Synthesis on Right-Turn Deceleration Lanes on Urban and Suburban Arterials

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SUMMARY

This synthesis presents a review of current literature and state and local highway agency policies and practices related to right-turn deceleration lanes on urban and suburban arterials. The synthesis documents current knowledge and practice concerning the advantages and disadvantages and the safety and operational tradeoffs of right-turn deceleration lanes for urban and suburban arterials. The research included an extensive review of literature and a survey of practice reported by highway agencies in 40 states and 35 cities and counties. The results of the highway agency survey indicate that 89 percent of state and local highway agencies currently use right-turn deceleration lanes and thus it is important that their effect on motorists, bicyclists, and pedestrians be properly understood.

Right-turn lanes are often defined as any added pavement adjoining the traveled way which may be used by vehicles slowing down before making right turns from the roadway. The AASHTO *Policy on Geometric Design of Highways and Streets*, commonly known as the *Green Book*, and NCHRP Report 279, *Intersection Channelization Design Guide,* provide direction on several key issues associated with the geometric design of right-turn lanes. While no definite warrants have been established for these facilities, several factors are identified in these documents and guidance is given for agencies to consider when determining whether right-turn lanes would be beneficial.

The components of the length of a right-turn lane considered in geometric design include taper, deceleration, and storage length. Right-turn lanes should be constructed with sufficient length to allow for comfortable deceleration to take place in the right-turn lane, thus preventing

unnecessary deceleration from taking place in a through lane. This provides not only an operational benefit, as through vehicles are not subjected to delays, but it also offers increased safety as the resulting number of rear-end accidents between through and turning vehicles is generally reduced. In some cases, the critical element in determining the necessary length is related to the amount of space required for turning-vehicle storage. Research suggests that in most circumstances a combination of necessary deceleration and storage length should be allotted. The inclusion of a taper on a right-turn deceleration lane helps drivers identify the additional lane and safely maneuver their vehicles appropriately.

In many ways, it may not be the design of the right-turn lane, but the type of traffic control (i.e., signing and pavement markings) at an intersection with a right-turn lane, that most directly affects the safety of travel through the intersection by pedestrians and bicyclists. Traffic control devices for right-turn lanes most often include signing upstream and pavement markings to alert motorists and bicyclists of the additional lane. Pedestrian controls at intersections with or without right-turn lanes are very similar and may include accessible pedestrian signals or pedestrian-actuated warning devices. This synthesis focuses on general traffic control issues and on traffic control solutions for accommodating pedestrians and bicyclists.

The primary traffic operational reasons for providing right-turn lanes are to increase vehicular capacity at an intersection and to reduce delay to drivers by removing deceleration traffic from the through stream. While only limited research has been conducted to compare the operational performance of urban intersections with and without right-turn lanes, it appears that right-turn lanes provide a net reduction in motor vehicle delay at intersections where they are installed. No data are available on the operational effects of installing pedestrian-activated signals along right-turn roadways. A traffic operational evaluation of intersections with right-turn lanes is needed to quantify the differences between alternative designs and to provide a better understanding of which pedestrian facilities are most effective.

The safety effects of right-turn lanes on motor vehicles, pedestrians, and bicyclists are largely unknown. It is generally accepted that right-turn lanes improve safety for motor vehicles at intersections where they are used, but there is only limited quantitative data to demonstrate this. No studies have been found concerning pedestrian safety at intersections with right-turn lanes that have used crash data to document the pedestrian safety implications of the right-turn lanes. There also appears to be an inherent risk to bicyclists at intersections with right-turn lanes because motor vehicles entering the turn lane must weave across the path of bicycles traveling straight through the intersection; however, no studies are available to support this presumption. The same potential conflict between through bicyclists and right-turn vehicles is present at conventional intersections as well.

This synthesis summarizes the advantages and disadvantages of providing right-turn lanes on urban and suburban arterials. These advantages and disadvantages reflect the current knowledge and experience of highway agencies concerning right-turn lanes. There are many unresolved issues concerning right-turn lanes that indicate a need for further research.

CHAPTER 1.

INTRODUCTION

BACKGROUND

Right-turn deceleration lanes reduce the incidence of rear-end collisions from vehicles slowing to make right-turn maneuvers. Right-turn lanes also improve arterial capacity by removing slower-moving vehicles from the main traffic stream. New access points, particularly busy commercial driveways, often contribute noticeably to congestion and reduced outside travel lane capacity. Several states have established application and design criteria for right-turn lanes for driveways and intersections, but the criteria vary widely from state to state. In addition, there is little information on the design and placement of bicycle lanes and handling of adjacent pedestrian paths at locations with right-turn deceleration lanes. Information is needed for transportation agencies to use in determining when a right-turn lane is needed and in designing that lane.

OBJECTIVES AND SCOPE

The objective of this synthesis is to document current literature and state and local standards, policies, and practices related to right-turn lanes at unsignalized intersections and driveways. This synthesis effort will focus on documenting current knowledge and practice concerning the advantages and disadvantages and the safety and operational tradeoffs of specific design practices for right-turn lanes. Effects of right-turn lanes on the pedestrian, bicycle, and vehicle modes of travel will be considered. The preparation of this synthesis included a critical review of relevant literature and a survey to determine the current practices of state and local highway agencies.

This synthesis was prepared as part of NCHRP Project 3-72, *Lane Widths, Channelized Right Turns, and Right-Turn Deceleration Lanes*, and includes the results of research performed for that project to better understand the traffic operational and safety effects of right-turn lanes on urban and suburban arterials. Separate syntheses have been prepared to address lane widths and channelized right turns on urban and suburban arterials.

ORGANIZATION OF THIS SYNTHESIS

This synthesis is organized as follows. Chapter 2 addresses the geometric design of right-turn lanes, based on the *Green Book* and on highway agency policies and practices. Chapter 3 addresses traffic control issues related to intersection with right-turn lanes. Chapter 4 summarizes current knowledge concerning traffic operational effects of right-turn lanes, and Chapter 5 summarizes current knowledge concerning traffic safety effects of right-turn lanes. Chapter 6 presents a summary of the advantages and disadvantages of providing right-turn lanes at unsignalized intersections and driveways. Appendix A presents the questionnaire used in the highway agency survey, while Appendix B summarizes the survey results concerning right-turn lanes.

CHAPTER 2.

GEOMETRIC DESIGN

The highway agency survey reported in Appendix B of this synthesis indicates that 89 percent of state and local highway agencies use right-turn lanes at intersections or driveways; even casual observation indicates that right-turn lanes are a relatively common geometric feature at intersections and driveways on urban and suburban arterials.

Chapter 9 of the AASHTO *Policy on Geometric Design of Highways and Streets* (*1*), commonly known as the *Green Book*, addresses the use of "speed-change" lanes at highway intersections. The term "speed-change lane" or "deceleration lane," as used in the *Green Book*, is often used broadly in referring to any added pavement adjoining the right-of-way which may be used by vehicles slowing down and does not necessarily imply a marked lane of consistent width. Although the *Green Book* is the primary reference for roadway design, design guidelines for installation of right-turn lanes are also provided in NCHRP Report 279, *Intersection Channelization Design Guide* (*2*).

This section presents a discussion of the following geometric design issues as they relate to right-turn lanes:

- Warrants

- Deceleration and storage lengths
- Taper

WARRANTS

The *Green Book* does not provide a definitive warrant for the use of speed-change lanes (including right-turn lanes). In Chapter 9, the *Green Book* states that "speed-change lanes are warranted on high-speed and on high-volume highways where a change in speed is necessary for vehicles entering or leaving the through-traffic lanes." It identifies several factors that should be considered: vehicle speeds, traffic volumes, percentage of trucks, capacity of the highway, type of highway, service provided, and the frequency and layout of intersections. Most of the language regarding warrants for the use of speed-change lanes is geared toward highways rather than urban and suburban arterials. However, later in Chapter 9, under the heading of "Deceleration Length," the *Green Book* states that "provision for deceleration clear of the through-traffic lanes is a desirable objective on arterial roads and streets and should be incorporated into design, whenever practical."

While NCHRP Report 279 (*2*) does not provide a specific warrant for right-turn lanes, it states that the following factors may contribute to the need for a right-turn lane:

In urban areas:

- Peak or design hour volume of right turns; significant percentage of approach volume as right-turning volume
- Safety problem involving rear-end or sideswipe accidents
- Pedestrian crossing volumes or presence of pedestrians who would conflict with right-turning vehicles
- Severe skew or grade that increases the difficulty of right turns

In suburban areas and at high-speed rural intersections:

- Large volumes of right turns generated by shopping centers, developments, and office buildings
- Safety problem involving rear-end accidents
- Vehicle speeds
- Adjacent lane use

Recent research by Potts et al. (*3*) has developed economic warrants for installation of right-turn lanes at unsignalized driveways and intersections in urban and suburban areas. These economic warrants consider both traffic operational and safety effects of right-turn lanes and are presented in Chapter 4 of this synthesis.

DECELERATION AND STORAGE LENGTHS

The *Green Book* states that, whenever practical, it is desirable to provide for deceleration clear of the through-traffic lanes on arterial streets. Table 1 presents recommended deceleration lengths for right-turn lanes to accommodate a comfortable deceleration to a stop from the full design speed of the roadway. The deceleration lengths in Table 1 are calculated based on grades of less than 3 percent.

TABLE 1. Deceleration lane lengths to accommodate comfortable deceleration from full design speed to a complete stop (*1*)

Speed mph (km/h)	Distance ft (m)
30 (50)	170 (50)
40 (60)	275 (70)
45 (70)	340 (95)
50 (80)	410 (120)
55 (90)	485 (150)

On many urban and suburban facilities, it may not be practical to design right-turn lanes with the lengths specified in Table 1. In many cases, the storage length required to accommodate the number of right-turning vehicles during a peak period is the critical factor in determining the length of the right-turn lane, and not the distance needed for a comfortable deceleration. In such cases, part of the deceleration of right-turning vehicles must take place in the through-traffic lane, before entering the right-turn lane. On many arterial streets, it is appropriate to assume that an approaching right-turning vehicle can decelerate comfortably to a speed of 15 km/h (10 mph) in the through lane before entering the right-turn lane (*1*). On collector streets, higher differential speeds may be acceptable due to higher levels of driver tolerance for vehicles leaving or entering the roadway. Shorter right-turn lane lengths will increase the speed differential between right-turning vehicles and through traffic.

The length of a right-turn lane should be sufficient to avoid the possibility of a queue of turning vehicles encroaching into the through lanes while waiting for a gap in the opposing traffic flow or a signal change. The *Green Book* recommends that, at unsignalized intersections, storage lengths exclusive of tapers be based on the number of vehicles likely to arrive in an average two-minute period during the peak hour, and at unsignalized intersections with more than 10 percent truck traffic, space should be provided for the storage of at least one truck and one car. Similarly, at signalized intersections, the necessary storage length should be based on the signal cycle length, signal phasing arrangement, and the rate of arrivals and departures of right-turning vehicles. Storage lengths are usually based on one and one-half to two times the average number of vehicles likely to be stored per cycle.

NCHRP Report 279 (*2*) provides guidance on deceleration and queue storage lengths. Table 2 presents recommended deceleration lengths, including taper, for right-turn lanes. These recommended lengths allow for a vehicle to decelerate and brake entirely outside of the through traffic lanes. The lengths are calculated assuming a deceleration of 3 s followed by comfortable braking to a stopped position or to the design speed of the corner radius.

Table 3 presents recommended storage lengths for right-turn lanes for STOP-controlled intersections. Figure 1 presents recommended storage lengths for right-turn lanes for signalized intersections. These recommended lengths allow for a reasonable number of vehicles to queue within the lane without affecting other lanes. The desired lengths are based on twice the mean arrival rate during the peak hour of traffic, while the minimum lengths are based on the mean arrival rate, with minimum storage for one vehicle.

TABLE 2. Recommended deceleration lengths (including taper) for right-turn deceleration lanes *(2)*

Highway design speed (mph)	Length of taper and lane for deceleration and braking (ft)				
	Stop condition[a]	Design speed of corner radius (mph)			
		15	20	25	30
30	235	185	160	140	–
40	315	295	265	235	185
50	435	405	385	355	315
60	530	500	490	460	430
65	570	540	530	490	480
70	615	590	570	550	510

[a] Appropriate for right-turn lanes on approaches to stop signs and traffic signals.

TABLE 3. Recommended storage lengths for right-turn lanes at STOP-controlled intersections *(2)*

DHV (veh/h)	Length of lane for storage (ft)
≤ 60	50-75
61-120	100
121-180	150
>180	≥ 200

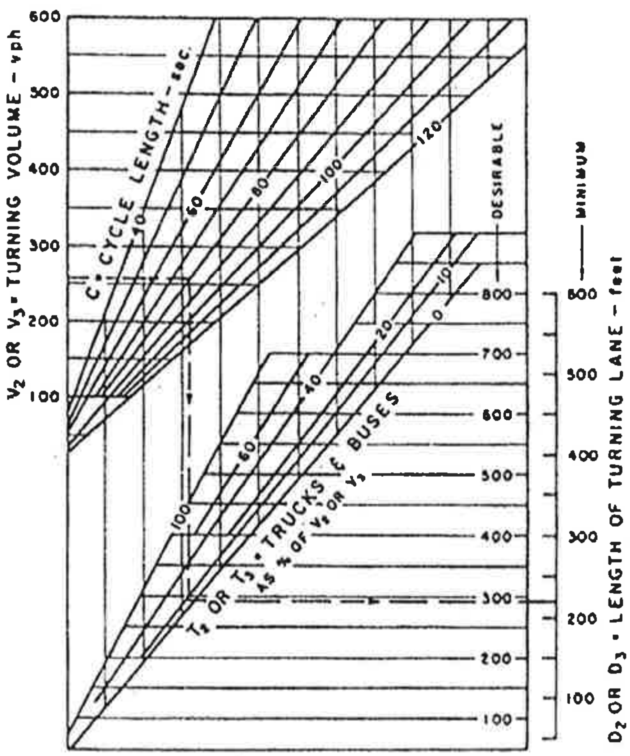


Figure 1. Desirable and minimum storage lengths for right-turn lanes at signalized intersections (2).

The design guidelines for deceleration and storage length presented in the *Green Book* and in NCHRP Report 279 only address right-turn lanes at signalized and STOP-controlled intersection approaches. Additional guidance is needed for the appropriate length of a right-turn lane along an uncontrolled approach to a two-way stop-controlled intersection.

TAPER

A taper provides the transition to a full-width right-turn lane. Tapers may be designed in a variety of ways. Figure 2 illustrates four types of taper designs for left-turn lanes, but the dimensions are also applicable for right-turn lanes.

Inclusion of the taper length as part of the deceleration distance assumes that an approaching right-turning vehicle will begin decelerating in the through lane before entering the right-turn lane. The *Green Book* provides guidance on tapers for right-turn lanes and states that, on high-speed roadways, it is common practice to use a taper rate between 8:1 and 15:1 (longitudinal:transverse or L:T) (*1*). Long tapers approximate the path followed by drivers when entering a right-turn lane. However, long tapers may entice some through drivers into the right-turn lane, especially when the taper is on a horizontal curve.

At urban intersections, shorter tapers may be preferable (*1*). Shorter tapers allow drivers to more easily identify the additional lane and maneuver their vehicle accordingly. Taper lengths of 30 m (100 ft) are used by many municipalities and counties on urban streets (*1*).

Some agencies permit the tapered section of the right-turn lane to be constructed in a "squared-off" section at full paving width and depth. This type of construction offers improved driver commitment to the right-turn maneuver (*1*).

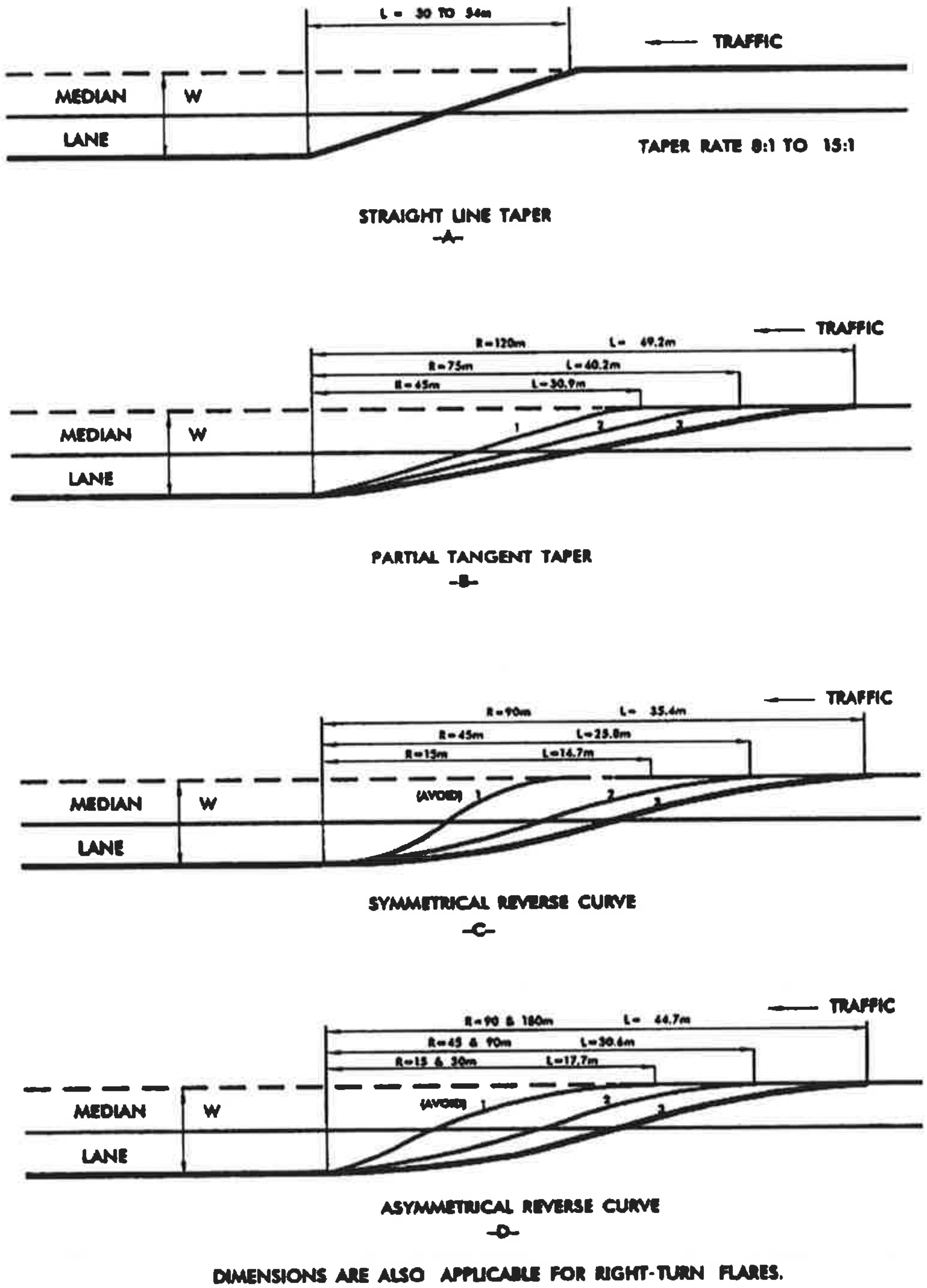


Figure 2. Taper design for auxiliary lanes (metric) (1).

CHAPTER 3.

TRAFFIC CONTROL

This chapter summarizes current knowledge concerning the traffic control issues at right-turn deceleration lanes. Traffic control issues related to motor vehicles, pedestrians, and bicycles are addressed separately.

TRAFFIC CONTROL FOR MOTOR VEHICLES

The *Manual on Uniform Traffic Control Devices* (MUTCD) (*4*) provides little guidance concerning the traffic control devices for right-turn lanes. Section 2B. 18 on intersection lane control signs indicates that, if used, intersection lane control signs shall require road users in certain lanes to turn, shall permit turns from a lane where such turns would otherwise not be permitted, shall require a road user to stay in the same lane and proceed straight through an intersection, or shall indicate permitted movements from a lane. Intersection lane control signs have three applications: mandatory movement control, optional movement control, and advance intersection lane control. Only mandatory movement lane control signs (R3-5 and R3-7) and advance intersection lane control signs (R3-8 series) are applicable to right-turn lanes (Figure 3). When used, intersection lane control signs should be mounted overhead, and each sign should be placed over a projection of the lane to which it applies, except when the number of through lanes on an approach is two or less, then the intersection lane control signs may be overhead or ground mounted. When mandatory movement lane control signs are used, they should also be accompanied by lane control pavement markings (Figure 4).

TRAFFIC CONTROL FOR PEDESTRIANS

Appropriate traffic control for pedestrians crossing intersections with or without right-turn lanes is much the same. There may be little difference to pedestrians between:

- Crossing the minor road at an unsignalized intersection without a right-turn lane on the major road
- Crossing the minor road at an unsignalized intersection with a right-turn lane on the major road

or between:

- Crossing a driveway without a right-turn lane on the major road
- Crossing a driveway with a right-turn lane on the major road.

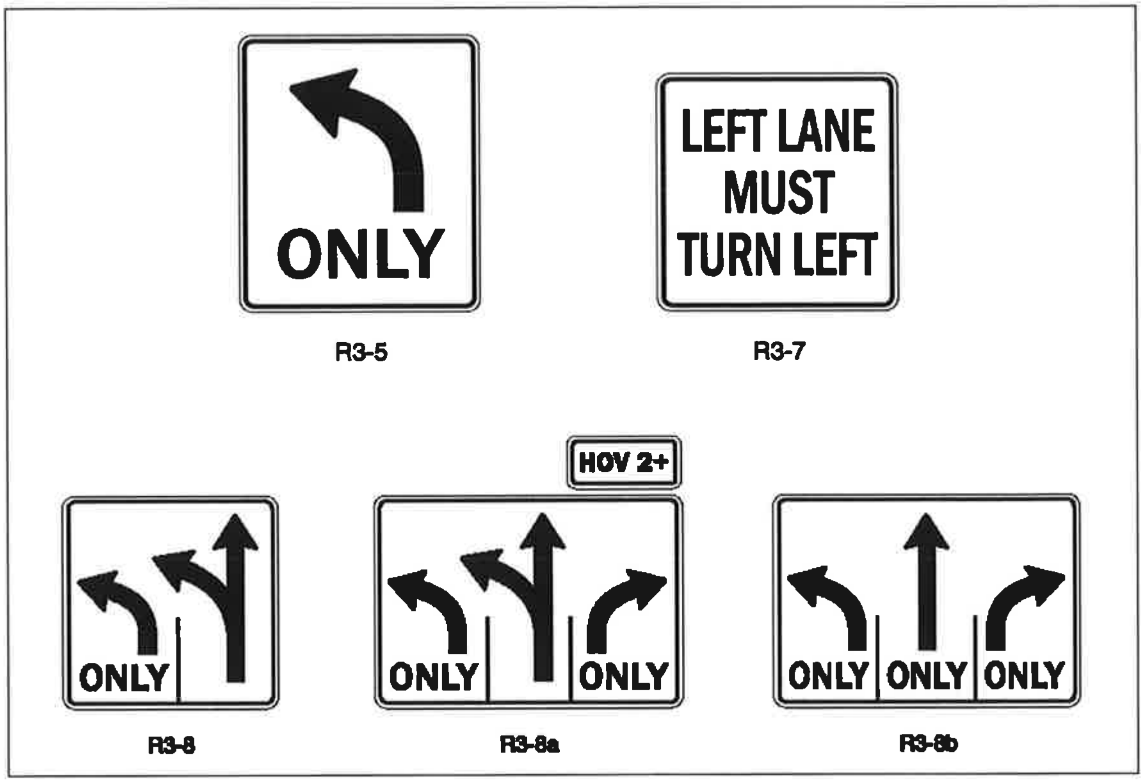


Figure 3. Intersection lane control signs applicable for right-turn lanes (4).

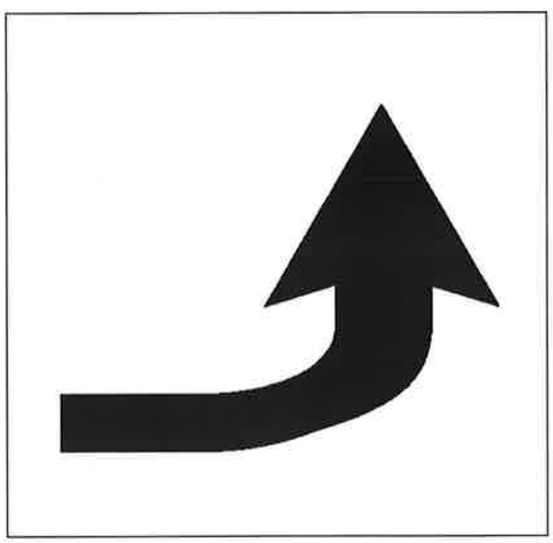


Figure 4. Typical turn lane-use pavement marking arrow (4).

In all cases, the pedestrian is potentially in conflict with major-road vehicles turning right from an uncontrolled approach. There is no traffic control device that requires turning vehicles to stop, only the legal requirement that vehicles yield to pedestrians. It is possible that the provision of a right-turn lane might affect the turning speed of vehicles, but it is likely that the curb return radius would have a greater effect than the presence or absence of a right-turn lane.

At unsignalized intersections or driveways, there may be a distinct difference between pedestrians crossing the major road and pedestrians crossing the minor road or driveway. There are typically no pedestrian crossing facilities on the major road at unsignalized intersections and driveways, and while very few pedestrians are likely to cross the major road at such a location, the presence of a right-turn lane would present a greater crossing distance for any pedestrians who do cross.

Crosswalks are the primary traffic control device for indicating the presence of a pedestrian crossing. Other traffic control approaches that have been considered for use at pedestrian crossings at intersections to enhance crossing safety for pedestrians, in general, and for pedestrians with vision impairments include:

- Use of high-visibility crosswalk markings (to improve conspicuity of pavement markings to motorists)
- Addition of fluorescent yellow-green signs both at the crosswalk and in advance of the crossing location (to supplement the high-visibility markings)

- Use of a real-time warning device to indicate to the motorist when a pedestrian is present in the area (may be activated via passive detection technologies, such as microwave or infrared, or via traditional methods, such as push buttons)
- Use of dynamic message signs (for real-time or static warning messages to motorists)
- Installation of traditional traffic signals with pedestrian signal heads (for warning or full stop control)

Signal systems with conventional pedestrian signals provide red, yellow, and green signal indicators to motor vehicle traffic and WALK (symbolized by a WALKING PERSON) and DON'T WALK (symbolized by an UPRAISED HAND) signal indicators to pedestrians. An accessible pedestrian signal (APS) is a device that communicates pedestrian signal information in a nonvisual format such as audible tones, verbal messages, and/or vibrating surfaces (*4*). APSs are now available in the United States that include a pushbutton locator tone to help pedestrians with vision impairments locate the crosswalk and let them know that a pushbutton is there to activate the pedestrian signal. Devices are available with speech pushbutton information and walk messages that can provide additional information about the intersection signalization or geometry. In these newer devices, a quiet audible walk indication is provided during the walk interval. These signals are engineered to respond to ambient traffic sound, decreasing in volume when the traffic volume is low and increasing when volume is heavy and noisy.

With crosswalk warning devices such as signs with beacons that flash when activated by a pedestrian, additional information is needed by pedestrians with vision impairments. Some

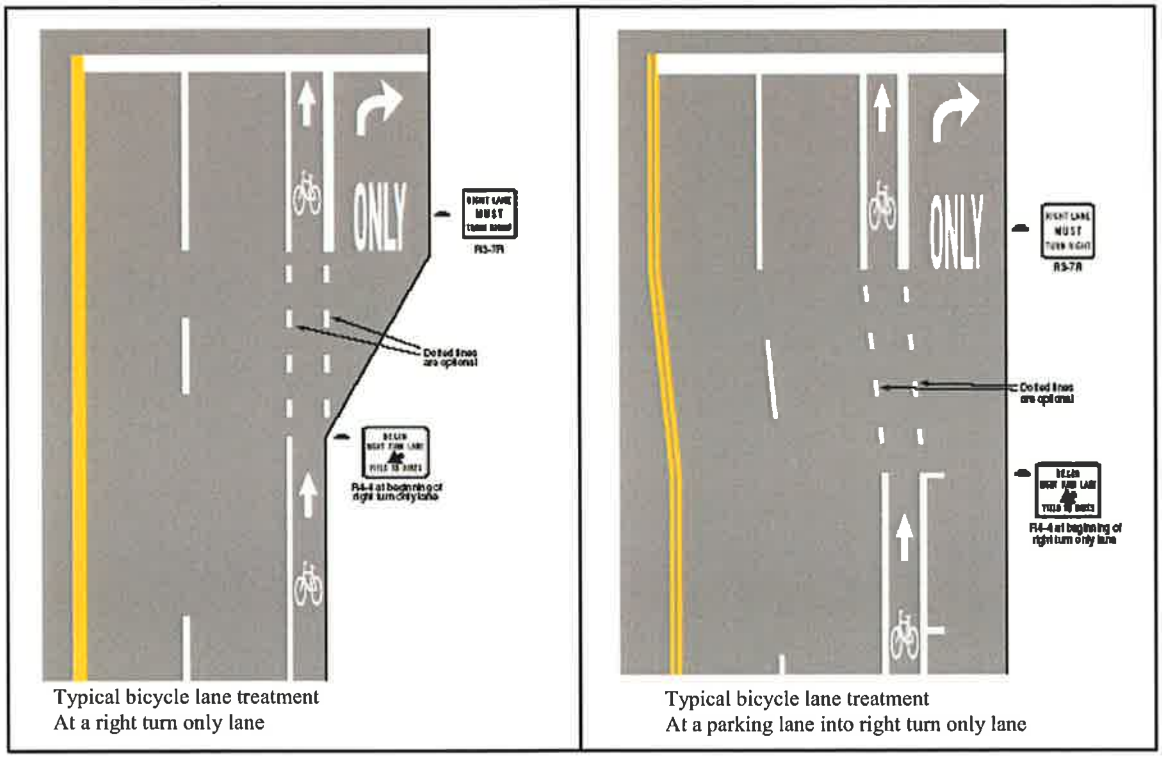
APS devices have been installed with a message that "the crosswalk warning devices are flashing" to give pedestrians with vision impairments the information typically available to sighted pedestrians at crosswalk warning devices. The advantages to pedestrians with vision impairments and to pedestrians, in general, of providing pedestrian-actuated signals at intersections are largely unproven, and guidelines related to traffic or pedestrian volumes are needed.

TRAFFIC CONTROL FOR BICYCLISTS

The treatment of marked bicycle lanes at intersections with right-turn lanes is the primary issue related to traffic control and bicyclists. The MUTCD (*4*) provides guidance for marking bicycle lanes at intersections with right-turn lanes. Figure 5 illustrates an intersection with a right-turn lane and an intersection with a parking lane and a right-turn lane. In both examples, the pavement markings for the bicycle lane are solid on the approach to the intersection. Where the right-turn lanes begin, the pavement markings for the bicycle lanes are dashed for an unspecified length, and then the pavement markings delineating the bicycle lane are solid again near the intersection proper. In addition to recommending dashed pavement markings across the right-turn lane, the MUTCD indicates that where motor vehicles entering an exclusive right-turn lane must weave across bicycle traffic in bicycle lanes, the BEGIN RIGHT TURN LANE YIELD TO BIKES (Figure 6) sign may be used to inform both the driver and the bicyclist of this weaving area. These striping and signing configurations are intended to encourage the motorists and bicyclists to cross paths in advance of intersections in a merging fashion (*5*) and encourage bicyclists to follow the rules of the road (i.e., through vehicles including bicyclists proceed to the left of right-turning vehicles) (*6*). These bicycle lane treatments are preferable to striping configurations that force motorists and bicyclists to cross in the immediate vicinity of the intersection. The primary advantages of having through bicyclists and right-turning motor vehicles cross prior to the intersection include:

- This conflict occurs away from the intersection and other conflicts
- The difference in travel speeds enables the motorist to pass a bicyclist rather than ride side-by-side

The AASHTO *Guide for the Development of Bicycle Facilities* (*5*) presents several optional treatments for pavement markings where a bicycle lane approaches an intersection with a right-turn lane. Figure 7 presents four of the treatments. Treatments "a" and "b" in Figure 7 are exactly the same as treatments recommended in the MUTCD (see Figure 5). AASHTO indicates, though, that the dashed lines in cases "a" and "b" are optional and presents a third type of treatment where the dashed lines are removed completely (case "c" in Figure 7). It is in this area, where the pavement markings for the bicycle lane are absent, that bicycle and motor vehicle traffic are to cross paths. It should be noted, though, that in each case (a, b, and c) solid pavement markings delineating the path of the bicycle lane are recommended at the intersection



Typical bicycle lane treatment
At a right turn only lane

Typical bicycle lane treatment
At a parking lane into right turn only lane

Figure 5. Typical intersection pavement markings (4).

Figure 6. Begin right-turn lane yield to bikes sign (4).

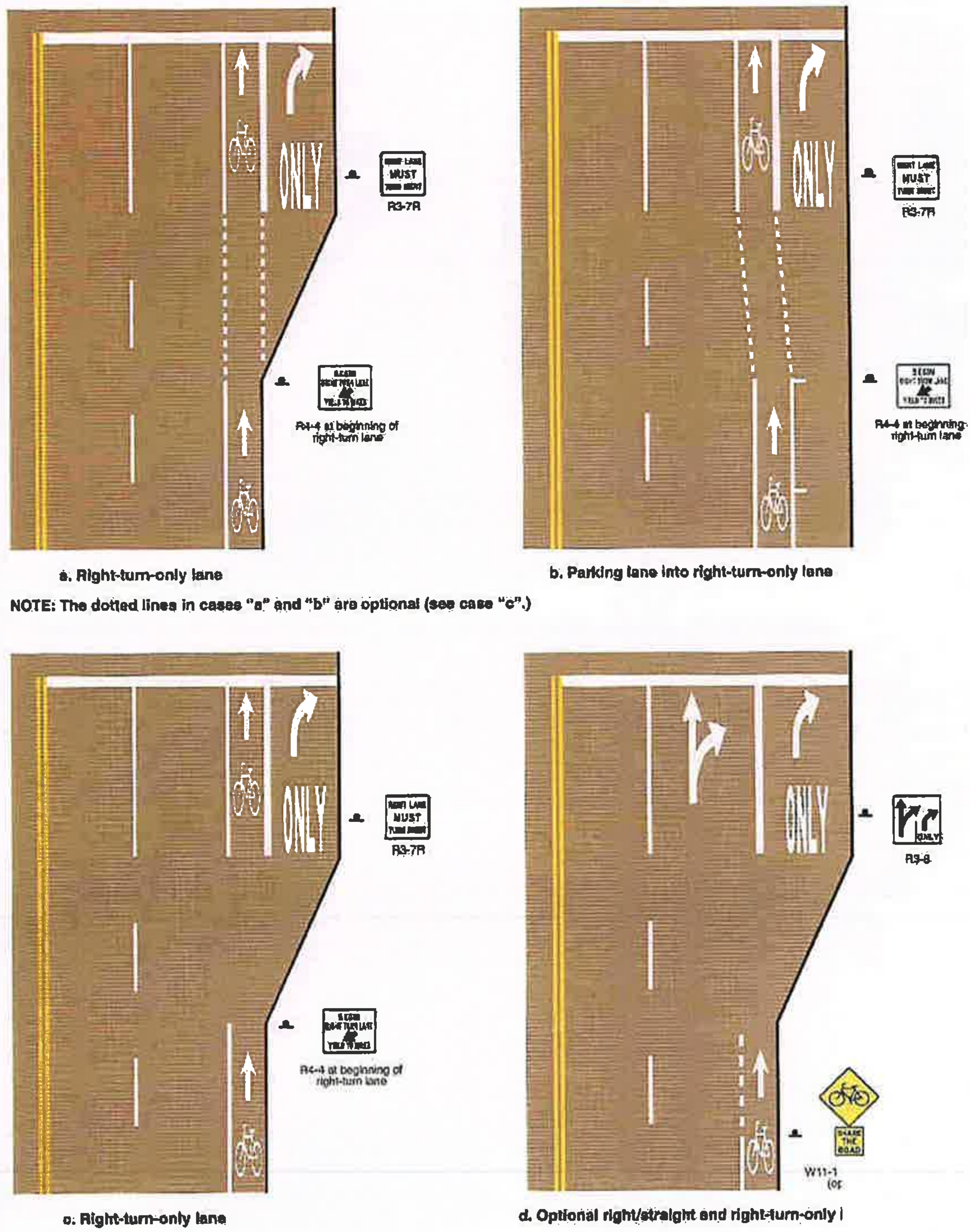


Figure 7. Bicycle lanes approaching right-turn-only lanes (5).

proper, assuming sufficient width is available. For case "d" where a right-turn lane and a shared through-and-right lane are present, the solid pavement markings delineating the bicycle lane are discontinued where the right-turn lane begins, and no pavement markings are provided at the intersection proper to delineate space for the bicycle lane. In response to the survey reported in Appendix B, several highway agencies cited Figure 7 from the AASHTO *Guide for the Development of Bicycle Facilities* and have incorporated it into their own agency guidelines.

Where there is insufficient room to mark a bike lane to the left of a right-turn lane, Oregon DOT *(6)* has provided the option to mark and sign the right-turn lane as a shared-use lane, to encourage through bicyclists to occupy the left portion of the turn lane (Figure 8). Oregon DOT notes that this type of design is most appropriate on slow-speed streets.

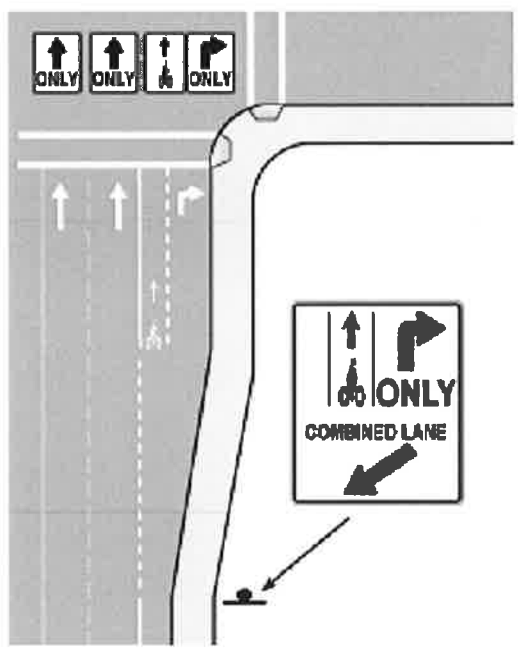


Figure 8. Joint use of right-turn deceleration lane for through bicyclists (6).

The AASHTO *Guide for the Development of Bicycle Facilities* (*5*) also indicates that the design of bicycle lanes should include appropriate signing at intersections to warn of conflicts, and the approach shoulder width should be provided through the intersection, where feasible, to accommodate right-turning bicyclists or bicyclists who prefer to use crosswalks to negotiate the intersection. The City of Chicago Department of Transportation has developed signing for a bicycle lane at an intersection where the bicycle lane continues to the stop bar to the left of the right-turn lane (Figure 9) (*7*). This sign conveys to both motorists and bicyclists the proper channelization through the intersection.

Figure 9. Standard signing for bicycle lane at intersection (7).

The practice of providing dashed pavement markings or discontinuing the bicycle lane completely in advance of the intersection is common among many state highway agencies, including Florida (*8*), Oregon (*6*), and Washington (*9*).

The highway agency survey in Appendix B of this synthesis requested that agencies provide guidelines by which they stripe bicycle lanes along right-turn lanes. Treatments of bicycle facilities at intersections with right-turn lanes, as reported by responding highway agencies, include:

- Bicycle facilities are located adjacent to through lanes and/or between the through and right-turn lanes.
- Bicycle facilities are designed using a given set of standards (AASHTO *Bicycle Guide* (*5*), MUTCD (*4*), etc.).
- Roadways are designed such that bicycle facilities are not present concurrently with right-turn lanes.

CHAPTER 4.

TRAFFIC OPERATIONS

The impact of right-turn deceleration lanes on traffic operations has been reviewed in many studies although very little research has focused on the operational impacts at unsignalized intersections and driveways. Published literature addresses warrants for right-turn lanes. This section presents a discussion of the traffic operational benefits of and warrants for right-turn lanes.

TRAFFIC OPERATIONAL BENEFITS OF RIGHT-TURN DECELERATION LANES

The 2000 edition of the *Highway Capacity Manual* (HCM) (*10*) includes a detailed procedure for estimating the capacity, delay, and level of service at unsignalized intersections, but does not account for the impacts of right-turning traffic on major street through traffic. However, the HCM does estimate that through-vehicle speeds are reduced by 4 km/h (2.5 mph) for every ten access points.

McCoy et al. (*11*) developed guidelines for the use of right-turn lanes at access points on urban two-lane and four-lane roadways. As part of the research, they estimated the operational cost savings provided by right-turn lanes, based on the reduction in stops, delay, and fuel consumption experienced by through traffic. Based on models developed by McCoy et al., right-turn lanes provide the following reduction in delay and fuel consumption as a function of right-turn volume:

$$\Delta D_{2L} = 0.0388\ V_{RT}$$

$$\Delta FC_{2L} = 0.0125\ V_{RT}$$

$$\Delta D_{4L} = 0.0200\ V_{RT}$$

$$\Delta FC_{4L} = 0.00435\ V_{RT}$$

where:

ΔD_{2L} = delay savings on a two-lane roadway (s/through vehicle)

ΔFC_{2L} = fuel consumption savings on a two-lane roadway (L/15 min)

ΔD_{4L} = delay savings on a four-lane roadway (s/through vehicle)

ΔFC_{4L} = fuel consumption savings on a four-lane roadway (L/15 min)

V_{RT} = right-turn volume (veh/15 min)

Bonneson (*12*) reviewed several studies that examined the effect of right-turn vehicles on through vehicle delay (*13,14,15*). Using the results of these studies, along with a traffic simulation model, Bonneson validated a model for predicting the delay to major-street through drivers due to vehicles turning right from the outside through traffic lane of the major roadway. A sensitivity analysis indicated that through vehicle delays due to right-turn activity typically range from 0 to 6 s/veh. This delay increases with increasing flow rate in the outside lane, increasing travel speed on the major road, increasing proportion of right turns, and decreasing right-turn speed. Bonneson suggests that, while the average delay to through vehicles may be relatively small, the total delay incurred by the through traffic stream can be quite large.

Wolf (*16*) evaluated the effect of radius of curvature for the right-turn movement on delay to the through vehicles at both signalized and unsignalized intersections. Wolf estimated the delay to through traffic by estimating the speed at which the right-turning traffic would decelerate to turn the corner and then estimated the impact of the deceleration and clearance time to through traffic. Figure 10 shows the results of the research.

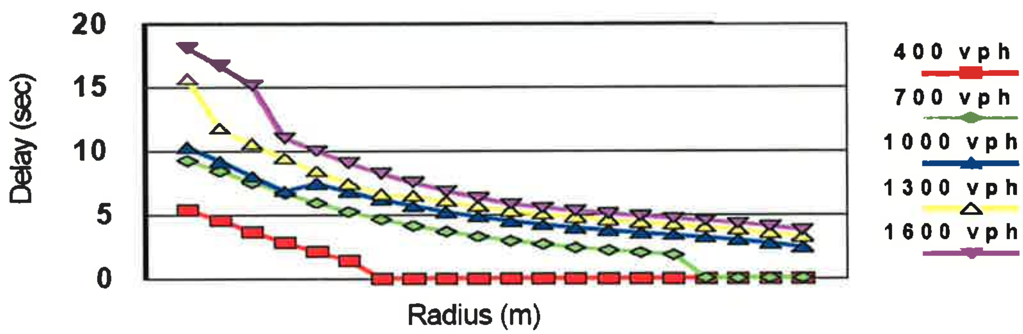


Figure 10. Effect of corner radius on delay (16).

While the focus of this synthesis is on right-turn lanes at unsignalized intersections and driveways, it is worth noting two studies that looked at the traffic operational effects of right-turn lanes at signalized intersections. A 1986 study by Zegeer (*17*) found that, at signalized intersections consisting of curb radii between 3 and 9 m (10 and 30 ft), the average saturation flow headway for right-turning vehicles was 19 percent longer than through vehicle headways. Agent and Crabtree (*18*) also studied the effect of turning radius of right-turning vehicles on saturation flow at signalized intersections. These studies primarily focused on signalized locations.

Right-turn lanes appear to provide a net reduction in delay at intersections where they are installed. It is also likely that right-turn lanes may improve air quality by reducing total vehicle emissions at intersections due to a reduction in the number of vehicle speed-change cycles and stops, but no quantitative estimates are available.

Very little research has been conducted on the design of right-turn lanes and the impacts on adjacent unsignalized accesses. NCHRP Report 279 (*2*) provides guidelines for the installation of right-turn lanes and tapers, but issues related to driveways within the boundaries of the right-turn lanes and spacing are not addressed.

Recent research concerning right-turn lanes has focused on access management issues. NCHRP Report 420 (*19*) evaluated the impact of right-turning traffic on through traffic for varying traffic volumes and access spacing. Based on data from 22 study locations, when the arterial right-lane through traffic volume ranged from 250 to 800 veh/h, the percentage of through vehicles affected at a single driveway was about 18 percent of the right-turn volume. Speed was then used to calculate the influence distances for the affected through vehicles and relate it to access spacing within a 0.4-km (0.25-mi) segment. Figure 11 shows the percent of right-lane through vehicles affected by right-turn volumes.

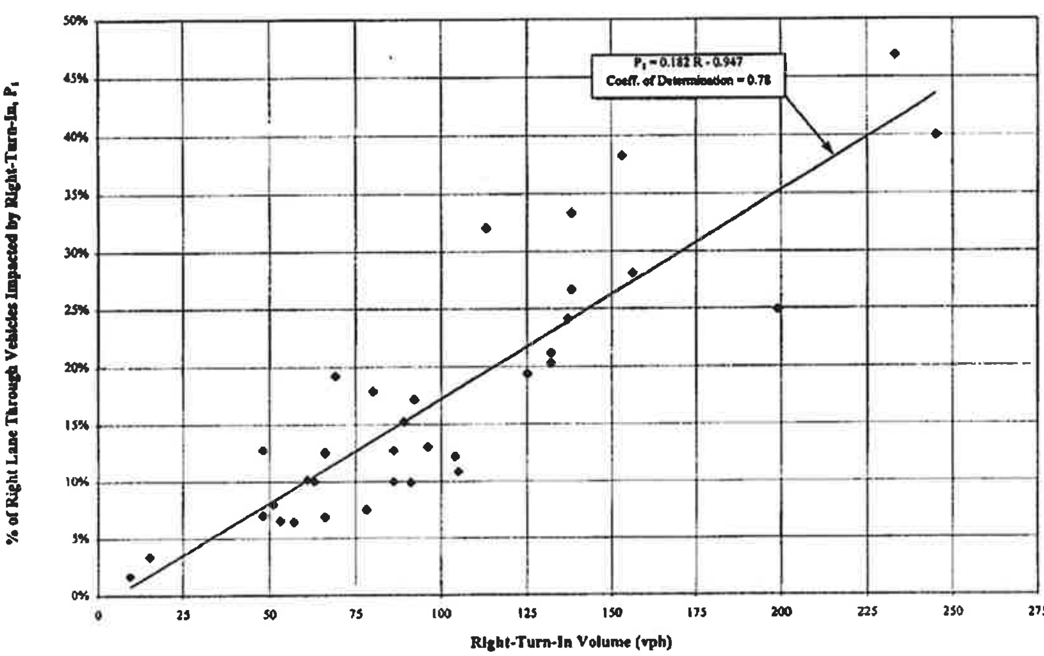


Figure 11. Right-lane through vehicle affected by right-turn lane (19).

The research reported in NCHRP Report 420 represents the most extensive study on how right turns impact through traffic. However, the research did not evaluate the amount of delay caused to the through traffic, the impact on capacity and saturation flow rate, and the impact of the corner radius.

The research by Potts et al. (*3*) included simulation modeling to investigate the operational impact of right-turn lanes on two- and four-lane arterials with a range of speed limits. It was found that two-lane arterials represent the situation in which provision of a right-turn lane may have the greatest benefit. On a multilane arterial, a through vehicle that might potentially be delayed by a right-turning vehicle can change lanes to avoid delay. On a two-lane arterial, with no right-turn lane present, slowing by a right-turning vehicle can delay following through vehicles. Figures 12 through 14 illustrate the estimated delay reduction provided by a right-turn lane on two-lane arterials for a range of major-road traffic speeds. The estimated reduction in delay to through vehicles provided by a right-turn lane typically ranges from 0 to 6 sec/through veh. The delay reduction is more pronounced as the mainline speeds, through volumes, and right-turn volumes increase.

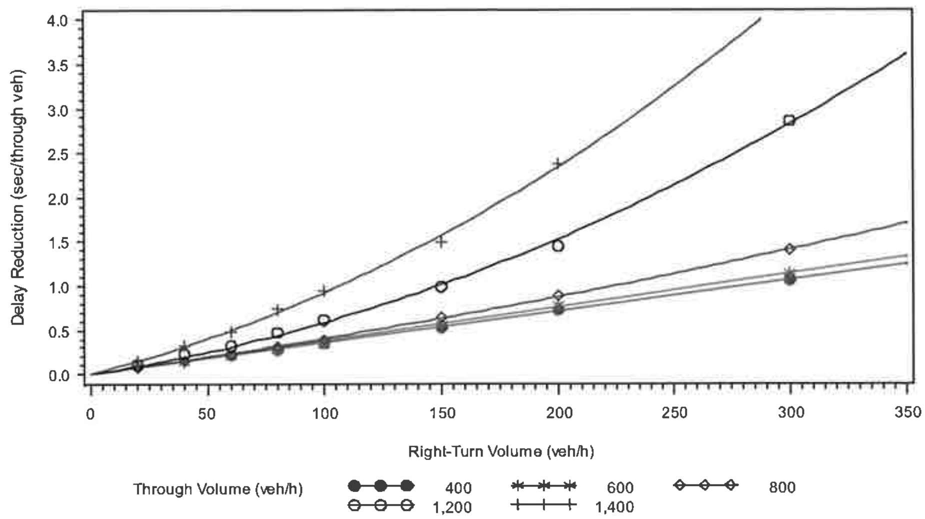


Figure 12. Delay reduction provided by provision of a right-turn lane on a 35-mph two-lane arterial (3).

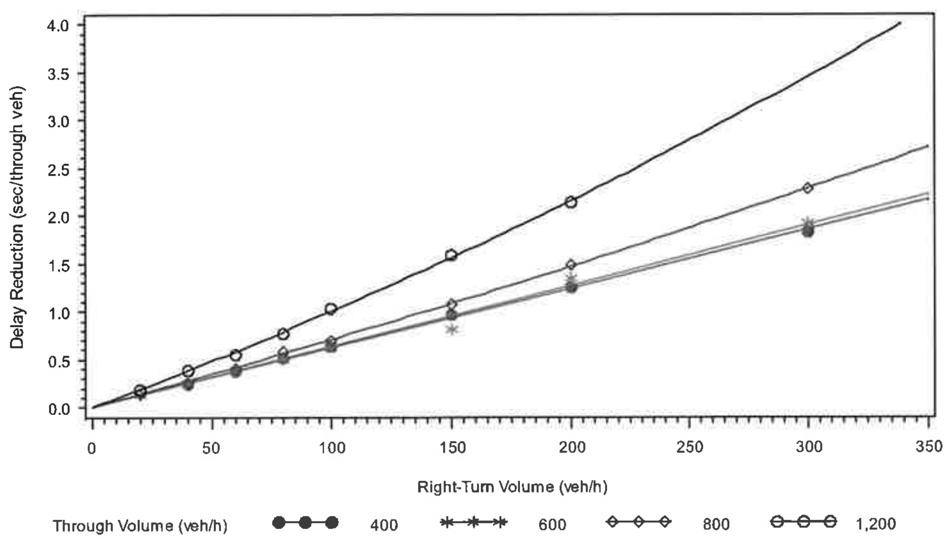


Figure 13. Delay reduction provided by provision of a right-turn lane on a 45-mph two-lane arterial (3).

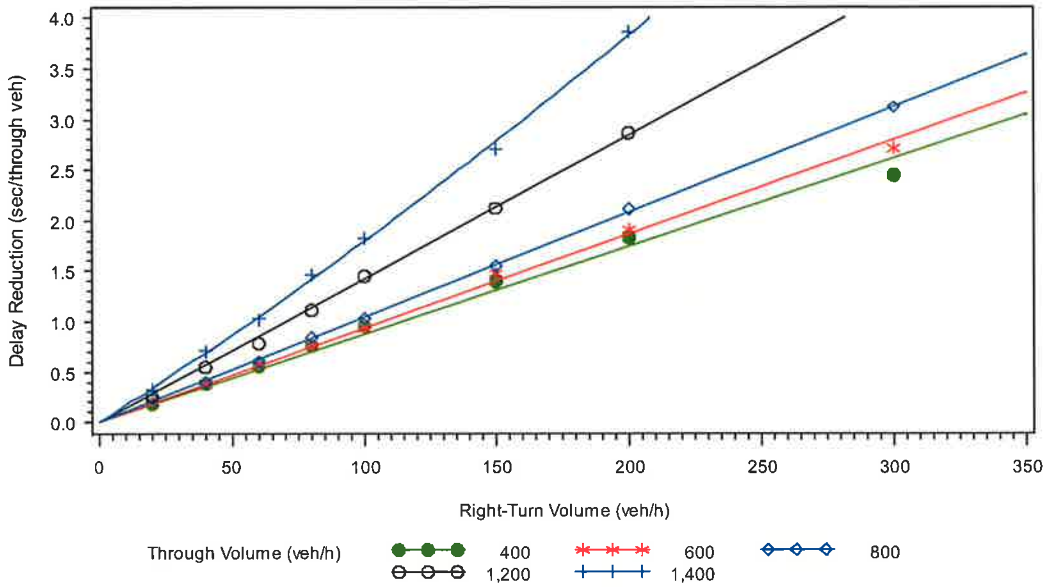


Figure 14. Delay reduction provided by provision of a right-turn lane on a 55-mph two-lane arterial (3).

Figures 15 through 17 show the delay reduction for a range of major-road traffic speeds for four-lane arterials. Typical delay reductions provided by right-turn lanes on four-lane arterials were found to be much less than those for two-lane arterials, ranging from 0 to 1 sec/through veh. These lower delays were primarily affected by two factors: (1) vehicles in the outside through lane are the only vehicles with potential to be delayed by right-turning vehicles and (2) some vehicles in the outside lane may change lanes to avoid delay caused by the right-turning vehicle.

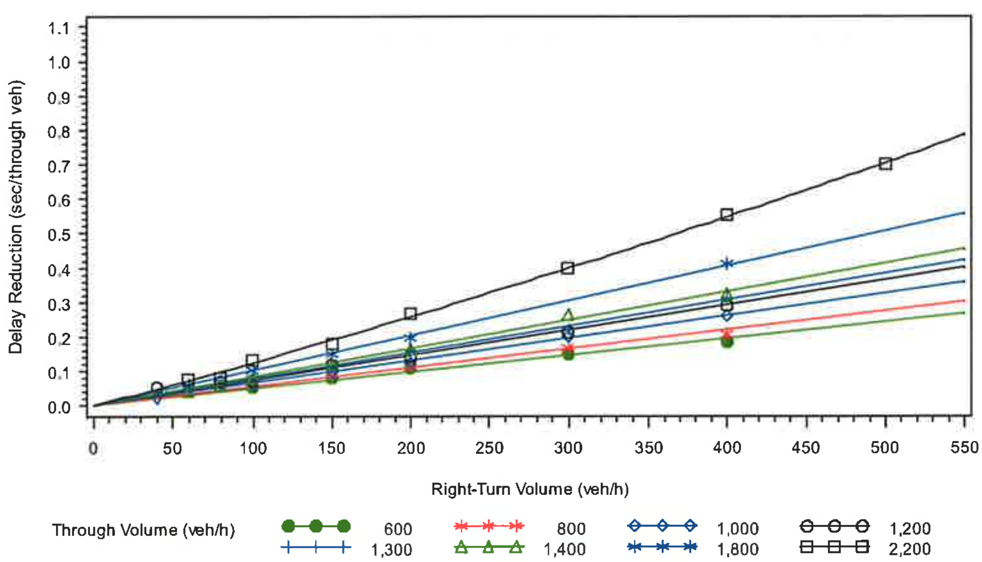


Figure 15. Delay reduction provided by provision of a right-turn lane on a 35-mph four-lane arterial (3).

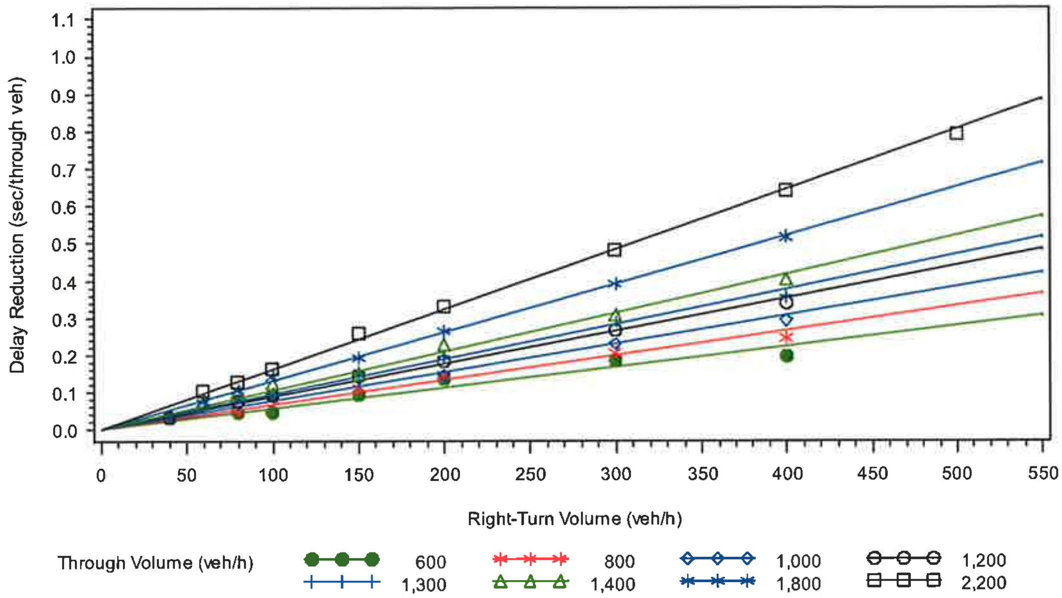


Figure 16. Delay reduction provided by provision of a right-turn lane on a 45-mph four-lane arteria (3).

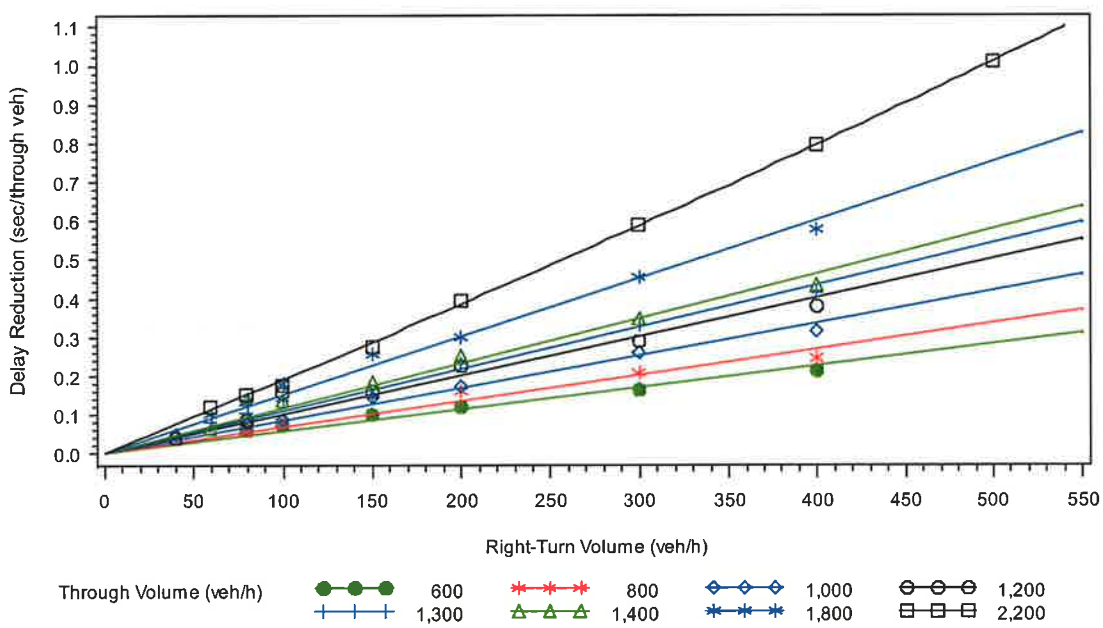


Figure 17. Delay reduction provided by provision of a right-turn lane on a 55-mph four-lane arterial (3).

Simulation modeling was also used to measure the additional delay to through traffic caused by right-turning vehicles having to yield to pedestrians crossing the minor road or driveway onto which they are turning.

Figures 18 through 20 illustrate the additional delay reduction to through vehicles, provided by a right-turn lane on a single-lane approach, for pedestrian volumes of 50, 100, and 200 ped/h crossing the minor road (or driveway). Tables 41 through 43 present the delay reduction values for pedestrian volumes 50, 100, and 200 ped/h, respectively.

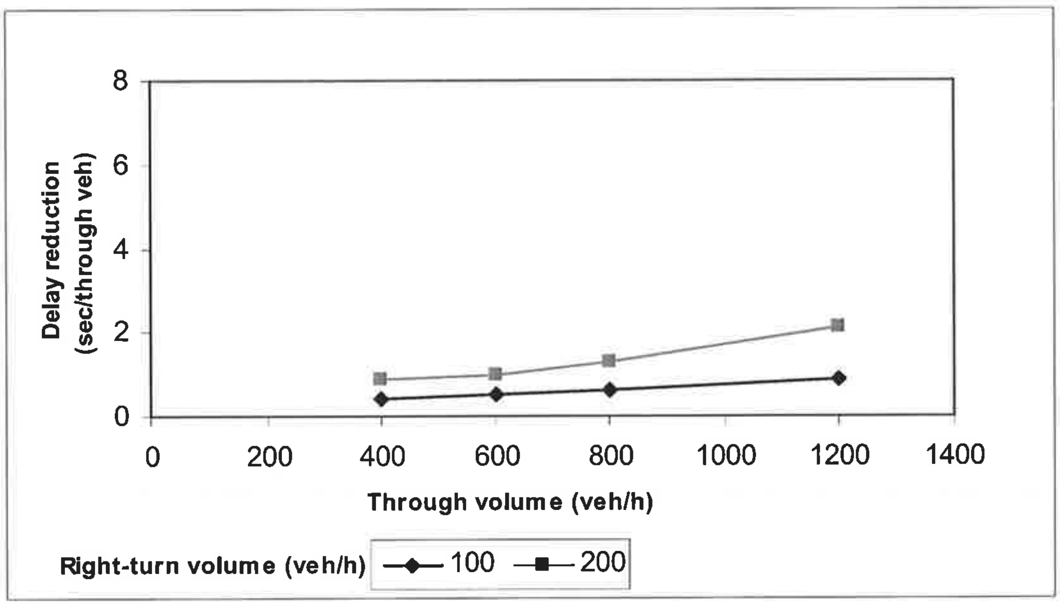


Figure 18. Additional delay reduction provided by right-turn lane where pedestrian activity is present (50 ped/h) (3).

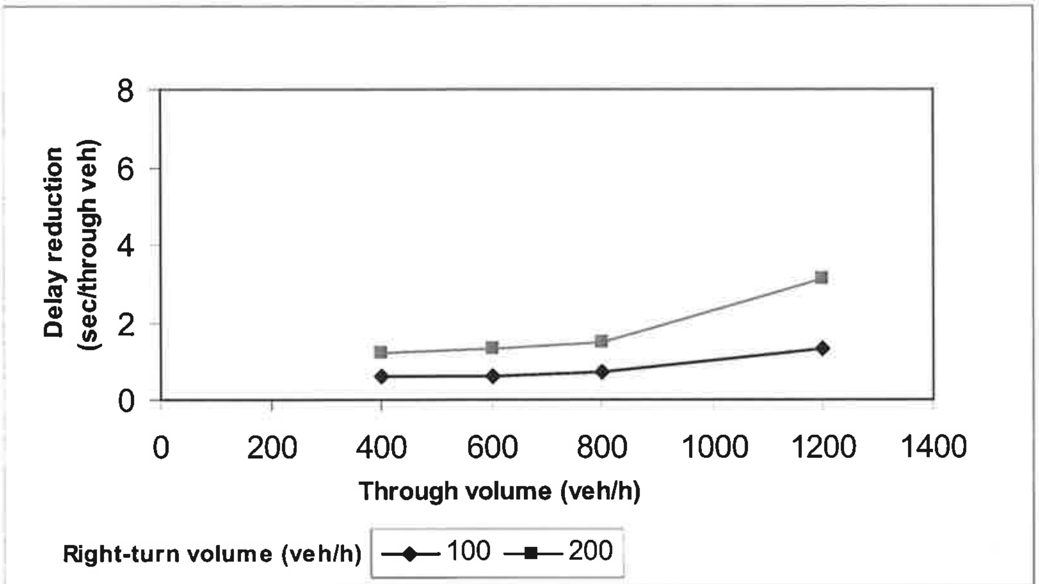


Figure 19. Additional delay reduction provided by right-turn lane where pedestrian activity is present (100 ped/h) (3).

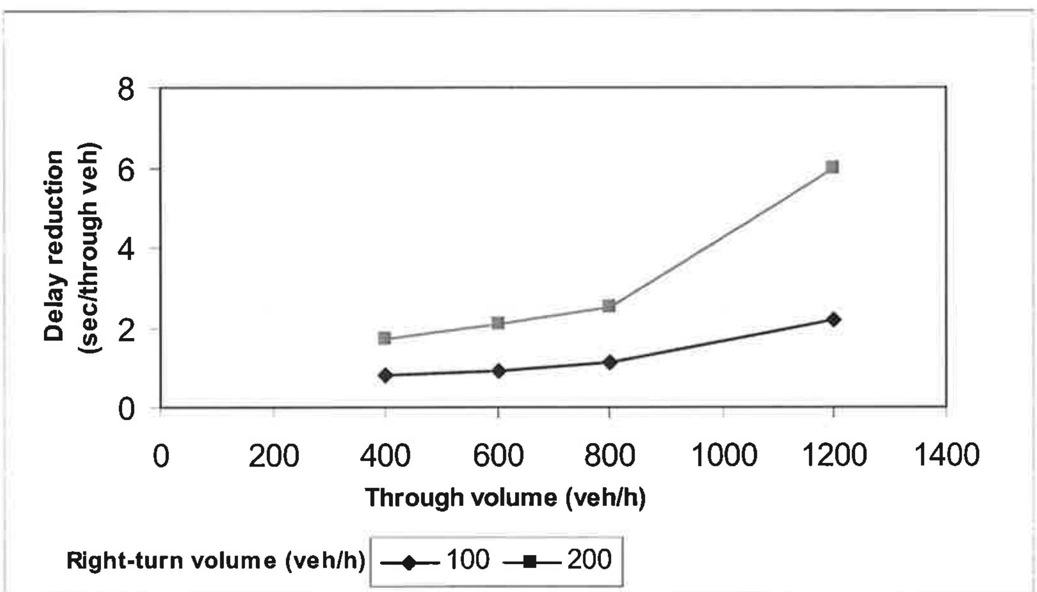


Figure 20. Additional delay reduction provided by right-turn lane where pedestrian activity is present (200 ped/h) (3).

Pedestrian activity at unsignalized intersections and driveways can have a substantial impact on delay to through vehicles due to right-turning vehicles having to yield to pedestrians.

The results demonstrate that the provision of a right-turn lane at such locations can provide substantial delay reduction benefits. At pedestrian volumes of 50 ped/h, delay reduction benefits range from 0.4 to 2.1 sec/through veh. At pedestrian volumes of 100 ped/h, delay reduction benefits range from 0.6 to 3.1 sec/through veh. Delay reduction benefits can be as high as 6 sec/through veh for pedestrian volumes of 200 ped/h.

WARRANTS FOR RIGHT-TURN DECELERATION LANES

Several studies have addressed warrants for the installation of right-turn lanes. These warrants are primarily based on a minimum right-turn volume that can be accommodated without significantly impacting through traffic on the approach.

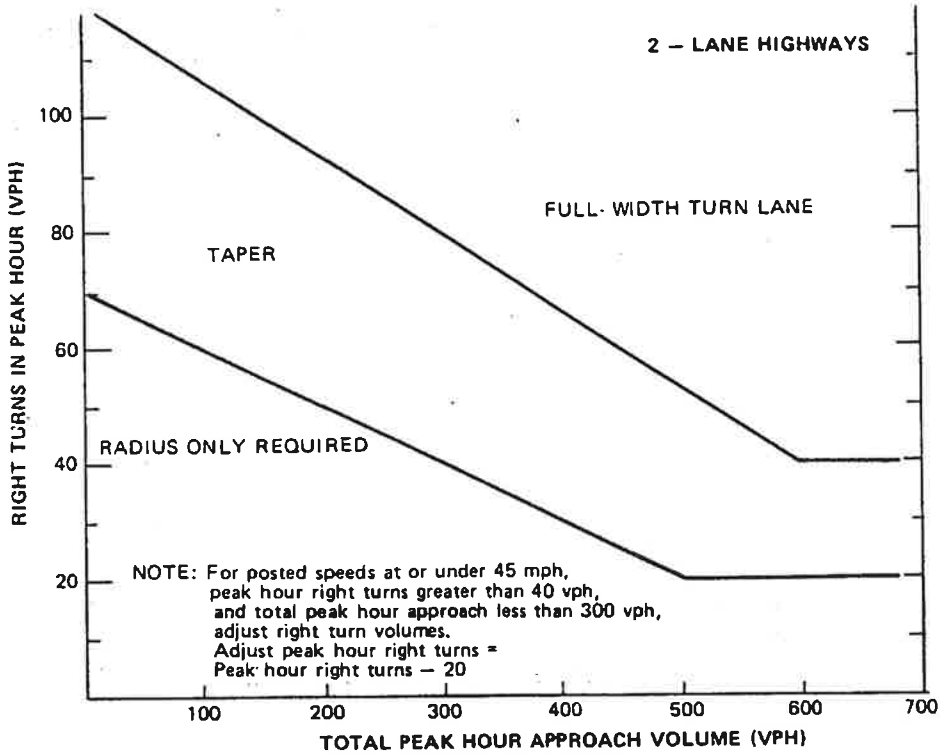
As part of the research conducted for NCHRP Report 279 (*2*), highway agency practice was reviewed to determine the conditions under which highway agencies provide right-turn lanes on rural highways. Table 4 presents the results of the highway agency review. In addition, NCHRP Report 279 presents traffic volume guidelines for the design of right-turn lanes along two-lane and four-lane highways, as illustrated in Figure 21. The guidelines have been adopted in some form by many state departments of transportation (DOTs), including Virginia and Washington (*20,21*).

TABLE 4. Summary of state design practice in providing right-turn lanes on rural highways (*2*)

State	Conditions warranting right-turn lane off major (through) highway		
	Through volume	Right-turn volume	Highway conditions
Alaska	N/A	DHV = 25 veh/h	
Idaho	DHV = 200 veh/h	DHV = 5 veh/h	2-lane
Michigan	N/A	ADT = 600 veh/d	2-lane
Minnesota	ADT = 1,500 veh/h	All	Design speed > 45 mph
Utah	DHV = 300 veh/h	Crossroad ADT = 100 veh/d	2-lane
Virginia	DHV = 500 veh/h	DHV = 40 veh/h	2-lane
	All	DHV = 120 veh/h	Design speed > 45 mph
	DHV = 1200 veh/h	DHV = 40 veh/h	4-lane
	All	DHV = 90 veh/h	
West Virginia	DHV = 500 veh/h	DHV = 250 veh/h	Divided highways
Wisconsin	ADT = 2500 veh/d	Crossroad ADT = 1000 veh/d	2-lane

DHV—Design Hourly Volume.
ADT—Average Daily Traffic.

Glennon et al. (*23*) conducted a benefit-cost analysis of right-turn lanes at driveway entrances. The analysis was based on data from the literature and assumptions about the operational and safety effects of right-turn lanes. The results of the analysis indicated that right-turn lanes are cost-effective at driveways when (a) the driveway volume is at least 1,000 veh/d with at least 40 right turns into the driveway during peak periods and (b) the roadway ADT is at least 10,000 veh/d and the roadway speed is at least 56 km/h (35 mph).



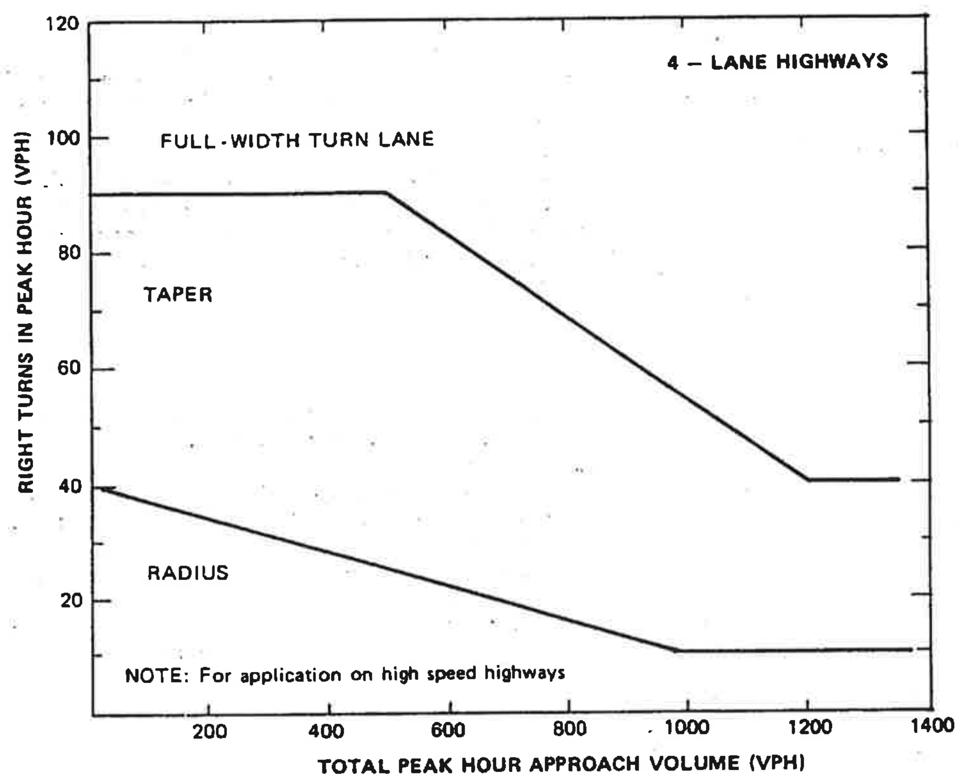


Figure 21. Traffic volume guidelines for the design of right-turn lanes (22).

Stover and Koepke (*24*) also recommended the use of right-turn lanes at driveways when (a) there are more than 1,000 right turns per day, (b) there are at least 40 right turns during the peak hour, and (c) speeds are over 56 km/h (35 mph).

McCoy et al. (*11*) developed guidelines for the use of right-turn lanes at access points on urban two-lane and four-lane roadways. The guidelines define the circumstances for which the costs of right-turn lanes at uncontrolled intersections and driveways on urban roadways are justified by the operational and accident cost savings they provide to road users. Tables 5 and 6 present the guidelines for urban two-lane and four-lane roadways, respectively. The guidelines define the right-turn design hourly volume required to justify a right-turn lane as a function of:

- Directional design-hour volume
- Roadway speed
- Number of lanes on the roadway
- Right-of-way costs

McCoy et al. noted that their guidelines were within the range of existing guidelines developed by others, and they also noted that the guidelines developed as part of their research were more definitive than other guidelines because they account for the effects of roadway speed and right-of-way costs.

TABLE 5. Right-turn lane guidelines for urban two-lane roadways (*11*)

Roadway DDHV (veh/h)	Minimum right-turn DHV (veh/h)															
	Within existing ROW				ROW cost = \$0.093/m^2				ROW cost = \$0.465/m^2				ROW cost = \$0.93/m^2			
	Roadway speed (km/h)				Roadway speed (km/h)				Roadway speed (km/h)				Roadway speed (km/h)			
	40	56	72	89	40	56	72	89	40	56	72	89	40	56	72	89
100			65	30			70	40								
125	65	60	40	25	70	65	50	25			75	45				
150	60	50	35	20	65	55	40	20	75	75	60	35	95	95	90	50
200	50	45	30	15	55	45	30	15	65	65	40	25	80	80	60	30
400	40	35	20	10	40	35	20	10	40	40	30	20	55	55	40	20
600	35	30	15	10	35	30	15	10	35	35	25	15	45	45	35	15
800	30	25	15	10	30	25	15	10	30	30	20	10	35	35	30	15
1000	25	20	15	10	30	25	15	10	30	30	20	10	35	35	30	15
1200	25	20	15	10	30	25	15	10	30	30	20	10	35	35	30	15

TABLE 6. Right-turn lane guidelines for urban four-lane roadways (*11*)

Roadway DDHV (veh/h)	Minimum right-turn DHV (veh/h)															
	Within existing ROW				ROW cost = $0.093/m^2				ROW cost = $0.465/m^2				ROW cost = $0.93/m^2			
	Roadway speed (km/h)				Roadway speed (km/h)				Roadway speed (km/h)				Roadway speed (km/h)			
	40	56	72	89	40	56	72	89	40	56	72	89	40	56	72	89
100				35				60								
150	80	65	40	25	85	70	45	25			70	40				60
200	70	55	35	20	75	60	35	20	85	75	50	30	110	100	70	40
500	45	40	25	15	50	45	25	15	60	50	35	25	70	60	40	30
1000	35	30	20	10	35	30	20	10	40	40	25	15	45	45	35	20
1500	30	25	15	5	30	25	15	5	35	35	20	10	40	40	30	15
2000	25	20	15	5	25	20	15	5	30	30	20	10	35	35	25	15
2500	20	20	15	5	20	20	15	5	25	25	20	10	30	30	20	15
3000	20	20	15	5	20	20	15	5	25	25	20	10	25	25	20	15

In NCHRP Report 420, *Impacts of Access Management Techniques*, Gluck et al. (*19*) developed guidelines for the installation of right-turn lanes while evaluating the impacts of selected access management techniques. The guidelines were developed based on the desire to keep the proportion of right-lane through vehicles affected to a specified minimum. For arterial right-turn volumes between 250 and 800 veh/h, Gluck et al. determined that the percentage of through vehicles impacted was about 0.18 times the right-turn volume. Based on a desired threshold, Table 7 provides the basis for decisions regarding the provision of right-turn lanes. Gluck et al. suggest that a criteria of 2 to 5 percent of through vehicles impacted may be applicable in rural settings and that a criteria of 15 to 20 percent of through vehicles impacted may be applicable in urban areas.

TABLE 7. Impacts of right turns on through vehicles (*19*)

Percent right-lane through vehicles impacted	Right-turn-in volume (veh/h)
0	0
2	10
5	30
10	60
15	85
20	110

Larson and Mannering (*25*) developed a system for analyzing the need for right-turn lane improvements to an intersection and prioritizing the severity of that need. The methodology incorporates both operational (i.e., volumes) and safety (i.e., accidents) conditions.

The economic warrant analysis from Potts et al. (*3*) is comprised of two major components: an accident reduction benefit and a travel time delay benefit. A series of plots that show situations in which provision of a right-turn lane is, or is not, economically warranted were developed. Each plot presented below includes a series of lines that correspond to a benefit-cost ratio of 1.0. Figures 22 through 25 illustrate example warrants for right-turn lanes for various combinations of two- and four-lane arterials and three- and four-leg intersections or driveways. The lines shown in the plots represent the minimum volumes that a right-turn lane would be warranted.

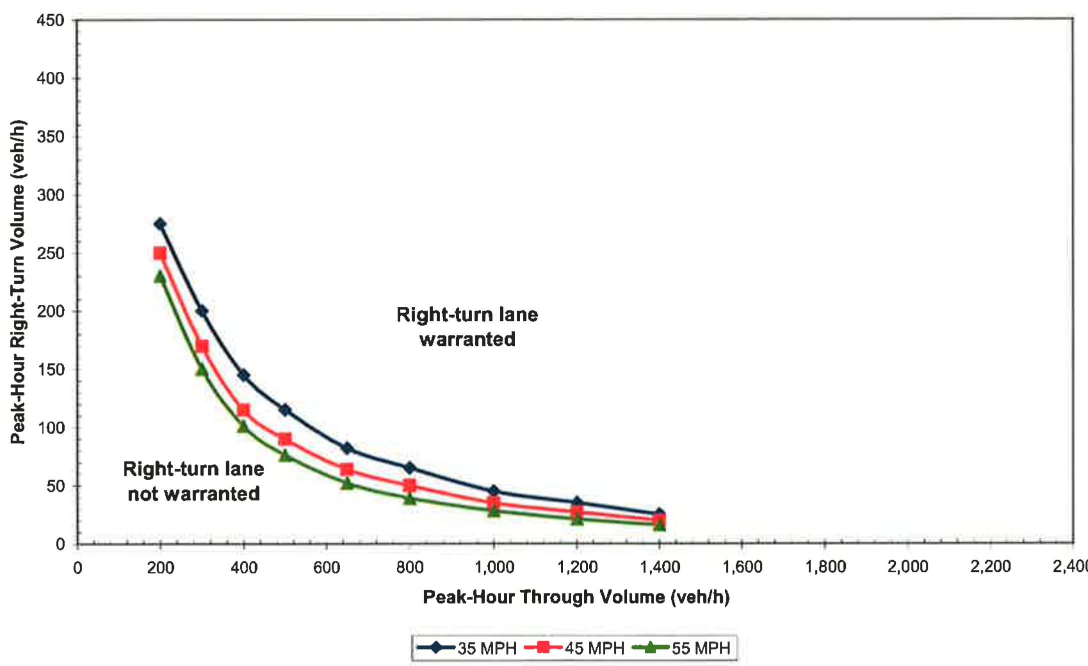


Figure 22. Economic warrant for a right-turn lane (Benefit/Cost = 1) for a four-leg unsignalized driveway or intersection on a two-lane arterial (3).

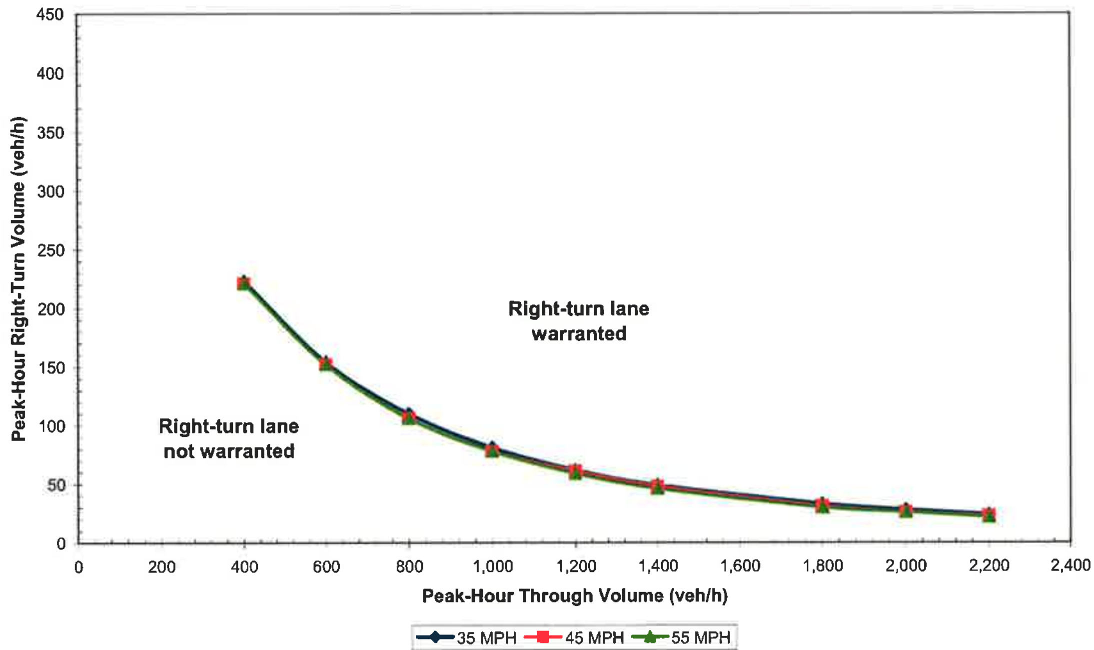


Figure 23. Economic warrant for a right-turn lane (Benefit/Cost = 1) for a four-leg unsignalized driveway or intersection on a four-lane arterial (3).

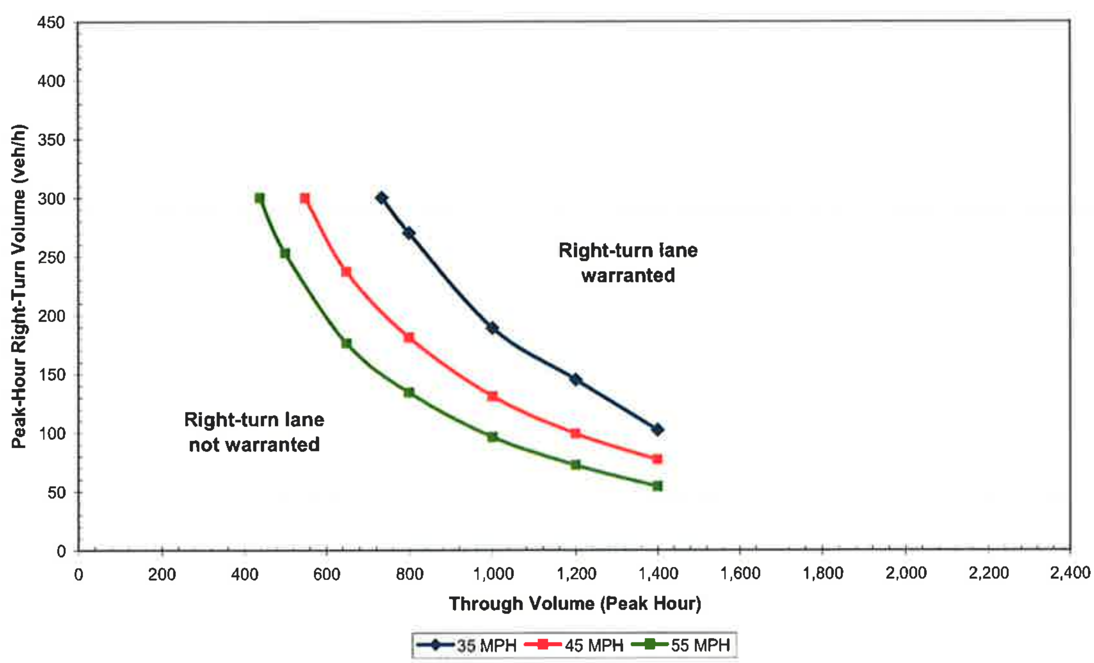


Figure 24. Economic warrant for a right-turn lane (Benefit/Cost = 1) for a three-leg unsignalized driveway intersection on a two-lane arteria (3).

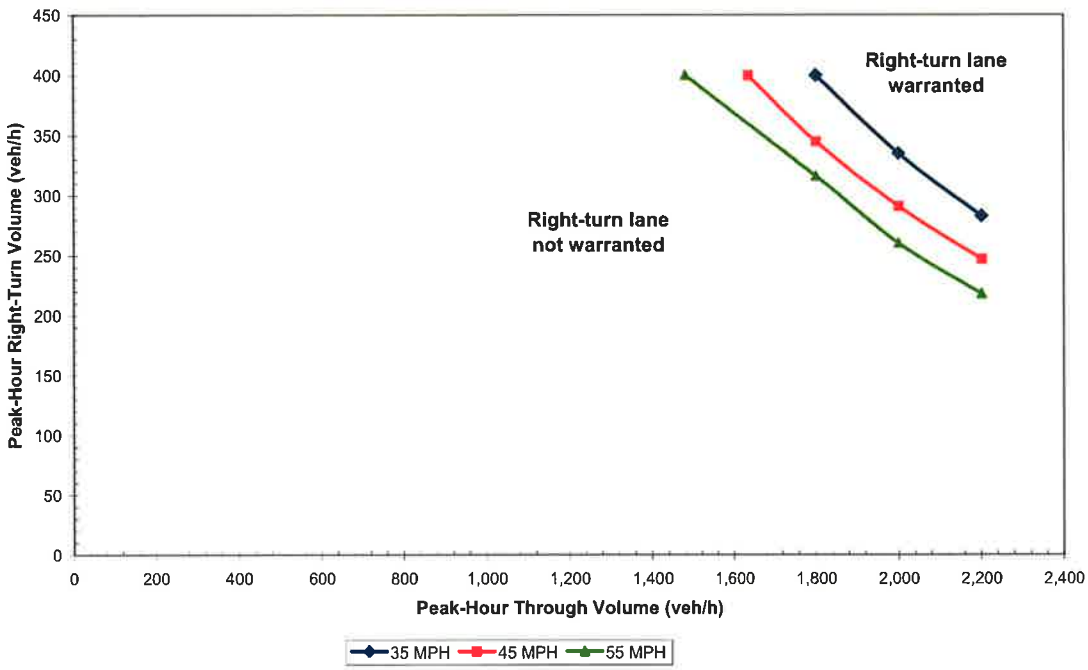


Figure 25. Economic warrant for a right-turn lane (Benefit/Cost = 1) for a three-leg driveway or intersection on a four-lane arterial (3).

The highway agency survey reported in Appendix B of this synthesis indicates that approximately 90 percent of state highway agencies and 89 percent of local highway agencies use right-turn lanes at intersections or driveways on urban and suburban arterials. Of these, 58 percent and 26 percent of the state and local agencies, respectively, refer to volume warrants to determine the need for a right-turn lane and identified at least one of the following as their resource for volume warrants:

- State highway standards
- *Highway Capacity Manual*
- Graphs similar to that shown in Figure 1
- Level of service or operational analysis

- Turning volume counts

Four of the responding agencies use accident analyses, rather than volume warrants, to determine the need for right-turn deceleration lanes.

CHAPTER 5.

TRAFFIC SAFETY

This chapter summarizes current knowledge concerning the traffic safety performance of right-turn deceleration lanes. Safety for motor vehicles, pedestrians, and bicycles are addressed separately.

SAFETY FOR MOTOR VEHICLES

It is generally accepted that the installation of right-turn lanes improves the safety of motor vehicles, but only limited quantitative data are available to demonstrate this. The research findings that are available are summarized below.

Harwood et al. (*26*) conducted the most recent and extensive investigation into the safety effectiveness of right-turn lanes. Harwood et al. performed a before-after evaluation of the safety effects of providing right-turn lanes for at-grade intersections. Geometric design, traffic control, traffic volume, and accident data were collected at 100 intersections where a right-turn lane had been installed and 100 intersections that exhibited similar characteristics to the improved sites. Three contrasting approaches to before-after evaluations were used to evaluate the safety effectiveness of right-turn lane improvements: the yoked comparison or matched-pair approach, the comparison group approach, and the empirical Bayes approach.

Harwood et al. (*26*) concluded that right-turn lanes are effective in improving safety at signalized and unsignalized intersections in both rural and urban areas. Installation of a single right-turn lane on a major-road approach would be expected to reduce total intersection accidents at rural unsignalized intersections by 14 percent and total accidents at urban signalized intersections by 4 percent. Right-turn lane installation reduced accidents on individual approaches to four-leg intersections by 27 percent at rural unsignalized intersections and by 18 percent at urban signalized intersections. Limited results were found for right-turn lane installation at three-leg intersections. Installation of right-turn lanes on both major-road approaches to four-leg intersections would be expected to increase, but not quite double, the resulting effectiveness measures for total intersection accidents. Table 8 presents the recommended accident modification factors (AMFs) for the installation of right-turn lanes on major-road approaches to both rural and urban intersections. AMFs are used in accident prediction algorithms to represent the safety effects of various geometric features (e.g., right-turn lanes). The base value of each AMF is 1.0. Any feature associated with a higher accident experience than the base condition has an AMF with a value greater than 1.0, and any feature associated with lower accident experience than the base condition has an AMF with a value less than 1.0.

TABLE 8. AMFs for right-turn lanes (*26*)

Intersection traffic control	Number of major-road approaches on which right-turn lanes are installed	
	One approach	Both approaches
STOP sign[a]	0.86	0.74
Traffic signal	0.96	0.92

[a] STOP signs on minor-road approach(es).

In earlier research, Harwood et al. (*27*) developed algorithms to predict the expected safety performance of rural two-lane highways. The prediction algorithms combined elements of historical accident data, predictions from statistical models, results of before-after studies, and expert judgments made by experienced engineers. As part of the research, an expert panel of safety researchers developed AMFs for specific geometric design and traffic control features, including right-turn lanes. The expert panel concluded that the presence of a right-turn lane along one major approach to a rural STOP-controlled intersection reduces intersection-related accidents by 5 percent and the presence of a right-turn lane along both major approaches to a rural STOP-controlled intersection reduces intersection-related accidents by 10 percent. Similarly, the expert panel concluded that the presence of a right-turn lane along one major approach to a rural signalized intersection reduces intersection-related accidents by 2.5 percent and the presence of a right-turn lane along both major approaches to a rural signalized intersection reduces intersection-related accidents by 5 percent.

In other studies, Vogt and Bared (*28*) modeled accidents for three-leg unsignalized intersections along rural two-lane highways and concluded that the presence of a right-turn lane increases intersection-related accidents by 27 percent; while Bauer and Harwood (*29*) indicate that right-turn deceleration lanes resulted in a decrease in both total multiple-vehicle accidents and fatal and injury multiple-vehicle accidents.

SAFETY FOR PEDESTRIANS

No studies have been found that have used crash data to document the pedestrian safety implications of right-turn lanes. Prior crash studies have focused on the vehicle-pedestrian collisions involving turning vehicles, but the geometrics of the intersection were not available to document the type of turning lane present.

A five-state analysis of more than 5,000 vehicle-pedestrian collisions found that 38 percent of all such crashes occurred at intersections (*30*). Further examination of the intersection accidents found that 30 percent of these crashes involved a turning vehicle. There was no further breakdown to determine if the vehicle was turning right or left. From a query of a North Carolina database that includes detailed crash types developed with the *Pedestrian and Bicycle Crash Analysis Tool*, one can determine the breakdown of turning vehicles (*31,32*). The North Carolina system includes five years of data (over 11,000 pedestrian-motor vehicle collisions). Intersection crashes account for 26 percent of those collisions. Left-turning vehicles account for 10 percent of the collisions at intersections, while right-turning vehicles account for 6 percent. Statistics gathered by the Oregon DOT (*20*) show that 19 percent of vehicle-pedestrian crashes occurring at intersections involve drivers making right turns.

Other crash-based analyses have focused on vulnerable pedestrians, particularly the elderly. One such study that looked specifically at the types of crashes occurring at intersections showed older pedestrians to be overrepresented in collisions with both left- and right-turn collisions (*33*). Collisions involving left-turning and right-turning vehicles accounted for 17 percent and 13 percent, respectively, of all intersection accidents involving pedestrians. Pedestrians who were age 75 or older and were involved in a vehicle-pedestrian collision were struck by a left-turning vehicle in 24 percent of cases and by a right-turning vehicle in 14 percent of cases. Those aged 65 to 74 were struck by a left-turning vehicle in 18 percent of cases and by a right-turning vehicle in 19 percent of cases.

From a traffic control standpoint, there may be little difference to pedestrians between:

- Crossing the minor road at an unsignalized intersection without a right-turn lane on the major road
- Crossing the minor road at an unsignalized intersection with a right-turn lane on the major road

or between:

- Crossing a driveway without a right-turn lane on the major road
- Crossing a driveway with a right-turn lane on the major road.

There may be little, if any, safety difference to pedestrians between these pairs of scenarios as well. In all cases, the pedestrian is potentially in conflict with major-road vehicles turning right from an uncontrolled approach. It is possible that the provision of a right-turn lane might affect the turning speed of vehicles, but it is likely that the curb return radius would have a greater effect than the presence or absence of a right-turn lane.

At unsignalized intersections or driveways, there may be a distinct difference between pedestrians crossing the major road and pedestrians crossing the minor road or driveway. There are typically no pedestrian crossing facilities on the major road at unsignalized intersections and driveways, and while very few pedestrians are likely to cross the major road at such a location, the presence of a right-turn lane would present a greater crossing distance for any pedestrians who do cross.

Crossing a minor road or driveway at an intersection with a right-turn lane may be particularly difficulty for pedestrians with vision impairments. Pedestrians who are blind or visually impaired typically listen for a steady movement of cars traveling parallel to them as they begin crossing a street or large driveway. Hearing a vehicle slowing is considered as a possible indication that the vehicle is about to turn across their path. Where there are deceleration lanes, blind pedestrians may not be aware of the added lane if there has been no traffic in it. (Slight deviations in travel path, such as might be caused by a widening of the road or by the sidewalk being moved over, may not be noticed.) The difficulty, then, at intersections with a right-turn lane is that pedestrians who are blind might be listening to a vehicle traveling in a major-road through lane, parallel to their path, that masks the sound of a right-turning vehicle in the right-turn lane that is turning into them. The same masking effect of through traffic may be present on a multilane street without a right-turn lane where a through vehicle is traveling in the left lane and a vehicle is slowing to turn right from the right lane. An advantage of a right-turn lane is that vehicles may be able to reduce their speed more and may be more willing to yield to pedestrians, since there is less concern about being rear-ended by through vehicles.

Crosswalks are the primary means of alerting motorists of the presence of a pedestrian crossing. However, if nothing else is done beyond marking crosswalks, pedestrians will not experience increased safety (*34*). Drivers do not always yield the right of way to pedestrians simply because they are in a crosswalk. This is evident given that the cause of 41 percent of pedestrian crashes in marked crosswalks at uncontrolled locations is identified as "motorist failure to yield," and when vehicle turn and merge crashes, which are generally the fault of the driver, account for 19 percent of pedestrian crashes in marked crosswalks at uncontrolled locations.

SAFETY FOR BICYCLISTS

There is an inherent risk to bicyclists at locations with right-turn lanes because motor vehicles entering the turn lane must weave across the path of bicycles traveling straight through the intersection. However, no studies based on crash history are available to support this presumption. Furthermore, the same type of conflict between through bicyclists and right-turning vehicles is present at all intersections, except at intersections where right turns are prohibited or at three-leg intersections where there is no leg to the right on a given approach. There are also no studies that provided data on the risk of collisions between motor vehicles and bicycles in the right-turn lane itself. The following discussion presents basic statistics on bicycle safety, followed by available information on bicycle-related safety issues at right-turn lanes.

In 2002, 662 bicyclists were killed and an additional 48,000 were injured in traffic accidents (*35*). Thus, bicyclists accounted for 2 percent of all traffic fatalities. Bicyclists accounted for 12 percent of all nonmotorized traffic fatalities, while pedestrians accounted for 86 percent, and the remaining 2 percent were skateboard riders, roller skaters, etc.

Oregon reports that most bicycle crashes (65 to 85 percent) do not involve collisions with motor vehicles but rather involve falls or collisions with stationary objects, other bicyclists, and pedestrians. Of the bicycle/motor vehicle crashes, 45 percent occurred at intersections (*6*). In another evaluation of bicycle/motor vehicle crashes, Tan reported that approximately 5 percent of bicycle/motor vehicle crashes occurred when a motorist made a right turn (*36*), but no information was provided on whether the respective crashes occurred at intersections with right-turn lanes. Tan also reported that approximately 4 percent of bicycle/motor vehicle crashes occurred at an intersection controlled by a signal at which the motorist struck the bicyclist while making a right turn on red.

Clark and Tracy (*37*) reported that 13 percent of all bicycle/motor vehicle crashes resulted when motorists were making a right-turn movement, and a majority of these crashes involved a straight-through bicyclist being struck by a right-turning motor vehicle. Clark and Tracy indicated that many bicyclists find changing lanes difficult or choose to ignore signing and pavement markings.

Much of the advice for highway designers in dealing with intersections and right-turn lanes is applicable only to locations where bicycle lanes already exist (or are planned in the future). As indicated in Chapter 3, the MUTCD (*4*) and AASHTO bicycle guide (*5*) recommend breaking bicycle lane markings ahead of the intersection and then marking the bicycle lane again at the intersection itself, to the left of the right-turn lane. This positions bicyclists traveling straight through the intersection away from any conflict with right-turning vehicles and allows a merge area for right-turning vehicles to get into right-turn lane.

Two recently completed studies for the FHWA have included observational studies of bicyclists and motorists as they maneuvered through a variety of right-turn lane configurations (*38,39*). One of the studies was a before-after effort in which the conflict zone, defined as the place where the paths of bicyclists and motorists crossed most often, was treated with blue pavement markings at 10 intersections in Portland, Oregon (*38*). Figure 26 illustrates the use of blue pavement markings at a right-turn lane. The configurations included exit ramps, right-turn lanes, and entrance ramps. The markings were also supplemented with unique signs showing the blue markings and yield signs for motorists (see Figure 27). Both video observations and survey feedback were collected as part of the study, with approximately 850 bicyclists and 190 motorists in the before period and 1,020 bicyclists and 300 motorists in the after period. The most important results were as follows:

- There was a significant increase in motorists yielding to bicyclists after the treatment was installed, from 71 percent in the before period to 87 percent in the after period.
- Significantly more bicyclists followed the path marked for bicyclists after the blue markings were in place, 85 percent in the before period compared to 93 percent in the after period.
- There was a decrease in head-turning and scanning on the part of bicyclists after the treatment was installed, from 43 percent in the before period to 26 percent in the after period, which was a concern. The authors were not sure of the reason for this result.
- While conflicts between the two modes were rare, the conflict rate decreased from 0.95 conflicts per 100 entering bicyclists in the before period to 0.59 conflicts per 100 entering bicyclists in the after period.

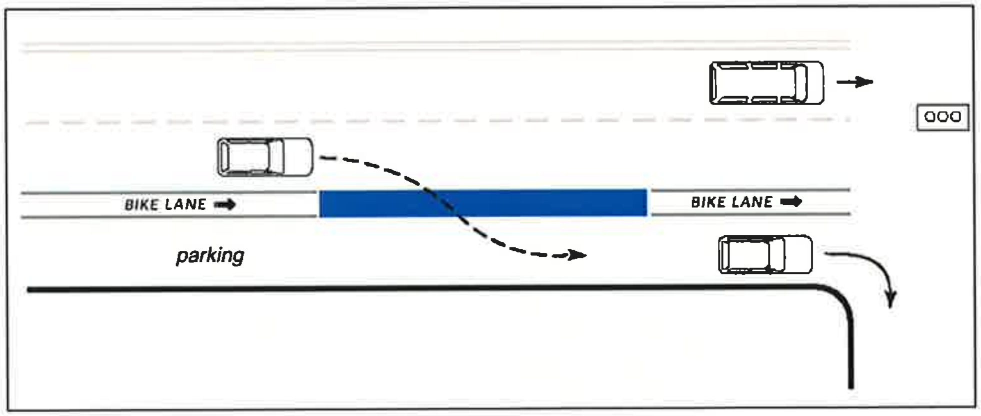


Figure 26. Blue pavement marking treatment at right-turn lane (38).

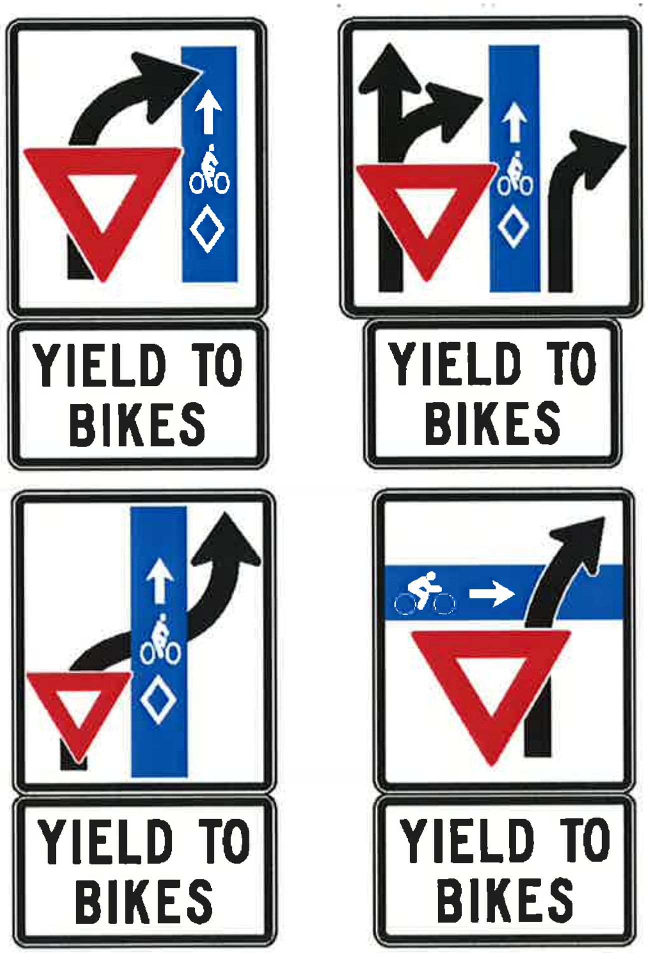


Figure 27. Signs used in Oregon blue bike lane program (38).

- The survey data showed that 70 percent of the motorists noticed the blue markings, and 59 percent noticed the accompanying sign. When asked about safety, 49 percent of the motorists thought it would increase safety, 20 percent thought it would be the same, 12 percent thought it would be less safe, and the remaining motorists were not sure.
- The bicyclists surveyed thought the treatment would increase safety (76 percent). Only 1 percent thought it would decrease safety.

Overall, it was found that the treatment resulted in a safer riding environment and a heightened awareness on the part of both bicyclists and motorists. The City of Portland continues to use this treatment at 6 of the 10 locations today.

The second study examined the behaviors of bicyclists and motorists at a "combined" bicycle lane/right-turn lane used in Eugene, Oregon (*39*). The results were compared to observations made at a more traditional right-turn lane. The combined lane created a 1.5-m (5-ft) bike pocket within a 3.6-m (12-ft) right-turn lane, leaving 2.1 m (7 ft) for right-turning vehicles (see Figure 28). The traditional lane location used for comparison was a 3.7-m (12-ft) right-turn lane and a 1.5-m (5-ft) bike pocket (see Figure 29). Approximately 600 bicyclists were videotaped at each location as they approached and continued straight through the intersection. The differences in the two types of right-turn lanes can be summarized as follows:

- Bicyclists and motorists tended to queue up behind one another more often in the combined lane facility (43 percent of the time) than in the standard lane facility (1 percent of the time).

- At both locations, bicyclists were most often able to position themselves in the bike pocket (94 percent of the time in the combined lane and 86 percent of the time in the standard lane). At the combined lane intersection, bicyclists tended to use the adjacent through lane more often (2 percent of the time) compared to virtually no such positioning at the standard lane. This was primarily due to the occasional bus that needed to turn right at the combined lane intersection, which then forced the approaching bicyclists to use the through lane.
- At both locations, the yielding behavior of each mode was captured. At the combined lane location, the motorist yielded to the bicyclist in 93 percent of the cases where the two parties would have collided had someone not slowed or stopped. At the standard lane location, motorist yield 48 percent of the time. This low percentage of yielding by motorists at the standard lane is believed to be an artifact of bicyclists having to shift to the left on the approach to the intersection in order to move from the bicycle lane adjacent to the curb to the bike pocket at the intersection.
- No conflicts requiring either mode to suddenly stop or change direction were observed at either location.

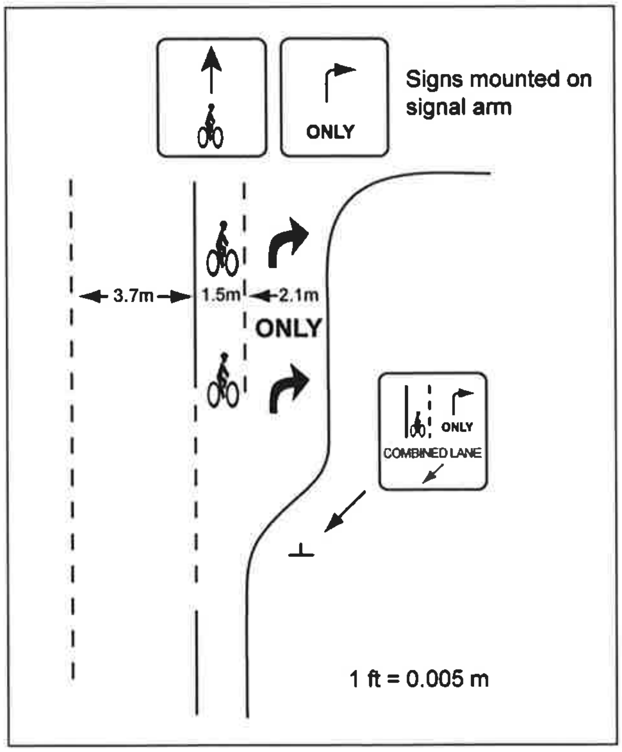


Figure 28. Combined bicycle lane/right-turn lane (39).

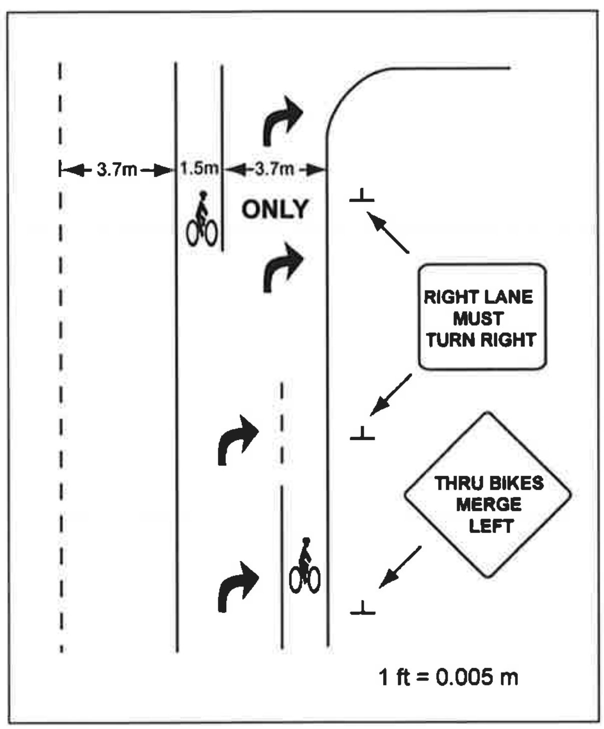


Figure 29. Traditional bike lane/right-turn lane (39).

In addition to the observational data, a brief survey of a sample of bicyclists was administered at both locations. When asked to compare the two locations, 18 percent said the combined lane was safer, 27 percent said it was less safe, and 55 percent said there was no difference. Overall, the observational and survey data showed the combined bicycle lane/right-turn lane to be an effective treatment that could be beneficial at locations where right-of-way constraints exist.

There has also been a perception study conducted for FHWA in which participants were asked to view a number of right-turn lane configurations and provide a rating of how comfortable they would be interacting with right-turning traffic in an effort to continue straight through the intersection (*40*). The configurations rated included:

- A standard right/through lane in which the bicyclist could travel straight on the approach and continue through the intersection.
- An auxiliary right-turn only lane that was added at the intersection, which allowed the bicyclist to travel straight on the approach and forced the motorist to cross the path of the bicyclist.
- A travel lane that became a right-turn lane at the intersection, forcing bicyclists to shift left across the path of motorists in order to continue straight through the intersection.
- A gradual increase in pavement width on the intersection approach that became a right-turn lane at the intersection, also forcing bicyclists to shift left across the path of motorists in order to continue straight through the intersection.

A regression model was developed using the perception ratings as the dependent variable and several geometric and operational variables as independent measures. The most significant predictors of the a bicyclist's comfort level were whether there was a bike lane present on the approach and whether the bicyclist had to shift to the left across the motorist path in order to continue through the intersection. The presence of a bike lane increased the comfort level, while the requirement to shift across the motorist's path decreased the comfort level. This result confirmed some of the observational data collected in the combined bicycle/right-turn lane study previously described.

An example of a treatment for bicycle lanes at intersections that is considered inappropriate suggests channeling bicyclists onto a sidewalk or bike path and having them behave as pedestrians (*37*). Crash records suggest this approach is seriously flawed, especially since it can encourage wrong-way riding.

On streets with bicycle lanes, the current recommended designs ensure straight-through bicyclists are positioned to the left of exclusive right-turn lanes. On streets without bicycle lanes, bicyclists and motorists must perform the same maneuvers as if separate lanes were marked. They must do so, however, without the guidance offered by the bicycle lane markings and without the same amount of space available to share the road at the intersection. In both instances, there are several important design features to remember (*37*):

- As the length of the right-turn lane increases, so does the exposure of the bicyclist to traffic driving on either side of them. In addition, the speed of vehicles in the right-turn lane may be greater. Thus, exclusive right-turn lanes should be kept as short as possible.

- As both bicyclists and motorists pass through intersections, they are concentrating on their own position on the road and on traffic within the intersection. No driveways should be positioned near the intersection to cause additional conflicts.

CHAPTER 6.

SUMMARY OF ADVANTAGES AND DISADVANTAGES OF RIGHT-TURN DECELERATION LANES

This chapter summarizes the advantages and disadvantages of right-turn deceleration lanes that have been noted in Chapters One through Five. These advantages and disadvantages, identified in Table 9, include geometric design, traffic operational, traffic safety, and environmental issues. While these advantages and disadvantages reflect the current knowledge and experience of highway agencies concerning right-turn lanes, there is limited quantitative data on their performance. There are many unresolved issues concerning right-turn lanes that indicate a need for further research.

TABLE 9. Summary of advantages and disadvantages of right-turn deceleration lanes on urban and suburban arterials

Advantages	Disadvantages
Motor Vehicles	
• Remove deceleration and stopping by right-turning vehicles from through-traffic stream • Reduce deceleration and stopping by through vehicles behind right-turning vehicles • Reduce delay to through vehicles by up to 6 sec/through veh on two-lane arterials and by up to 1 sec/through veh on four-lane arterials • Provide storage area for right-turning vehicles that does not impede through vehicles • Increase vehicular capacity for the intersection approach and for the intersection as a whole • Improve safety by reducing number of rear-end and sideswipe conflicts • Reduce vehicle operating costs by reducing fuel usage, which also results in a reduction in vehicle emissions and improved air quality	• Right-turning vehicles in the deceleration lane may become a sight obstruction to drivers entering or crossing the major road from the minor road • Some through motorists may mistake the right-turn deceleration lane for a through lane
Pedestrians	
• Assist pedestrians in distinguishing the intended movements of through and right-turning vehicles • Since right-turn vehicles can decelerate without impeding through vehicles, they can make a right turn more slowly and be better prepared to yield to pedestrians where the right turn meets a sidewalk or crosswalk	• Increase pedestrian crossing distance • Increase number of right-turn-on-red maneuvers at signalized intersections, where permitted, which may increase vehicle-pedestrian conflicts • Driver's attention may be focused on the cross-street traffic • Provide less separation between edge of major-road traveled way and sidewalk, in some cases

Bicyclists	
• Striping and signing for bicycle lanes are intended to encourage motorists and bicyclists to cross paths in advance of intersections in a merging fashion, away from other conflicts • Striping and signing for bicycle lanes encourage bicyclists to follow the rules of the road • By forcing bicyclists and motorists to cross in advance of the intersection, the difference in travel speeds enables the motorist to pass a bicyclist rather than travel side-by-side	• Motor vehicles entering the right-turn deceleration lane must weave across bicycle traffic to execute the right-turn maneuver • As the length of the right-turn deceleration lane increases, so does the exposure to bicyclists from traffic driving on either side of them

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Appendix A

Survey Questionnaire

National Cooperative Highway Research Program
Project 3-72

"Lane Widths, Channelized Right Turns, and Right-Turn Deceleration Lanes in Urban and Suburban Areas"

The following survey on lane widths, right-turn deceleration lanes, and channelized right turns on urban and suburban arterials is being conducted as part of the National Cooperative Highway Research Program (NCHRP), which is sponsored by the American Association of State Highway and Transportation Officials (AASHTO) in cooperation with the Federal Highway Administration (FHWA). Your responses to the following questions concerning your agency's geometric design policies and practices regarding lane widths, right-turn deceleration lanes, and channelized right turns on urban and suburban arterials would be greatly appreciated.

SURVEY QUESTIONNAIRE

*(Please return by **August 15, 2003**)*

1. What type of highway agency do you represent?

___ State highway agency
___ County highway agency
___ City/municipal highway agency
___ Metropolitan planning organization
___ Other: ______________________________

AGENCY DESIGN GUIDELINES

2. Does your agency use lane width criteria that differ from the AASHTO *Green Book*? .... ☐Yes ☐No

Does your agency use design guidelines for right-turn deceleration lanes that differ from the AASHTO *Green Book*? .... ☐Yes ☐No

Does your agency use design guidelines for channelized right turns that differ from the AASHTO *Green Book*? .... ☐Yes ☐No

If YES, to any of the questions above, please attach a copy of your guidelines.

3. Is your agency considering any changes in your policies concerning lane widths, right-turn deceleration lanes, or channelized right turns on urban and suburban arterials? .... ☐Yes ☐No

If YES, please elaborate: ______________________________

LANE WIDTHS

4. Does your agency use different lane widths for midblock locations and signalized intersection approaches on urban and suburban arterials? .... ☐Yes ☐No

5. What is the narrowest lane width that your agency considers will perform acceptably for urban and suburban arterials?

___ft (for midblock locations)
___ft (for signalized intersection approaches)

6. Has your agency used lanes narrower than 11 ft on urban or suburban arterials?

___ YES, at midblock locations only
___ YES, on signalized intersection approaches only

___ YES, at both midblock locations and signalized intersections
___ NO

7. What factors does your agency consider in selecting an appropriate lane width for an urban or suburban arterial? (Check all that apply)

___ Established geometric design policies
___ Level of service considerations at midblock locations
___ Level of service considerations at signalized intersections
___ Running speeds at midblock locations
___ Availability of space for a roadway median
___ Availability of space for bicycle facilities
___ Crossing time/distance for pedestrians
___ Potential interference with existing development
___ Other (Please describe:____)

8. What pedestrian issues (i.e., crossing distance, vehicle speeds adjacent to pedestrian areas, etc.) does your agency consider when determining lane widths on urban and suburban arterials?

____

____

9. What bicycle issues (i.e., bicycle lane, wider curb lane, shoulders, etc) does your agency consider when determining lane widths on urban and suburban arterials?

____

____

10. Has your agency evaluated the traffic operational or safety effects of using narrower lanes on urban and suburban arterials? .... ☐Yes ☐No

If YES, please describe the results or attach a copy of the evaluation report.

11. Has your agency implemented projects within the last 5 to 7 years in which an existing urban or suburban arterial was:

Restriped with narrower lanes (i.e., to accommodate an auxiliary lane, bicycle lane, median or wider median, etc)? .... ☐Yes ☐No

Restriped to provide wider lanes?.. ☐Yes ☐No

Would any of these projects be suitable for evaluation as part of this research? .... ☐Yes ☐No

RIGHT-TURN DECELERATION LANES

12. Does your agency use right-turn deceleration lanes at intersections or driveways on urban and suburban arterials?.......... ☐Yes ☐No

Does your agency have volume warrants for right-turn deceleration lanes at intersections or driveways on urban and suburban arterials?.......... ☐Yes ☐No

If YES, please elaborate **(or attach a copy of your warrants)**: ____________________

____

13. At what types of locations does your agency use right-turn deceleration lanes on urban and suburban arterials? (Check all that apply)

___ Signalized intersections or driveways
___ Unsignalized intersections
___ Unsignalized major driveways

14. How are bicycle lanes striped along right-turn deceleration lanes?

____

____

15. Has your agency encountered any traffic operational or safety problems associated with right-turn deceleration lanes on urban and suburban arterials?.......... ☐Yes ☐No
If YES, please elaborate: ____________________

____

Has your agency encountered any traffic operational or safety problems associated with *the lack of* right-turn deceleration lanes on urban and suburban arterials?.......... ☐Yes ☐No
If YES to either question, please elaborate: ____________________

____

16. Has your agency implemented projects within the last 5 to 7 years in which a right-turn deceleration lane was installed to accommodate right-turn traffic at an intersection or driveway? .... ☐Yes ☐No

Would any of these projects be suitable for evaluation as part of this research?.......... ☐Yes ☐No

CHANNELIZED RIGHT TURNS

17. Does your agency use channelized right-turn roadways, set off from the through lanes by a triangular island, at intersections on urban and suburban arterials?.......... ☐Yes ☐No

18. Where does your agency place pedestrian crosswalks at channelized right-turn roadways?

___ At the upstream end of the channelized roadway
___ In the middle of the channelized roadway
___ At the downstream end of the channelized roadway

19. Does your agency have a formal policy concerning the traffic control for channelized right-turn roadways?? .... ☐Yes ☐No

If YES, please attach a copy of your policy.

20. Does your agency install pedestrian-actuated signals at channelized right-turn roadways on urban and suburban arterials?

___ YES, at all locations
___ YES, at selected locations
___ NO

21. Has your agency developed or used any strategies specifically intended to assist visually impaired pedestrians in crossing channelized right-turn roadways without pedestrian signals? ☐Yes ☐No

If YES, please describe: ______________________________

____

22. Are pedestrian considerations a factor in determining the radius and/or width of a channelized right-turn roadway? ☐Yes ☐No

If YES, please describe: ______________________________

____

23. Has your agency encountered any safety problems related to pedestrians crossings at channelized right-turn roadways on urban and suburban arterials? ☐Yes ☐No

If YES, please describe: ______________________________

____

24. Has your agency implemented any of the following innovative traffic control devices at channelized right-turn roadways?

High-visibility crosswalk markings (to improve conspicuity)? ☐Yes ☐No
Fluorescent yellow-green signs at the crosswalk and/or in advance of the crossing location? ☐Yes ☐No
Real-time warning device to indicate to the motorist when a pedestrian is present in the area? ☐Yes ☐No
Other dynamic message signs? ☐Yes ☐No
Other: ______________________________

25. Does your agency use deceleration lanes in advance of channelized right-turn roadways? ...... ☐Yes ☐No

Does your agency use acceleration lanes downstream of channelized right-turn roadways? ☐Yes ☐No

26. How are bicycle lanes striped on the approach to and within a channelized right-turn roadway?

____

____

27. Has your agency implemented projects within the last 5 to 7 years in which a conventional intersection has been reconstructed to include a channelized right-turn lane(s)? ☐Yes ☐No

Would any of these projects be suitable for evaluation as part of this research? ☐Yes ☐No

28. Do you have any other observations or comments?

____

____

29. May we have the name of an engineer in your agency that we may contact to clarify any aspect of your response or to obtain additional information?

Contact: ____________________ Title: ____________________
Agency: ____
Address: ____
____
Telephone #: ____________________ Fax #: ____________________
e-mail address: ____

Please return the completed survey by **August 15, 2003**, to:

Ingrid B. Potts, P.E.
Senior Traffic Engineer
Midwest Research Institute
425 Volker Blvd.
Kansas City, MO 64110
ipotts@mriresearch.org

Appendix B

Survey Results Concerning Current Design Policies and Practices of Highway Agencies Related to Right-Turn Deceleration Lanes

This appendix presents a summary of the responses of highway agencies to the questions on the survey questionnaire, which is presented in Appendix A, related to right-turn deceleration lanes. The questionnaire presented in Appendix A also addresses highway agency policies concerning lane widths and channelized right turns; the survey results on these topics are addressed in separate syntheses. Design policies at the national level are based on the AASHTO *Green Book* (*1*). Many states also have their own geometric design manuals and policies, which may differ from the *Green Book* in some particulars.

Survey Recipients

The survey questionnaire was distributed at the Urban Street Symposium, held in Anaheim in July 2003. The questionnaire was also mailed to state and local highway agencies throughout the United States. The mailing list for the survey included:

- 50 state highway agencies
- 125 local highway agencies (99 cities and 26 counties)

Thus, a total of 175 survey questionnaires were mailed.

The questionnaires for state highway agencies were generally sent to the state design engineer. The names and addresses of the design engineers were determined from the membership roster of the AASHTO Subcommittee on Design.

Most of the local highway agency engineers on the mailing list for the questionnaires were city and county traffic engineers. Their addresses were obtained from the ITE directory, city websites, and county websites. The local agencies include approximately two major cities from each state and 26 selected urban or suburban counties. Rural counties were not surveyed because the focus of the study is on urban and suburban arterials.

Response Rate

Table B-1 summarizes the responses to the survey that were received. A total of 75 responses were received out of the 175 questionnaires that were mailed. The responses received include 40 state agencies, 27 cities, and 8 counties. The overall response rate was 43 percent, including a response rate of 80 percent for state highway agencies and 28 percent for local highway agencies.

TABLE B-1. Response Rate for the Highway Agency Survey

Agency type	Number of questionnaires mailed	Number of responses received	Response rate (%)
State agencies	50	40	80.0
Local agencies	125	35	28.0
Total	175	75	42.9

Agency Design Guidelines

In Question 2, highway agencies were asked whether their design guidelines for lane widths, channelized right turns, and right-turn deceleration lanes differ from the AASHTO *Green Book*. Table B-2 summarizes the responses to this question. The responses indicate that the majority of responding agencies use the *Green Book* as their design guidelines for lane widths, channelized right turns, and right-turn deceleration lanes.

TABLE B-2. Number of Agencies With Design Policies Different From the *Green Book*

	Number (percentage) of agencies					
Type of policy	State agencies		Local agencies		Total	
Lane width	2	(5.0)	10	(28.6)	12	(16.0)
Channelized right turns	4	(10.0)	4	(11.4)	8	(10.7)
Right-turn deceleration lanes	8	(20.0)	6	(17.1)	14	(18.7)
Total number of agencies responding	40		35		75	

In Question 3, highway agencies were asked whether they are considering any changes in their policies concerning lane widths, channelized right turns, or right-turn deceleration lanes on urban and suburban arterials. Approximately 20 percent of state highway agencies and 26 percent of local highway agencies are considering changes to their current policies.

Design and Operation of Right-Turn Deceleration Lanes

In Question 12, highway agencies were asked if they use right-turn deceleration lanes at intersections or driveways on urban and suburban arterials. Approximately 90 percent of state highway agencies and 89 percent of local highway agencies use right-turn deceleration lanes at intersections or driveways on urban and suburban arterials. Of the highway agencies that use right-turn deceleration lanes, 58 percent of state highway agencies and 26 percent of local highway agencies have volume warrants and identified at least one of the following as their resource for volume warrants (Note: Some agencies identified multiple sources.):

- State highway standards (9 agencies)
- Level of service or operational analysis (5 agencies)
- Graphs, similar to Figure 1 of the synthesis (4 agencies)
- Turning volume counts:
  - greater than 100 veh/h (4 agencies)
  - greater than 200 veh/h (1 agency)
  - greater than 300 veh/h (3 agencies)
- *Highway Capacity Manual* (2 agencies)

Four agencies use accident analyses, rather than volume warrants, to determine the need for right-turn deceleration lanes.

In Question 13, highway agencies that use right-turn deceleration lanes were asked to identify at which types of locations their agency uses these lanes on urban and suburban arterials. Table B-7 presents the highway agency responses to this question.

TABLE B-3. Locations at Which Highway Agencies Use Right-Turn Deceleration Lanes

Location	Number (percentage) of agencies					
	State agencies		Local agencies		Total	
Signalized intersections or driveways	35	(97.2)	31	(100)	66	(98.5)
Unsignalized intersections	30	(83.3)	20	(64.5)	50	(74.6)
Unsignalized major driveways	28	(77.8)	26	(83.9)	54	(80.6)

NOTE: Columns total to more than 100 percent because of multiple responses.

In Question 14, highway agencies were asked how their agency stripes bicycle lanes along right-turn deceleration lanes. Approximately 45 percent of responding agencies indicated that they continue striping the bicycle lane between the through lane and the right-turn deceleration lane; 13 percent of the agencies reported terminating bicycle facilities in advance of the intersection. Resources such as the AASHTO Bicycle Guide (13 percent) and the MUTCD (10 percent) are used by highway agencies in determining bicycle lane treatments. Approximately 18 percent of highway agencies responded that they do not currently incorporate bicycle lanes into their roadway systems.

Question 15 addressed whether highway agencies have encountered any traffic operational or safety problems associated with right-turn deceleration lanes, or the lack thereof, on urban and suburban arterials. Approximately 25 percent of state and local highway agencies have encountered either traffic operational or safety problems associated with right-turn deceleration lanes. Approximately 70 percent of state highway agencies and 49 percent of local highway agencies have encountered either traffic operational or safety problems associated with the lack of right-turn deceleration lanes.

Most of these highway agencies provided a description of the nature of the traffic operational or safety problems they have encountered; their responses are summarized below.

Problems associated with the presence of right-turn deceleration lanes:

- Lanes not properly used by vehicles (turn lanes utilized for through movements and through lanes utilized for turn movements) (4 agencies)
- Pedestrian crossing time (3 agencies)
- Inadequate lane length (3 agencies)
- Vehicle and pedestrian interaction (2 agencies)
- Sight distance (2 agencies)
- Vehicle and bicycle interaction (1 agency)
- Driveways located along right-turn deceleration lanes (1 agency)
- Right-turn deceleration lanes are too narrow (1 agency)

Problems associated with the absence of right-turn deceleration lanes:

- Lower capacity or level of service (29 agencies)
- Increased accidents (i.e., rear-end crashes) (16 agencies)

In Question 16, highway agencies were asked if they have implemented projects within the last 5 to 7 years in which a right-turn deceleration lane was installed to accommodate right-turn traffic at an intersection or driveway. Approximately 83 percent of state highway agencies and 77 percent of local highway agencies indicated they had implemented at least one project of this type. Of the agencies that have installed right-turn deceleration lanes, 7 state highway agencies and 13 local highway agencies indicated that their projects may be suitable for evaluation as part of this research.