Channelization and Turn Bays

Outline

- Principles of Channelization
- Turn Bay Design
- Median Openings
- Some Examples Around Ames

Principles of Channelization

Channelization purpose:

- Facilitate safe and orderly movement
- Separate or regulate conflicting movements
- Define paths of travel
- Use traffic islands or pavement markings
- … for both vehicles and pedestrians

Types/functions

- Directional – control, direct, guide
- Divisional – divide and alert
- Refuge – aid and protect pedestrians and bicyclists

Island Channelization

- Flush or raised, paved or unpaved, always marked, sometimes delineated
- If raised … use lighting
- If raised rural … also delineate and slope curbs
- Size: large enough to command attention
- Must delineate a path that is natural and convenient for the driver

Island Channelization

- Must have sufficient approach sight distance to islands
- Right turn island size (75 square feet at least to command attention)
- Minimum length of left turn bay 100’
- If used at series of rural intersections, keep geometry consistent

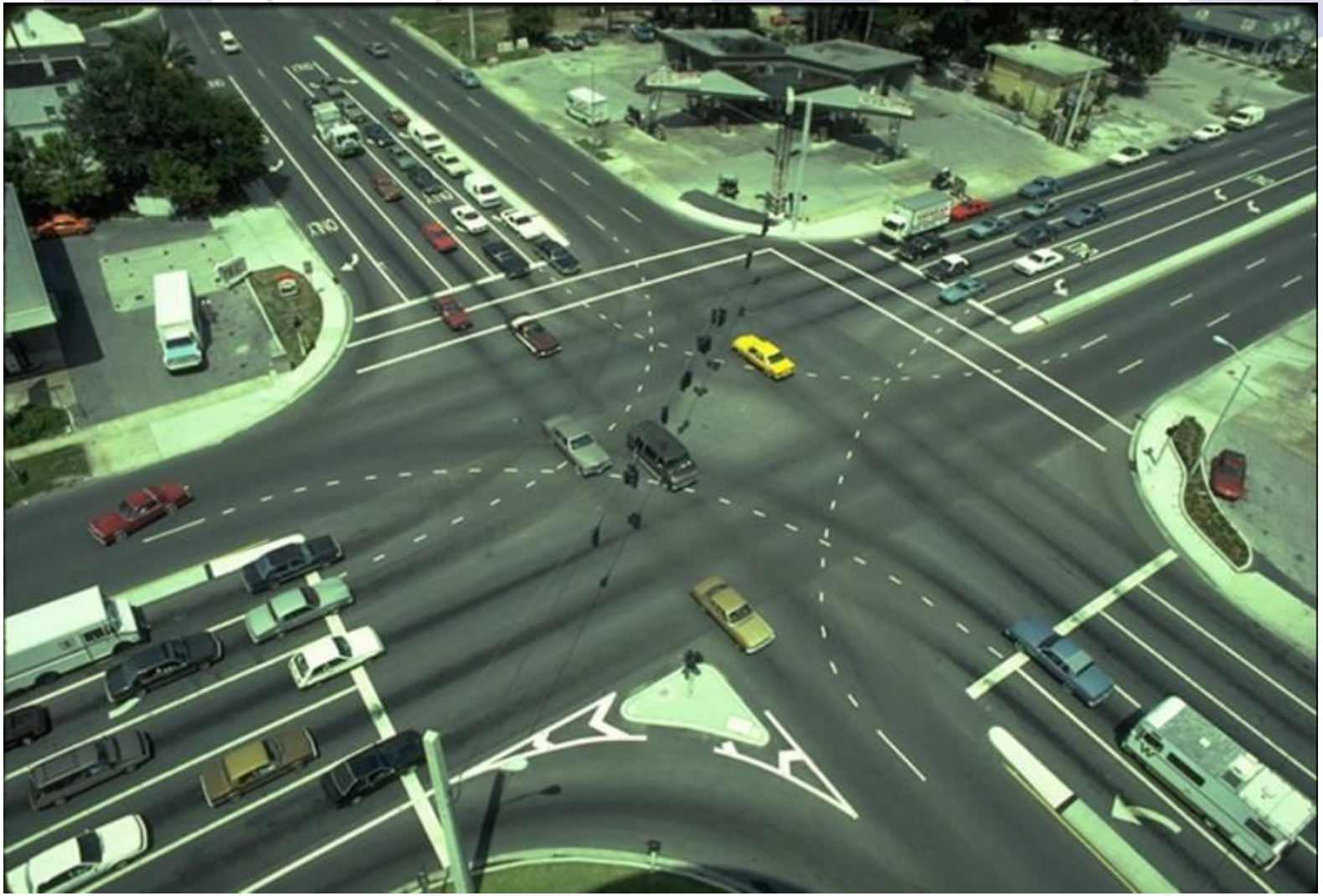
Channelization

- Gives priority to dominant movements
- Provides storage and/or deceleration area for turning vehicles
- Controls prohibited turns
- Restricts speed





Delineation With Pavement Marking



Usage expected in Iowa???

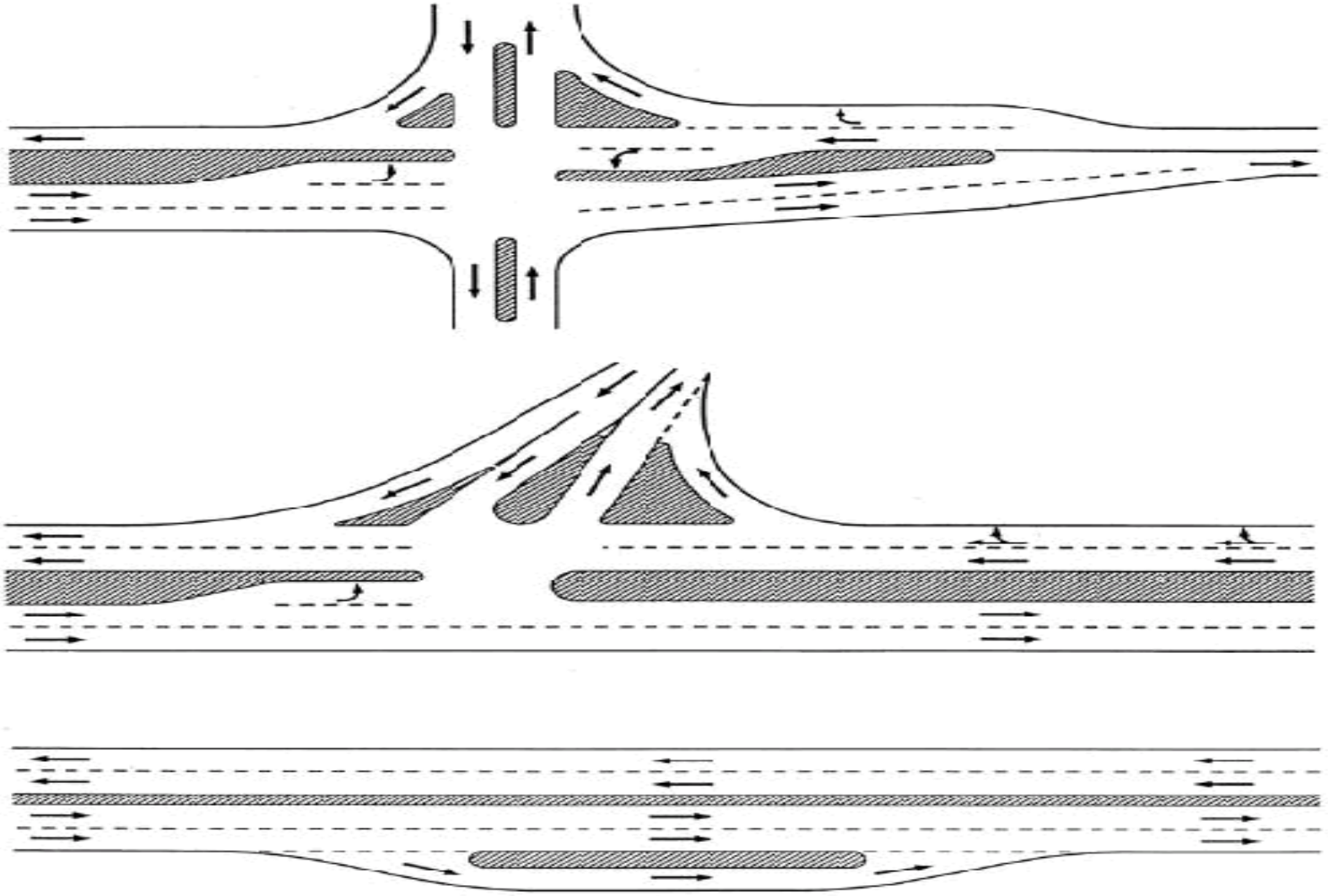


Exhibit 9-35. General Types and Shapes of Islands and Medians

Functional Objectives

Limit Conflict Points (i.e., prohibit certain movements, non-overlap of opposing LTs), esp. in vicinity of intersection functional area (see figures)

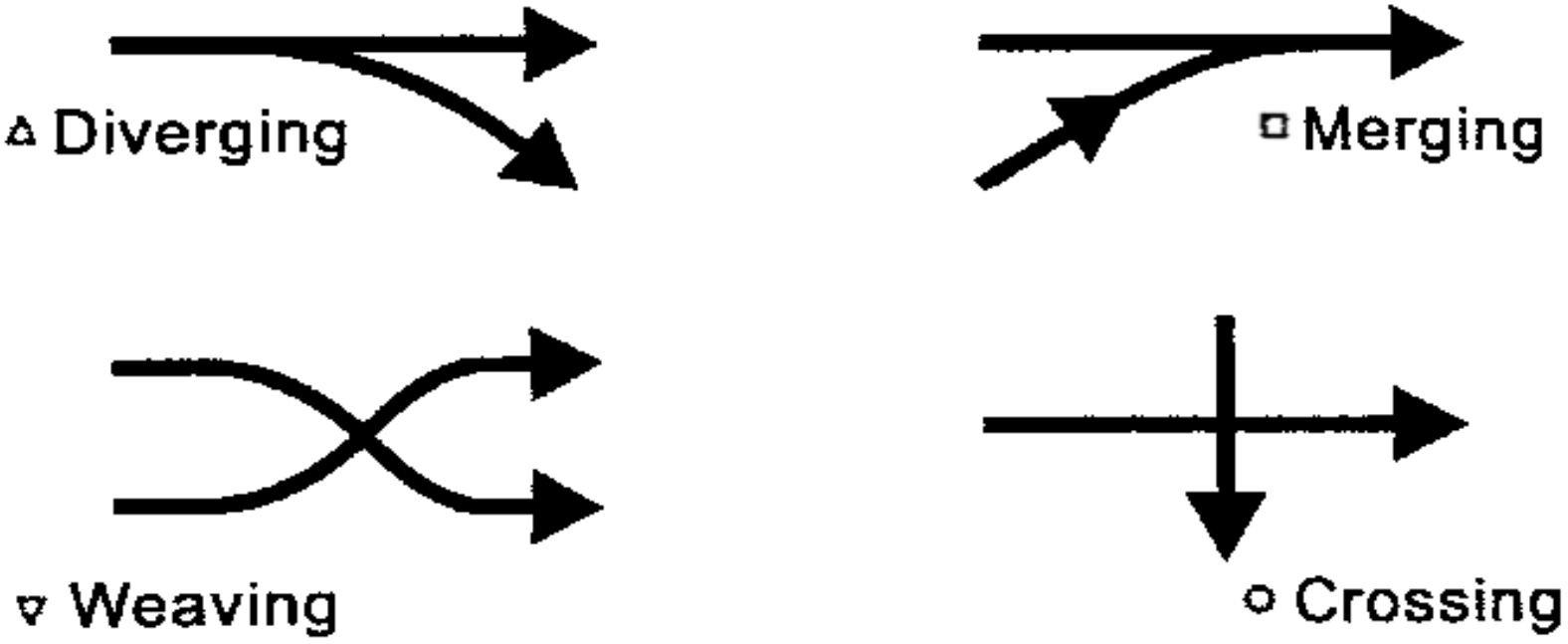
Limit Conflict Area Complexity (i.e., eliminate legs, add turn lanes, islands)

Limit Conflict Frequency (i.e., add turn lanes, use right angles)

Limit Conflict Severity (i.e., small angles, adequate turn bay length/curb radii for speed differential issues)

Points of Conflict

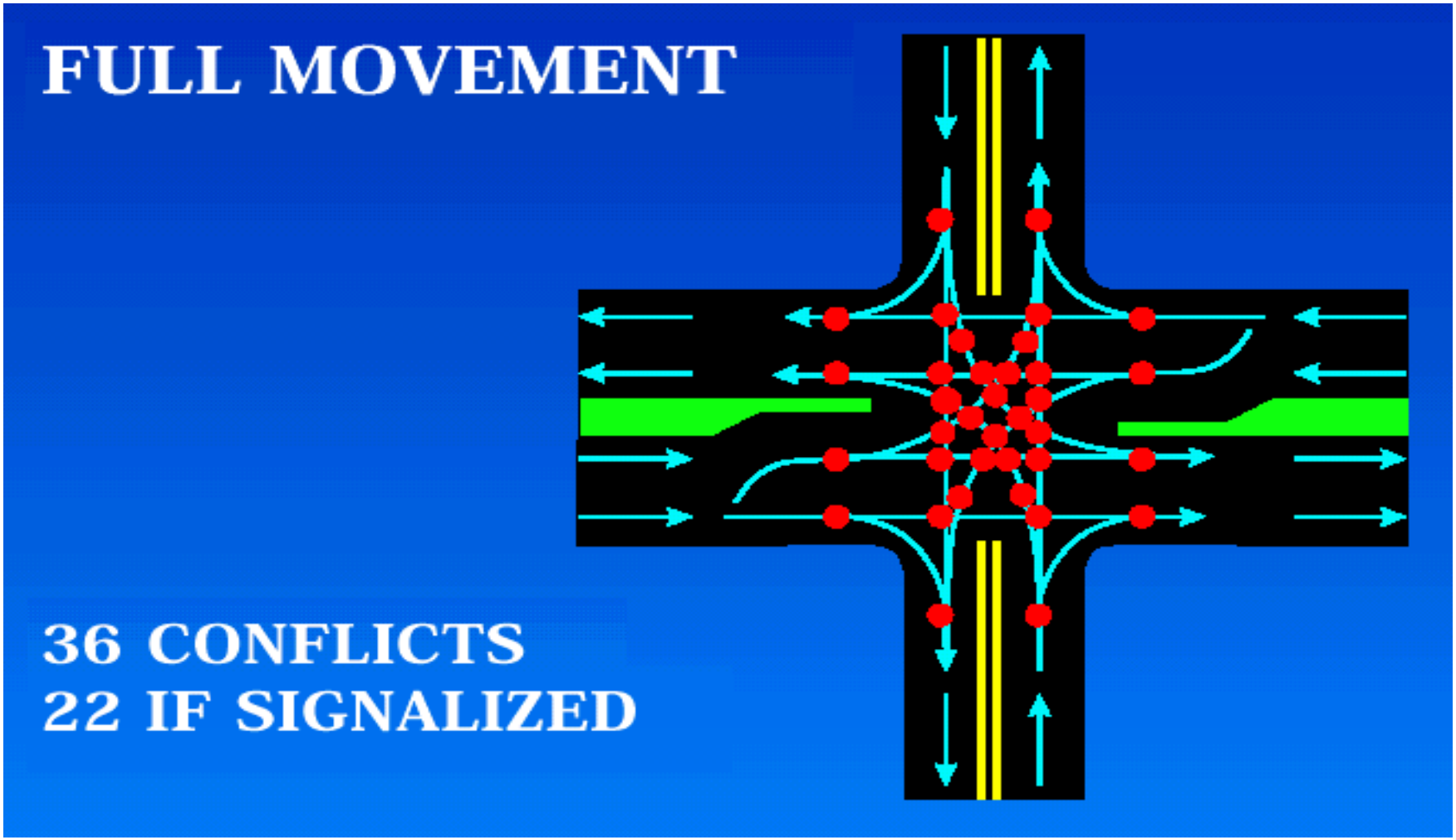
Traffic conflicts occur where the path of traffic movement crosses.



Urban Intersection



Conflict Points at Intersection



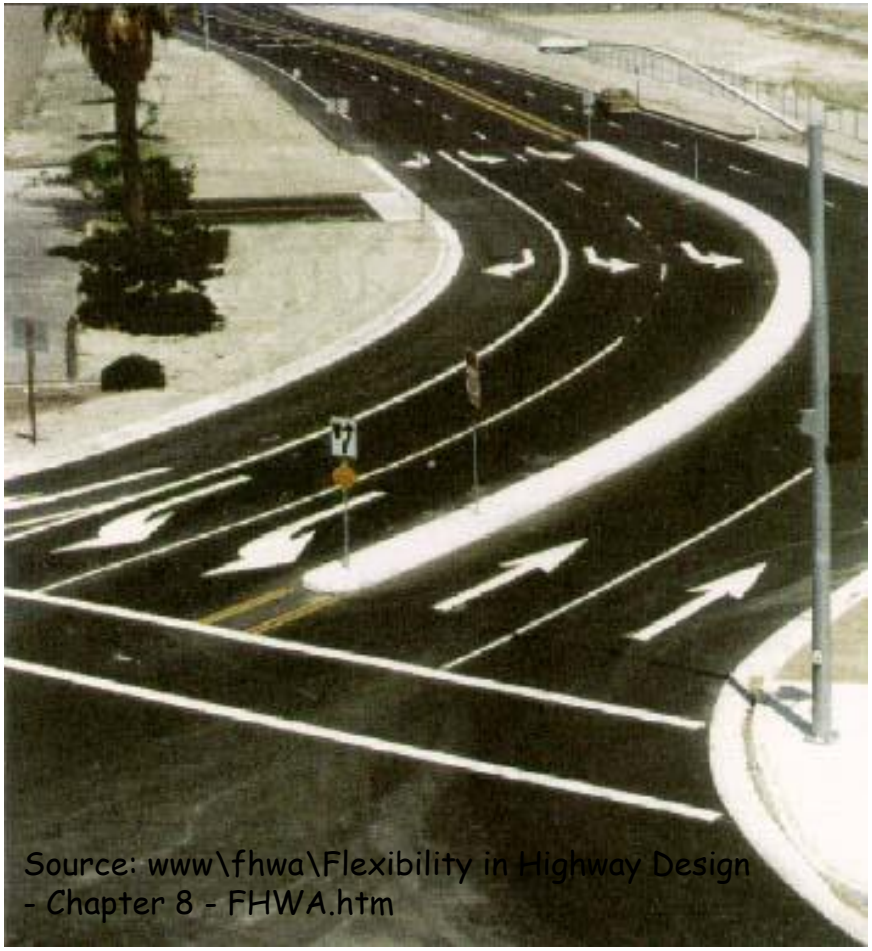
Urban Channelized Intersection-



Left & Right Turn Lanes

Left & Right Turn Lane Requirements

- Turning movement volumes/ capacity
  - Length of vehicles
- Accident (crash) experience (MUTCD? Other?)



Left Turn Lane Warrants – Iowa DOT

- New Construction:
  - all unstopped approaches on primary, high speed rural highway intersections with other primary roadways
  - Other approaches where through, left, and opposing volumes justify
  - 12 ft. lanes
- Rehabilitation:
  - Typically installed where there is a safety issue with vehicles turning left
  - 11 ft. or 12 ft. lanes

Table 4-5. Appropriate design widths of left-turn lanes.

LOCATION AND SPEED	FUNCTIONAL CLASSIFICATION	LEFT-TURN LANE WIDTH (FT)
Rural (high speed)	Primary and minor arterials	12—new design 11—minimum for 3R design
Suburban (high and moderate speed)	Primary and minor arterials	11 – 12
Suburban (moderate speed)	Collectors	10 – 12
Urban (moderate and low speed)	Arterials	11 – 12—new design 10—minimum for 3R design
	Collectors	9 – 12 (9 ft is appropriate only in unusual cases)

Metric					US Customary				
Opposing volume (veh/h)	Advancing volume (veh/h) 5% left turns	10% left turns	20% left turns	30% left turns	Opposing volume (veh/h)	Advancing volume (veh/h) 5% left turns	10% left turns	20% left turns	30% left turns
60-km/h operating speed					40-mph operating speed				
800	330	240	180	160	800	330	240	180	160
600	410	305	225	200	600	410	305	225	200
400	510	380	275	245	400	510	380	275	245
200	640	470	350	305	200	640	470	350	305
100	720	515	390	340	100	720	515	390	340
80-km/h operating speed					50-mph operating speed				
800	280	210	165	135	800	280	210	165	135
600	350	260	195	170	600	350	260	195	170
400	430	320	240	210	400	430	320	240	210
200	550	400	300	270	200	550	400	300	270
100	615	445	335	295	100	615	445	335	295
100-km/h operating speed					60-mph operating speed				
800	230	170	125	115	800	230	170	125	115
600	290	210	160	140	600	290	210	160	140
400	365	270	200	175	400	365	270	200	175
200	450	330	250	215	200	450	330	250	215
100	505	370	275	240	100	505	370	275	240

Exhibit 9-75. Guide for Left-Turn Lanes on Two-Lane Highways (6)

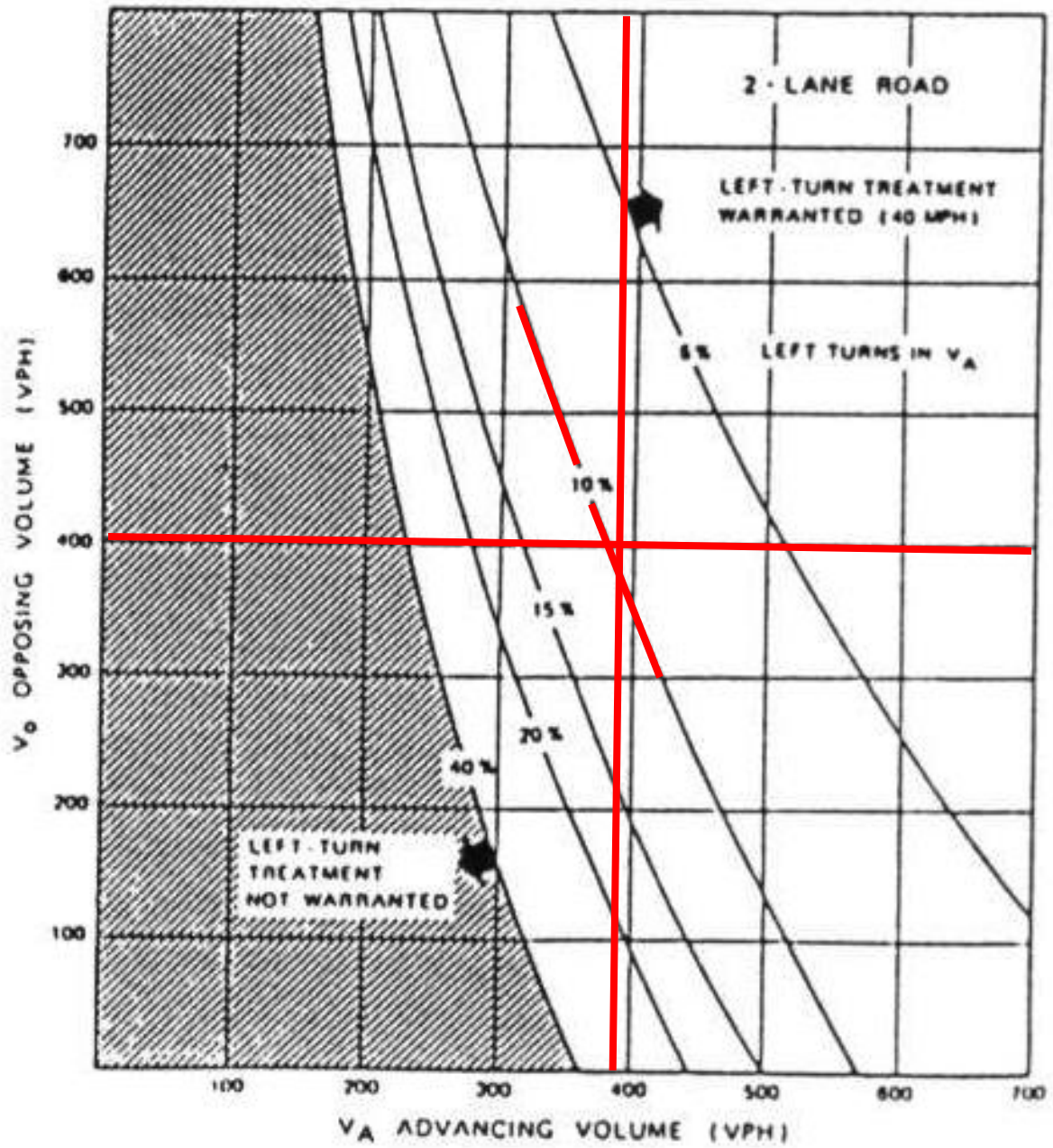
Warrants (cont.)

Consider left turn lane if advancing volume/percent left combination exceeds these values.

Note: for advancing left turn volume > 300 VPH total, consider dual left turn lane.

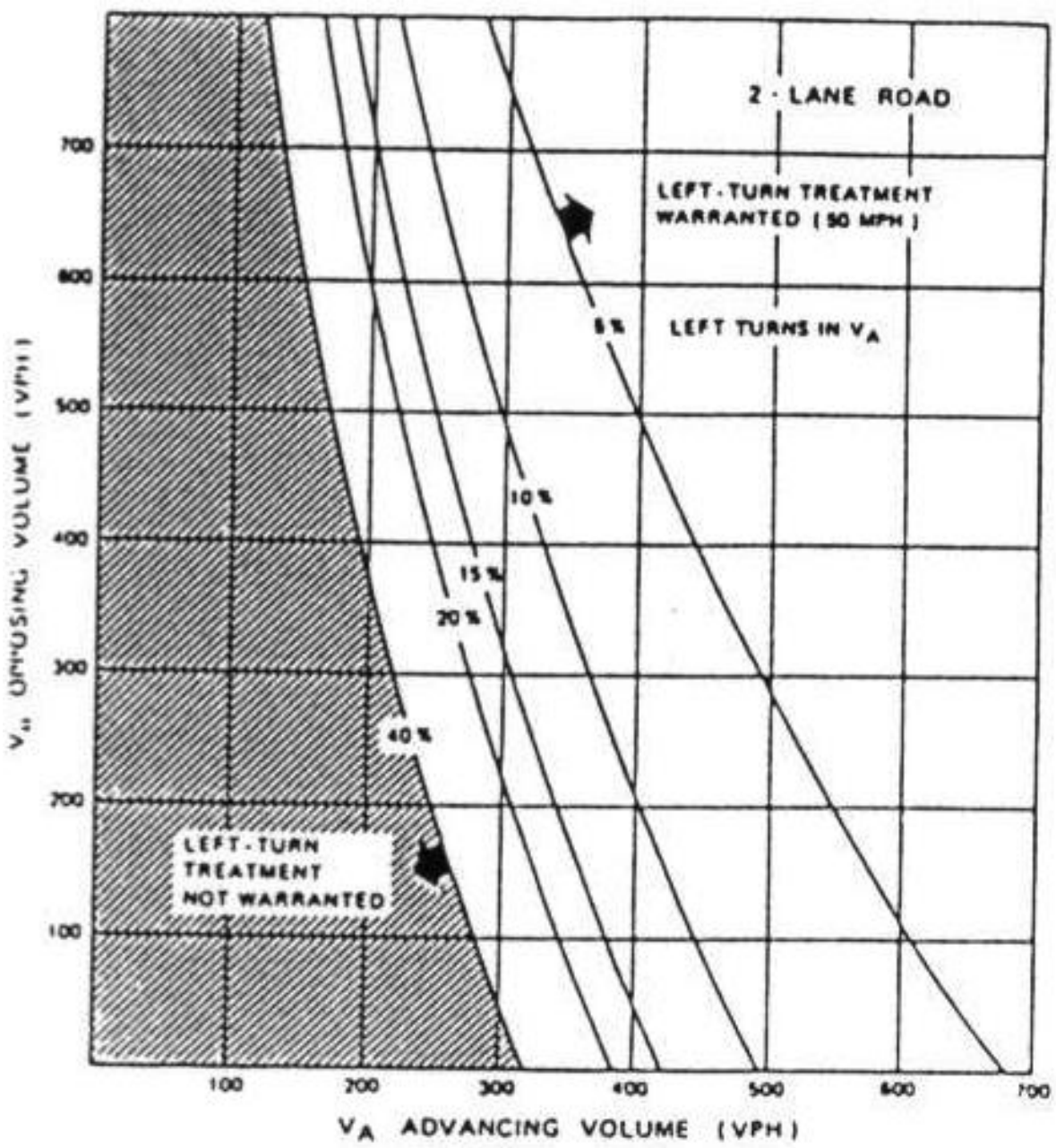
Source: Green book 2001

Figure 4-12. Volume warrants for left-turn lanes at unsignalized intersections. (Source: Ref. 4-7)



40mph

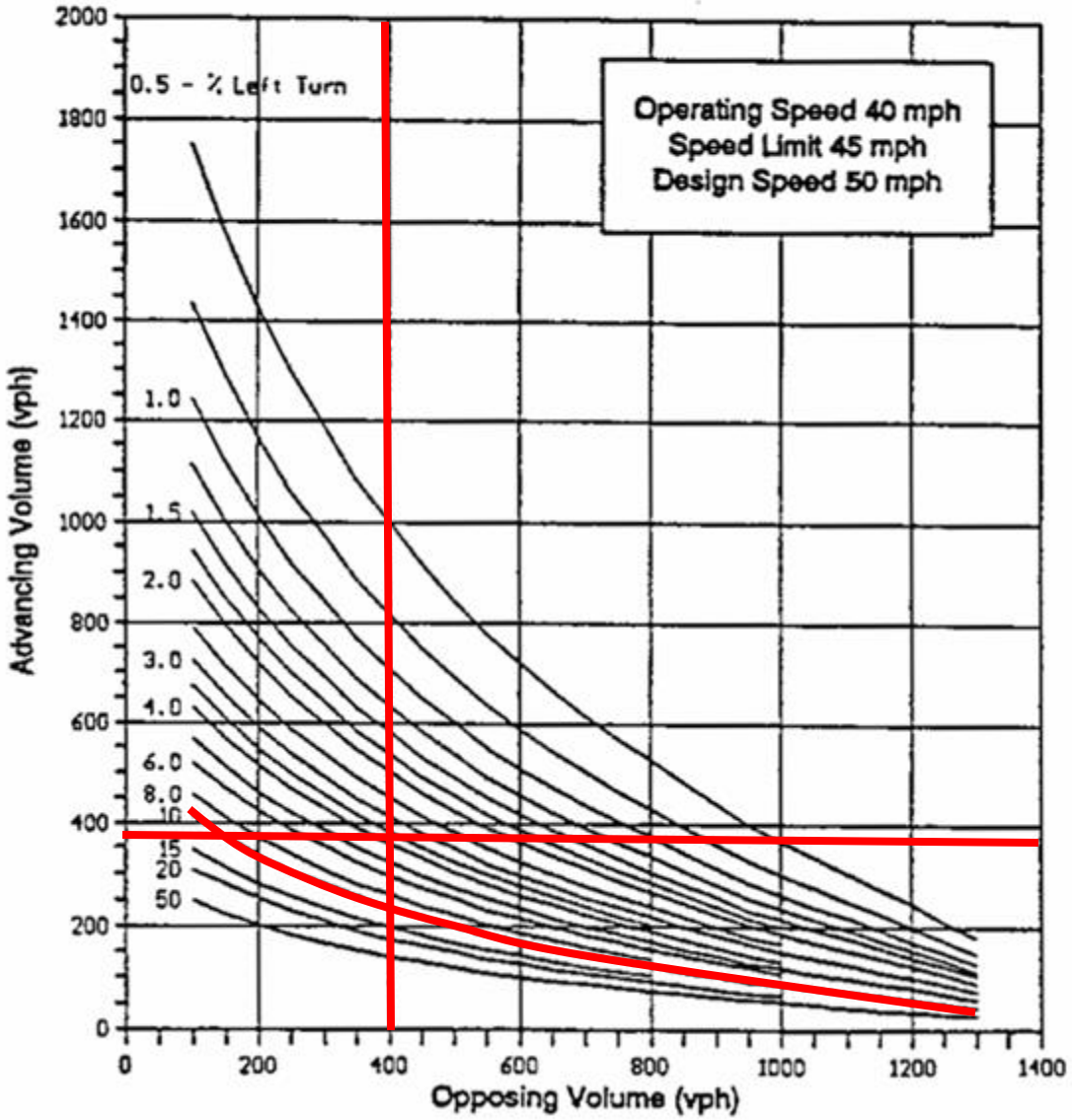
Figure 4-12. Volume warrants for left-turn lanes at unsignalized intersections. (Source: Ref. 4-7)



50mph

Warrants (cont.) – SUDAS?

FIGURE 5.20 LEFT-TURN LANE AT UNSIGNALIZED DRIVEWAY/INTERSECTION - ¶
TWO-LANE ROADWAY¶



TYPE OF TRAFFIC CONTROL	DESIGN SPEED OF HIGHWAY					
	50-60 mph Traffic Volume*		40-45 mph Traffic Volume*		30-35 mph Traffic Volume*	
	High	Low	High	Low	High	Low
Traffic Signal	Deceleration and Storage		Deceleration and Storage		Storage	
Stop Control (Stopped Approach)	Storage		Storage		Storage	
Stop Control Through Approach)	Deceleration and Storage	Deceleration	Deceleration and Storage	Deceleration	Storage	

* Left turn demand volume

Figure 4-17. Recommended functional basis for design length of left-turn lanes.

Lane Length

- Deceleration
  - Provide distance for turning vehicles to decelerate without interfering with through traffic
  - Deceleration lane length depends on:
    - Speed
    - number of queued vehicles
    - vehicle length
  - Minimum: accommodate deceleration from D.S. – 10 mph to stop (PRT & 10 MPH reduction occurs upstream of bay; more in congested, urban conditions)
- Storage
  - Unsignalized, accommodate 2 minutes of demand, at least 2 cars (or 1 car and 1 truck if truck% > 10)

Length required, unsignalized left turn lanes

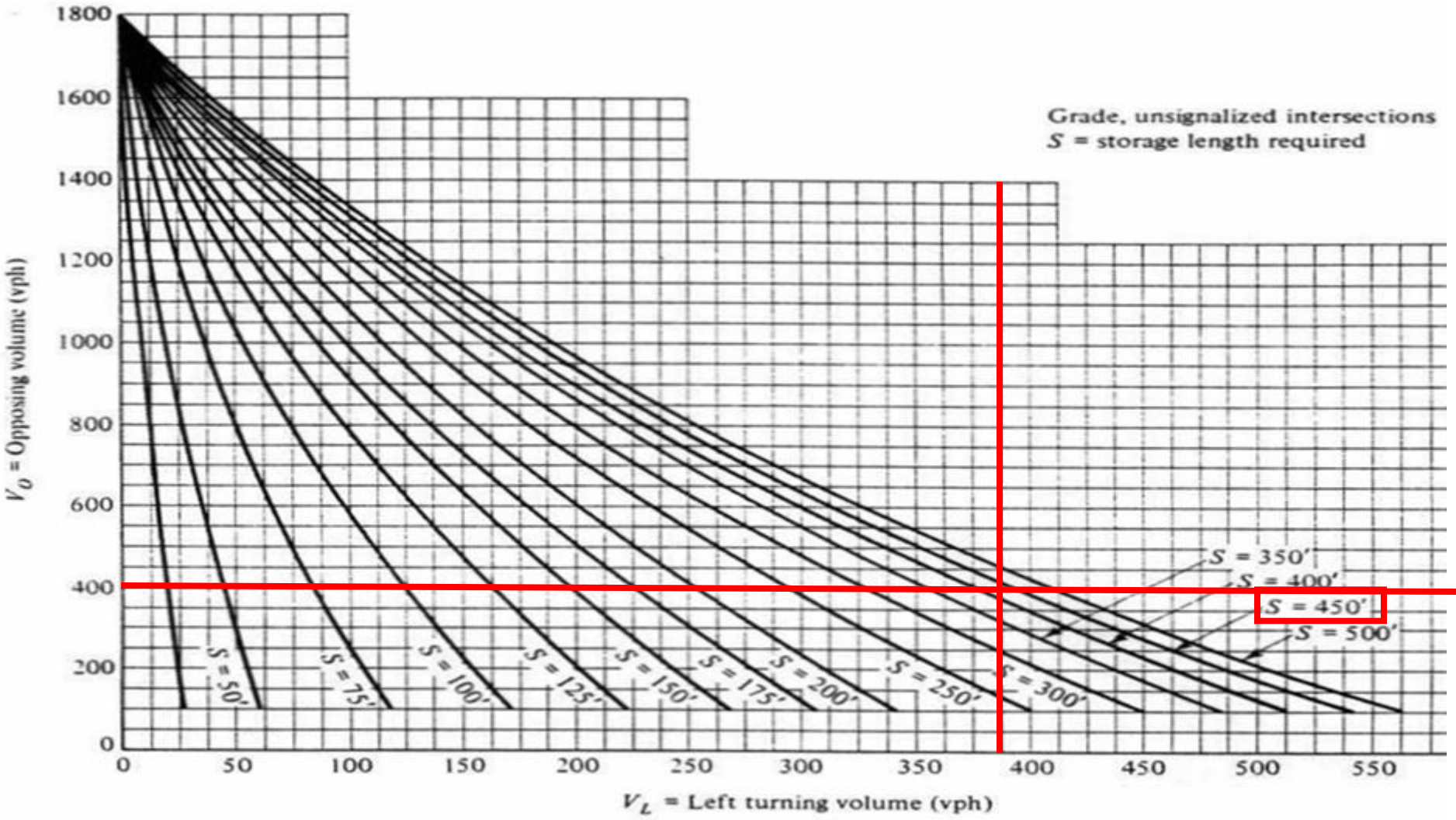


Figure 5-15 Nomograph for left-turn storage at nonsignalized intersections. The nomograph is used by reading horizontally from the

Turn Bay Components

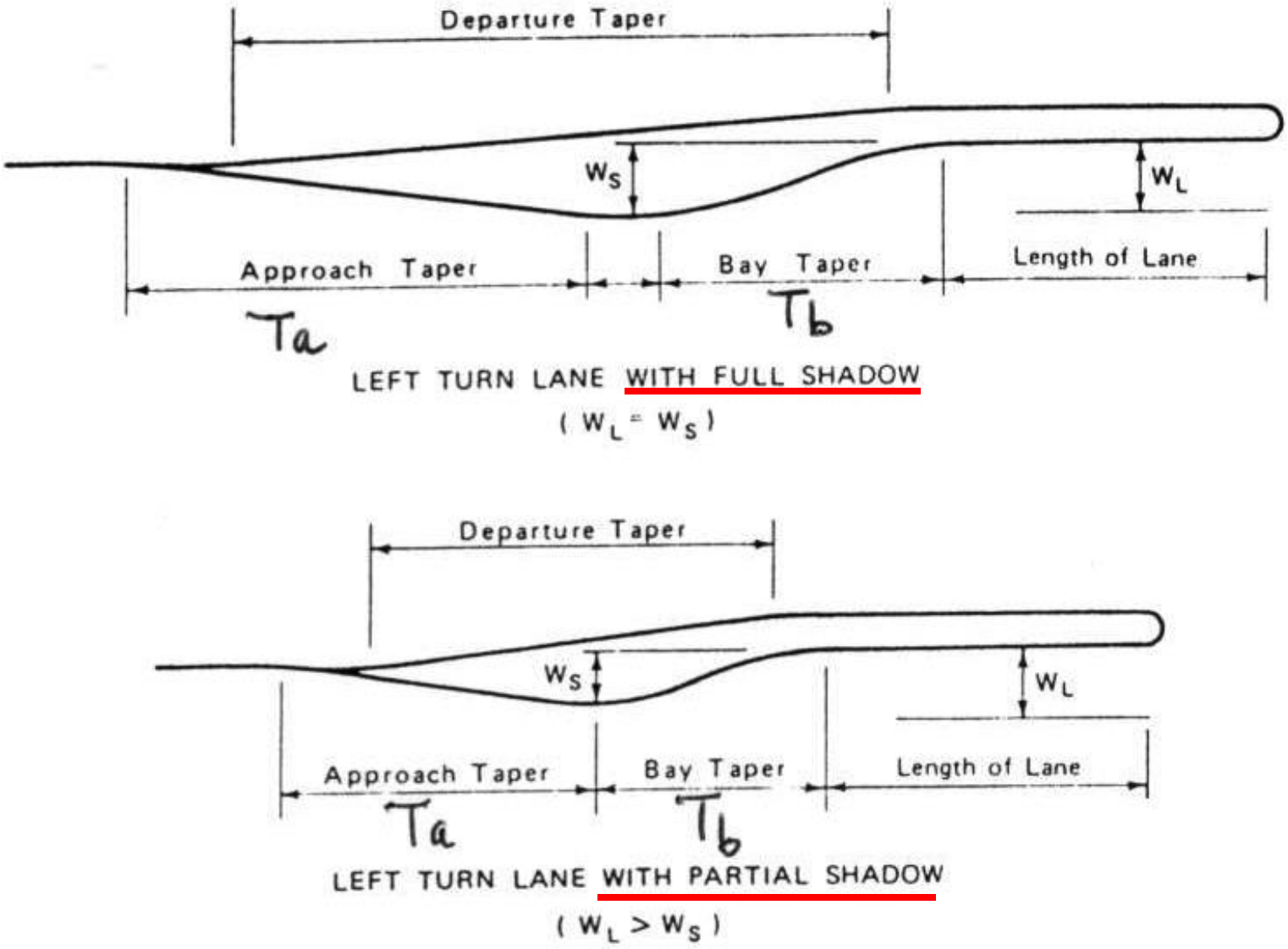


Figure 4-14. Elements of left-turn lane design.

T_a -- Approach Taper Design

Functional Basis: To provide a smooth lateral transition for all vehicles approaching the interesection

Form of Alinement: Tangent

Desirable Design: Provide a fully shadowed lane ($W_S > W_L$). Recommended for high speed intersections and intersections in rural and open urban areas with no space constraints.

$$T_a = \frac{W_L S^2}{60}$$

W_L = Width of Lane (ft)

S = Speed (mph)

Typical Values for T_a*

S--Speed (mph)	W_L -- Width of Lane (ft) 11	11.5	12
30	165	170	180
40	295	305	320
50	460	480	500
60	660	690	720

* Rounded to nearest 5 ft

Minimum Design: Provide a partially shadowed lane (see Figure 4.14) with $W_S < W_L$. Design as follows:

$$T_a = W_S S$$

W_S = Offset (ft)

S = Speed (mph)

As a minimum, a 10:1 taper ratio should be used.

T_b -- Bay Taper Design

Functional Basis: To direct left-turning vehicles into the turn lane

Form of Alinement: Tangent; or reverse curves with 1/3 of the total length comprised of a central tangent

Desirable Design: For fully shadowed left turn lane

$$T_b = \frac{W_L S}{2.5}$$

W_L = Width of Lane

S = Speed (mph)

Typical Values for T_b*

S--Speed (mph)	W_L -- Width of Lane (ft) 11	11.5	12
30	130	140	145
40	175	185	190
50	220	230	240
60	265	275	290

* Rounded to nearest 5 ft

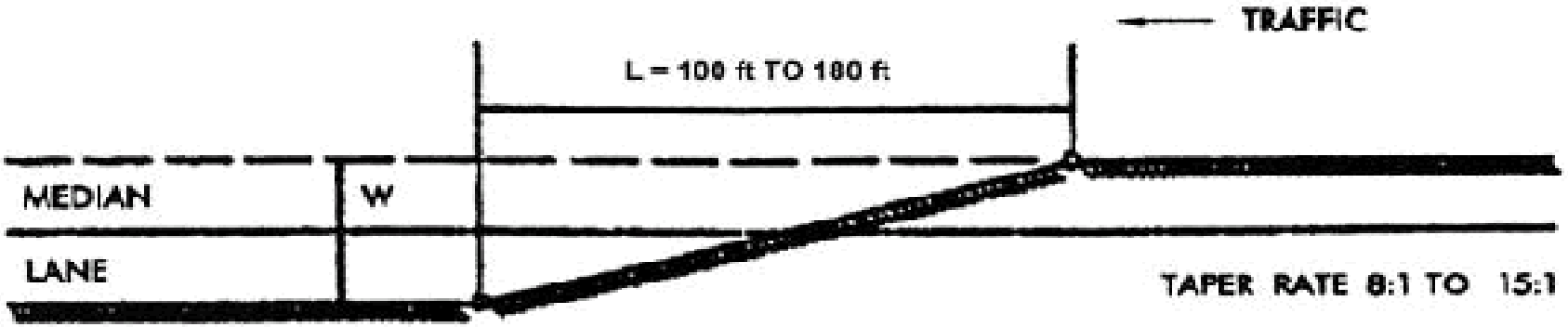
Minimum Design: Taper ratios of 8:1 can be used for tangent bay tapers. For constrained locations, ratios as low as 4:1 can be used with painted channelization.

Figure 4-19. Guidelines for design tapers of left-turn lanes. (Source: Refs. 4-9, 4-10)

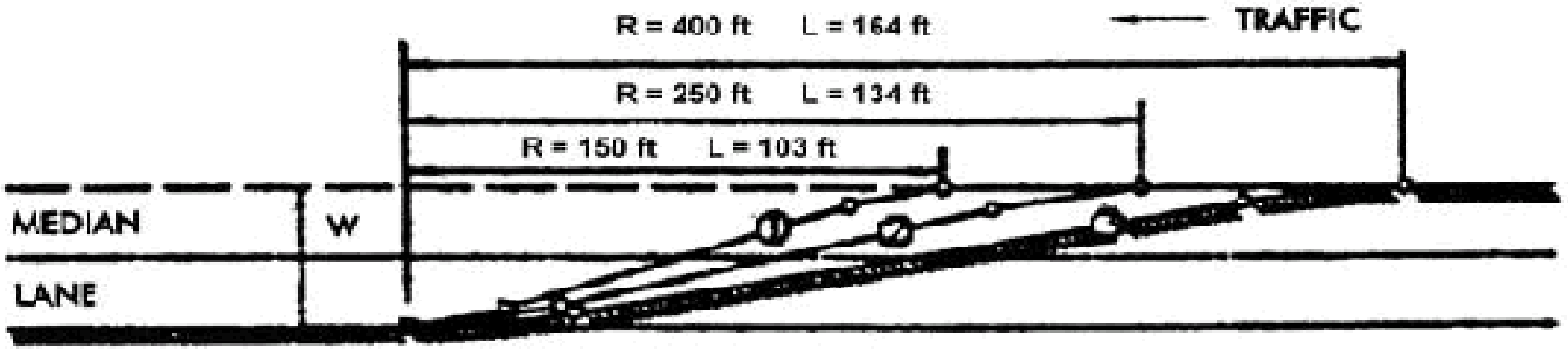
Some Turn Lane Details

- Transitions are often symmetrical reverse curves or straight line
- Curves at each end are desirable
- Green Book: 8:1 to 15:1 tapers for high speed highways … urban use 100’ for single and 150’ for dual left turn lane

Design

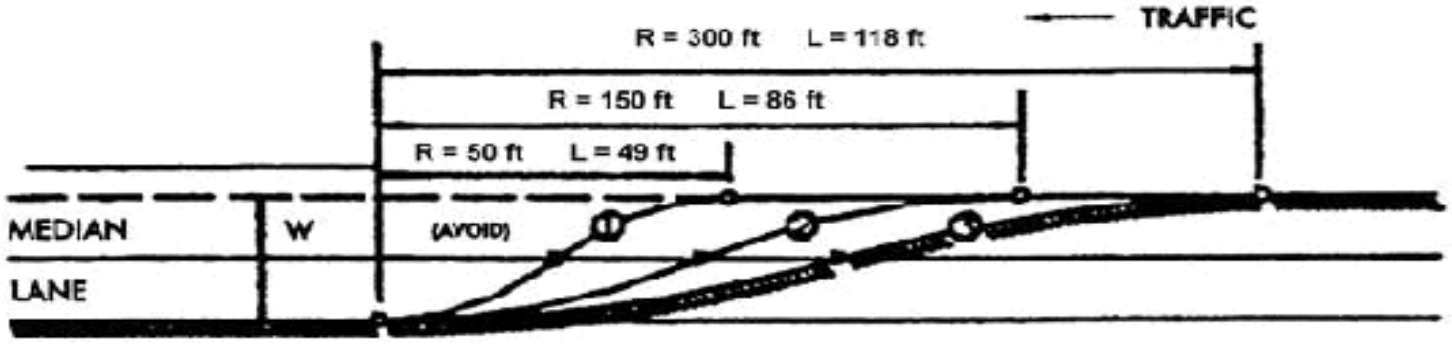


STRAIGHT LINE TAPER
–A–



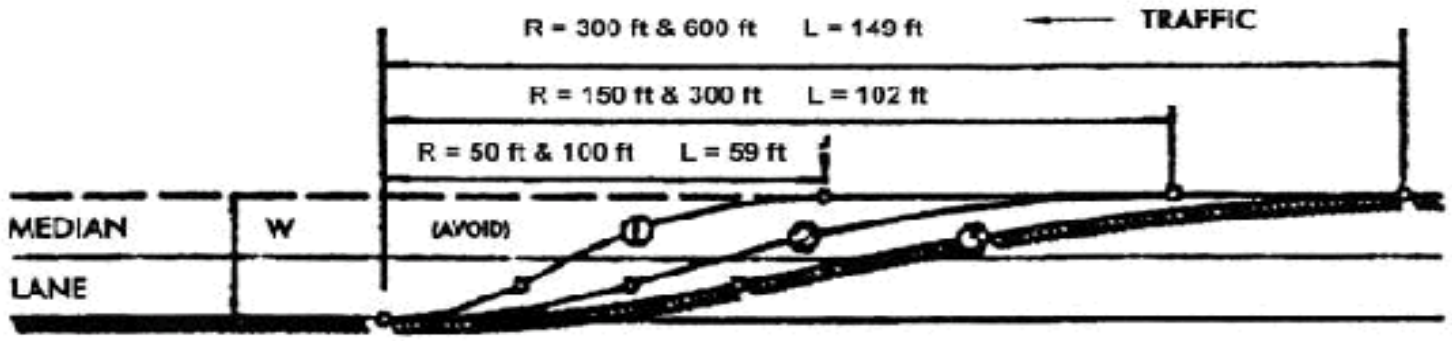
PARTIAL TANGENT TAPER
–B–

Design



SYMMETRICAL REVERSE CURVE

—C—



ASYMMETRICAL REVERSE CURVE

—D—

DIMENSIONS ARE ALSO APPLICABLE FOR RIGHT-TURN FLARES.

Exhibit 9-95. Taper Design for Auxiliary Lanes (U.S. Customary) (Continued)

Left Turn Bay Circular Transition



Left Turn Bay Taper



Left Turn Bay (No Transition)



Left Turn Separated [Tiger Tail]



Figure 4-15. Functional bases for design of left-turn lanes for deceleration.

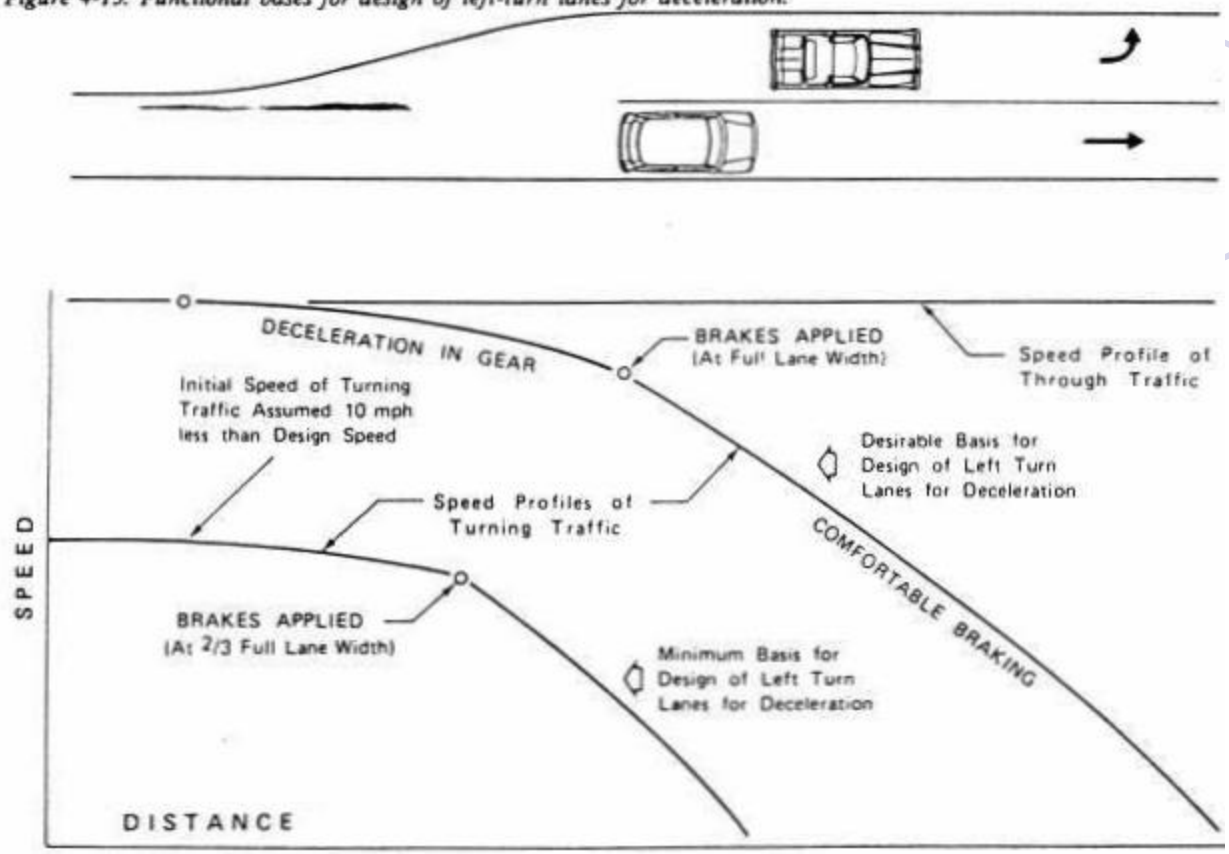


TABLE 5-8 Deceleration Distances

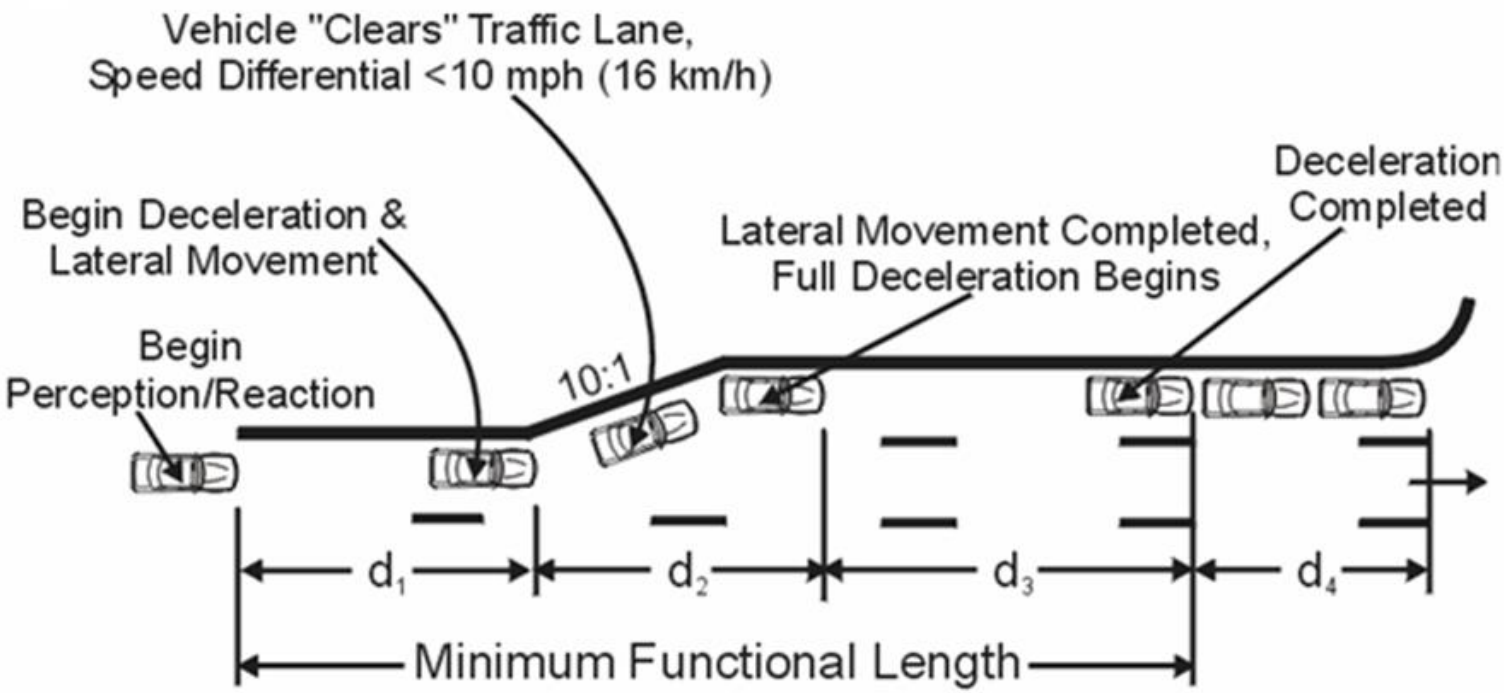
Speed (mph)	*Deceleration Distance (feet) (rounded for design)*	
	Desirable[a]	*Minimum*[b]
30	200	150
35	275	250
40	350	300
45	425	375

[a] Assumes 2.5 seconds perception–reaction time, 7 fps^2 maximum deceleration, and 10 mph speed differential.

[b] Assumes 1.0 second perception–reaction time, 9 fps^2 maximum deceleration, and 15 mph speed differential.

Left Turn Lane Length with Raised Medians

If speed limit = 45
Initial v = 35 = 50fps
d_2=10:1 x 12 = 120'
Delta v = ?
$120=1/2(4.5)t^2 + 50t$
t=2.2s
Delta v = 2.2x4.5=10fps
v_3=50-10=40fps
t_3=40/9=4.5s
$d_3=1/2(9)(4.5)^2 = 92' \sim 100'$
d_2+d_3=220' for decel. Only (within the lane only)



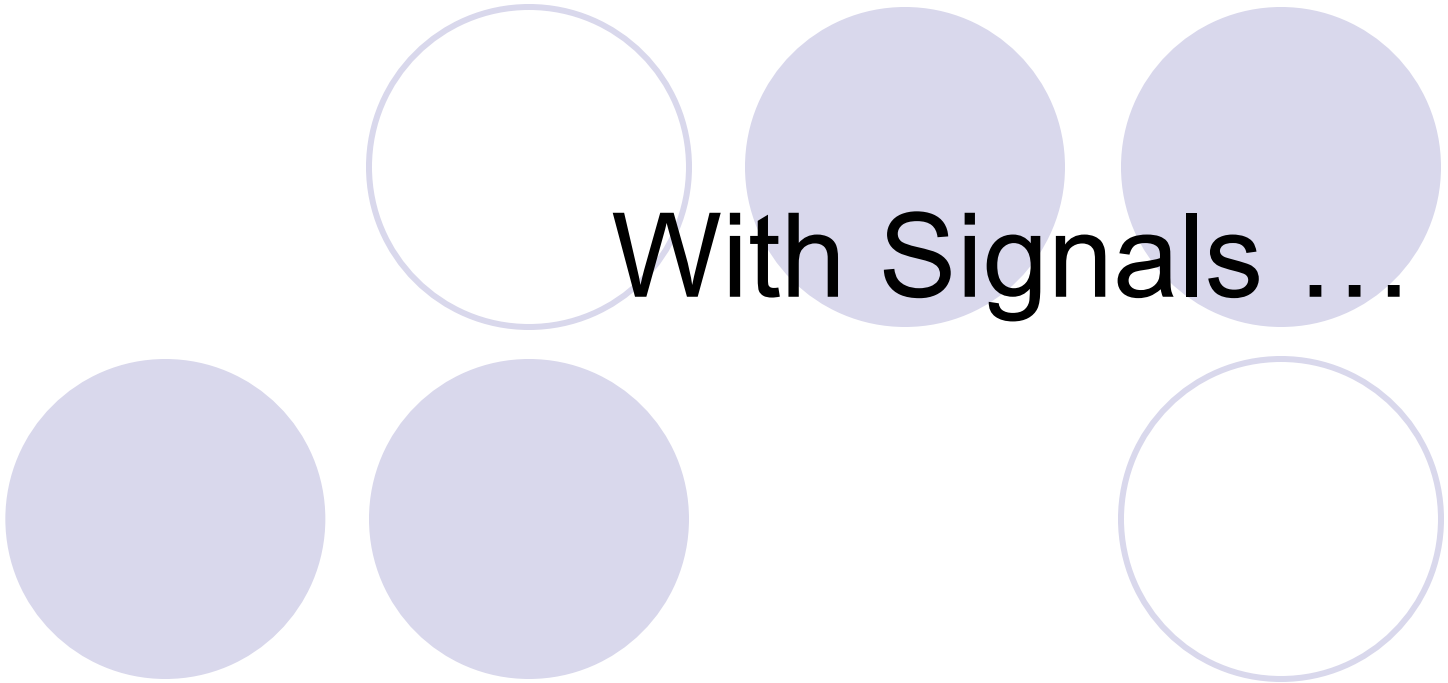
No crossing traffic (driveway or intersection) should be within the functional length or storage length.

d_1 = distance traveled during perception -reaction time (2.5 sec.)

d_2 = distance traveled while driver decelerates and maneuvers laterally (4.5 fps^2)

d_3 = distance traveled during full deceleration and coming to a stop or to a speed at which the turn can be comfortably executed (9.0 fps^2)

d_4 = storage length


With Signals …

Signalized storage required:

- Signalized, accommodate twice the expected average storage needed – depends on cycle and phasing

$L_d/_b$ -- Length of Taper and Lane For Deceleration and Braking

Functional Basis: To provide sufficient length for a vehicle to decelerate and brake entirely outside the through traffic lanes

Desirable Design: Deceleration in gear for 3 seconds (occurs over bay taper) followed by comfortable braking to a stopped position

Design Values For $L_d/_b$

S--Speed (mph)	Length (ft) Total	Lane	Bay Taper
30	235	90	(145)
40	315	125	(190)
50	435	195	(240)
60	530	240	(290)

Minimum Design: Braking begins at 2/3 full lane width, with minimum 50-foot storage. For low speeds only, the following values apply:

Design Values For $L_d/_b$

S--Speed (mph)	Length (ft) Total	Lane	Bay Taper
30	230	50	(180)
35	250	70	(180)
40	280	100	(180)
45	320	140	(180)

Figure 4-18. Guidelines for design lengths of left-turn lanes.

L_s -- Length of Lane For Storage (Full Width Lane)

Functional Basis: To provide sufficient length for a reasonable number of vehicles to queue within the lane without affecting other lanes

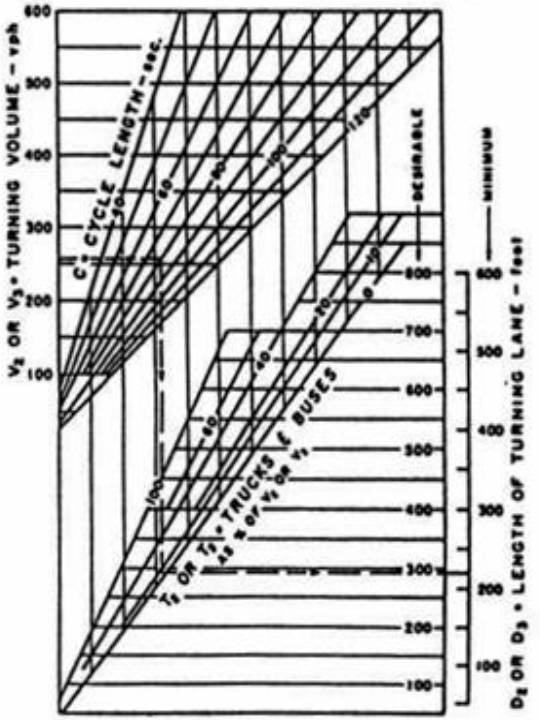
Desirable Design: Based on twice the mean arrival rate (per cycle for signals, per 2-minute period for stop control) during the peak hour of traffic

Minimum Design: Based on mean arrival rate, with minimum storage for one vehicle

L_s for Stop Control

DHV (vph)	L_s (ft)
<60	50-75
61-120	100
121-180	150
>180	200 or more

L_s for Traffic Signal Control



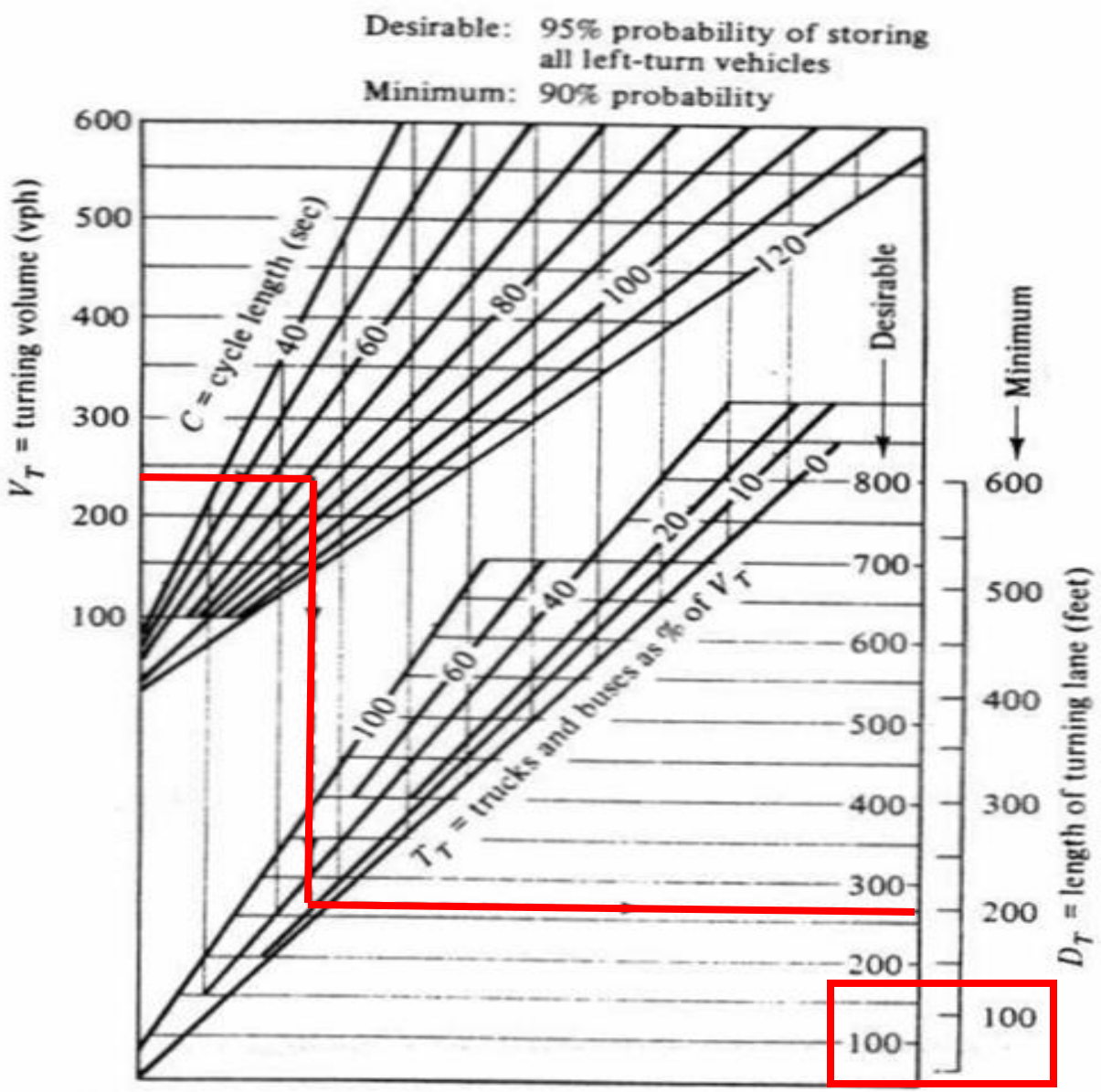


Figure 5-14 Nomograph for a single-lane left-turn storage at signalized intersections.

SOURCE: V.G. Stover and F.J. Koepke. *Transportation and Land Development*. Englewood Cliffs, NJ: Prentice Hall, 1988.

Right Turn Bays

- Right turn bay length depends on corner radius (design speed)

L_d/b -- Length of Taper and Lane For Deceleration and Braking

Functional Basis: To provide sufficient length for a vehicle to decelerate and brake entirely outside the through traffic lanes.

Desirable Design: Deceleration in gear for 3 seconds (occurs over bay taper) followed by comfortable braking to a stopped position or to the design speed of the corner radius.

Design Values For L_d/b

For Design Speed of Corner Radius (mph)

Highway Design speed, V (mph)	Stop Condition*	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

*Appropriate for right turn lanes on approaches to stop signs and traffic signals.

L_s -- Length of Lane For Storage (Full Width Lane)

Functional Basis: To provide sufficient length for a reasonable number of vehicles to queue within the lane without affecting other lanes.

Desirable Design: Based on twice the mean arrival rate (per cycle for signals, per 2-minute period for stop control) during the peak hour of traffic.

Minimum Design: Based on mean arrival rate, with minimum storage for one vehicle.

L_s for Stop Control

DHV (vph)	L_s (ft)
<60	50-75
61-120	100
121-180	150
>180	200 or more

L_s for Traffic Signal Control

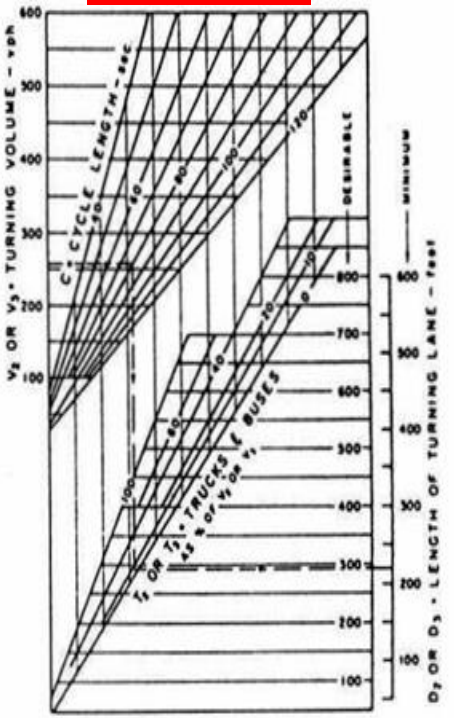


Figure 4-24. Guidelines for design lengths of right-turn lanes.

Source: T.R. Neuman, "Intersection Channelization Design Guide." NCHRP Report 279. 1985.

r Radius (mph)

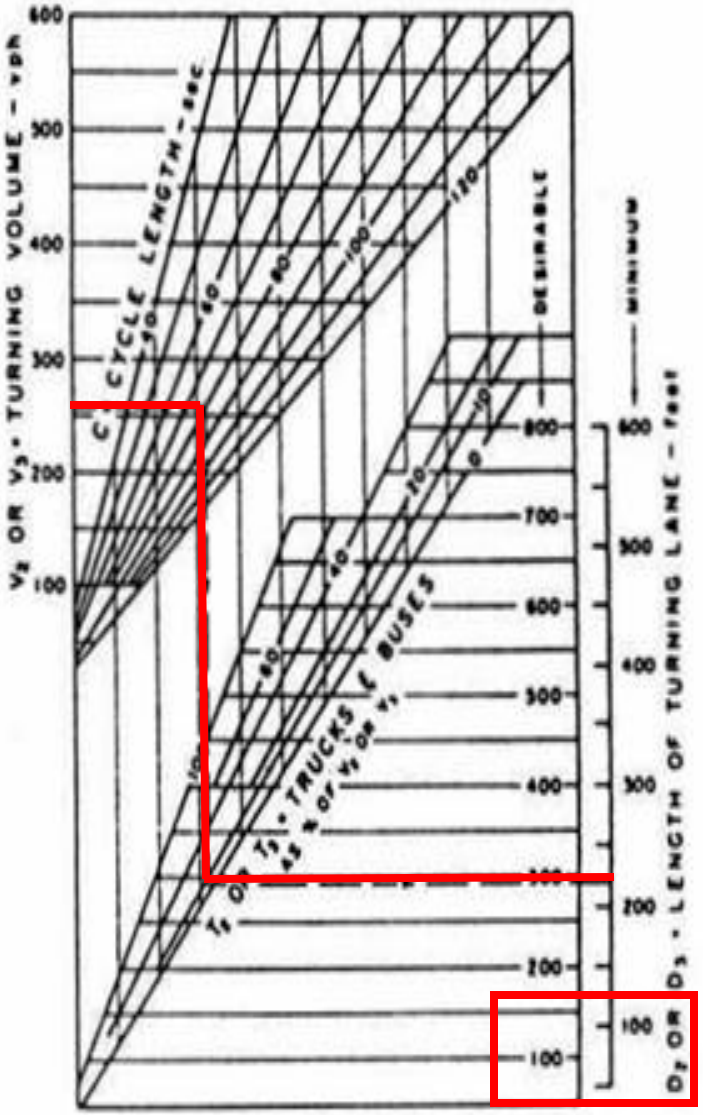
20	25	30
160	140	-
265	235	185
385	355	315
490	460	430
530	490	480
570	550	510

anes on approaches
gnals.

L_S for Stop Control

DHV (vph)	L_S (ft)
≤60	50-75
61-120	100
121-180	150
>180	200 or more

L_S for Traffic Signal Control



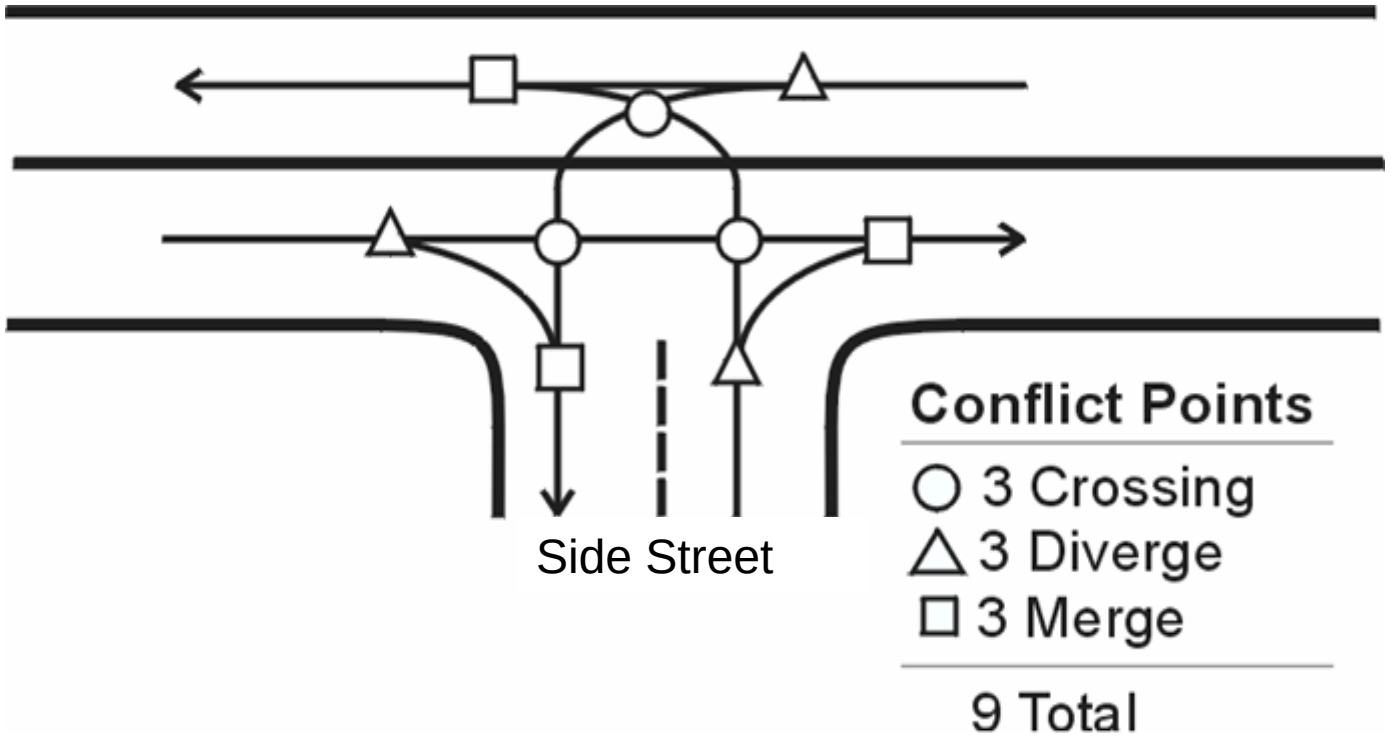
Median Openings

Raised Median: Clive



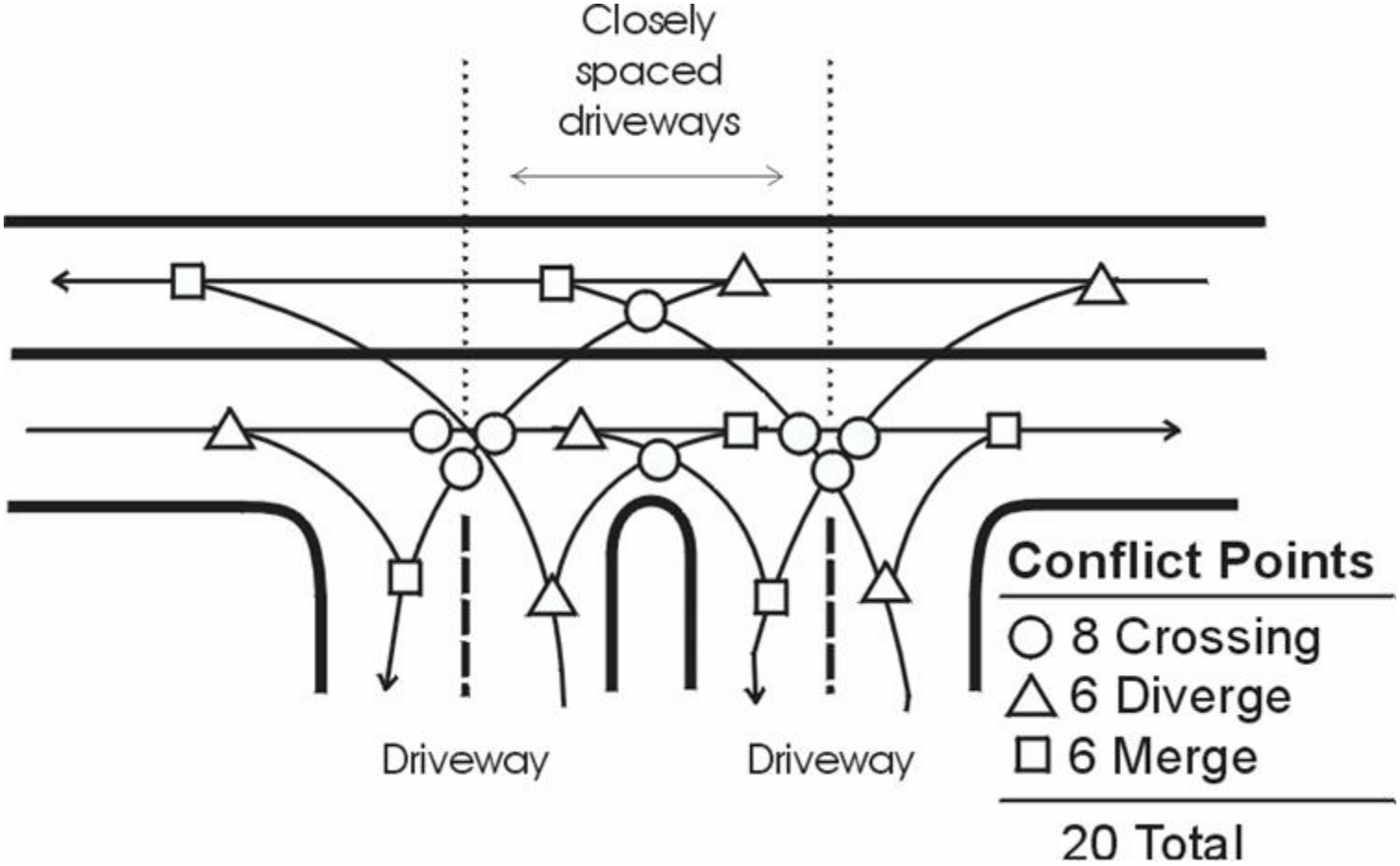
T-Intersection or Driveway

Two Lane Undivided Street



T-Intersection or Driveway

Two Lane Undivided Street



Median Closure

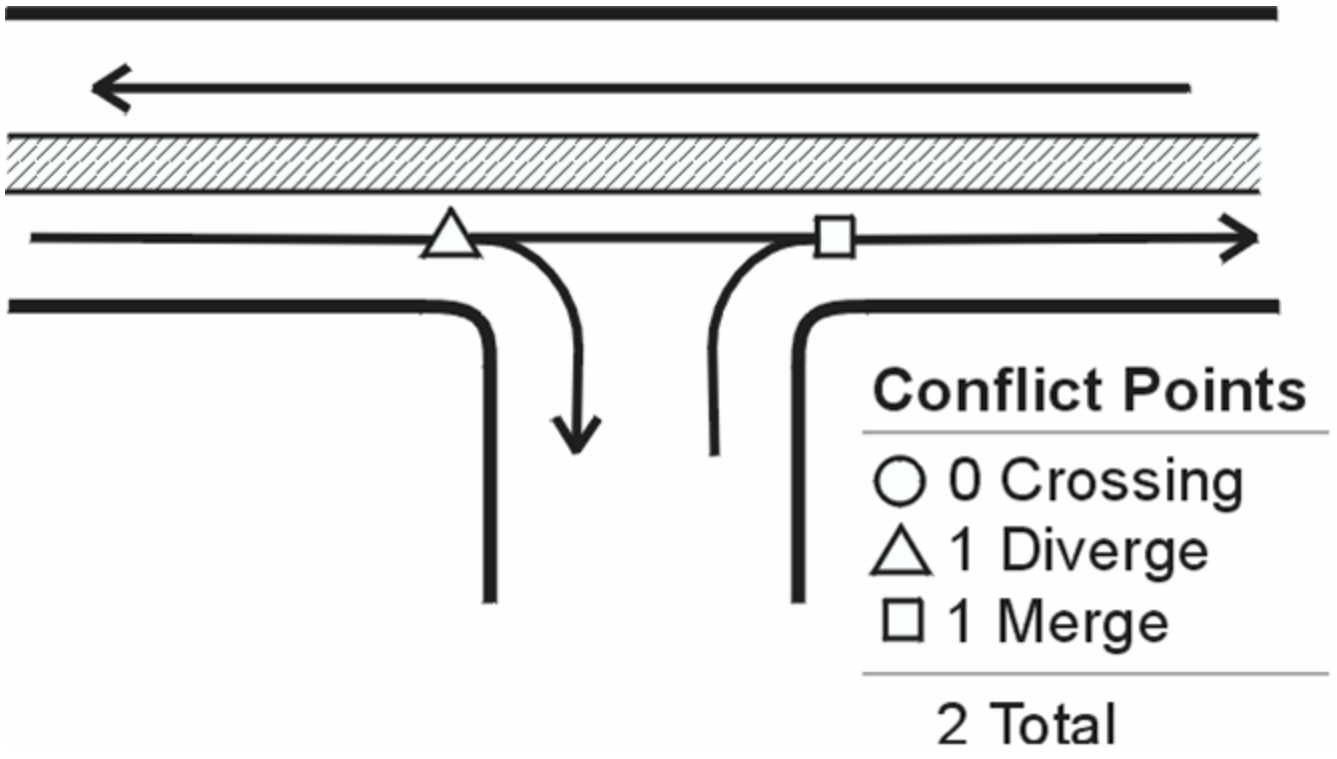
- Application – Median openings should be considered for closure when:
  - ✓ A safety or operational problem is evident and an appropriate retrofit cannot be made.
  - ✓ Median width <11 ft.
  - ✓ The left-turn bay of a nearby signalized intersection needs to be extended.
  - ✓ Where a pattern of left-turn crashes is evident.
  - ✓ Where heavy pedestrian use is predicted or accidents involving pedestrians have occurred at intersections.

Median Closure - Design

- The need for visual cues is especially critical during nighttime hours where a 4-way intersection previously existed or there are access drives directly opposite each other.
- Minimum 4 ft. width face-to-face of curbs is recommended.
- Select and locate landscaping materials to delineate the median.
- Landscaping must not obscure sight distances.

T-Intersection or Driveway

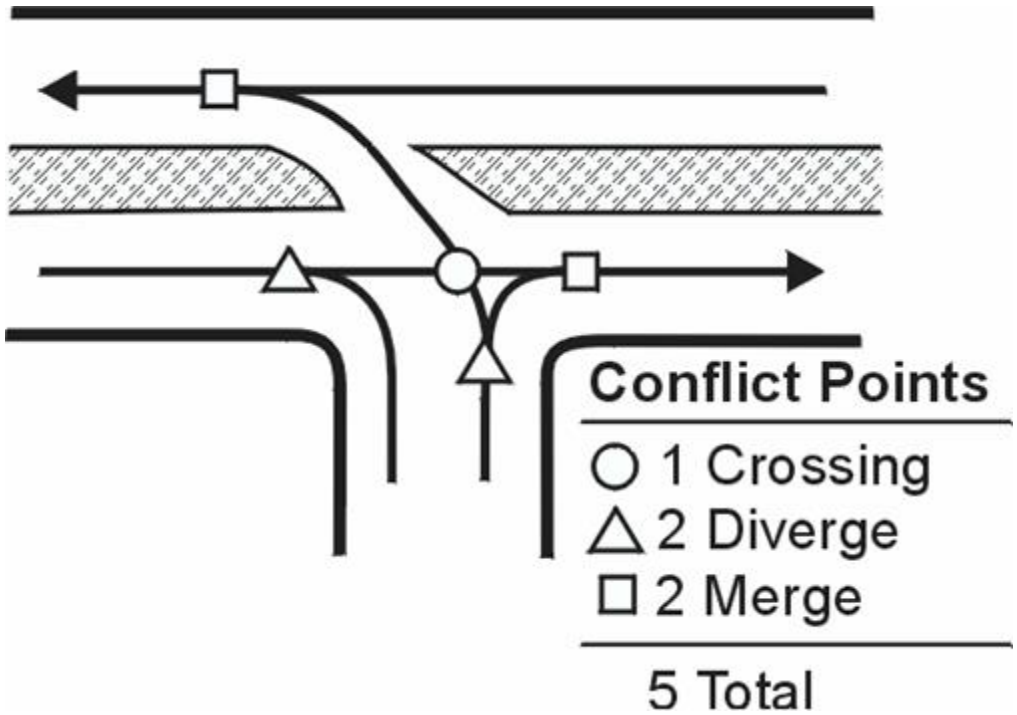
Two lane roadway with raised median closed, no left-turn





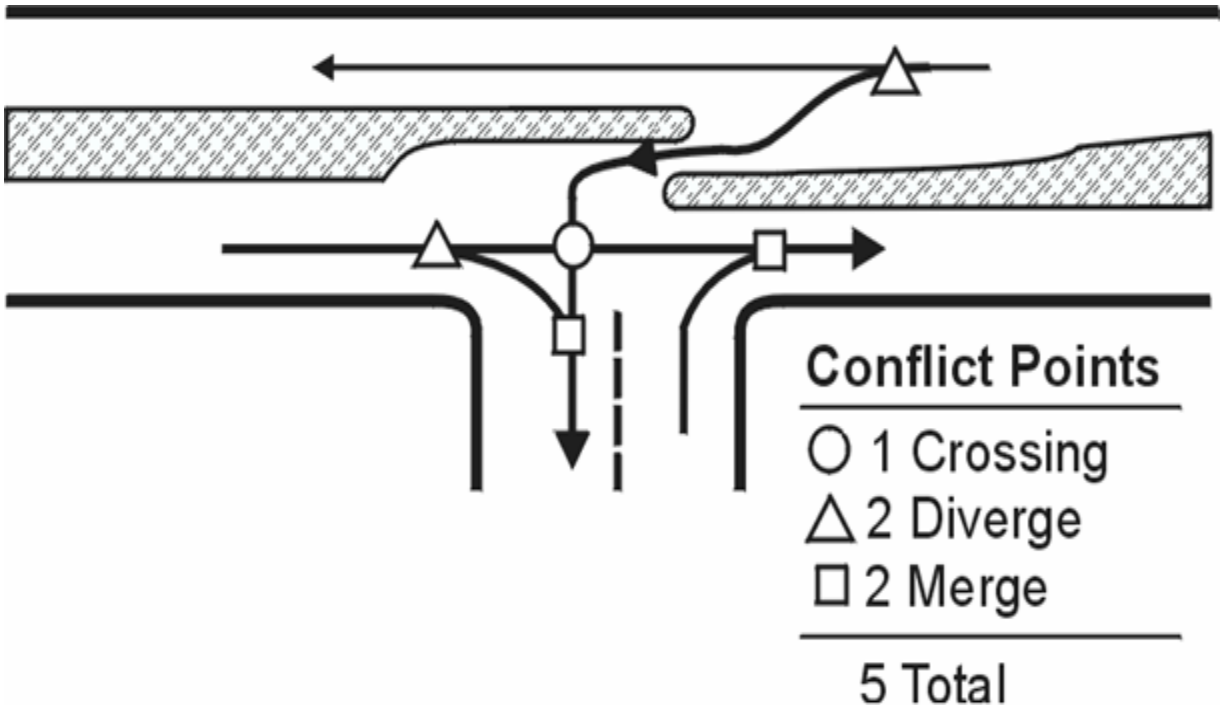
T-Intersection or Driveway

Two-lane roadway with raised median (left turn egress only from intersection or driveway)



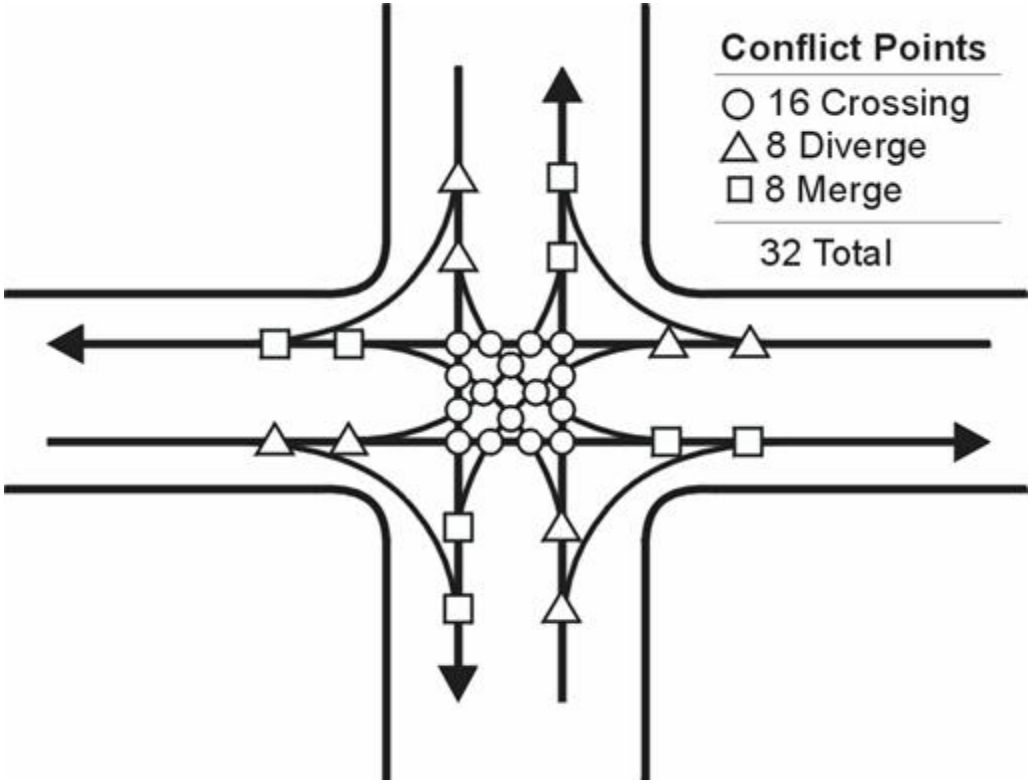
T-Intersection or Driveway

Two-lane roadway with raised median (left turn ingress only into driveway)



4-Way Intersection or Driveway

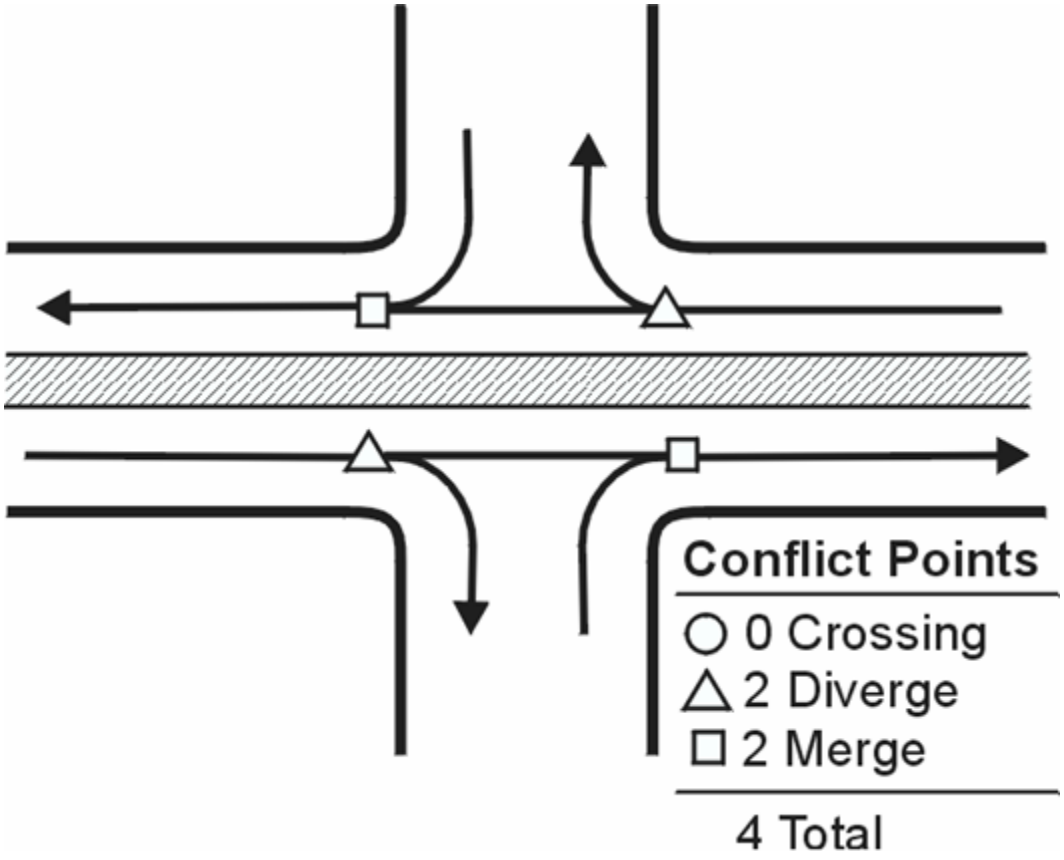
Note: Add 4 conflicts to each for four lane roadways



40 conflicts with Four Lane on major street

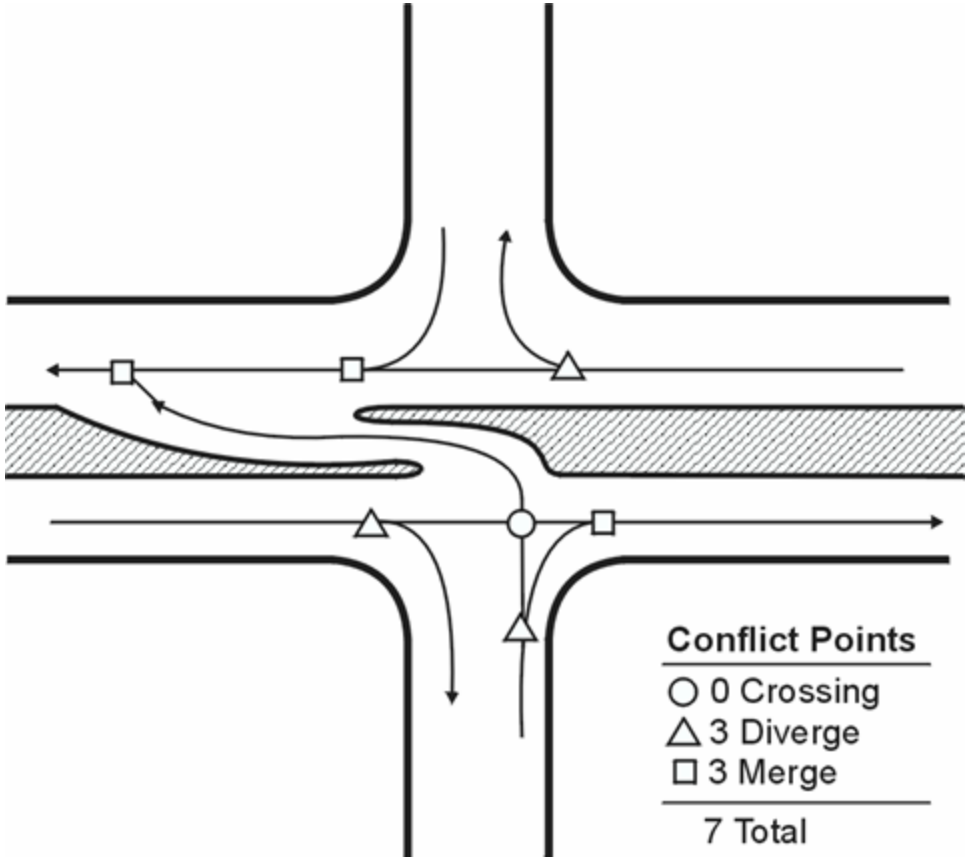
4-Way Intersection or Driveway

Added median close eliminates left-turn conflicts



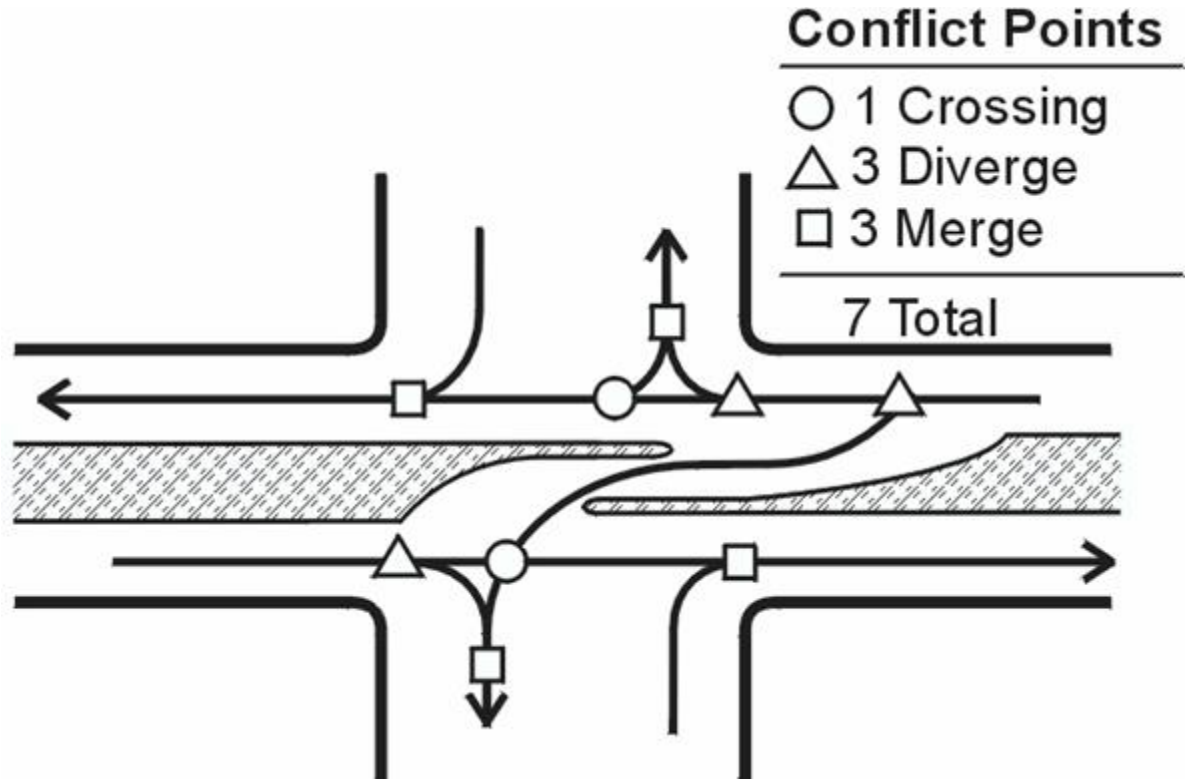
4-Way Intersection or Driveway

Two-lane roadway with raised median (left turn egress only from intersection or driveway)



4-Way Intersection or Driveway

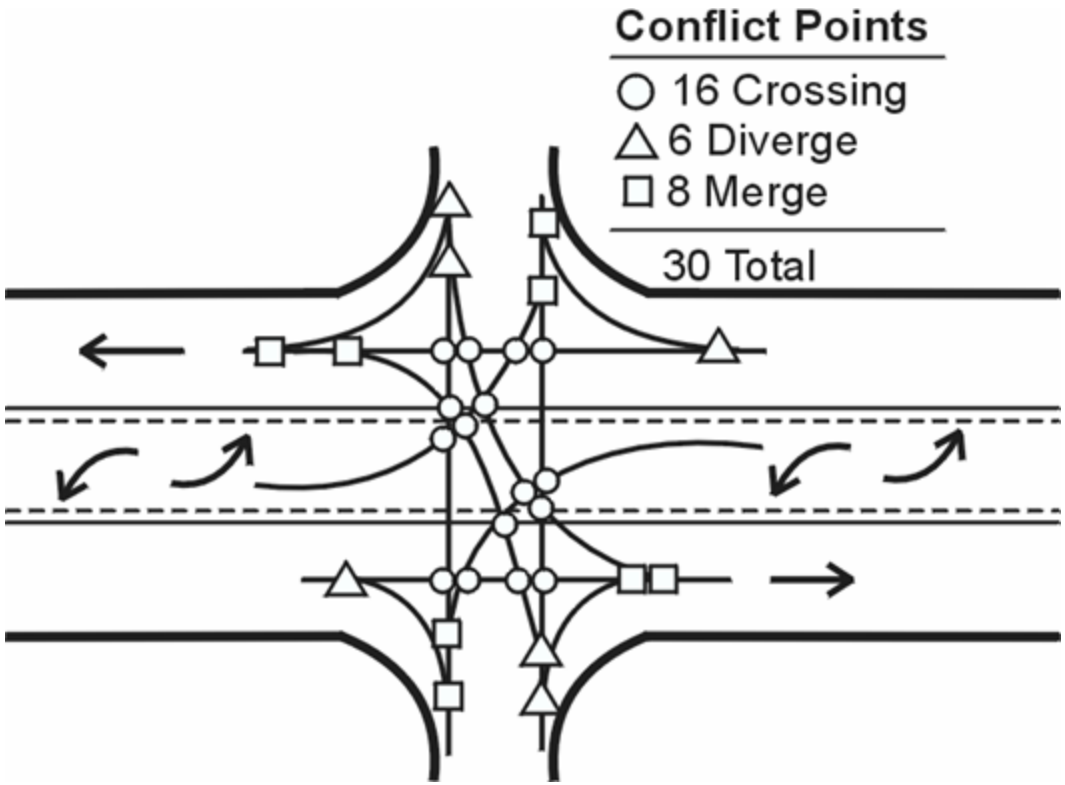
Two-lane roadway with raised median (left turn ingress only into intersection or driveway)



Two-Way Left-Turn Lanes at Intersection or Driveway:

Two-way left-turn lanes (TWLTL) (3 lane roadway)

Reduces rear-end accidents and allows merging traffic to store in TWLTL



Openings in the Raised Median

- New median openings should not be permitted except to accommodate intersecting public roads or streets or large traffic-generating facilities such as shopping centers or industrial plants.

- Median openings may be permitted in these instances if satisfactorily justified and in the public interest.

Median Openings …(see GB for Design specs)

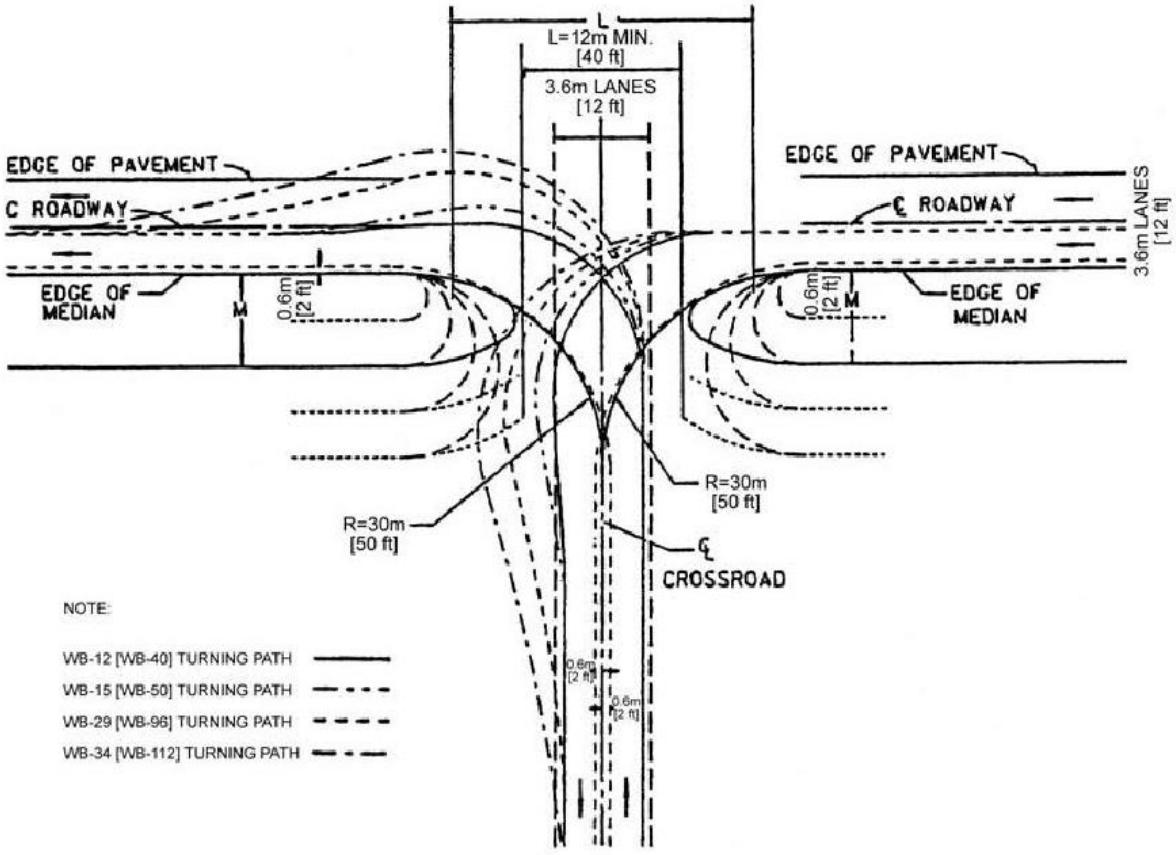


Exhibit 9-81. Minimum Design of Median Openings (SU Design Vehicle, Control Ra 15 m [50 ft])

Metric			US Customary		
M Width of median (m)	L = Minimum length of median opening (m)		M Width of median (ft)	L = Minimum length of median opening (ft)	
	Semicircular	Bullet nose		Semicircular	Bullet nose
1.2	43.8	36.6	4	146	122
1.8	43.2	34.5	6	144	115
2.4	42.6	33.0	8	142	110
3.0	42.0	31.5	10	140	105
3.6	41.4	30.0	12	138	100
4.2	40.8	28.8	14	136	96
4.8	40.2	27.6	16	134	92
6.0	39.0	25.5	20	130	85
7.2	37.8	23.4	24	126	78
8.4	36.6	21.9	28	122	73
9.6	35.4	20.1	32	118	67
10.8	34.2	18.6	36	114	62
12.0	30.0	17.1	40	100	57
18.0	27.0	12.0 min	60	90	40 min
24.0	21.0	12.0 min	80	70	40 min
30.0	15.0	12.0 min	100	50	40 min
33.0	12.0 min	12.0 min	110	40 min	40 min
36.0	12.0 min	12.0 min	120	40 min	40 min

Exhibit 9-80. Minimum Design of Median Openings (WB-12 [WB-40] Design Vehicle, Control Radius of 23 m [75 ft])

Island for No Left Turn



Some examples around Ames

Striping through Intersection: Difficult to See



Curb Radius Parking Lot



Island for No Left Turn



Right Turn Bay Curve



Left Turn Bay Pavement Markings



Curb Radius Curb Cut



Turn Lane Pedestrian Refuge



Curb Cut



RR Crossing



RR Crossing Raised Median



Right Turn Island



Island Pedestrian Refuge



Median End Treatment



Left Turn Bay Curve, Right Turn Bay Taper



Median to Discourage U-Turns



3 Leg Intersection



Median End (Keep Right)



Median End Delineation



Median in front of Lowes



Intersection Approach Lincoln Way at University



Intersection Approach 4th at Lincoln Way



Median: University Blvd. at Airport Rd.

