7.8	0.083	0.002	7.700	0.016	0.319
8.0	0.085	0.002	7.900	0.016	0.335
8.2	0.087	0.002	8.100	0.016	0.352
8.4	0.089	0.002	8.300	0.017	0.368
8.6	0.091	0.002	8.500	0.017	0.386
8.8	0.093	0.002	8.700	0.018	0.403
9.0	0.095	0.002	8.900	0.018	0.421

AVERAGE PEDESTRIAN DELAY = 0.42 seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet b

AVERAGE PEDESTRIAN DELAY

q = 20
N= 3
q'= 60

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.003	0.003	0.100	0.000	0.000
0.4	0.007	0.003	0.300	0.001	0.001
0.6	0.010	0.003	0.500	0.002	0.003
0.8	0.013	0.003	0.700	0.002	0.005
1.0	0.017	0.003	0.900	0.003	0.008
1.2	0.020	0.003	1.100	0.004	0.012
1.4	0.023	0.003	1.300	0.004	0.016
1.6	0.026	0.003	1.500	0.005	0.021
1.8	0.030	0.003	1.700	0.006	0.026
2.0	0.033	0.003	1.900	0.006	0.033
2.2	0.036	0.003	2.100	0.007	0.039
2.4	0.039	0.003	2.300	0.007	0.047
2.6	0.042	0.003	2.500	0.008	0.055
2.8	0.046	0.003	2.700	0.009	0.063
3.0	0.049	0.003	2.900	0.009	0.073
3.2	0.052	0.003	3.100	0.010	0.082
3.4	0.055	0.003	3.300	0.010	0.093
3.6	0.058	0.003	3.500	0.011	0.104
3.8	0.061	0.003	3.700	0.012	0.115
4.0	0.064	0.003	3.900	0.012	0.128
4.2	0.068	0.003	4.100	0.013	0.140
4.4	0.071	0.003	4.300	0.013	0.154
4.6	0.074	0.003	4.500	0.014	0.168
4.8	0.077	0.003	4.700	0.014	0.182
5.0	0.080	0.003	4.900	0.015	0.197
5.2	0.083	0.003	5.100	0.016	0.213
5.4	0.086	0.003	5.300	0.016	0.229
5.6	0.089	0.003	5.500	0.017	0.246
5.8	0.092	0.003	5.700	0.017	0.263
6.0	0.095	0.003	5.900	0.018	0.281
6.2	0.098	0.003	6.100	0.018	0.299
6.4	0.101	0.003	6.300	0.019	0.318
6.6	0.104	0.003	6.500	0.019	0.337
6.8	0.107	0.003	6.700	0.020	0.357
7.0	0.110	0.003	6.900	0.021	0.378
7.2	0.113	0.003	7.100	0.021	0.399
7.4	0.116	0.003	7.300	0.022	0.420
7.6	0.119	0.003	7.500	0.022	0.443
7.8	0.122	0.003	7.700	0.023	0.465
8.0	0.125	0.003	7.900	0.023	0.488
8.2	0.128	0.003	8.100	0.024	0.512
8.4	0.131	0.003	8.300	0.024	0.536
8.6	0.134	0.003	8.500	0.025	0.560
8.8	0.136	0.003	8.700	0.025	0.586
9.0	0.139	0.003	8.900	0.026	0.611
	AVERAGE PEDESTRIAN DELAY =				**0.61 seconds**

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet c

AVERAGE PEDESTRIAN DELAY

q = 20
N= 4
q'= 80

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.004	0.004	0.100	0.000	0.000
0.4	0.009	0.004	0.300	0.001	0.002
0.6	0.013	0.004	0.500	0.002	0.004
0.8	0.018	0.004	0.700	0.003	0.007
1.0	0.022	0.004	0.900	0.004	0.011
1.2	0.026	0.004	1.100	0.005	0.016
1.4	0.031	0.004	1.300	0.006	0.021
1.6	0.035	0.004	1.500	0.006	0.028
1.8	0.039	0.004	1.700	0.007	0.035
2.0	0.043	0.004	1.900	0.008	0.043
2.2	0.048	0.004	2.100	0.009	0.052
2.4	0.052	0.004	2.300	0.010	0.062
2.6	0.056	0.004	2.500	0.011	0.072
2.8	0.060	0.004	2.700	0.011	0.084
3.0	0.064	0.004	2.900	0.012	0.096
3.2	0.069	0.004	3.100	0.013	0.109
3.4	0.073	0.004	3.300	0.014	0.122
3.6	0.077	0.004	3.500	0.014	0.137
3.8	0.081	0.004	3.700	0.015	0.152
4.0	0.085	0.004	3.900	0.016	0.168
4.2	0.089	0.004	4.100	0.017	0.184
4.4	0.093	0.004	4.300	0.017	0.202
4.6	0.097	0.004	4.500	0.018	0.220
4.8	0.101	0.004	4.700	0.019	0.239
5.0	0.105	0.004	4.900	0.020	0.258
5.2	0.109	0.004	5.100	0.020	0.278
5.4	0.113	0.004	5.300	0.021	0.299
5.6	0.117	0.004	5.500	0.022	0.321
5.8	0.121	0.004	5.700	0.022	0.343
6.0	0.125	0.004	5.900	0.023	0.366
6.2	0.129	0.004	6.100	0.024	0.390
6.4	0.133	0.004	6.300	0.024	0.414
6.6	0.136	0.004	6.500	0.025	0.439
6.8	0.140	0.004	6.700	0.026	0.465
7.0	0.144	0.004	6.900	0.026	0.491
7.2	0.148	0.004	7.100	0.027	0.518
7.4	0.152	0.004	7.300	0.028	0.546
7.6	0.155	0.004	7.500	0.028	0.574
7.8	0.159	0.004	7.700	0.029	0.603
8.0	0.163	0.004	7.900	0.029	0.632
8.2	0.167	0.004	8.100	0.030	0.662
8.4	0.170	0.004	8.300	0.031	0.693
8.6	0.174	0.004	8.500	0.031	0.724
8.8	0.178	0.004	8.700	0.032	0.756
9.0	0.181	0.004	8.900	0.032	0.789

AVERAGE PEDESTRIAN DELAY = **0.79** seconds

TABLE 10.8 -- Pedestrian Delays (Access Managment Driveways)

Sheet d

AVERAGE PEDESTRIAN DELAY

q = 20
N= 5
q'= 100

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.006	0.006	0.100	0.001	0.001
0.4	0.011	0.006	0.300	0.002	0.002
0.6	0.017	0.005	0.500	0.003	0.005
0.8	0.022	0.005	0.700	0.004	0.009
1.0	0.027	0.005	0.900	0.005	0.014
1.2	0.033	0.005	1.100	0.006	0.020
1.4	0.038	0.005	1.300	0.007	0.027
1.6	0.043	0.005	1.500	0.008	0.035
1.8	0.049	0.005	1.700	0.009	0.044
2.0	0.054	0.005	1.900	0.010	0.054
2.2	0.059	0.005	2.100	0.011	0.065
2.4	0.064	0.005	2.300	0.012	0.077
2.6	0.070	0.005	2.500	0.013	0.089
2.8	0.075	0.005	2.700	0.014	0.103
3.0	0.080	0.005	2.900	0.015	0.118
3.2	0.085	0.005	3.100	0.016	0.134
3.4	0.090	0.005	3.300	0.017	0.151
3.6	0.095	0.005	3.500	0.018	0.168
3.8	0.100	0.005	3.700	0.019	0.187
4.0	0.105	0.005	3.900	0.019	0.206
4.2	0.110	0.005	4.100	0.020	0.227
4.4	0.115	0.005	4.300	0.021	0.248
4.6	0.120	0.005	4.500	0.022	0.270
4.8	0.125	0.005	4.700	0.023	0.293
5.0	0.130	0.005	4.900	0.024	0.317
5.2	0.134	0.005	5.100	0.025	0.341
5.4	0.139	0.005	5.300	0.025	0.367
5.6	0.144	0.005	5.500	0.026	0.393
5.8	0.149	0.005	5.700	0.027	0.420
6.0	0.154	0.005	5.900	0.028	0.448
6.2	0.158	0.005	6.100	0.029	0.476
6.4	0.163	0.005	6.300	0.029	0.506
6.6	0.168	0.005	6.500	0.030	0.536
6.8	0.172	0.005	6.700	0.031	0.567
7.0	0.177	0.005	6.900	0.032	0.598
7.2	0.181	0.005	7.100	0.032	0.631
7.4	0.186	0.005	7.300	0.033	0.664
7.6	0.190	0.005	7.500	0.034	0.698
7.8	0.195	0.004	7.700	0.035	0.732
8.0	0.199	0.004	7.900	0.035	0.768
8.2	0.204	0.004	8.100	0.036	0.804
8.4	0.208	0.004	8.300	0.037	0.840
8.6	0.212	0.004	8.500	0.037	0.877
8.8	0.217	0.004	8.700	0.038	0.915
9.0	0.221	0.004	8.900	0.039	0.954

AVERAGE PEDESTRIAN DELAY = 0.95 seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet e

AVERAGE PEDESTRIAN DELAY

q = 40
N= 1
q'= 40

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.002	0.002	0.100	0.000	0.000
0.4	0.004	0.002	0.300	0.001	0.001
0.6	0.007	0.002	0.500	0.001	0.002
0.8	0.009	0.002	0.700	0.002	0.004
1.0	0.011	0.002	0.900	0.002	0.006
1.2	0.013	0.002	1.100	0.002	0.008
1.4	0.015	0.002	1.300	0.003	0.011
1.6	0.018	0.002	1.500	0.003	0.014
1.8	0.020	0.002	1.700	0.004	0.018
2.0	0.022	0.002	1.900	0.004	0.022
2.2	0.024	0.002	2.100	0.005	0.026
2.4	0.026	0.002	2.300	0.005	0.031
2.6	0.028	0.002	2.500	0.005	0.037
2.8	0.031	0.002	2.700	0.006	0.043
3.0	0.033	0.002	2.900	0.006	0.049
3.2	0.035	0.002	3.100	0.007	0.056
3.4	0.037	0.002	3.300	0.007	0.063
3.6	0.039	0.002	3.500	0.007	0.070
3.8	0.041	0.002	3.700	0.008	0.078
4.0	0.043	0.002	3.900	0.008	0.086
4.2	0.046	0.002	4.100	0.009	0.095
4.4	0.048	0.002	4.300	0.009	0.104
4.6	0.050	0.002	4.500	0.010	0.114
4.8	0.052	0.002	4.700	0.010	0.124
5.0	0.054	0.002	4.900	0.010	0.134
5.2	0.056	0.002	5.100	0.011	0.145
5.4	0.058	0.002	5.300	0.011	0.156
5.6	0.060	0.002	5.500	0.011	0.167
5.8	0.062	0.002	5.700	0.012	0.179
6.0	0.064	0.002	5.900	0.012	0.191
6.2	0.067	0.002	6.100	0.013	0.204
6.4	0.069	0.002	6.300	0.013	0.217
6.6	0.071	0.002	6.500	0.013	0.230
6.8	0.073	0.002	6.700	0.014	0.244
7.0	0.075	0.002	6.900	0.014	0.259
7.2	0.077	0.002	7.100	0.015	0.273
7.4	0.079	0.002	7.300	0.015	0.288
7.6	0.081	0.002	7.500	0.015	0.303
7.8	0.083	0.002	7.700	0.016	0.319
8.0	0.085	0.002	7.900	0.016	0.335
8.2	0.087	0.002	8.100	0.016	0.352
8.4	0.089	0.002	8.300	0.017	0.368
8.6	0.091	0.002	8.500	0.017	0.386
8.8	0.093	0.002	8.700	0.018	0.403
9.0	0.095	0.002	8.900	0.018	0.421

AVERAGE PEDESTRIAN DELAY = 0.42 seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet f

AVERAGE PEDESTRIAN DELAY

q = 40
N= 2
q'= 80

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.004	0.004	0.100	0.000	0.000
0.4	0.009	0.004	0.300	0.001	0.002
0.6	0.013	0.004	0.500	0.002	0.004
0.8	0.018	0.004	0.700	0.003	0.007
1.0	0.022	0.004	0.900	0.004	0.011
1.2	0.026	0.004	1.100	0.005	0.016
1.4	0.031	0.004	1.300	0.006	0.021
1.6	0.035	0.004	1.500	0.006	0.028
1.8	0.039	0.004	1.700	0.007	0.035
2.0	0.043	0.004	1.900	0.008	0.043
2.2	0.048	0.004	2.100	0.009	0.052
2.4	0.052	0.004	2.300	0.010	0.062
2.6	0.056	0.004	2.500	0.011	0.072
2.8	0.060	0.004	2.700	0.011	0.084
3.0	0.064	0.004	2.900	0.012	0.096
3.2	0.069	0.004	3.100	0.013	0.109
3.4	0.073	0.004	3.300	0.014	0.122
3.6	0.077	0.004	3.500	0.014	0.137
3.8	0.081	0.004	3.700	0.015	0.152
4.0	0.085	0.004	3.900	0.016	0.168
4.2	0.089	0.004	4.100	0.017	0.184
4.4	0.093	0.004	4.300	0.017	0.202
4.6	0.097	0.004	4.500	0.018	0.220
4.8	0.101	0.004	4.700	0.019	0.239
5.0	0.105	0.004	4.900	0.020	0.258
5.2	0.109	0.004	5.100	0.020	0.278
5.4	0.113	0.004	5.300	0.021	0.299
5.6	0.117	0.004	5.500	0.022	0.321
5.8	0.121	0.004	5.700	0.022	0.343
6.0	0.125	0.004	5.900	0.023	0.366
6.2	0.129	0.004	6.100	0.024	0.390
6.4	0.133	0.004	6.300	0.024	0.414
6.6	0.136	0.004	6.500	0.025	0.439
6.8	0.140	0.004	6.700	0.026	0.465
7.0	0.144	0.004	6.900	0.026	0.491
7.2	0.148	0.004	7.100	0.027	0.518
7.4	0.152	0.004	7.300	0.028	0.546
7.6	0.155	0.004	7.500	0.028	0.574
7.8	0.159	0.004	7.700	0.029	0.603
8.0	0.163	0.004	7.900	0.029	0.632
8.2	0.167	0.004	8.100	0.030	0.662
8.4	0.170	0.004	8.300	0.031	0.693
8.6	0.174	0.004	8.500	0.031	0.724
8.8	0.178	0.004	8.700	0.032	0.756
9.0	0.181	0.004	8.900	0.032	0.789

AVERAGE PEDESTRIAN DELAY = 0.79 seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet g

AVERAGE PEDESTRIAN DELAY					**q =**	**40**
					N=	**3**
					q'=	**120**
ti	P(t)	delta P	t (ave)	Product	Accumulated Product	
0.0	0.000					
0.2	0.007	0.007	0.100	0.001	0.001	
0.4	0.013	0.007	0.300	0.002	0.003	
0.6	0.020	0.007	0.500	0.003	0.006	
0.8	0.026	0.007	0.700	0.005	0.010	
1.0	0.033	0.006	0.900	0.006	0.016	
1.2	0.039	0.006	1.100	0.007	0.023	
1.4	0.046	0.006	1.300	0.008	0.032	
1.6	0.052	0.006	1.500	0.010	0.041	
1.8	0.058	0.006	1.700	0.011	0.052	
2.0	0.064	0.006	1.900	0.012	0.064	
2.2	0.071	0.006	2.100	0.013	0.077	
2.4	0.077	0.006	2.300	0.014	0.091	
2.6	0.083	0.006	2.500	0.015	0.106	
2.8	0.089	0.006	2.700	0.016	0.123	
3.0	0.095	0.006	2.900	0.018	0.140	
3.2	0.101	0.006	3.100	0.019	0.159	
3.4	0.107	0.006	3.300	0.020	0.179	
3.6	0.113	0.006	3.500	0.021	0.199	
3.8	0.119	0.006	3.700	0.022	0.221	
4.0	0.125	0.006	3.900	0.023	0.244	
4.2	0.131	0.006	4.100	0.024	0.268	
4.4	0.136	0.006	4.300	0.025	0.293	
4.6	0.142	0.006	4.500	0.026	0.319	
4.8	0.148	0.006	4.700	0.027	0.345	
5.0	0.154	0.006	4.900	0.028	0.373	
5.2	0.159	0.006	5.100	0.029	0.402	
5.4	0.165	0.006	5.300	0.030	0.431	
5.6	0.170	0.006	5.500	0.031	0.462	
5.8	0.176	0.006	5.700	0.031	0.493	
6.0	0.181	0.005	5.900	0.032	0.526	
6.2	0.187	0.005	6.100	0.033	0.559	
6.4	0.192	0.005	6.300	0.034	0.593	
6.6	0.197	0.005	6.500	0.035	0.628	
6.8	0.203	0.005	6.700	0.036	0.664	
7.0	0.208	0.005	6.900	0.037	0.700	
7.2	0.213	0.005	7.100	0.037	0.737	
7.4	0.219	0.005	7.300	0.038	0.776	
7.6	0.224	0.005	7.500	0.039	0.815	
7.8	0.229	0.005	7.700	0.040	0.854	
8.0	0.234	0.005	7.900	0.040	0.895	
8.2	0.239	0.005	8.100	0.041	0.936	
8.4	0.244	0.005	8.300	0.042	0.978	
8.6	0.249	0.005	8.500	0.043	1.021	
8.8	0.254	0.005	8.700	0.043	1.064	
9.0	0.259	0.005	8.900	0.044	1.108	
	AVERAGE PEDESTRIAN DELAY =				**1.11**	**seconds**
TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)						
						Sheet h

AVERAGE PEDESTRIAN DELAY

q = 40
N= 4
q'= 160

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.009	0.009	0.100	0.001	0.001
0.4	0.018	0.009	0.300	0.003	0.004
0.6	0.026	0.009	0.500	0.004	0.008
0.8	0.035	0.009	0.700	0.006	0.014
1.0	0.043	0.009	0.900	0.008	0.022
1.2	0.052	0.008	1.100	0.009	0.031
1.4	0.060	0.008	1.300	0.011	0.042
1.6	0.069	0.008	1.500	0.012	0.054
1.8	0.077	0.008	1.700	0.014	0.068
2.0	0.085	0.008	1.900	0.016	0.084
2.2	0.093	0.008	2.100	0.017	0.101
2.4	0.101	0.008	2.300	0.018	0.119
2.6	0.109	0.008	2.500	0.020	0.139
2.8	0.117	0.008	2.700	0.021	0.160
3.0	0.125	0.008	2.900	0.023	0.183
3.2	0.133	0.008	3.100	0.024	0.207
3.4	0.140	0.008	3.300	0.025	0.232
3.6	0.148	0.008	3.500	0.027	0.259
3.8	0.155	0.008	3.700	0.028	0.287
4.0	0.163	0.007	3.900	0.029	0.316
4.2	0.170	0.007	4.100	0.030	0.346
4.4	0.178	0.007	4.300	0.032	0.378
4.6	0.185	0.007	4.500	0.033	0.411
4.8	0.192	0.007	4.700	0.034	0.445
5.0	0.199	0.007	4.900	0.035	0.480
5.2	0.206	0.007	5.100	0.036	0.516
5.4	0.213	0.007	5.300	0.037	0.553
5.6	0.220	0.007	5.500	0.038	0.591
5.8	0.227	0.007	5.700	0.039	0.631
6.0	0.234	0.007	5.900	0.040	0.671
6.2	0.241	0.007	6.100	0.041	0.712
6.4	0.248	0.007	6.300	0.042	0.755
6.6	0.254	0.007	6.500	0.043	0.798
6.8	0.261	0.007	6.700	0.044	0.842
7.0	0.267	0.007	6.900	0.045	0.887
7.2	0.274	0.006	7.100	0.046	0.933
7.4	0.280	0.006	7.300	0.047	0.980
7.6	0.287	0.006	7.500	0.048	1.028
7.8	0.293	0.006	7.700	0.049	1.077
8.0	0.299	0.006	7.900	0.049	1.126
8.2	0.305	0.006	8.100	0.050	1.176
8.4	0.312	0.006	8.300	0.051	1.227
8.6	0.318	0.006	8.500	0.052	1.279
8.8	0.324	0.006	8.700	0.053	1.332
9.0	0.330	0.006	8.900	0.053	1.385

AVERAGE PEDESTRIAN DELAY = 1.38 seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet i

AVERAGE PEDESTRIAN DELAY

q = 40
N= 5
q'= 200

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.011	0.011	0.100	0.001	0.001
0.4	0.022	0.011	0.300	0.003	0.004
0.6	0.033	0.011	0.500	0.005	0.010
0.8	0.043	0.011	0.700	0.007	0.017
1.0	0.054	0.011	0.900	0.010	0.027
1.2	0.064	0.010	1.100	0.011	0.038
1.4	0.075	0.010	1.300	0.013	0.052
1.6	0.085	0.010	1.500	0.015	0.067
1.8	0.095	0.010	1.700	0.017	0.084
2.0	0.105	0.010	1.900	0.019	0.103
2.2	0.115	0.010	2.100	0.021	0.124
2.4	0.125	0.010	2.300	0.022	0.146
2.6	0.134	0.010	2.500	0.024	0.171
2.8	0.144	0.010	2.700	0.026	0.196
3.0	0.154	0.009	2.900	0.027	0.224
3.2	0.163	0.009	3.100	0.029	0.253
3.4	0.172	0.009	3.300	0.031	0.283
3.6	0.181	0.009	3.500	0.032	0.315
3.8	0.190	0.009	3.700	0.033	0.349
4.0	0.199	0.009	3.900	0.035	0.384
4.2	0.208	0.009	4.100	0.036	0.420
4.4	0.217	0.009	4.300	0.038	0.458
4.6	0.226	0.009	4.500	0.039	0.497
4.8	0.234	0.009	4.700	0.040	0.537
5.0	0.243	0.008	4.900	0.041	0.578
5.2	0.251	0.008	5.100	0.043	0.621
5.4	0.259	0.008	5.300	0.044	0.665
5.6	0.267	0.008	5.500	0.045	0.710
5.8	0.275	0.008	5.700	0.046	0.756
6.0	0.283	0.008	5.900	0.047	0.803
6.2	0.291	0.008	6.100	0.048	0.852
6.4	0.299	0.008	6.300	0.049	0.901
6.6	0.307	0.008	6.500	0.050	0.951
6.8	0.315	0.008	6.700	0.051	1.003
7.0	0.322	0.008	6.900	0.052	1.055
7.2	0.330	0.007	7.100	0.053	1.108
7.4	0.337	0.007	7.300	0.054	1.162
7.6	0.344	0.007	7.500	0.055	1.217
7.8	0.352	0.007	7.700	0.056	1.273
8.0	0.359	0.007	7.900	0.057	1.329
8.2	0.366	0.007	8.100	0.057	1.387
8.4	0.373	0.007	8.300	0.058	1.445
8.6	0.380	0.007	8.500	0.059	1.504
8.8	0.387	0.007	8.700	0.060	1.563
9.0	0.393	0.007	8.900	0.060	1.624

AVERAGE PEDESTRIAN DELAY = 1.62 seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet j

AVERAGE PEDESTRIAN DELAY

q = 60
N= 1
q'= 60

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.003	0.003	0.100	0.000	0.000
0.4	0.007	0.003	0.300	0.001	0.001
0.6	0.010	0.003	0.500	0.002	0.003
0.8	0.013	0.003	0.700	0.002	0.005
1.0	0.017	0.003	0.900	0.003	0.008
1.2	0.020	0.003	1.100	0.004	0.012
1.4	0.023	0.003	1.300	0.004	0.016
1.6	0.026	0.003	1.500	0.005	0.021
1.8	0.030	0.003	1.700	0.006	0.026
2.0	0.033	0.003	1.900	0.006	0.033
2.2	0.036	0.003	2.100	0.007	0.039
2.4	0.039	0.003	2.300	0.007	0.047
2.6	0.042	0.003	2.500	0.008	0.055
2.8	0.046	0.003	2.700	0.009	0.063
3.0	0.049	0.003	2.900	0.009	0.073
3.2	0.052	0.003	3.100	0.010	0.082
3.4	0.055	0.003	3.300	0.010	0.093
3.6	0.058	0.003	3.500	0.011	0.104
3.8	0.061	0.003	3.700	0.012	0.115
4.0	0.064	0.003	3.900	0.012	0.128
4.2	0.068	0.003	4.100	0.013	0.140
4.4	0.071	0.003	4.300	0.013	0.154
4.6	0.074	0.003	4.500	0.014	0.168
4.8	0.077	0.003	4.700	0.014	0.182
5.0	0.080	0.003	4.900	0.015	0.197
5.2	0.083	0.003	5.100	0.016	0.213
5.4	0.086	0.003	5.300	0.016	0.229
5.6	0.089	0.003	5.500	0.017	0.246
5.8	0.092	0.003	5.700	0.017	0.263
6.0	0.095	0.003	5.900	0.018	0.281
6.2	0.098	0.003	6.100	0.018	0.299
6.4	0.101	0.003	6.300	0.019	0.318
6.6	0.104	0.003	6.500	0.019	0.337
6.8	0.107	0.003	6.700	0.020	0.357
7.0	0.110	0.003	6.900	0.021	0.378
7.2	0.113	0.003	7.100	0.021	0.399
7.4	0.116	0.003	7.300	0.022	0.420
7.6	0.119	0.003	7.500	0.022	0.443
7.8	0.122	0.003	7.700	0.023	0.465
8.0	0.125	0.003	7.900	0.023	0.488
8.2	0.128	0.003	8.100	0.024	0.512
8.4	0.131	0.003	8.300	0.024	0.536
8.6	0.134	0.003	8.500	0.025	0.560
8.8	0.136	0.003	8.700	0.025	0.586
9.0	0.139	0.003	8.900	0.026	0.611

AVERAGE PEDESTRIAN DELAY = 0.61 seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet k

AVERAGE PEDESTRIAN DELAY

q = 60
N= 2
q'= 120

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.007	0.007	0.100	0.001	0.001
0.4	0.013	0.007	0.300	0.002	0.003
0.6	0.020	0.007	0.500	0.003	0.006
0.8	0.026	0.007	0.700	0.005	0.010
1.0	0.033	0.006	0.900	0.006	0.016
1.2	0.039	0.006	1.100	0.007	0.023
1.4	0.046	0.006	1.300	0.008	0.032
1.6	0.052	0.006	1.500	0.010	0.041
1.8	0.058	0.006	1.700	0.011	0.052
2.0	0.064	0.006	1.900	0.012	0.064
2.2	0.071	0.006	2.100	0.013	0.077
2.4	0.077	0.006	2.300	0.014	0.091
2.6	0.083	0.006	2.500	0.015	0.106
2.8	0.089	0.006	2.700	0.016	0.123
3.0	0.095	0.006	2.900	0.018	0.140
3.2	0.101	0.006	3.100	0.019	0.159
3.4	0.107	0.006	3.300	0.020	0.179
3.6	0.113	0.006	3.500	0.021	0.199
3.8	0.119	0.006	3.700	0.022	0.221
4.0	0.125	0.006	3.900	0.023	0.244
4.2	0.131	0.006	4.100	0.024	0.268
4.4	0.136	0.006	4.300	0.025	0.293
4.6	0.142	0.006	4.500	0.026	0.319
4.8	0.148	0.006	4.700	0.027	0.345
5.0	0.154	0.006	4.900	0.028	0.373
5.2	0.159	0.006	5.100	0.029	0.402
5.4	0.165	0.006	5.300	0.030	0.431
5.6	0.170	0.006	5.500	0.031	0.462
5.8	0.176	0.006	5.700	0.031	0.493
6.0	0.181	0.005	5.900	0.032	0.526
6.2	0.187	0.005	6.100	0.033	0.559
6.4	0.192	0.005	6.300	0.034	0.593
6.6	0.197	0.005	6.500	0.035	0.628
6.8	0.203	0.005	6.700	0.036	0.664
7.0	0.208	0.005	6.900	0.037	0.700
7.2	0.213	0.005	7.100	0.037	0.737
7.4	0.219	0.005	7.300	0.038	0.776
7.6	0.224	0.005	7.500	0.039	0.815
7.8	0.229	0.005	7.700	0.040	0.854
8.0	0.234	0.005	7.900	0.040	0.895
8.2	0.239	0.005	8.100	0.041	0.936
8.4	0.244	0.005	8.300	0.042	0.978
8.6	0.249	0.005	8.500	0.043	1.021
8.8	0.254	0.005	8.700	0.043	1.064
9.0	0.259	0.005	8.900	0.044	1.108
	AVERAGE PEDESTRIAN DELAY =				**1.11 seconds**

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet1

AVERAGE PEDESTRIAN DELAY					q =	60
					N=	3
					q'=	180
ti	P(t)	delta P	t (ave)	Product	Accumulated Product	
0.0	0.000					
0.2	0.010	0.010	0.100	0.001	0.001	
0.4	0.020	0.010	0.300	0.003	0.004	
0.6	0.030	0.010	0.500	0.005	0.009	
0.8	0.039	0.010	0.700	0.007	0.016	
1.0	0.049	0.010	0.900	0.009	0.024	
1.2	0.058	0.009	1.100	0.010	0.035	
1.4	0.068	0.009	1.300	0.012	0.047	
1.6	0.077	0.009	1.500	0.014	0.061	
1.8	0.086	0.009	1.700	0.016	0.076	
2.0	0.095	0.009	1.900	0.017	0.094	
2.2	0.104	0.009	2.100	0.019	0.112	
2.4	0.113	0.009	2.300	0.021	0.133	
2.6	0.122	0.009	2.500	0.022	0.155	
2.8	0.131	0.009	2.700	0.024	0.179	
3.0	0.139	0.009	2.900	0.025	0.204	
3.2	0.148	0.009	3.100	0.027	0.230	
3.4	0.156	0.008	3.300	0.028	0.258	
3.6	0.165	0.008	3.500	0.029	0.288	
3.8	0.173	0.008	3.700	0.031	0.318	
4.0	0.181	0.008	3.900	0.032	0.350	
4.2	0.189	0.008	4.100	0.033	0.384	
4.4	0.197	0.008	4.300	0.035	0.419	
4.6	0.205	0.008	4.500	0.036	0.455	
4.8	0.213	0.008	4.700	0.037	0.492	
5.0	0.221	0.008	4.900	0.038	0.530	
5.2	0.229	0.008	5.100	0.040	0.570	
5.4	0.237	0.008	5.300	0.041	0.610	
5.6	0.244	0.008	5.500	0.042	0.652	
5.8	0.252	0.008	5.700	0.043	0.695	
6.0	0.259	0.007	5.900	0.044	0.739	
6.2	0.267	0.007	6.100	0.045	0.784	
6.4	0.274	0.007	6.300	0.046	0.830	
6.6	0.281	0.007	6.500	0.047	0.877	
6.8	0.288	0.007	6.700	0.048	0.925	
7.0	0.295	0.007	6.900	0.049	0.973	
7.2	0.302	0.007	7.100	0.050	1.023	
7.4	0.309	0.007	7.300	0.051	1.074	
7.6	0.316	0.007	7.500	0.052	1.125	
7.8	0.323	0.007	7.700	0.052	1.178	
8.0	0.330	0.007	7.900	0.053	1.231	
8.2	0.336	0.007	8.100	0.054	1.285	
8.4	0.343	0.007	8.300	0.055	1.340	
8.6	0.349	0.007	8.500	0.056	1.395	
8.8	0.356	0.006	8.700	0.056	1.452	
9.0	0.362	0.006	8.900	0.057	1.509	
	AVERAGE PEDESTRIAN DELAY =				**1.51**	**seconds**

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet m

AVERAGE PEDESTRIAN DELAY

q = 60
N= 4
q'= 240

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.013	0.013	0.100	0.001	0.001
0.4	0.026	0.013	0.300	0.004	0.005
0.6	0.039	0.013	0.500	0.006	0.012
0.8	0.052	0.013	0.700	0.009	0.021
1.0	0.064	0.013	0.900	0.011	0.032
1.2	0.077	0.012	1.100	0.014	0.046
1.4	0.089	0.012	1.300	0.016	0.061
1.6	0.101	0.012	1.500	0.018	0.080
1.8	0.113	0.012	1.700	0.020	0.100
2.0	0.125	0.012	1.900	0.022	0.122
2.2	0.136	0.012	2.100	0.024	0.146
2.4	0.148	0.011	2.300	0.026	0.173
2.6	0.159	0.011	2.500	0.028	0.201
2.8	0.170	0.011	2.700	0.030	0.231
3.0	0.181	0.011	2.900	0.032	0.263
3.2	0.192	0.011	3.100	0.034	0.297
3.4	0.203	0.011	3.300	0.035	0.332
3.6	0.213	0.011	3.500	0.037	0.369
3.8	0.224	0.010	3.700	0.039	0.407
4.0	0.234	0.010	3.900	0.040	0.447
4.2	0.244	0.010	4.100	0.042	0.489
4.4	0.254	0.010	4.300	0.043	0.532
4.6	0.264	0.010	4.500	0.044	0.576
4.8	0.274	0.010	4.700	0.046	0.622
5.0	0.283	0.010	4.900	0.047	0.669
5.2	0.293	0.009	5.100	0.048	0.718
5.4	0.302	0.009	5.300	0.050	0.767
5.6	0.312	0.009	5.500	0.051	0.818
5.8	0.321	0.009	5.700	0.052	0.870
6.0	0.330	0.009	5.900	0.053	0.923
6.2	0.339	0.009	6.100	0.054	0.978
6.4	0.347	0.009	6.300	0.055	1.033
6.6	0.356	0.009	6.500	0.056	1.089
6.8	0.364	0.009	6.700	0.057	1.146
7.0	0.373	0.008	6.900	0.058	1.204
7.2	0.381	0.008	7.100	0.059	1.263
7.4	0.389	0.008	7.300	0.060	1.323
7.6	0.397	0.008	7.500	0.061	1.384
7.8	0.405	0.008	7.700	0.061	1.445
8.0	0.413	0.008	7.900	0.062	1.507
8.2	0.421	0.008	8.100	0.063	1.570
8.4	0.429	0.008	8.300	0.064	1.634
8.6	0.436	0.008	8.500	0.064	1.698
8.8	0.444	0.007	8.700	0.065	1.763
9.0	0.451	0.007	8.900	0.066	1.829

AVERAGE PEDESTRIAN DELAY = 1.83 seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet n

AVERAGE PEDESTRIAN DELAY					q =	60
					N=	5
					q'=	300
ti	P(t)	delta P	t (ave)	Product	Accumulated Product	
0.0	0.000					
0.2	0.017	0.017	0.100	0.002	0.002	
0.4	0.033	0.016	0.300	0.005	0.007	
0.6	0.049	0.016	0.500	0.008	0.015	
0.8	0.064	0.016	0.700	0.011	0.026	
1.0	0.080	0.015	0.900	0.014	0.039	
1.2	0.095	0.015	1.100	0.017	0.056	
1.4	0.110	0.015	1.300	0.019	0.076	
1.6	0.125	0.015	1.500	0.022	0.098	
1.8	0.139	0.014	1.700	0.025	0.122	
2.0	0.154	0.014	1.900	0.027	0.149	
2.2	0.168	0.014	2.100	0.029	0.179	
2.4	0.181	0.014	2.300	0.032	0.210	
2.6	0.195	0.014	2.500	0.034	0.244	
2.8	0.208	0.013	2.700	0.036	0.280	
3.0	0.221	0.013	2.900	0.038	0.318	
3.2	0.234	0.013	3.100	0.040	0.358	
3.4	0.247	0.013	3.300	0.042	0.400	
3.6	0.259	0.012	3.500	0.044	0.443	
3.8	0.271	0.012	3.700	0.045	0.489	
4.0	0.283	0.012	3.900	0.047	0.536	
4.2	0.295	0.012	4.100	0.049	0.584	
4.4	0.307	0.012	4.300	0.050	0.634	
4.6	0.318	0.011	4.500	0.052	0.686	
4.8	0.330	0.011	4.700	0.053	0.739	
5.0	0.341	0.011	4.900	0.054	0.793	
5.2	0.352	0.011	5.100	0.056	0.849	
5.4	0.362	0.011	5.300	0.057	0.905	
5.6	0.373	0.011	5.500	0.058	0.963	
5.8	0.383	0.010	5.700	0.059	1.022	
6.0	0.393	0.010	5.900	0.060	1.083	
6.2	0.403	0.010	6.100	0.061	1.144	
6.4	0.413	0.010	6.300	0.062	1.206	
6.6	0.423	0.010	6.500	0.063	1.269	
6.8	0.433	0.010	6.700	0.064	1.333	
7.0	0.442	0.009	6.900	0.065	1.397	
7.2	0.451	0.009	7.100	0.065	1.463	
7.4	0.460	0.009	7.300	0.066	1.529	
7.6	0.469	0.009	7.500	0.067	1.596	
7.8	0.478	0.009	7.700	0.068	1.664	
8.0	0.487	0.009	7.900	0.068	1.732	
8.2	0.495	0.008	8.100	0.069	1.801	
8.4	0.503	0.008	8.300	0.069	1.870	
8.6	0.512	0.008	8.500	0.070	1.940	
8.8	0.520	0.008	8.700	0.070	2.010	
9.0	0.528	0.008	8.900	0.071	2.080	
	AVERAGE PEDESTRIAN DELAY =				**2.08**	**seconds**

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet o

AVERAGE PEDESTRIAN DELAY					**q =**	**80**
					N=	**1**
					q'=	**80**
ti	P(t)	delta P	t (ave)	Product	Accumulated Product	
0.0	0.000					
0.2	0.004	0.004	0.100	0.000	0.000	
0.4	0.009	0.004	0.300	0.001	0.002	
0.6	0.013	0.004	0.500	0.002	0.004	
0.8	0.018	0.004	0.700	0.003	0.007	
1.0	0.022	0.004	0.900	0.004	0.011	
1.2	0.026	0.004	1.100	0.005	0.016	
1.4	0.031	0.004	1.300	0.006	0.021	
1.6	0.035	0.004	1.500	0.006	0.028	
1.8	0.039	0.004	1.700	0.007	0.035	
2.0	0.043	0.004	1.900	0.008	0.043	
2.2	0.048	0.004	2.100	0.009	0.052	
2.4	0.052	0.004	2.300	0.010	0.062	
2.6	0.056	0.004	2.500	0.011	0.072	
2.8	0.060	0.004	2.700	0.011	0.084	
3.0	0.064	0.004	2.900	0.012	0.096	
3.2	0.069	0.004	3.100	0.013	0.109	
3.4	0.073	0.004	3.300	0.014	0.122	
3.6	0.077	0.004	3.500	0.014	0.137	
3.8	0.081	0.004	3.700	0.015	0.152	
4.0	0.085	0.004	3.900	0.016	0.168	
4.2	0.089	0.004	4.100	0.017	0.184	
4.4	0.093	0.004	4.300	0.017	0.202	
4.6	0.097	0.004	4.500	0.018	0.220	
4.8	0.101	0.004	4.700	0.019	0.239	
5.0	0.105	0.004	4.900	0.020	0.258	
5.2	0.109	0.004	5.100	0.020	0.278	
5.4	0.113	0.004	5.300	0.021	0.299	
5.6	0.117	0.004	5.500	0.022	0.321	
5.8	0.121	0.004	5.700	0.022	0.343	
6.0	0.125	0.004	5.900	0.023	0.366	
6.2	0.129	0.004	6.100	0.024	0.390	
6.4	0.133	0.004	6.300	0.024	0.414	
6.6	0.136	0.004	6.500	0.025	0.439	
6.8	0.140	0.004	6.700	0.026	0.465	
7.0	0.144	0.004	6.900	0.026	0.491	
7.2	0.148	0.004	7.100	0.027	0.518	
7.4	0.152	0.004	7.300	0.028	0.546	
7.6	0.155	0.004	7.500	0.028	0.574	
7.8	0.159	0.004	7.700	0.029	0.603	
8.0	0.163	0.004	7.900	0.029	0.632	
8.2	0.167	0.004	8.100	0.030	0.662	
8.4	0.170	0.004	8.300	0.031	0.693	
8.6	0.174	0.004	8.500	0.031	0.724	
8.8	0.178	0.004	8.700	0.032	0.756	
9.0	0.181	0.004	8.900	0.032	0.789	
	AVERAGE PEDESTRIAN DELAY =				**0.79**	**seconds**

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet p

AVERAGE PEDESTRIAN DELAY

q = 80
N= 2
q'= 160

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.009	0.009	0.100	0.001	0.001
0.4	0.018	0.009	0.300	0.003	0.004
0.6	0.026	0.009	0.500	0.004	0.008
0.8	0.035	0.009	0.700	0.006	0.014
1.0	0.043	0.009	0.900	0.008	0.022
1.2	0.052	0.008	1.100	0.009	0.031
1.4	0.060	0.008	1.300	0.011	0.042
1.6	0.069	0.008	1.500	0.012	0.054
1.8	0.077	0.008	1.700	0.014	0.068
2.0	0.085	0.008	1.900	0.016	0.084
2.2	0.093	0.008	2.100	0.017	0.101
2.4	0.101	0.008	2.300	0.018	0.119
2.6	0.109	0.008	2.500	0.020	0.139
2.8	0.117	0.008	2.700	0.021	0.160
3.0	0.125	0.008	2.900	0.023	0.183
3.2	0.133	0.008	3.100	0.024	0.207
3.4	0.140	0.008	3.300	0.025	0.232
3.6	0.148	0.008	3.500	0.027	0.259
3.8	0.155	0.008	3.700	0.028	0.287
4.0	0.163	0.007	3.900	0.029	0.316
4.2	0.170	0.007	4.100	0.030	0.346
4.4	0.178	0.007	4.300	0.032	0.378
4.6	0.185	0.007	4.500	0.033	0.411
4.8	0.192	0.007	4.700	0.034	0.445
5.0	0.199	0.007	4.900	0.035	0.480
5.2	0.206	0.007	5.100	0.036	0.516
5.4	0.213	0.007	5.300	0.037	0.553
5.6	0.220	0.007	5.500	0.038	0.591
5.8	0.227	0.007	5.700	0.039	0.631
6.0	0.234	0.007	5.900	0.040	0.671
6.2	0.241	0.007	6.100	0.041	0.712
6.4	0.248	0.007	6.300	0.042	0.755
6.6	0.254	0.007	6.500	0.043	0.798
6.8	0.261	0.007	6.700	0.044	0.842
7.0	0.267	0.007	6.900	0.045	0.887
7.2	0.274	0.006	7.100	0.046	0.933
7.4	0.280	0.006	7.300	0.047	0.980
7.6	0.287	0.006	7.500	0.048	1.028
7.8	0.293	0.006	7.700	0.049	1.077
8.0	0.299	0.006	7.900	0.049	1.126
8.2	0.305	0.006	8.100	0.050	1.176
8.4	0.312	0.006	8.300	0.051	1.227
8.6	0.318	0.006	8.500	0.052	1.279
8.8	0.324	0.006	8.700	0.053	1.332
9.0	0.330	0.006	8.900	0.053	1.385

AVERAGE PEDESTRIAN DELAY = **1.38** **seconds**

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet q

AVERAGE PEDESTRIAN DELAY					q =	80
					N=	3
					q'=	240
ti	P(t)	delta P	t (ave)	Product	Accumulated Product	
0.0	0.000					
0.2	0.013	0.013	0.100	0.001	0.001	
0.4	0.026	0.013	0.300	0.004	0.005	
0.6	0.039	0.013	0.500	0.006	0.012	
0.8	0.052	0.013	0.700	0.009	0.021	
1.0	0.064	0.013	0.900	0.011	0.032	
1.2	0.077	0.012	1.100	0.014	0.046	
1.4	0.089	0.012	1.300	0.016	0.061	
1.6	0.101	0.012	1.500	0.018	0.080	
1.8	0.113	0.012	1.700	0.020	0.100	
2.0	0.125	0.012	1.900	0.022	0.122	
2.2	0.136	0.012	2.100	0.024	0.146	
2.4	0.148	0.011	2.300	0.026	0.173	
2.6	0.159	0.011	2.500	0.028	0.201	
2.8	0.170	0.011	2.700	0.030	0.231	
3.0	0.181	0.011	2.900	0.032	0.263	
3.2	0.192	0.011	3.100	0.034	0.297	
3.4	0.203	0.011	3.300	0.035	0.332	
3.6	0.213	0.011	3.500	0.037	0.369	
3.8	0.224	0.010	3.700	0.039	0.407	
4.0	0.234	0.010	3.900	0.040	0.447	
4.2	0.244	0.010	4.100	0.042	0.489	
4.4	0.254	0.010	4.300	0.043	0.532	
4.6	0.264	0.010	4.500	0.044	0.576	
4.8	0.274	0.010	4.700	0.046	0.622	
5.0	0.283	0.010	4.900	0.047	0.669	
5.2	0.293	0.009	5.100	0.048	0.718	
5.4	0.302	0.009	5.300	0.050	0.767	
5.6	0.312	0.009	5.500	0.051	0.818	
5.8	0.321	0.009	5.700	0.052	0.870	
6.0	0.330	0.009	5.900	0.053	0.923	
6.2	0.339	0.009	6.100	0.054	0.978	
6.4	0.347	0.009	6.300	0.055	1.033	
6.6	0.356	0.009	6.500	0.056	1.089	
6.8	0.364	0.009	6.700	0.057	1.146	
7.0	0.373	0.008	6.900	0.058	1.204	
7.2	0.381	0.008	7.100	0.059	1.263	
7.4	0.389	0.008	7.300	0.060	1.323	
7.6	0.397	0.008	7.500	0.061	1.384	
7.8	0.405	0.008	7.700	0.061	1.445	
8.0	0.413	0.008	7.900	0.062	1.507	
8.2	0.421	0.008	8.100	0.063	1.570	
8.4	0.429	0.008	8.300	0.064	1.634	
8.6	0.436	0.008	8.500	0.064	1.698	
8.8	0.444	0.007	8.700	0.065	1.763	
9.0	0.451	0.007	8.900	0.066	1.829	
	AVERAGE PEDESTRIAN DELAY =				1.83	seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet r

AVERAGE PEDESTRIAN DELAY

q = 80
N= 4
q'= 320

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.018	0.018	0.100	0.002	0.002
0.4	0.035	0.017	0.300	0.005	0.007
0.6	0.052	0.017	0.500	0.009	0.015
0.8	0.069	0.017	0.700	0.012	0.027
1.0	0.085	0.016	0.900	0.015	0.042
1.2	0.101	0.016	1.100	0.018	0.060
1.4	0.117	0.016	1.300	0.021	0.080
1.6	0.133	0.016	1.500	0.023	0.104
1.8	0.148	0.015	1.700	0.026	0.130
2.0	0.163	0.015	1.900	0.029	0.158
2.2	0.178	0.015	2.100	0.031	0.189
2.4	0.192	0.014	2.300	0.033	0.222
2.6	0.206	0.014	2.500	0.036	0.258
2.8	0.220	0.014	2.700	0.038	0.296
3.0	0.234	0.014	2.900	0.040	0.336
3.2	0.248	0.013	3.100	0.042	0.377
3.4	0.261	0.013	3.300	0.044	0.421
3.6	0.274	0.013	3.500	0.046	0.467
3.8	0.287	0.013	3.700	0.047	0.514
4.0	0.299	0.013	3.900	0.049	0.563
4.2	0.312	0.012	4.100	0.051	0.614
4.4	0.324	0.012	4.300	0.052	0.666
4.6	0.336	0.012	4.500	0.054	0.720
4.8	0.347	0.012	4.700	0.055	0.775
5.0	0.359	0.012	4.900	0.056	0.831
5.2	0.370	0.011	5.100	0.058	0.889
5.4	0.381	0.011	5.300	0.059	0.947
5.6	0.392	0.011	5.500	0.060	1.007
5.8	0.403	0.011	5.700	0.061	1.068
6.0	0.413	0.011	5.900	0.062	1.130
6.2	0.424	0.010	6.100	0.063	1.194
6.4	0.434	0.010	6.300	0.064	1.258
6.6	0.444	0.010	6.500	0.065	1.322
6.8	0.454	0.010	6.700	0.066	1.388
7.0	0.463	0.010	6.900	0.066	1.454
7.2	0.473	0.009	7.100	0.067	1.522
7.4	0.482	0.009	7.300	0.068	1.589
7.6	0.491	0.009	7.500	0.068	1.658
7.8	0.500	0.009	7.700	0.069	1.727
8.0	0.509	0.009	7.900	0.070	1.797
8.2	0.518	0.009	8.100	0.070	1.867
8.4	0.526	0.009	8.300	0.071	1.937
8.6	0.534	0.008	8.500	0.071	2.008
8.8	0.543	0.008	8.700	0.071	2.080
9.0	0.551	0.008	8.900	0.072	2.151

AVERAGE PEDESTRIAN DELAY = **2.15 seconds**

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet s

AVERAGE PEDESTRIAN DELAY

q = 80
N= 5
q'= 400

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.022	0.022	0.100	0.002	0.002
0.4	0.043	0.021	0.300	0.006	0.009
0.6	0.064	0.021	0.500	0.011	0.019
0.8	0.085	0.021	0.700	0.014	0.034
1.0	0.105	0.020	0.900	0.018	0.052
1.2	0.125	0.020	1.100	0.022	0.073
1.4	0.144	0.019	1.300	0.025	0.098
1.6	0.163	0.019	1.500	0.028	0.126
1.8	0.181	0.018	1.700	0.031	0.158
2.0	0.199	0.018	1.900	0.034	0.192
2.2	0.217	0.018	2.100	0.037	0.229
2.4	0.234	0.017	2.300	0.040	0.269
2.6	0.251	0.017	2.500	0.042	0.311
2.8	0.267	0.016	2.700	0.044	0.355
3.0	0.283	0.016	2.900	0.047	0.402
3.2	0.299	0.016	3.100	0.049	0.451
3.4	0.315	0.015	3.300	0.051	0.501
3.6	0.330	0.015	3.500	0.053	0.554
3.8	0.344	0.015	3.700	0.055	0.609
4.0	0.359	0.014	3.900	0.056	0.665
4.2	0.373	0.014	4.100	0.058	0.723
4.4	0.387	0.014	4.300	0.059	0.782
4.6	0.400	0.013	4.500	0.061	0.842
4.8	0.413	0.013	4.700	0.062	0.904
5.0	0.426	0.013	4.900	0.063	0.968
5.2	0.439	0.013	5.100	0.064	1.032
5.4	0.451	0.012	5.300	0.065	1.097
5.6	0.463	0.012	5.500	0.066	1.164
5.8	0.475	0.012	5.700	0.067	1.231
6.0	0.487	0.012	5.900	0.068	1.299
6.2	0.498	0.011	6.100	0.069	1.368
6.4	0.509	0.011	6.300	0.070	1.437
6.6	0.520	0.011	6.500	0.070	1.507
6.8	0.530	0.011	6.700	0.071	1.578
7.0	0.541	0.010	6.900	0.071	1.649
7.2	0.551	0.010	7.100	0.072	1.721
7.4	0.561	0.010	7.300	0.072	1.793
7.6	0.570	0.010	7.500	0.072	1.866
7.8	0.580	0.009	7.700	0.073	1.938
8.0	0.589	0.009	7.900	0.073	2.011
8.2	0.598	0.009	8.100	0.073	2.084
8.4	0.607	0.009	8.300	0.073	2.158
8.6	0.615	0.009	8.500	0.073	2.231
8.8	0.624	0.008	8.700	0.074	2.305
9.0	0.632	0.008	8.900	0.074	2.378

AVERAGE PEDESTRIAN DELAY = 2.38 seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet t

AVERAGE PEDESTRIAN DELAY

q = 100
N= 1
q'= 100

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.006	0.006	0.100	0.001	0.001
0.4	0.011	0.006	0.300	0.002	0.002
0.6	0.017	0.005	0.500	0.003	0.005
0.8	0.022	0.005	0.700	0.004	0.009
1.0	0.027	0.005	0.900	0.005	0.014
1.2	0.033	0.005	1.100	0.006	0.020
1.4	0.038	0.005	1.300	0.007	0.027
1.6	0.043	0.005	1.500	0.008	0.035
1.8	0.049	0.005	1.700	0.009	0.044
2.0	0.054	0.005	1.900	0.010	0.054
2.2	0.059	0.005	2.100	0.011	0.065
2.4	0.064	0.005	2.300	0.012	0.077
2.6	0.070	0.005	2.500	0.013	0.089
2.8	0.075	0.005	2.700	0.014	0.103
3.0	0.080	0.005	2.900	0.015	0.118
3.2	0.085	0.005	3.100	0.016	0.134
3.4	0.090	0.005	3.300	0.017	0.151
3.6	0.095	0.005	3.500	0.018	0.168
3.8	0.100	0.005	3.700	0.019	0.187
4.0	0.105	0.005	3.900	0.019	0.206
4.2	0.110	0.005	4.100	0.020	0.227
4.4	0.115	0.005	4.300	0.021	0.248
4.6	0.120	0.005	4.500	0.022	0.270
4.8	0.125	0.005	4.700	0.023	0.293
5.0	0.130	0.005	4.900	0.024	0.317
5.2	0.134	0.005	5.100	0.025	0.341
5.4	0.139	0.005	5.300	0.025	0.367
5.6	0.144	0.005	5.500	0.026	0.393
5.8	0.149	0.005	5.700	0.027	0.420
6.0	0.154	0.005	5.900	0.028	0.448
6.2	0.158	0.005	6.100	0.029	0.476
6.4	0.163	0.005	6.300	0.029	0.506
6.6	0.168	0.005	6.500	0.030	0.536
6.8	0.172	0.005	6.700	0.031	0.567
7.0	0.177	0.005	6.900	0.032	0.598
7.2	0.181	0.005	7.100	0.032	0.631
7.4	0.186	0.005	7.300	0.033	0.664
7.6	0.190	0.005	7.500	0.034	0.698
7.8	0.195	0.004	7.700	0.035	0.732
8.0	0.199	0.004	7.900	0.035	0.768
8.2	0.204	0.004	8.100	0.036	0.804
8.4	0.208	0.004	8.300	0.037	0.840
8.6	0.212	0.004	8.500	0.037	0.877
8.8	0.217	0.004	8.700	0.038	0.915
9.0	0.221	0.004	8.900	0.039	0.954

AVERAGE PEDESTRIAN DELAY = 0.95 seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet u

AVERAGE PEDESTRIAN DELAY

q = 100
N= 2
q'= 200

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.011	0.011	0.100	0.001	0.001
0.4	0.022	0.011	0.300	0.003	0.004
0.6	0.033	0.011	0.500	0.005	0.010
0.8	0.043	0.011	0.700	0.007	0.017
1.0	0.054	0.011	0.900	0.010	0.027
1.2	0.064	0.010	1.100	0.011	0.038
1.4	0.075	0.010	1.300	0.013	0.052
1.6	0.085	0.010	1.500	0.015	0.067
1.8	0.095	0.010	1.700	0.017	0.084
2.0	0.105	0.010	1.900	0.019	0.103
2.2	0.115	0.010	2.100	0.021	0.124
2.4	0.125	0.010	2.300	0.022	0.146
2.6	0.134	0.010	2.500	0.024	0.171
2.8	0.144	0.010	2.700	0.026	0.196
3.0	0.154	0.009	2.900	0.027	0.224
3.2	0.163	0.009	3.100	0.029	0.253
3.4	0.172	0.009	3.300	0.031	0.283
3.6	0.181	0.009	3.500	0.032	0.315
3.8	0.190	0.009	3.700	0.033	0.349
4.0	0.199	0.009	3.900	0.035	0.384
4.2	0.208	0.009	4.100	0.036	0.420
4.4	0.217	0.009	4.300	0.038	0.458
4.6	0.226	0.009	4.500	0.039	0.497
4.8	0.234	0.009	4.700	0.040	0.537
5.0	0.243	0.008	4.900	0.041	0.578
5.2	0.251	0.008	5.100	0.043	0.621
5.4	0.259	0.008	5.300	0.044	0.665
5.6	0.267	0.008	5.500	0.045	0.710
5.8	0.275	0.008	5.700	0.046	0.756
6.0	0.283	0.008	5.900	0.047	0.803
6.2	0.291	0.008	6.100	0.048	0.852
6.4	0.299	0.008	6.300	0.049	0.901
6.6	0.307	0.008	6.500	0.050	0.951
6.8	0.315	0.008	6.700	0.051	1.003
7.0	0.322	0.008	6.900	0.052	1.055
7.2	0.330	0.007	7.100	0.053	1.108
7.4	0.337	0.007	7.300	0.054	1.162
7.6	0.344	0.007	7.500	0.055	1.217
7.8	0.352	0.007	7.700	0.056	1.273
8.0	0.359	0.007	7.900	0.057	1.329
8.2	0.366	0.007	8.100	0.057	1.387
8.4	0.373	0.007	8.300	0.058	1.445
8.6	0.380	0.007	8.500	0.059	1.504
8.8	0.387	0.007	8.700	0.060	1.563
9.0	0.393	0.007	8.900	0.060	1.624

AVERAGE PEDESTRIAN DELAY = 1.62 seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet v

AVERAGE PEDESTRIAN DELAY

q = 100
N= 3
q'= 300

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.017	0.017	0.100	0.002	0.002
0.4	0.033	0.016	0.300	0.005	0.007
0.6	0.049	0.016	0.500	0.008	0.015
0.8	0.064	0.016	0.700	0.011	0.026
1.0	0.080	0.015	0.900	0.014	0.039
1.2	0.095	0.015	1.100	0.017	0.056
1.4	0.110	0.015	1.300	0.019	0.076
1.6	0.125	0.015	1.500	0.022	0.098
1.8	0.139	0.014	1.700	0.025	0.122
2.0	0.154	0.014	1.900	0.027	0.149
2.2	0.168	0.014	2.100	0.029	0.179
2.4	0.181	0.014	2.300	0.032	0.210
2.6	0.195	0.014	2.500	0.034	0.244
2.8	0.208	0.013	2.700	0.036	0.280
3.0	0.221	0.013	2.900	0.038	0.318
3.2	0.234	0.013	3.100	0.040	0.358
3.4	0.247	0.013	3.300	0.042	0.400
3.6	0.259	0.012	3.500	0.044	0.443
3.8	0.271	0.012	3.700	0.045	0.489
4.0	0.283	0.012	3.900	0.047	0.536
4.2	0.295	0.012	4.100	0.049	0.584
4.4	0.307	0.012	4.300	0.050	0.634
4.6	0.318	0.011	4.500	0.052	0.686
4.8	0.330	0.011	4.700	0.053	0.739
5.0	0.341	0.011	4.900	0.054	0.793
5.2	0.352	0.011	5.100	0.056	0.849
5.4	0.362	0.011	5.300	0.057	0.905
5.6	0.373	0.011	5.500	0.058	0.963
5.8	0.383	0.010	5.700	0.059	1.022
6.0	0.393	0.010	5.900	0.060	1.083
6.2	0.403	0.010	6.100	0.061	1.144
6.4	0.413	0.010	6.300	0.062	1.206
6.6	0.423	0.010	6.500	0.063	1.269
6.8	0.433	0.010	6.700	0.064	1.333
7.0	0.442	0.009	6.900	0.065	1.397
7.2	0.451	0.009	7.100	0.065	1.463
7.4	0.460	0.009	7.300	0.066	1.529
7.6	0.469	0.009	7.500	0.067	1.596
7.8	0.478	0.009	7.700	0.068	1.664
8.0	0.487	0.009	7.900	0.068	1.732
8.2	0.495	0.008	8.100	0.069	1.801
8.4	0.503	0.008	8.300	0.069	1.870
8.6	0.512	0.008	8.500	0.070	1.940
8.8	0.520	0.008	8.700	0.070	2.010
9.0	0.528	0.008	8.900	0.071	2.080

AVERAGE PEDESTRIAN DELAY = 2.08 seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet w

	AVERAGE PEDESTRIAN DELAY					q =	**100**
						N=	**4**
						q'=	**400**
	ti	P(t)	delta P	t (ave)	Product	Accumulated Product	
	0.0	0.000					
	0.2	0.022	0.022	0.100	0.002	0.002	
	0.4	0.043	0.021	0.300	0.006	0.009	
	0.6	0.064	0.021	0.500	0.011	0.019	
	0.8	0.085	0.021	0.700	0.014	0.034	
	1.0	0.105	0.020	0.900	0.018	0.052	
	1.2	0.125	0.020	1.100	0.022	0.073	
	1.4	0.144	0.019	1.300	0.025	0.098	
	1.6	0.163	0.019	1.500	0.028	0.126	
	1.8	0.181	0.018	1.700	0.031	0.158	
	2.0	0.199	0.018	1.900	0.034	0.192	
	2.2	0.217	0.018	2.100	0.037	0.229	
	2.4	0.234	0.017	2.300	0.040	0.269	
	2.6	0.251	0.017	2.500	0.042	0.311	
	2.8	0.267	0.016	2.700	0.044	0.355	
	3.0	0.283	0.016	2.900	0.047	0.402	
	3.2	0.299	0.016	3.100	0.049	0.451	
	3.4	0.315	0.015	3.300	0.051	0.501	
	3.6	0.330	0.015	3.500	0.053	0.554	
	3.8	0.344	0.015	3.700	0.055	0.609	
	4.0	0.359	0.014	3.900	0.056	0.665	
	4.2	0.373	0.014	4.100	0.058	0.723	
	4.4	0.387	0.014	4.300	0.059	0.782	
	4.6	0.400	0.013	4.500	0.061	0.842	
	4.8	0.413	0.013	4.700	0.062	0.904	
	5.0	0.426	0.013	4.900	0.063	0.968	
	5.2	0.439	0.013	5.100	0.064	1.032	
	5.4	0.451	0.012	5.300	0.065	1.097	
	5.6	0.463	0.012	5.500	0.066	1.164	
	5.8	0.475	0.012	5.700	0.067	1.231	
	6.0	0.487	0.012	5.900	0.068	1.299	
	6.2	0.498	0.011	6.100	0.069	1.368	
	6.4	0.509	0.011	6.300	0.070	1.437	
	6.6	0.520	0.011	6.500	0.070	1.507	
	6.8	0.530	0.011	6.700	0.071	1.578	
	7.0	0.541	0.010	6.900	0.071	1.649	
	7.2	0.551	0.010	7.100	0.072	1.721	
	7.4	0.561	0.010	7.300	0.072	1.793	
	7.6	0.570	0.010	7.500	0.072	1.866	
	7.8	0.580	0.009	7.700	0.073	1.938	
	8.0	0.589	0.009	7.900	0.073	2.011	
	8.2	0.598	0.009	8.100	0.073	2.084	
	8.4	0.607	0.009	8.300	0.073	2.158	
	8.6	0.615	0.009	8.500	0.073	2.231	
	8.8	0.624	0.008	8.700	0.074	2.305	
	9.0	0.632	0.008	8.900	0.074	2.378	
		AVERAGE PEDESTRIAN DELAY =				**2.38**	**seconds**
TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)							
							Sheet x

AVERAGE PEDESTRIAN DELAY

q = 100
N= 5
q'= 500

ti	P(t)	delta P	t (ave)	Product	Accumulated Product
0.0	0.000				
0.2	0.027	0.027	0.100	0.003	0.003
0.4	0.054	0.027	0.300	0.008	0.011
0.6	0.080	0.026	0.500	0.013	0.024
0.8	0.105	0.025	0.700	0.018	0.041
1.0	0.130	0.025	0.900	0.022	0.063
1.2	0.154	0.024	1.100	0.026	0.090
1.4	0.177	0.023	1.300	0.030	0.120
1.6	0.199	0.023	1.500	0.034	0.154
1.8	0.221	0.022	1.700	0.037	0.191
2.0	0.243	0.021	1.900	0.041	0.231
2.2	0.263	0.021	2.100	0.044	0.275
2.4	0.283	0.020	2.300	0.046	0.321
2.6	0.303	0.020	2.500	0.049	0.371
2.8	0.322	0.019	2.700	0.052	0.422
3.0	0.341	0.019	2.900	0.054	0.476
3.2	0.359	0.018	3.100	0.056	0.532
3.4	0.376	0.018	3.300	0.058	0.590
3.6	0.393	0.017	3.500	0.060	0.650
3.8	0.410	0.017	3.700	0.061	0.711
4.0	0.426	0.016	3.900	0.063	0.774
4.2	0.442	0.016	4.100	0.064	0.839
4.4	0.457	0.015	4.300	0.066	0.904
4.6	0.472	0.015	4.500	0.067	0.971
4.8	0.487	0.014	4.700	0.068	1.039
5.0	0.501	0.014	4.900	0.069	1.108
5.2	0.514	0.014	5.100	0.070	1.178
5.4	0.528	0.013	5.300	0.071	1.248
5.6	0.541	0.013	5.500	0.071	1.320
5.8	0.553	0.013	5.700	0.072	1.391
6.0	0.565	0.012	5.900	0.072	1.464
6.2	0.577	0.012	6.100	0.073	1.536
6.4	0.589	0.012	6.300	0.073	1.609
6.6	0.600	0.011	6.500	0.073	1.682
6.8	0.611	0.011	6.700	0.073	1.756
7.0	0.622	0.011	6.900	0.074	1.829
7.2	0.632	0.010	7.100	0.074	1.903
7.4	0.642	0.010	7.300	0.074	1.976
7.6	0.652	0.010	7.500	0.074	2.050
7.8	0.662	0.010	7.700	0.073	2.123
8.0	0.671	0.009	7.900	0.073	2.197
8.2	0.680	0.009	8.100	0.073	2.270
8.4	0.689	0.009	8.300	0.073	2.342
8.6	0.697	0.009	8.500	0.073	2.415
8.8	0.705	0.008	8.700	0.072	2.487
9.0	0.713	0.008	8.900	0.072	2.559

AVERAGE PEDESTRIAN DELAY = 2.56 seconds

TABLE 10.8 – Pedestrian Delays (Access Managment Driveways)

Sheet y

	q (vph)				
N	20	40	60	80	100
1	0.22	0.42	0.61	0.80	0.95
2	0.42	0.80	1.11	1.38	1.62
3	0.61	1.11	1.51	1.83	2.08
4	0.80	1.38	1.83	2.15	2.38
5	0.95	1.62	2.08	2.38	2.56

Note: Table entries are average delays in seconds per gap.

TABLE 10.9 -- SUMMARY OF DELAYS (ACCESS MGMT DRIVEWAYS)

						N=	1
q	20	40	60	80	100	vph	
q' (=n*q)	20	40	60	80	100		
tc	9.0	9.0	9.0	9.0	9.0	seconds	
P(delay)	0.049	0.095	0.139	0.181	0.221	(a)	
Ave delay per gap	0.22	0.42	0.61	0.80	0.95	(b)	
% of pedestrians							
needing a: 1st gap	100.00%	100.00%	100.00%	100.00%	100.00%		
2nd gap	4.9%	9.5%	13.9%	18.1%	22.1%		
3rd gap	0.2%	0.9%	1.9%	3.3%	4.9%		
4th gap	0.0%	0.1%	0.3%	0.6%	1.1%		
5th gap	0.0%	0.0%	0.0%	0.1%	0.2%		
6th gap	0.0%	0.0%	0.0%	0.0%	0.1%		
7th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
8th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
9th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
10th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
11th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
12th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
13th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
14th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
15th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
16th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
17th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
18th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
19th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
20th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
Overall delay through all gaps	0.23	0.46	0.71	0.98	1.22		

(a) : From Table 10.4
(b) : From Table 10.9

TABLE 10.10 – Pedestrian Delays at a Single Access Management Driveway

Sheet a

						N=	2
q	20	40	60	80	100	vph	
q' (=n*q)	40	80	120	160	200		
tc	9.0	9.0	9.0	9.0	9.0	seconds	
P(delay)	0.095	0.181	0.259	0.330	0.393	(a)	
Ave delay per gap	0.42	0.80	1.11	1.38	1.62	(b)	
% of pedestrians							
needing a: 1st gap	100.00%	100.00%	100.00%	100.00%	100.00%		
2nd gap	9.5%	18.1%	25.9%	33.0%	39.3%		
3rd gap	0.9%	3.3%	6.7%	10.9%	15.5%		
4th gap	0.1%	0.6%	1.7%	3.6%	6.1%		
5th gap	0.0%	0.1%	0.5%	1.2%	2.4%		
6th gap	0.0%	0.0%	0.1%	0.4%	0.9%		
7th gap	0.0%	0.0%	0.0%	0.1%	0.4%		
8th gap	0.0%	0.0%	0.0%	0.0%	0.1%		
9th gap	0.0%	0.0%	0.0%	0.0%	0.1%		
10th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
11th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
12th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
13th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
14th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
15th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
16th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
17th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
18th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
19th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
20th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
Overall delay through all gaps	0.46	0.98	1.50	2.06	2.67		

(a) : From Table 10.4

(b) : From Table 10.9

TABLE 10.10 -- Pedestrian Delays at a Single Access Management Driveway

Sheet b

						N=	3
q	20	40	60	80	100	vph	
q' (=n*q)	60	120	180	240	300		
tc	9.0	9.0	9.0	9.0	9.0	seconds	
P(delay)	0.139	0.259	0.362	0.451	0.528	(a)	
Ave delay per gap	0.61	1.11	1.51	1.83	2.08	(b)	
% of pedestrians							
needing a: 1st gap	100.00%	100.00%	100.00%	100.00%	100.00%		
2nd gap	13.9%	25.9%	36.2%	45.1%	52.8%		
3rd gap	1.9%	6.7%	13.1%	20.4%	27.8%		
4th gap	0.3%	1.7%	4.8%	9.2%	14.7%		
5th gap	0.0%	0.5%	1.7%	4.1%	7.8%		
6th gap	0.0%	0.1%	0.6%	1.9%	4.1%		
7th gap	0.0%	0.0%	0.2%	0.8%	2.2%		
8th gap	0.0%	0.0%	0.1%	0.4%	1.1%		
9th gap	0.0%	0.0%	0.0%	0.2%	0.6%		
10th gap	0.0%	0.0%	0.0%	0.1%	0.3%		
11th gap	0.0%	0.0%	0.0%	0.0%	0.2%		
12th gap	0.0%	0.0%	0.0%	0.0%	0.1%		
13th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
14th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
15th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
16th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
17th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
18th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
19th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
20th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
Overall delay through all gaps	0.71	1.50	2.37	3.33	4.40		

(a) : From Table 10.4
(b) : From Table 10.9

TABLE 10.10 – Pedestrian Delays at a Single Access Management Driveway

Sheet c

						N=	4
q	20	40	60	80	100	vph	
q' (=n*q)	80	160	240	320	400		
tc	9.0	9.0	9.0	9.0	9.0	seconds	
P(delay)	0.181	0.330	0.451	0.551	0.632	(a)	
Ave delay per gap	0.80	1.38	1.83	2.15	2.38	(b)	
% of pedestrians							
needing a: 1st gap	100.00%	100.00%	100.00%	100.00%	100.00%		
2nd gap	18.1%	33.0%	45.1%	55.1%	63.2%		
3rd gap	3.3%	10.9%	20.4%	30.3%	40.0%		
4th gap	0.6%	3.6%	9.2%	16.7%	25.3%		
5th gap	0.1%	1.2%	4.1%	9.2%	16.0%		
6th gap	0.0%	0.4%	1.9%	5.1%	10.1%		
7th gap	0.0%	0.1%	0.8%	2.8%	6.4%		
8th gap	0.0%	0.0%	0.4%	1.5%	4.0%		
9th gap	0.0%	0.0%	0.2%	0.8%	2.5%		
10th gap	0.0%	0.0%	0.1%	0.5%	1.6%		
11th gap	0.0%	0.0%	0.0%	0.3%	1.0%		
12th gap	0.0%	0.0%	0.0%	0.1%	0.6%		
13th gap	0.0%	0.0%	0.0%	0.1%	0.4%		
14th gap	0.0%	0.0%	0.0%	0.0%	0.3%		
15th gap	0.0%	0.0%	0.0%	0.0%	0.2%		
16th gap	0.0%	0.0%	0.0%	0.0%	0.1%		
17th gap	0.0%	0.0%	0.0%	0.0%	0.1%		
18th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
19th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
20th gap	0.0%	0.0%	0.0%	0.0%	0.0%		
Overall delay through all gaps	0.98	2.06	3.33	4.78	6.47		

(a) : From Table 10.4

(b) : From Table 10.9

TABLE 10.10 – Pedestrian Delays at a Single Access Management Driveway

Sheet d

						N=	5
q	20	40	60	80	100	vph	
q' (=n*q)	100	200	300	400	500		
tc	9.0	9.0	9.0	9.0	9.0	seconds	
P(delay)	0.221	0.393	0.528	0.632	0.713	(a)	
Ave delay per gap	0.95	1.62	2.08	2.38	2.56	(b)	
% of pedestrians							
needing a: 1st gap	100.00%	100.00%	100.00%	100.00%	100.00%		
2nd gap	22.1%	39.3%	52.8%	63.2%	71.3%		
3rd gap	4.9%	15.5%	27.8%	40.0%	50.9%		
4th gap	1.1%	6.1%	14.7%	25.3%	36.3%		
5th gap	0.2%	2.4%	7.8%	16.0%	25.9%		
6th gap	0.1%	0.9%	4.1%	10.1%	18.5%		
7th gap	0.0%	0.4%	2.2%	6.4%	13.2%		
8th gap	0.0%	0.1%	1.1%	4.0%	9.4%		
9th gap	0.0%	0.1%	0.6%	2.5%	6.7%		
10th gap	0.0%	0.0%	0.3%	1.6%	4.8%		
11th gap	0.0%	0.0%	0.2%	1.0%	3.4%		
12th gap	0.0%	0.0%	0.1%	0.6%	2.4%		
13th gap	0.0%	0.0%	0.0%	0.4%	1.7%		
14th gap	0.0%	0.0%	0.0%	0.3%	1.2%		
15th gap	0.0%	0.0%	0.0%	0.2%	0.9%		
16th gap	0.0%	0.0%	0.0%	0.1%	0.6%		
17th gap	0.0%	0.0%	0.0%	0.1%	0.5%		
18th gap	0.0%	0.0%	0.0%	0.0%	0.3%		
19th gap	0.0%	0.0%	0.0%	0.0%	0.2%		
20th gap	0.0%	0.0%	0.0%	0.0%	0.2%		
Overall delay through all gaps	1.22	2.67	4.40	6.47	8.92		

(a) : From Table 10.4
(b) : From Table 10.9

TABLE 10.10 – Pedestrian Delays at a Single Access Management Driveway

Sheet e

	q (vph)				
N	**20**	**40**	**60**	**80**	**100**
1	0.23	0.46	0.71	0.98	1.22
2	0.46	0.98	1.50	2.06	2.67
3	0.71	1.50	2.37	3.33	4.40
4	0.98	2.06	3.33	4.78	6.47
5	1.22	2.67	4.40	6.47	8.92

Note: Table entries are average delays in seconds through 20 gaps

TABLE 10.11 -- Summary of Delays at a Single Access Management Driveway

	Block length =		400	feet	(122 m)	
	Walking speed =		4	fps	(1.22 mps)	
	PIEV time =		2.5	seconds		
		20	40	60	80	100
N						
1	t1	100.0	100.0	100.0	100.0	100.0
	t2	2.5	2.5	2.5	2.5	2.5
	t3	0.2	0.5	0.7	1.0	1.2
	T	**102.7**	**103.0**	**103.2**	**103.5**	**103.7**
2	t1	100.0	100.0	100.0	100.0	100.0
	t2	2.5	2.5	2.5	2.5	2.5
	t3	0.5	1.0	1.5	2.1	2.7
	T	**103.0**	**103.5**	**104.0**	**104.6**	**105.2**
3	t1	100.0	100.0	100.0	100.0	100.0
	t2	2.5	2.5	2.5	2.5	2.5
	t3	0.7	1.5	2.4	3.3	4.4
	T	**103.2**	**104.0**	**104.9**	**105.8**	**106.9**
4	t1	100.0	100.0	100.0	100.0	100.0
	t2	2.5	2.5	2.5	2.5	2.5
	t3	1.0	2.1	3.3	4.8	6.5
	T	**103.5**	**104.6**	**105.8**	**107.3**	**109.0**
5	t1	100.0	100.0	100.0	100.0	100.0
	t2	2.5	2.5	2.5	2.5	2.5
	t3	1.2	2.7	4.4	6.5	8.9
	T	**103.7**	**105.2**	**106.9**	**109.0**	**111.4**

TABLE 10.12 -- Pedestrian Travel Times
Access Management Driveways

		q (vph)				
		20	40	60	80	100
N						
1	T (normal)	102.6	102.6	102.7	102.8	102.8
	T (acc mgmt)	102.7	103.0	103.2	103.5	103.7
	Ratio	**1.00**	**1.00**	**1.00**	**1.01**	**1.01**
2	T (normal)	105.1	105.3	105.4	105.5	105.6
	T (acc mgmt)	103.0	103.5	104.0	104.6	105.2
	Ratio	**0.98**	**0.98**	**0.99**	**0.99**	**1.00**
3	T (normal)	107.7	107.9	108.0	108.3	108.5
	T (acc mgmt)	103.2	104.0	104.9	105.8	106.9
	Ratio	**0.96**	**0.96**	**0.97**	**0.98**	**0.99**
4	T (normal)	110.2	110.5	110.7	111.0	111.3
	T (acc mgmt)	103.5	104.6	105.8	107.3	109.0
	Ratio	**0.94**	**0.95**	**0.96**	**0.97**	**0.98**
5	T (normal)	112.8	113.2	113.4	113.8	114.1
	T (acc mgmt)	103.7	105.2	106.9	109.0	111.4
	Ratio	**0.92**	**0.93**	**0.94**	**0.96**	**0.98**

TABLE 10.13 -- RELATIVE MAGNITUDES OF PEDESTRIAN TRAVEL TIMES FOR BLOCKS WITH ACCESS MANAGEMENT VERSUS NORMAL DRIVEWAYS

11. CONCLUSIONS AND RECOMMENDATIONS

11.1 Conclusions

1. Several factors support the importance of considering the impacts of access management on pedestrians, bicycles and transit. Such factors include:

   - Oregon's Statewide Planning Goal 12 requires that transportation planning and design be pursued from a broad, multimodal perspective that goes beyond a vehicular-traffic-only viewpoint.
   - The Oregon Land Conservation and Development Commission (LCDC) has adopted the Transportation Planning Rule which emphasizes the need for a "balanced" transportation system.
   - Several goals, policies and actions specified in the Oregon Transportation Plan suggest that these access management impacts are an important issue.
   - There is a broad commonality among the benefits of access management and the benefits of bicycling and walking as identified in the Oregon Bicycle and Pedestrian Plan.
   - The safety of pedestrians and bicycles should be an important concern for transportation professionals.

2. Very little field data exists which describe the effects of access management on pedestrians, transit and bicycles.

3. Collection of field data will be time-consuming and tedious, especially if experimental procedures preclude the use of "planted" pedestrians and bicycles.

4. The application of access management techniques to arterial streets and roadways in Oregon will produce both positive and negative impacts on pedestrians, bicycles and transit.

5. Based on the data collected for this report, it appears that the presence of a pedestrian does not alter the behavior of vehicles (as measured by average vehicular speeds) entering driveways.

6. Based on the limited data collected for this report, it appears that the presence of a right-turn lane decreased the average speed of right-turning vehicles entering the driveways at the tested locations.

7. It is likely that many factors influence the comparative speeds of left and right-turning vehicles entering the same driveway.

8. A significant commitment of research time and resources will be necessary to collect field data describing the interactions between bicycles and vehicles at driveways or other roadway elements related to access management.

9. A typical "access management driveway" exposes a pedestrian to a larger area of potential conflict with vehicles when compared to a "normal driveway." As additional normal driveways are consolidated into a single access management driveway, total conflict area of the (multiple) normal driveways quickly exceeds that of the single access management driveway.

10. The probability of a random conflict between a pedestrian and a vehicle at a driveway can be estimated using the Poisson distribution.

11. The probability of a random conflict between a pedestrian and a vehicle at a driveway is higher for access management driveways compared to normal driveways.

12. Average pedestrian delays at driveways can be estimated using the Poisson distribution. These delays can then be used to estimate pedestrian travel times along an arterial.

13. Based on the assumptions in Section 10 of this report, calculated pedestrian travel times are generally shorter along blocks with access management driveways when compared to blocks with normal driveways. Differences in travel times are relatively small and may not be discernible to the average pedestrian.

11.2 Recommendations

1. Additional research time and resources should be devoted to the continuing investigation of the impacts of access management on pedestrians, bicycles and transit.

2. Potential areas for additional research include:
    - The relationship between increasing median control and the frequency of bicycle/vehicle crashes. (See Section 4.3.)
    - The relationship between the presence of a right-turn lane and the speed of right-turning vehicles entering a driveway. (See Section 7.)
    - The relationship between the presence of a right-turn lane and the frequency of pedestrian/vehicle and bicycle/vehicle crashes at driveways.
    - The comparative speeds of right and left-turning vehicles entering driveways. (See Section 8.)
    - The interaction between bicycles and vehicles at driveways and other roadway elements related to access management. (See Section 9.)

3. As Oregon continues to investigate the impacts of access management on pedestrians, bicycles and transit, all persons involved should strive to maintain a "balanced" perspective. "Vehicle advocates" should keep in mind Oregon's commitment to providing

a multimodal transportation system. Pedestrian and bicycle advocates should keep in mind that on many transportation facilities (including those studied here) pedestrian and bicycle volumes are several orders of magnitude smaller than vehicular volumes. It is therefore logical to question the efficacy of designing such facilities with a "pedestrian-and-bicycle-first" mind set.