CHAPTER NINE

AT GRADE INTERSECTIONS

"BULB" TYPE CHANNELIZATION 9-1

Intersection "Bulbs" shall be designed in accordance with the Policy and Procedure Manual 23/1. When there is not adequate space to show intersection details on the plans, intersection detail sheets shall be inserted. Information shown on the sheets shall be restricted to design criteria only that is necessary for the construction of the intersection.

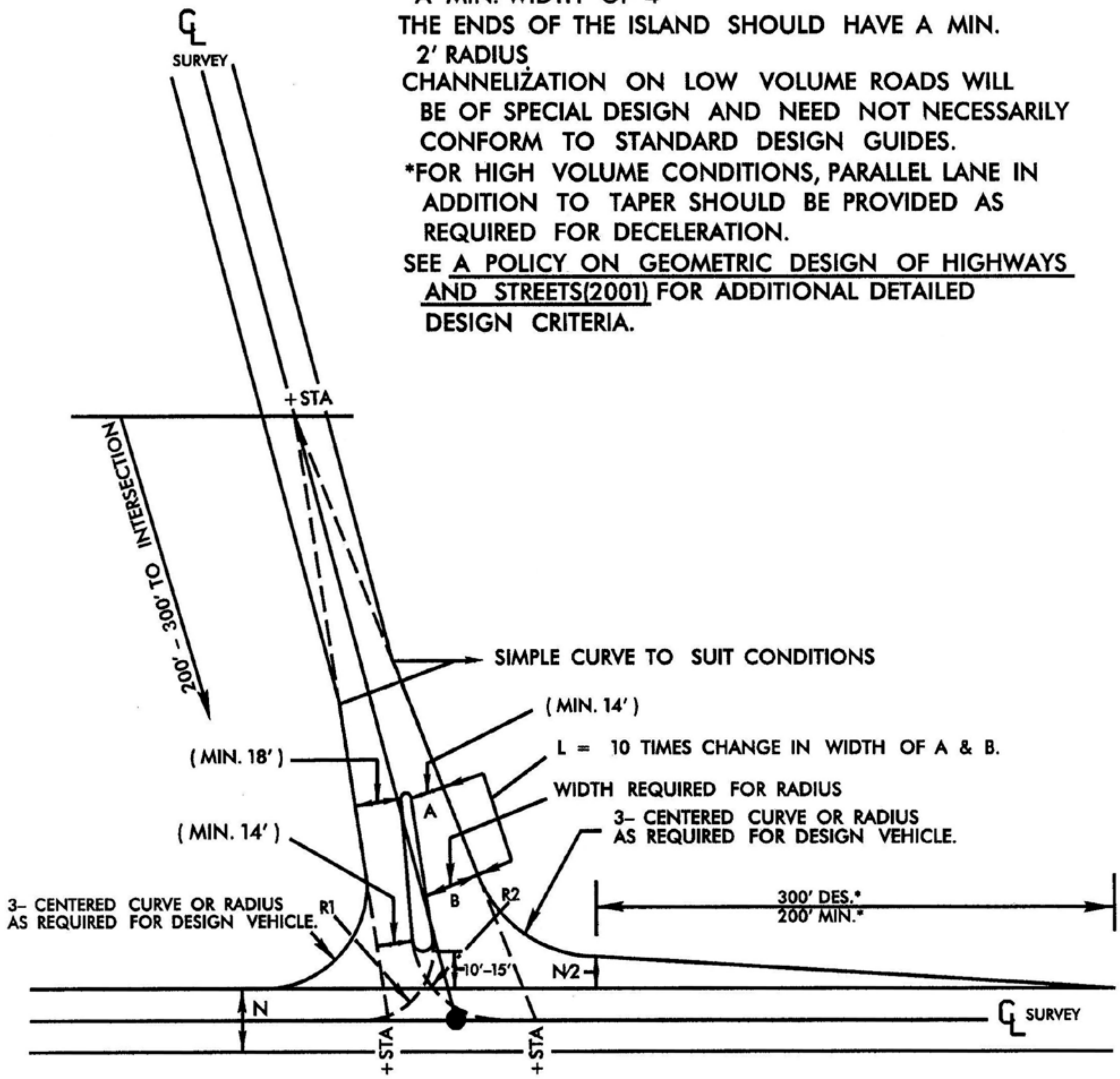
NOTES:

1) Bulb type intersections are to be used on all divided facilities on both paved and unpaved -Y- lines.

2) For additional information, see Chapter 9-1, Figures 1and 2.

FIGURE 1 **9 – 1**
F – 1

NOTES:
SEE POLICY AND PROCEDURE MANUAL 23/1 FOR POLICY ON BULB TYPE INTERSECTIONS.
THE DESIRABLE WIDTH OF THE ISLAND IS 8′ WITH A MIN. WIDTH OF 4′
THE ENDS OF THE ISLAND SHOULD HAVE A MIN. 2′ RADIUS
CHANNELIZATION ON LOW VOLUME ROADS WILL BE OF SPECIAL DESIGN AND NEED NOT NECESSARILY CONFORM TO STANDARD DESIGN GUIDES.
*FOR HIGH VOLUME CONDITIONS, PARALLEL LANE IN ADDITION TO TAPER SHOULD BE PROVIDED AS REQUIRED FOR DECELERATION.
SEE <u>A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS(2001)</u> FOR ADDITIONAL DETAILED DESIGN CRITERIA.

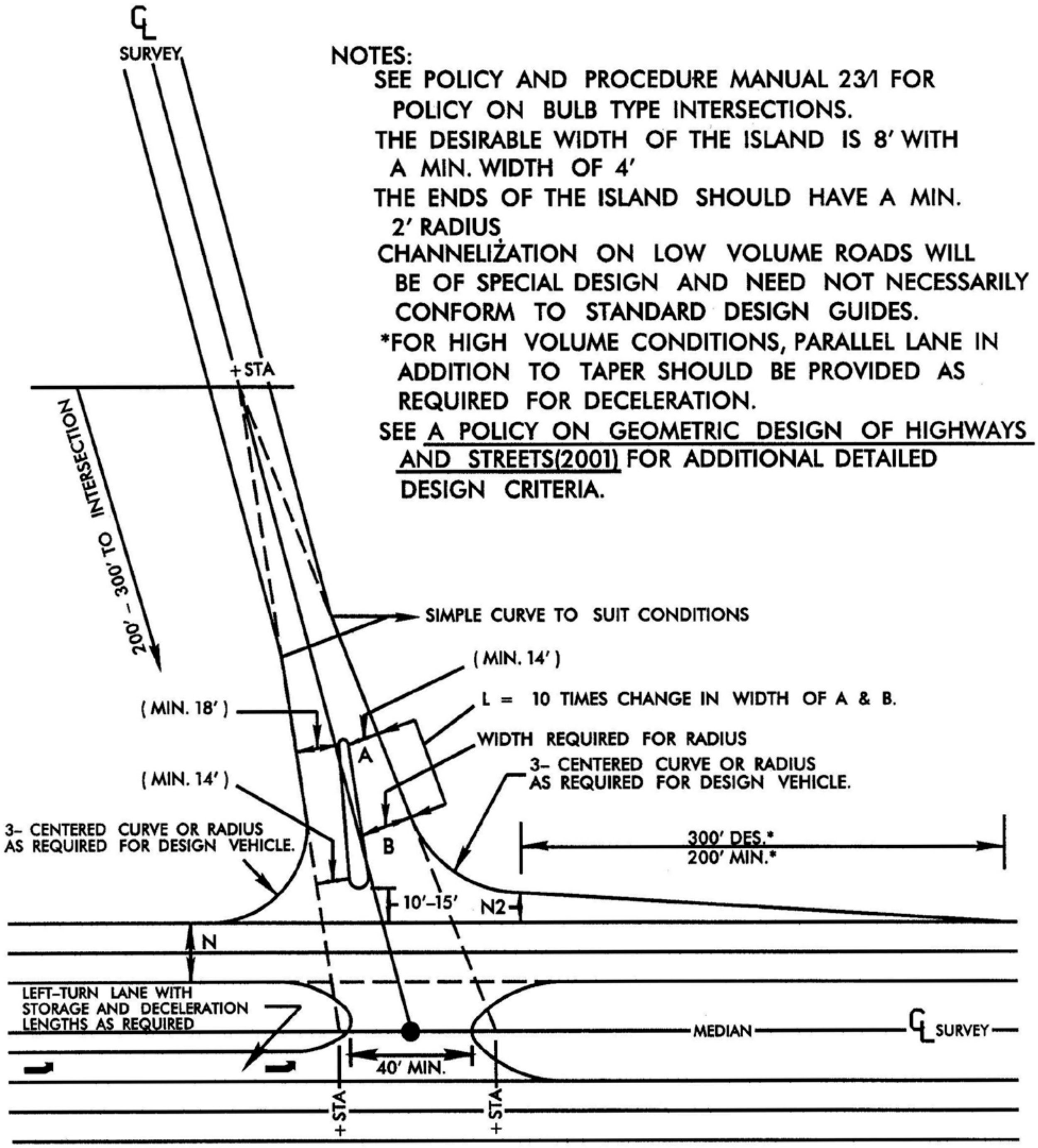


DESIGN GUIDE I

INTERSECTION WITH TWO–LANE FACILITY
USING RIGHT–TURN TAPER

FIGURE 2 **9 – 1**

F – 2

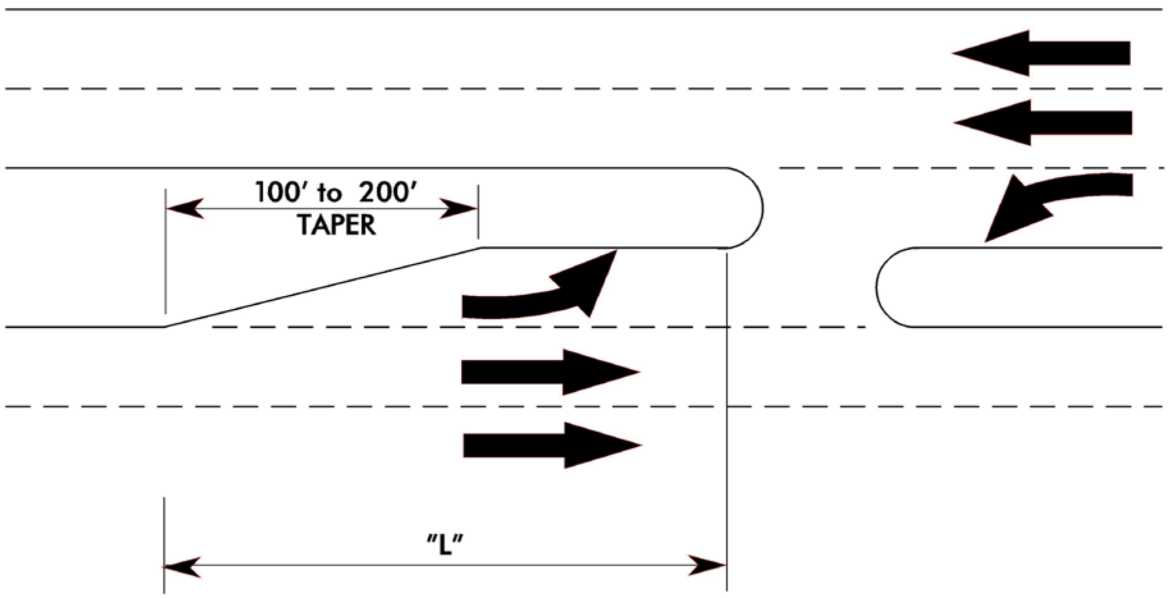


DESIGN GUIDE II

INTERSECTION WITH FOUR–LANE DIVIDED FACILITY

FIGURE 3 **9 – 1**
F – 3

DECELERATION LENGTHS FOR MEDIAN CROSSOVERS AND LEFT TURNING MOVEMENTS



"L" (WHERE VEHICLE STORAGE DOES NOT GOVERN)

NO WAITING VEHICLES

DESIGN SPEED	"L"
40 MPH	330′
50 MPH	550′
60 MPH	680′

Guidelines for Use of Positive Offset
Left Turn Lanes on Median Divided Facilities

Positive offset left turn lanes will be required on median divided facilities where the median width is greater than 20 feet and the following criteria is met.

1. Use at all proposed *signalized* intersections which meet either of the following criteria:

   a. If left turns are designed with exclusive* movements due to inadequate horizontal and/or vertical alignment and there is adequate cross section width available;

   b. TEE intersections with opposing left turn lanes for U-turn traffic

2. Use at all *unsignalized* intersections which meet either of the following criteria:

   a. If 10 year traffic projections satisfy any signal warrants;

   b. Major route left turns meet or exceed 60 vph during the peak hour

3. Use at locations where the engineer determines that its use will improve or provide safer or more efficient traffic operations.

4. Positive offset left turn lanes on median divided facilities should be discussed at the preliminary field inspection.

* Positive offset left turn lanes will help to enhance exclusive left turn signal operations by reducing the time required for the left turn movements to clear the intersection.

FIGURE 3A 9 – 1
F – 3A – 1

GUIDELINES FOR OFFSETTING OPPOSING LEFT–TURN LANES ON DIVIDED ROADWAYS

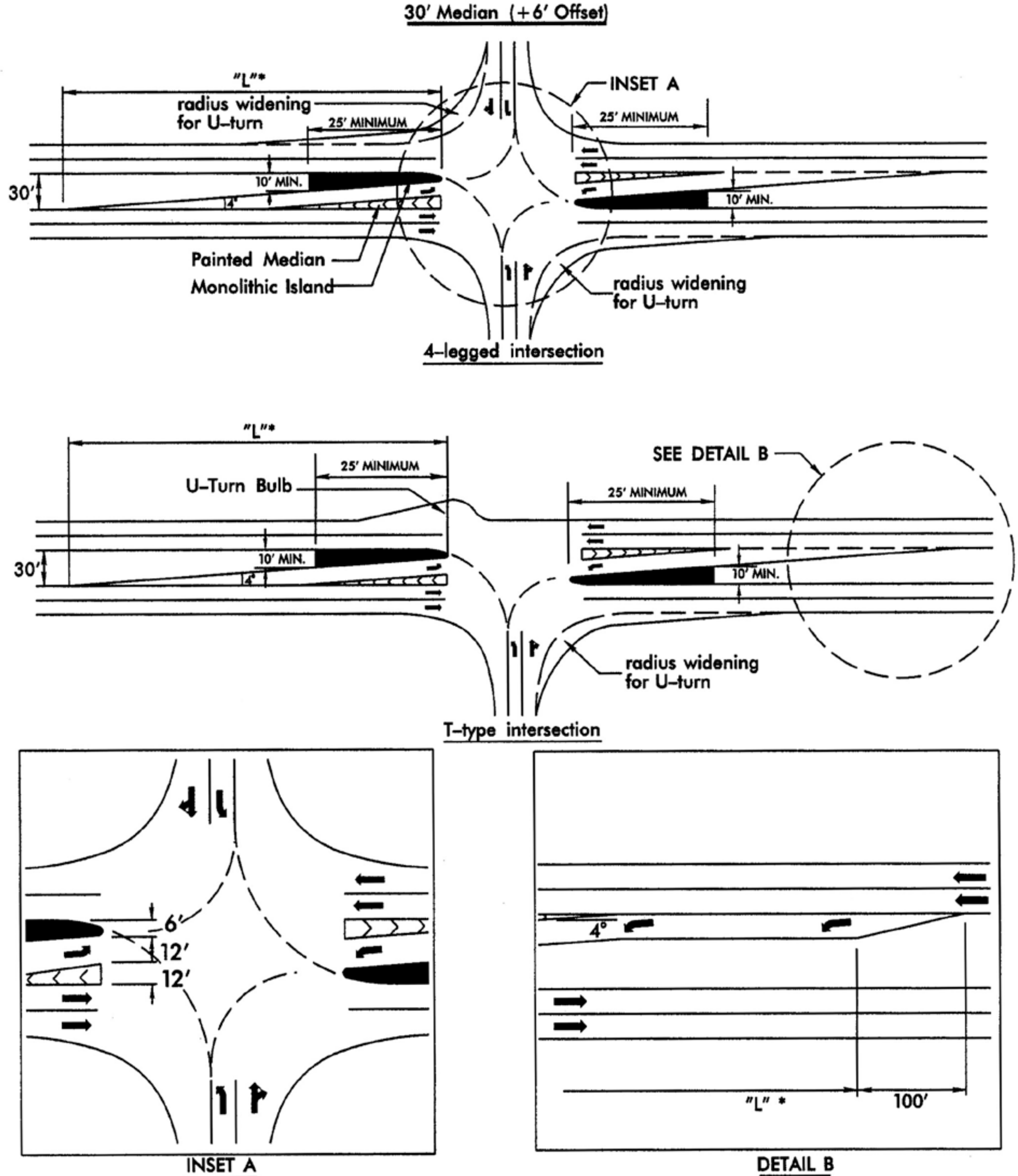
"L" (WHERE VEHICLE STORAGE DOES NOT GOVERN)

DESIGN SPEED	"L"
40 MPH	330'
50 MPH	550'
60 MPH	680'

FIGURE 3A 9-1

F - 3A - 2

GUIDELINES FOR OFFSETTING OPPOSING LEFT–TURN LANES ON DIVIDED ROADWAYS



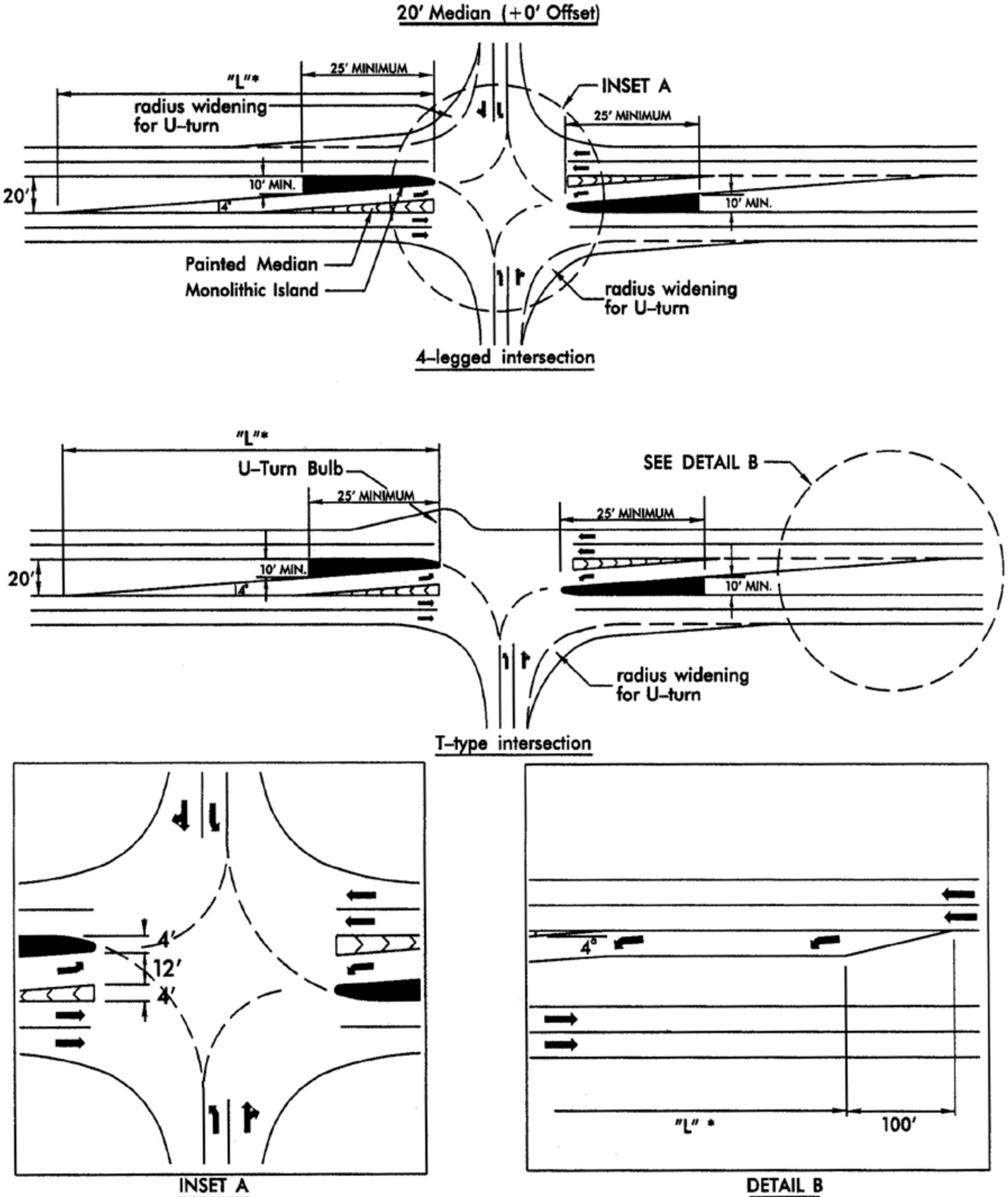
*Note:
A 4 degree skew angle will provide approximately 340′ of deceleration lengths for design speeds up to 40 mph. A parallel deceleration lane can be incorporated for design speeds 50 mph and higher or where additional storage length is required. See Detail B

Design U–turns for passenger vehicles unless project information dictates otherwise.

FIGURE 3-A 9-1

F - 3A - 3

GUIDELINES FOR OFFSETTING OPPOSING LEFT–TURN LANES ON DIVIDED ROADWAYS



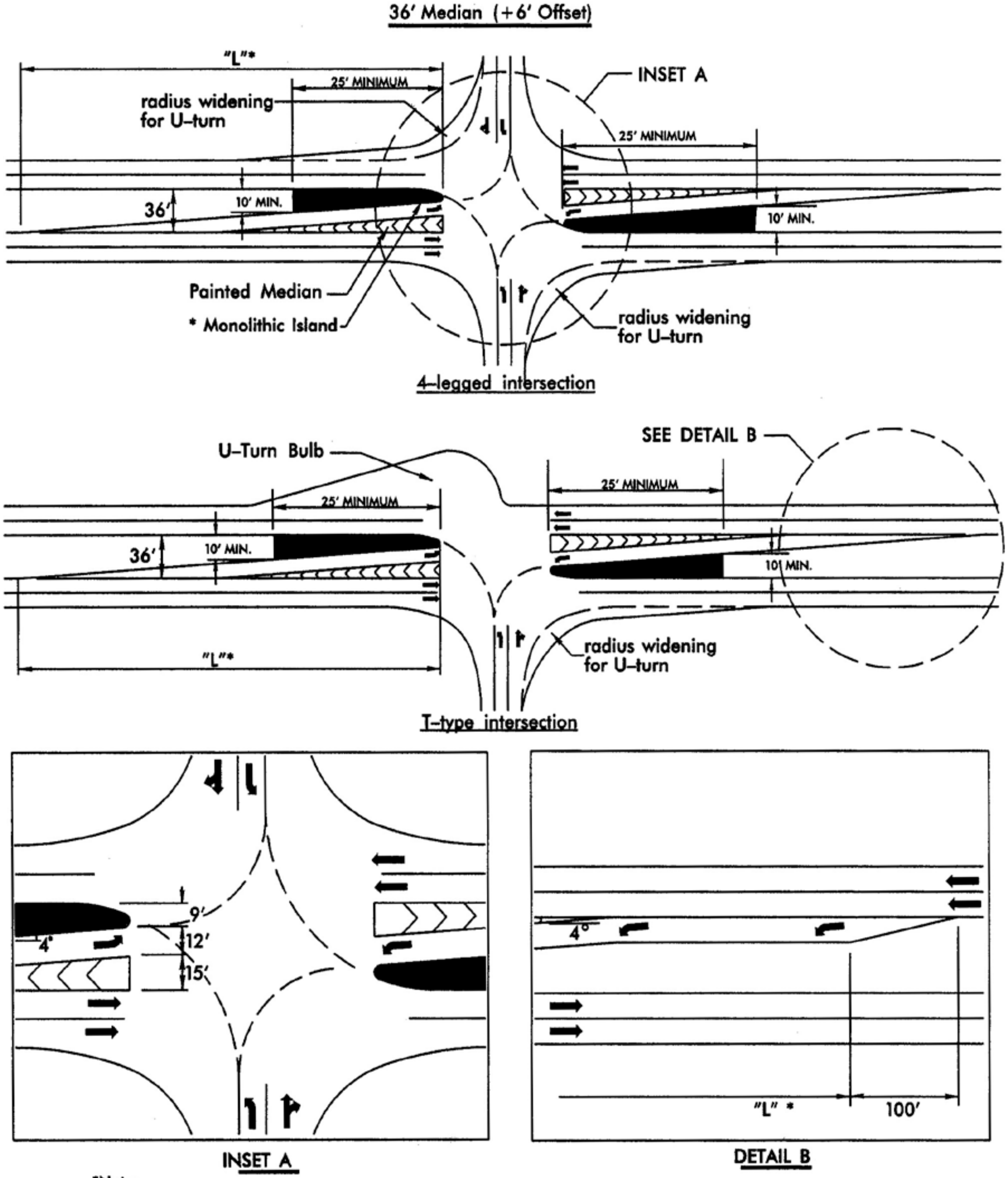
*Note:
A 4 degree skew angle will provide approximately 230′ of deceleration lengths for design speeds up to 30 mph. A parallel deceleration lane can be incorporated for design speeds 40 mph and higher or where additional storage length is required. See Detail B

Design U–turns for passenger vehicles unless project information dictates otherwise.

FIGURE 3-A 9-1

F - 3A - 4

GUIDELINES FOR OFFSETTING OPPOSING LEFT–TURN LANES ON DIVIDED ROADWAYS



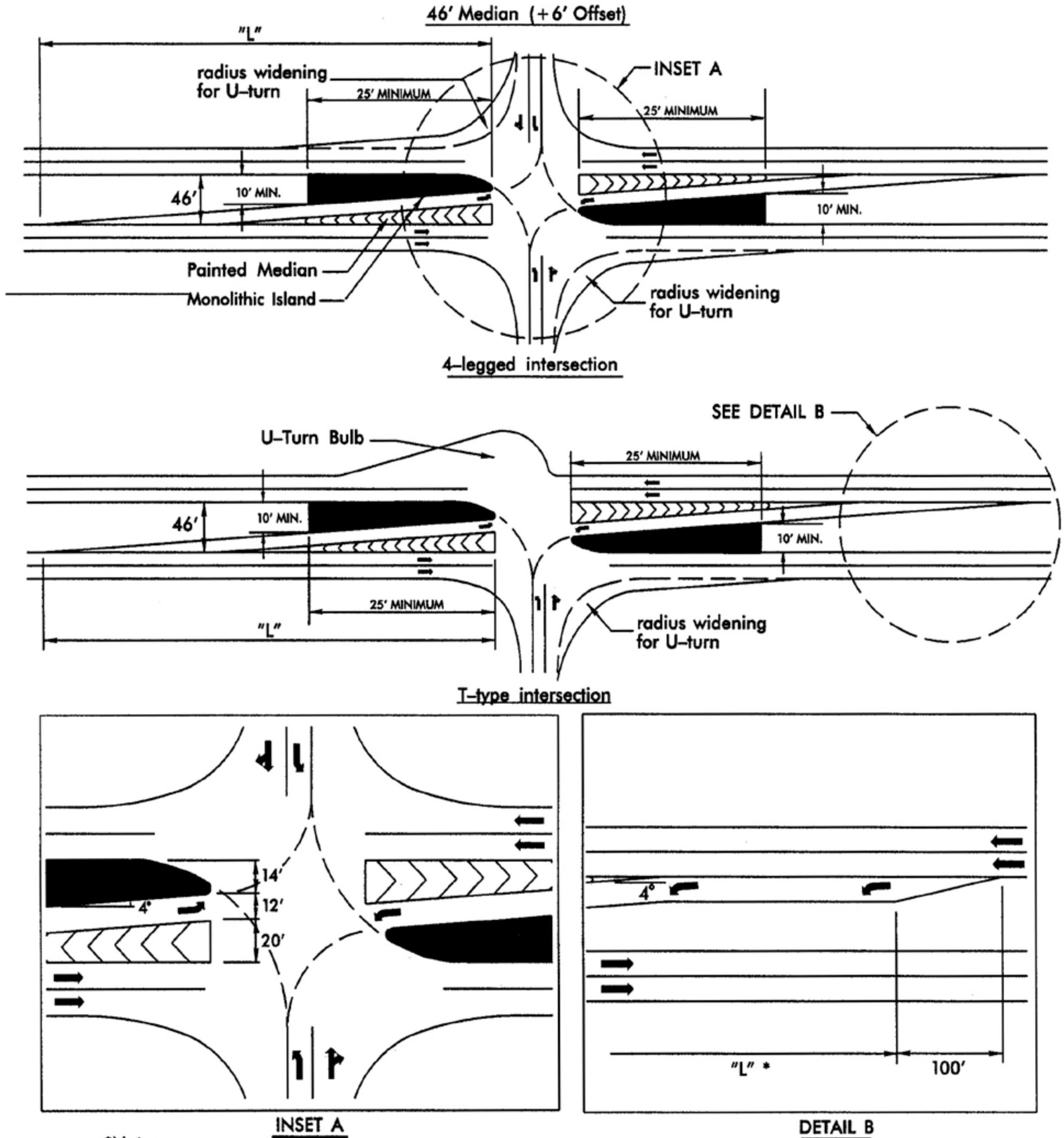
*Note:
A 4 degree skew angle will provide approximately 385′ of deceleration lengths for design speeds up to 40 mph. A parallel deceleration lane can be incorporated for design speeds 50 mph and higher or where additional storage length is required. See Detail B

Design U–turns for passenger vehicles unless project information dictates otherwise.

FIGURE 3-A 9-1

F - 3A - 5

GUIDELINES FOR OFFSETTING OPPOSING LEFT–TURN LANES ON DIVIDED ROADWAYS



*Note:
A 4 degree skew angle will provide approximately 455′ of deceleration lengths for design speeds up to 50 mph. A parallel deceleration lane can be incorporated for design speeds 60 mph and higher or where additional storage length is required. See Detail B

Design U–turns for passenger vehicles unless project information dictates otherwise.

GUIDELINES FOR RIGHT TURN LANE WARRANTS, LEFT AND RIGHT TURN LANE STORAGE LENGTHS AND TAPER LENGTH

RIGHT TURN WARRANTS

Figure 4 charts determine the warrants for either a full right turn lane, taper only, or radius only. These charts were taken from NCHRP 279, “Intersection Channelization Design Guide,” figure 4-23. They were developed from a 1981 Virginia Highway and Transportation Research Council Report.

LEFT AND RIGHT TURN LANE LENGTHS

Once the right turn warrant has been determined and also figures F-4 A, B, and C determine the minimum turn lane or taper length. The left turn lane lengths were revised to reflect the 2001 AASHTO Design Book. This revision basically excluded the taper from the required deceleration length. These lengths are found in A POLICY ON GEOMETRIC DEIGN OF HIGHWAYS AND STREETS (2001) edition, page 718. There were some concerns raised that these revised lengths (deceleration length plus taper length) were excessive. After reviewing in the field, we agreed. Therefore, we recommended revising the turn lane lengths to the distances shown below which include the taper. The justification for including the taper as part of the deceleration length is found in A POLICY ON GEOMETRIC DEIGN OF HIGHWAYS AND STREETS (2001) edition, page 718. It states:

Design Speed	Minimum Right and Left Turn Lane Lengths*	Taper Only For Right Turns
40 mph	330 ′	230′
50 mph	550 ′	265′
60 mph	680 ′	300′

*This length includes the taper. The taper length can range from a minimum of 100′ to a maximum of 150′.

GUIDELINES FOR RIGHT TURN LANE WARRANTS, LEFT AND RIGHT TURN LANE STORAGE LENGTHS AND TAPER LENGTH (Continued)

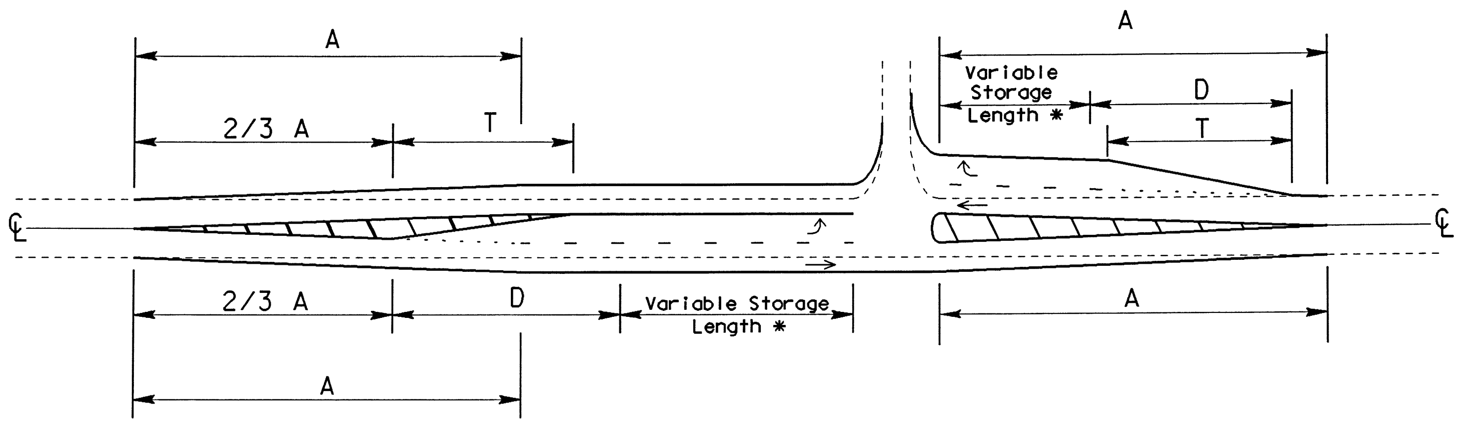
The turn lane lengths have been discussed with the FHWA and no design exceptions are required for the above lengths. As with any guidelines, there will be exceptions based on site conditions and engineering judgement. However, these guidelines should provide some overall consistency.

FIGURE 4 **9 - 1**

F – 4 A

Recommended Treatment for Turn Lanes

Symmetrical Widening



Design Speed (mph)	Posted Speed (mph)	Minimum Deceleration Length (D)	Desirable Deceleration Length (D)	Bay Taper Length (T)	Approach / Departure Taper (A)
30	≦ 25	100'	150'	75'	$A = WS^2/60$ (IF $S \leq 40$ MPH)
35	30	100'	150'	75'	$A = WS$ (IF $S > 40$ MPH)
40	35	150'	200'	100'	S = Design Speed
45	40	150'	250'	100'	W = Width of Lateral Shift
50	45	150'	300'	100'	* Storage length for waiting vehicles should be calculated based on the latest version of the Highway Capacity Manual or Policy on Street and Driveway Access to North Carolina Highways.
55	50	200'	500'	150'	
60	55	250'	575'	200'	

FIGURE 4 **9 - 1**

F – 4 B

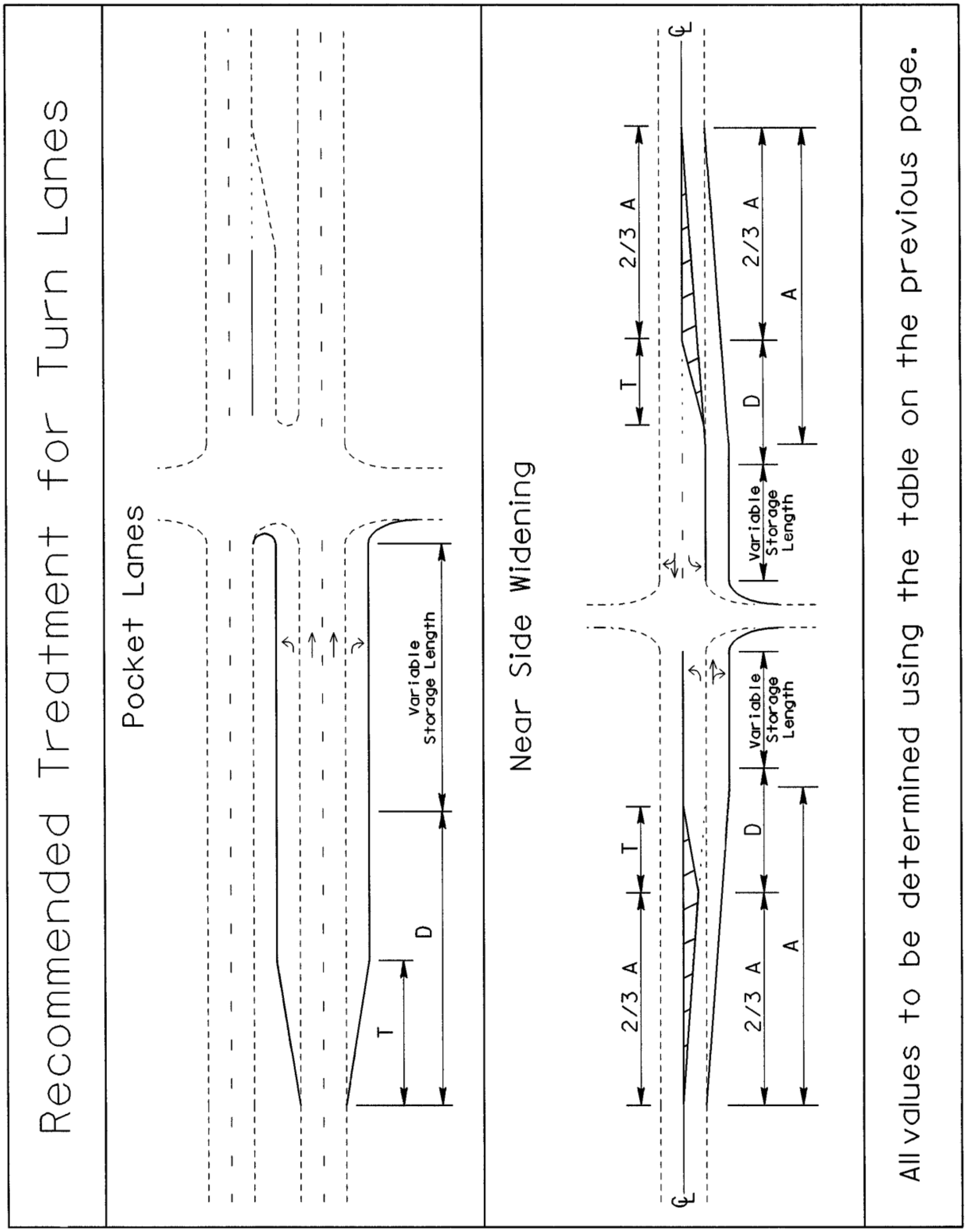
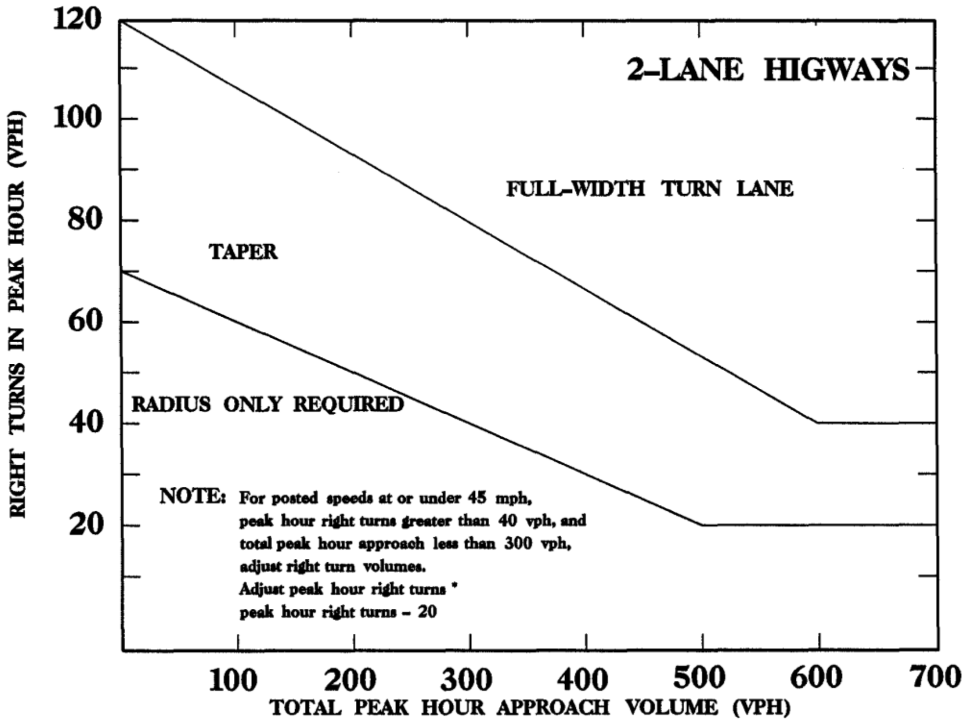
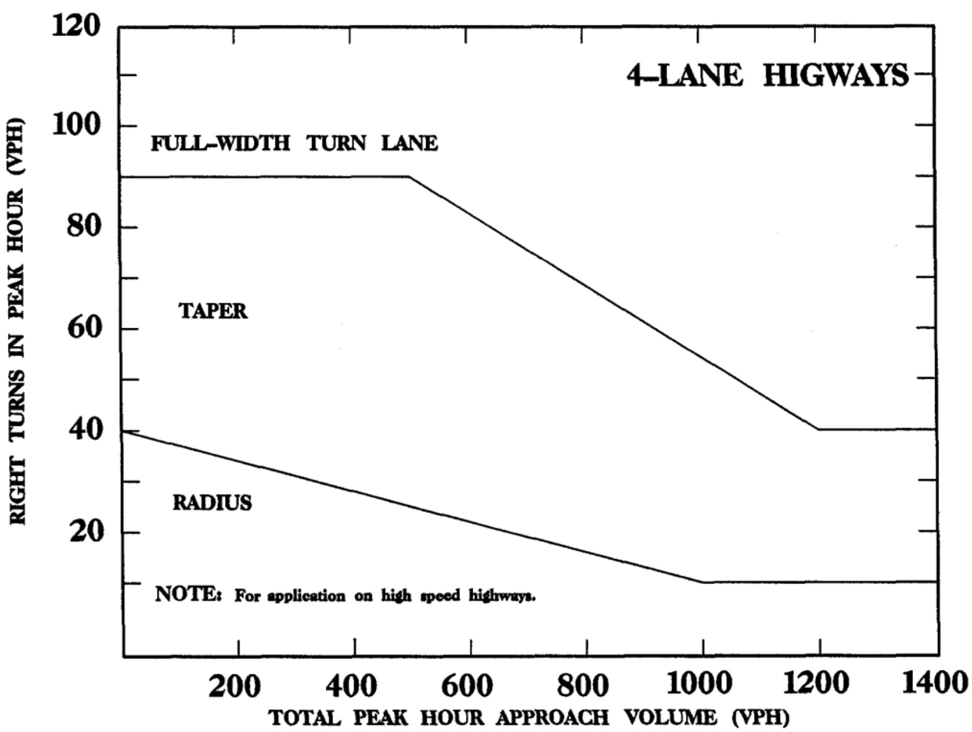


FIGURE 4 **9 - 1**

F – 4 C

RIGHT TURN LANE WARRANTS





THREE CENTERED CURVES 9-2

Three centered curves shall be constructed at locations in accordance with the Policy and Procedure Manual 23/1. The critical dimensions of three centered curves have been worked out for each combination of radii in increments of one degree of angle of turn. These intervals permit a straight line interpolation between the listed values with a maximum error of 0.02’ which is within the practical limits of field layout or construction.

Normally, the range in angles of turn permitted for an at-grade intersection is between 60 degrees and 120 degrees. The computations in these tables have been extended to the range of 53 degrees to 128 degrees to provide for those few cases which exceed these normal limits.

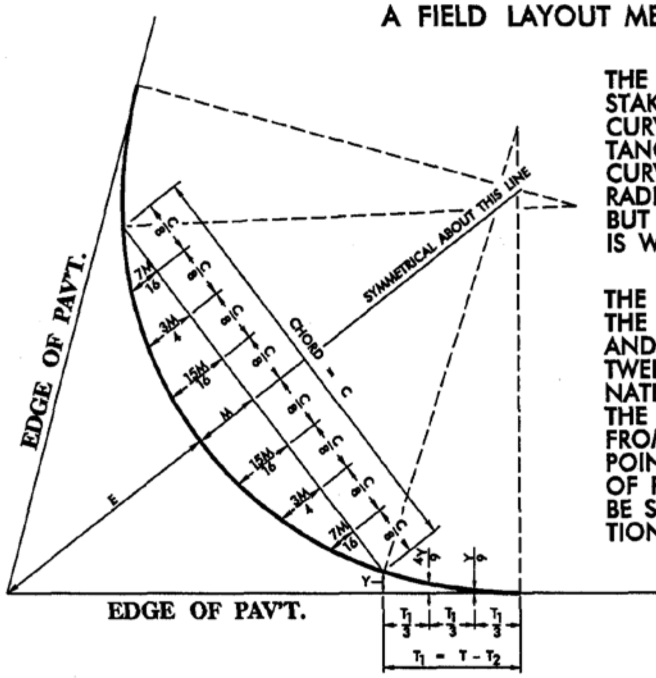
When three-centered compound curves are recommended on a project and the design computations are not in the Design Manual, they shall be shown on the plans for the benefit of the Resident Engineer in laying out the curves in the field.

FIGURE 1

9 – 2

F – 1

A FIELD LAYOUT METHOD

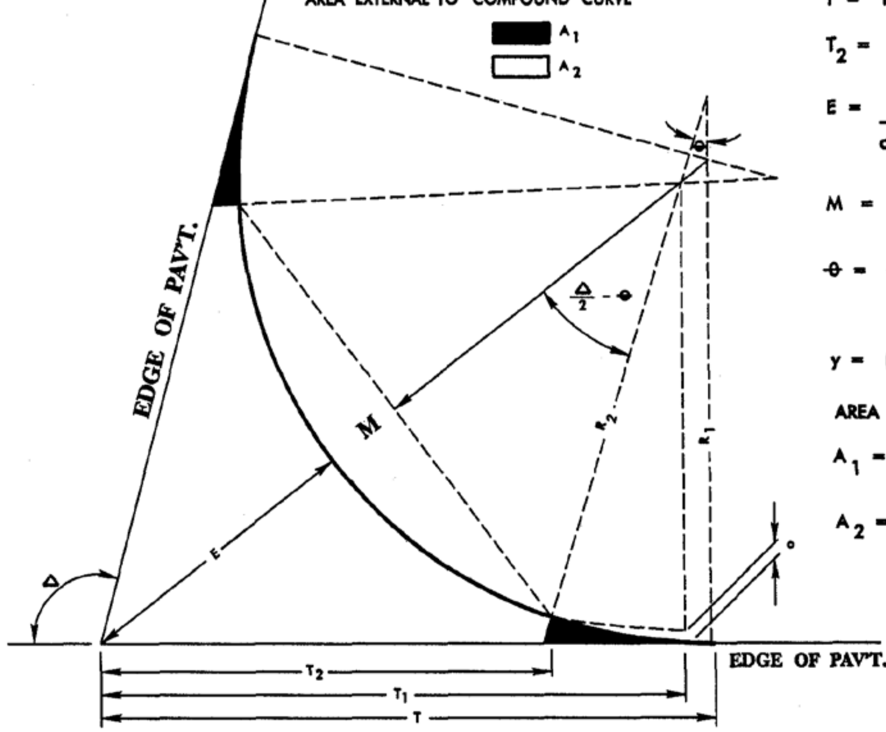


THE FOLLOWNG METHOD IS SUGGESTED FOR STAKING OUT 3–CENTERED CURVES (WHEN CURVE CENTERS ARE INACCESSIBLE) BY TANGENT OFFSETS FOR THE LONG RADIUS CURVE AND CHORD OFFSETS FOR THE SHORT RADIUS CURVE. THE CURVES ARE PARABOLIC BUT ANY DEVIATON FROM A CIRCULAR CURVE IS WITHIN TOLORABLE LIMITS.

THE CHORD IS DETERMINED BY STAKING OUT THE TWO POINTS OF COMPOUND CURVATUE AND THEN MEASURNG THE DISTANCE BETWEEN THESE TWO POINTS. THE MID ORDINATE M IS DETERMINED BY SUBTRACTING THE EXTERNAL FROM THE MEASURED DISTANCE FROM THE MID POINT ON THE CHORD TO THE POINT OF INTERSECTION OF THE TWO EDGES OF PAVEMENT. THE VALUE OF M MAY ALSO BE SELECTED DIRECTLY (OR BY INTERPOLATION) FROM THE APPROPRIATE TABLE.

FORMULAS USED

GIVEN Δ, o, R_1 AND R_2
TO FIND T, T_1, T_2, E, M, θ, y AND
AREA EXTERNAL TO COMPOUND CURVE



$$T_1 = (R_2 + o)\tan\frac{\Delta}{2}$$

$$T = T_1 + (R_1 - R_2)\sin\theta$$

$$T_2 = T_1 + R_2\sin\theta$$

$$E = \frac{R_2 + o}{\cos\frac{\Delta}{2}} - R_2$$

$$M = R_2 - [R_2\cos(\frac{\Delta}{2} - \theta)]$$

$$\theta = \cos^{-1}\frac{R_1 - R_2 - o}{R_1 - R_2}$$

$$y = (R_2 + o) - R_2\cos\theta$$

$$AREA = A_1 + A_2$$

$$A_1 = R_1^2\tan\theta - \frac{\pi R_1^2\theta}{180}$$

$$A_2 = (R_2 + o)[T_1 - (R_2 + o)\tan\theta] - \frac{\pi R_2^2(\frac{\Delta}{2} - \theta)}{180}$$

TABLE 2 **9 – 2**

T – 2

TYPICAL DESIGNS FOR TURNING ROADWAYS

ANGLE OF TURN (DEGREES)	DESIGN CLASSIFICATION	THREE – CENTERED COMPOUND CURVE RADII (ft)	THREE – CENTERED COMPOUND CURVE OFFSET (ft)	WIDTH OF LANE (ft)	APPROX. ISLAND SIZE (ft)
75	A	150–75–150	3.5	14	60
	B	150–75–150	5.0	18	50
	C	220–135–220	5.0	22	360
90[a]	A	150–50–150	3.0	14	50
	B	150–50–150	11.0	21	150
	C	200–70–200	11.0	25	270
105	A	120–40–120	2.0	15	70
	B	150–35–150	11.5	29	65
	C	180–60–180	9.5	32	260
120	A	100–30–100	2.5	16	120
	B	150–30–150	10.5	33	130
	C	140–55–140	7.0	45	215
135	A	100–30–100	2.5	16	460
	B	150–30–150	10.0	38	395
	C	140–45–140	7.0	52	485
150	A	100–30–100	2.5	16	1400
	B	150–30–150	9.0	42	1350
	C	160–40–160	6.0	53	1590

[a] ILLUSTRATED IN EXHIBIT 9–43 IN " A POLICY ON GEOMENTRIC DESIGN OF HIGHWAYS AND STREETS" (2011)

NOTE: ASYMMETRIC THREE – CENTERED COMPOUND CURVES AND STRAIGHT TAPERS WITH A SIMPLE CURVE CAN ALSO BE USED WITHOUT SIGNIFICANTLY ALTERING THE WIDTH OF ROADWAY OR CORNER ISLAND SIZE. PAINTED ISLAND DELINEATION IS RECOMMENDED FOR ISLANDS LESS THAN 75 $ft.^2$ IN SIZE.

DESIGN CLASSIFICATION:

A – PRIMARILY PASSENGER VEHICLES; PERMITS OCCASIONAL DESIGN SINGLE–UNIT TRUCKS TO TURN WITH RESTRICTED CLEARANCES.

B – PROVIDES ADEQUATELY FOR THE SU–30 AND SU–40 DESIGN VEHICLES; PERMITS OCCASIONAL WB–62 DESIGN VEHICLES TO TURN WITH SLIGHT ENCROACHMENT ON ADJACENT TRAFFIC LANES.

C – PROVIDES FULLY FOR WB–62.

TABLE 3 9-2

T-3

See Edge of Traveled Way For Turns at Intersections
(Simple Curve), Table 9-15

Angle of Turn (Degrees)	Design Vehicle	Simple Curve Radius	Simple Curve Radius with Taper		
			Radius (ft.)	Offset (ft.)	Taper (ft.:ft.)
30	P	60	-	-	-
	SU-30	100	-	-	-
	SU-40	140	-	-	-
	WB-40	150	-	-	-
	WB-62	360	220	3.0	15:1
	WB-67	380	220	3.0	15.1
	WB-92D	365	190	3.0	15.1
	WB-100T	260	125	3.0	15.1
	WB-109D	475	260	3.5	20.1
45	P	50	-	-	-
	SU-30	75	-	-	-
	SU-40	115	-	-	-
	WB-40	120	-	-	-
	WB-62	230	145	4.0	15:1
	WB-67	250	145	4.5	15:1
	WB-92D	270	145	4.0	15:1
	WB-100T	200	115	2.5	15:1
	WB-109D	-	200	4.5	20:1
60	P	40	-	-	-
	SU-30	60	-	-	-
	SU-40	100			
	WB-40	90	-	-	-
	WB-62	170	140	4.0	15:1
	WB-67	200	140	4.5	15:1
	WB-92D	230	120	5.0	15:1
	WB-100T	150	95	2.5	15:1
	WB-109D	-	180	4.5	20:1

TABLE 3 (continued) 9-2
T-3

See Edge of Traveled Way For Turns at Intersections
(Simple Curve)

Angle of Turn (Degrees)	Design Vehicle	Simple Curve Radius	Simple Curve Radius with Taper		
			Radius (ft.)	Offset (ft.)	Taper (ft.:ft.)
75	P	35	25	2.0	10:1
	SU-30	55	45	2.0	10:1
	SU-40	90	60	2.0	10:1
	WB-40		60	2.0	15:1
	WB-62		145	4.0	20:1
	WB-67	-	145	4.5	20:1
	WB-92D	-	110	5.0	15:1
	WB-100T		85	3.0	15:1
	WB-109D	-	140	5.5	20:1
90	P	30	20	2.5	10:1
	SU-30	50	40	2.0	10:1
	SU-40	80	45	4.0	10:1
	WB-40		45	4.0	10:1
	WB-62		120	4.5	30:1
	WB-67		125	4.5	30:1
	WB-92D	-	95	6.0	10:1
	WB-100T	-	85	2.5	15:1
	WB-109D	-	115	2.9	15:1
105	P	-	20	2.5	8:1
	SU-30		35	3.0	10:1
	SU-40		45	4.0	10:1
	WB-40		40	4.0	10:1
	WB-62		115	3.0	15:1
	WB-67	-	115	3.0	15:1
	WB-92D	-	80	8.0	10:1
	WB-100T	-	75	3.0	15:1
	WB-109D	-	90	9.2	20:1

TABLE 3 (continued) 9-2
T-3

See Edge of Traveled Way For Turns at Intersections
(Simple Curve)

Angle of Turn (Degrees)	Design Vehicle	Simple Curve Radius	Simple Curve Radius with Taper		
			Radius (ft.)	Offset (ft.)	Taper (ft.:ft.)
120	P	-	20	2.0	10:1
	SU-30	-	30	3.0	10:1
	SU-40	-	35	6.0	8:1
	WB-40	-	35	5.0	8:1
	WB-62	-	100	5.0	15:1
	WB-67	-	105	5.2	15:1
	WB-92D	-	80	7.0	10:1
	WB-100T	-	65	3.5	15:1
	WB-109D	-	85	9.2	20:1
135	P	-	20	1.5	10:1
	SU-30	-	30	4.0	10:1
	SU-40	-	40	4.0	8:1
	WB-40	-	30	8.0	15:1
	WB-62	-	80	5.0	20:1
	WB-67	-	85	5.2	20:1
	WB-92D	-	75	7.3	10:1
	WB-100T	-	65	5.5	15:1
	WB-109D	-	85	8.5	20:1
150	P	-	18	2.0	10:1
	SU-30	-	30	4.0	8:1
	SU-40		35	7.0	8:1
	WB-40		30	6.0	8:1
	WB-62		60	10.0	10:.
	WB-67		65	10.2	10:1
	WB-92D	-	65	11.0	10:1
	WB-100T	-	65	7.3	10:1
	WB-109D	-	65	15.1	10:1

TABLE 3 (continued) 9-2
T-3

See Edge of Traveled Way For Turns at Intersections
(Simple Curve)

Angle of Turn (Degrees)	Design Vehicle	Simple Curve Radius	Simple Curve Radius with Taper		
			Radius (ft.)	Offset (ft.)	Taper (ft.:ft.)
180	P	-	15	0.5	20:1
	SU-30	-	30	1.5	10:1
	SU-40	-	35	6.4	10:1
	WB-40	-	20	9.5	5:1
	WB-62	-	55	10.0	15:1
	WB-67	-	55	13.8	10:1
	WB-92D	-	55	16.8	10:1
	WB-100T	-	55	10.2	10:1
	WB-109D	-	55	20.0	10:1

For Additional Information, See A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS (2011) edition.

TABLE 3A 9-2

T-3A

See Edge of Traveled Way For Turns at Intersections
(Compound Curve), Exhibit 9-20

Design Vehicle	Angle of Turn	3-Centered Compound		3-Centered Compound	
		Curve Radii	Symmetric Offset	Curve Radii	Asymmetric Offset
	Degrees	Feet	Feet	Feet	Feet
P	30	-	-	-	-
SU-30		-	-	-	-
SU-40		-	-	-	-
WB-40		-	-	-	-
WB-62		-	-	-	-
WB-67		460-175-460	4.0	300-175-550	2.0-4.5
WB-92D		550-155-500	4.0	200-150-500	2.0-6.0
WB-100T		220-80-220	4.5	200-80-300	2.5-5.0
WB-109D		550-250-550	5.0	250-200-650	1.5-7.0
P	45	-	-	-	-
SU-30		-	-	-	-
SU-40		-	-	-	-
WB-40		-	-	-	-
WB-62		460-240-460	2.0	120-140-500	3.0-8.5
WB-67		460-175-460	4.0	250-125-600	1.0-6.0
WB-92D		525-155-525	5.0	200-140-500	1.5-6.0
WB-100T		250-80-250	4.5	200-80-300	2.5-5.5
WB-109D		550-200-550	5.0	200-170-650	1.5-7.0
P	60	-	-	-	-
SU-30		-	-	-	-
SU-40		-	-	-	-
WB-40		-	-	-	-
WB-62		400-100-400	15.0	110-100-220	10.0-12.5
WB-67		400-100-400	8.0	250-125-600	1.0-6.0
WB-92D		480-110-480	6.0	150-110-300	3.0-9.0
WB-100T		250-80-250	4.5	200-80-300	2.0-5.5
WB-109D		650-150-650	5.5	200-140-600	1.5-8.0

TABLE 3A (continued) 9-2
T-3A

See Edge of Traveled Way For Turns at Intersections
(Compound Curve)

Design Vehicle	Angle of Turn	3-Centered Compound Curve Radii	3-Centered Compound Symmetric Offset	3-Centered Compound Curve Radii	3-Centered Compound Asymmetric Offset
	Degrees	Feet	Feet	Feet	Feet
P	75	30-8-30	0.6	-	-
SU-30		36-14-36	0.6	-	-
SU-40		61-11-61	1.5	18-14-61	0.3-1.4
WB-40		36-14-36	1.5	36-14-60	0.6-2.0
WB-62		134-23-134	4.5	43-30-165	1.5-3.6
WB-67		128-23-128	3.0	61-24-183	0.3-3.0
WB-92D		152-29-152	2.1	46-30-152	0.3-2.4
WB-100T		76-24-76	1.4	30-24-91	0.5-1.5
WB-109D		213-38-213	2.0	46-34-168	0.5-3.5
P	90	100-20-100	2.5	-	-
SU-30		120-40-120	2.0	-	-
SU-40		200-30-200	7.0	60-45-200	1.0-4.5
WB-40		120-40-120	5.0	120-40-200	2.0-6.5
WB-62		400-70-400	10.0	160-70-360	6.0-10.0
WB-67		440-65-440	10.0	200-70-600	1.0-11.0
WB-92D		470-75-470	10.0	150-90-500	1.5-8.5
WB-100T		250-70-250	4.5	200-70-300	1.0-5.0
WB-109D		700-110-700	6.5	100-95-550	2.0-11.5
P	105	100-20-100	2.5	-	-
SU-30		100-35-100	3.0	-	-
SU-40		200-35-200	6.0	60-40-190	1.5-6.0
WB-40		100-35-100	5.0	100-55-200	2.0-8.0
WB-62		520-50-520	15.0	360-75-600	4.0-10.5
WB-67		500-50-500	13.0	200-65-600	1.0-11.0
WB-92D		500-80-500	8.0	150-80-500	2.0-10.0
WB-100T		250-60-250	5.0	100-60-300	1.5-6.0
WB-109D		700-95-700	8.0	150-80-500	3.0-15.0

TABLE 3A (continued) 9-2
T-3A

See Edge of Traveled Way For Turns at Intersections
(Compound Curve)

Design Vehicle	Angle of Turn	3-Centered Compound Curve Radii	3-Centered Compound Symmetric Offset	3-Centered Compound Curve Radii	3-Centered Compound Asymmetric Offset
	Degrees	Feet	Feet	Feet	Feet
P	120	100-20-100	2.0	-	-
SU-30		100-30-100	3.0	-	-
SU-40		200-35-200	6.0	60-40-190	1.5-5.0
WB-40		120-30-120	6.0	100-30-180	2.0-9.0
WB-62		520-70-520	10.0	80-55-520	24.0-17.0
WB-67		550-45-550	15.0	200-60-600	2.0-12.5
WB-92D		500-70-500	10.0	150-70450	3.0-10.5
WB-100T		250-60-250	5.0	100-60-300	1.5-6.0
WB-109D		700-85-700	9.0	150-70-500	7.0-17.4
P	135	100-20-100	1.5	-	-
SU-30		100-30-100	4.0	-	-
SU-40		200-40-200	4.0	60-40-180	1.5-5.0
WB-40		120-30-120	6.5	100-25-180	3.0-13.0
WB-62		600-60-600	12.0	100-60-640	14.0-7.0
WB-67		550-45-550	16.0	200-60-600	2.0-12.5
WB-92D		450-70-450	9.0	150-65-450	7.0-13.5
WB-100T		250-60-250	5.5	100-60-300	2.5-7.0
WB-109D		700-70-700	12.0	150-65-500	14.0-18.4
P	150	75-20-75	2.0	-	-
SU-30		100-30-100	4.0	-	-
SU-40		200-35-200	6.5	60-40-200	1.0-4.5
WB-40		100-30-100	6.0	90-25-160	1.0-12.0
WB-62		480-55-480	15.0	140-60-560	8.0-10.0
WB-67		550-45-550	19.0	200-55-600	7.0-16.4
WB-92D		350-60-350	15.0	120-65-450	6.0-13.0
WB-100T		250-60-250	7.0	100-60-300	5.0-8.0
WB-109D		700-65-700	15.0	200-65-500	9.0-18.4

See Edge of Traveled Way For Turns at Intersections
(Compound Curve)

Design Vehicle	Angle of Turn	3-Centered Compound Curve Radii	3-Centered Compound Symmetric Offset	3-Centered Compound Curve Radii	3-Centered Compound Asymmetric Offset
	Degrees	Feet	Feet	Feet	Feet
P	180	50-15-50	0.5	-	-
SU-30		100-30-100	1.5	-	-
SU-40		150-35-150	6.2	50-35-130	5.5-7.0
WB-40		100-20-100	9.5	85-20-150	6.0-13.0
WB-62		800-45-800	20.0	100-55-900	15.0-15.0
WB-67		600-45-600	20.5	100-55-400	6.0-15.0
WB-92D		400-55-400	16.8	120-60-400	9.0-14.5
WB-100T		250-55-250	9.5	100-55-300	8.5-10.5
WB-109D		700-55-700	20.0	200-60-500	10.0-21.0

For Additional Information, See A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS (2011) edition.

TABLE 4 **9 - 2**

T - 4

VARIABLE DIMENSIONS OF 3-CENTERED CURVES WITHOUT ISLANDS (Refer to 9-2 Table 2)

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	113	46.97	60.43	85.43	37.47	5.94	1245.1	113
C43	112	45.84	59.30	84.30	36.53	5.77	1210.5	112
	111	44.74	58.20	83.20	35.62	5.61	1177.1	111
R1 = 100'	110	43.66	57.13	82.13	34.74	5.44	1144.8	110
R2 = 35'	109	42.62	56.08	81.08	33.88	5.28	1113.6	109
	108	41.59	55.06	80.06	33.05	5.12	1083.4	108
• = 5.0'	107	40.60	54.06	79.06	32.25	4.96	1054.1	107
	106	39.62	53.08	78.08	31.47	4.81	1025.8	106
Θ = 22°37.20'								
	105	38.68	52.13	77.13	30.71	4.65	998.4	105
y = 7.69'	104	37.74	51.20	76.20	29.97	4.50	971.9	104
	103	36.83	50.29	75.29	29.26	4.35	946.1	103
	102	35.93	49.40	74.40	28.56	4.21	921.2	102
	101	35.06	48.52	73.52	27.89	4.06	897.0	101
	100	34.21	47.67	72.67	27.23	3.92	873.5	100
	99	33.37	46.83	71.83	26.59	3.78	850.8	99
	98	32.55	46.02	71.02	25.97	3.64	828.7	98

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	98	39.43	48.32	66.09	24.02	7.71	672.5	98
SU	97	38.58	47.47	65.25	23.39	7.50	651.1	97
	96	37.76	46.65	64.42	22.77	7.30	630.3	96
R1 = 120'	95	36.95	45.84	63.61	22.17	7.10	610.2	95
R2 = 40'	94	36.15	45.04	62.82	21.58	6.90	590.8	94
	93	35.37	44.26	62.04	21.02	6.71	572.0	93
• = 2.0'	92	34.60	43.49	61.27	20.46	6.51	553.7	92
	91	33.85	42.74	60.52	19.92	6.33	536.1	91
Θ = 12°50.34'								
	90	33.11	42.00	59.78	19.40	6.14	519.0	90
y = 3.00'	89	32.39	41.27	59.05	18.89	5.95	502.4	89
	88	31.67	40.56	58.34	18.39	5.77	486.4	88
	87	30.97	39.86	57.63	17.90	5.59	470.8	87
	86	30.28	39.17	56.94	17.43	5.42	455.8	86
	85	29.60	38.49	56.26	16.97	5.24	441.2	85
	84	28.93	37.82	55.59	16.52	5.07	427.1	84
	83	28.27	37.16	54.94	16.08	4.90	413.4	83

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	113	56.71	70.25	107.51	44.25	7.93	1788.4	113
C50	112	55.39	68.94	106.19	43.16	7.72	1741.2	112
	111	54.11	67.66	104.91	42.10	7.52	1695.6	111
R1 = 150'	110	52.86	66.41	103.66	41.07	7.32	1651.5	110
R2 = 40'	109	51.64	65.19	102.44	40.08	7.12	1608.8	109
	108	50.46	64.00	101.25	39.11	6.92	1567.5	108
• = 6.5'	107	49.30	62.84	100.09	38.18	6.72	1527.5	107
	106	48.16	61.71	98.96	37.27	6.53	1488.8	106
Θ = 19°47.70'								
	105	47.05	60.60	97.85	36.38	6.34	1451.2	105
y = 8.86'	104	45.97	59.52	96.77	35.53	6.15	1414.8	104
	103	44.91	58.46	95.71	34.70	5.97	1379.5	103
	102	43.88	57.42	94.68	33.89	5.79	1345.4	102
	101	42.86	56.41	93.66	33.10	5.61	1312.2	101
	100	41.87	55.42	92.67	32.34	5.43	1280.0	100
	99	40.90	54.44	91.70	31.60	5.26	1248.8	99
	98	39.95	53.49	90.74	30.88	5.08	1218.4	98

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	98	37.85	51.77	79.61	28.59	4.89	1005.2	98
C43	97	36.94	50.86	78.70	27.91	4.73	978.5	97
	96	36.06	49.98	77.82	27.25	4.56	952.6	96
R1 = 120'	95	35.19	49.11	76.95	26.61	4.40	927.5	95
R2 = 40'	94	34.34	48.26	76.10	25.98	4.25	903.1	94
	93	33.50	47.42	75.26	25.37	4.09	879.4	93
• = 5.0'	92	32.68	46.60	74.44	24.78	3.94	856.4	92
	91	31.87	45.79	73.63	24.20	3.79	834.1	91
Θ = 20°21.84'								
	90	31.08	45.00	72.84	23.64	3.64	812.4	90
y = 7.50'	89	30.30	44.22	72.06	23.09	3.50	791.3	89
	88	29.54	43.46	71.30	22.56	3.36	770.8	88
	87	28.78	42.70	70.54	22.04	3.22	750.9	87
	86	28.04	41.96	69.80	21.53	3.08	731.6	86
	85	27.32	41.24	69.07	21.04	2.95	712.8	85
	84	26.60	40.52	68.36	20.55	2.82	694.5	84
	83	25.89	39.81	67.65	20.08	2.69	676.7	83

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	98	20.92	25.88	45.73	14.30	3.54	264.8	98
P	97	20.47	25.43	45.28	13.96	3.45	258.1	97
	96	20.03	24.99	44.83	13.63	3.35	251.6	96
R1 = 100'	95	19.59	24.55	44.40	13.30	3.25	245.4	95
R2 = 20'	94	19.17	24.13	43.97	12.99	3.16	239.3	94
	93	18.75	23.71	43.55	12.69	3.06	233.3	93
• = 2.5'	92	18.34	23.30	43.14	12.39	2.97	227.6	92
	91	17.94	22.90	42.74	12.10	2.88	222.0	91
Θ = 14°21.72'								
	90	17.54	22.50	42.34	11.82	2.79	216.6	90
y = 3.13'	89	17.15	22.11	41.95	11.55	2.70	211.3	89
	88	16.77	21.73	41.57	11.30	2.62	206.2	88
	87	16.39	21.35	41.20	11.02	2.53	201.2	87
	86	16.02	20.98	40.83	10.77	2.45	196.4	86
	85	15.66	20.62	40.46	10.52	2.36	191.7	85
	84	15.30	20.26	40.10	10.28	2.28	187.1	84
	83	14.95	19.91	39.75	10.04	2.20	182.7	83

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	98	47.66	63.27	94.50	33.83	7.05	1391.7	98
C50	97	46.55	62.17	93.39	33.00	6.83	1352.8	97
	96	45.47	61.08	92.31	32.20	6.61	1315.1	96
R1 = 150'	95	44.41	60.02	91.25	31.41	6.40	1278.5	95
R2 = 50'	94	43.37	58.98	90.21	30.65	6.19	1243.1	94
	93	42.35	57.96	89.18	29.90	5.98	1208.6	93
• = 5.0'	92	41.34	56.95	88.18	29.18	5.77	1175.3	92
	91	40.36	55.97	87.19	28.47	5.57	1142.8	91
Θ = 18°11.70'								
	90	39.39	55.00	86.23	27.78	5.37	1111.4	90
y = 7.50'	89	38.44	54.05	85.27	27.11	5.18	1080.9	89
	88	37.50	53.11	84.34	26.46	4.99	1051.3	88
	87	36.58	52.19	83.42	25.82	4.80	1022.5	87
	86	35.68	51.29	82.51	25.20	4.61	994.5	86
	85	34.79	50.40	81.62	24.60	4.43	967.4	85
	84	33.91	49.52	80.75	24.01	4.25	941.0	84
	83	33.05	48.66	79.89	23.44	4.08	915.4	83

TABLE 4 (continued)

VARIABLE DIMENSIONS OF 3-CENTERED CURVES WITHOUT ISLANDS (Refer to 9-2 Table 3)

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	128	40.66	45.11	62.88	30.19	7.46	563.1	128
P	127	39.68	44.13	61.90	29.31	7.32	545.0	127
	126	38.73	43.18	60.95	28.46	7.19	527.7	126
R1 = 100'	125	37.82	42.26	60.04	27.65	7.05	511.0	125
R2 = 20'	124	36.93	41.38	59.15	26.86	6.92	495.0	124
	123	36.08	40.52	58.30	26.11	6.79	479.7	123
° = 2.0'	122	35.25	39.69	57.47	25.38	6.66	464.9	122
	121	34.44	38.89	56.66	24.68	6.53	450.7	121
Θ = 12°50.34'								
	120	33.66	38.11	55.88	24.00	6.40	437.0	120
y = 2.50'	119	32.91	37.35	55.13	23.35	6.27	423.9	119
	118	32.17	36.61	54.39	22.72	6.15	411.2	118
	117	31.46	35.90	53.68	22.11	6.02	399.0	117
	116	30.76	35.21	52.98	21.52	5.90	387.2	116
	115	30.09	34.53	52.31	20.95	5.77	375.9	115
	114	29.43	33.88	51.65	20.39	5.65	365.0	114
	113	28.79	33.24	51.02	19.86	5.53	354.4	113

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	128	72.20	86.11	119.89	60.81	8.42	2336.2	128
C50	127	70.33	84.24	118.02	59.13	8.22	2268.2	127
	126	68.52	82.43	116.21	57.51	8.03	2202.9	126
R1 = 120'	125	66.77	80.68	114.46	55.96	7.83	2140.2	125
R2 = 35'	124	65.08	78.99	112.77	54.46	7.64	2079.9	124
	123	63.45	77.35	111.13	53.02	7.45	2021.8	123
° = 7.0'	122	61.86	75.77	109.55	51.63	7.26	1966.0	122
	121	60.33	74.24	108.01	50.29	7.08	1912.2	121
Θ = 23°24.90'								
	120	58.84	72.75	106.53	49.00	6.90	1860.4	120
y = 9.88'	119	57.39	71.30	105.08	47.75	6.71	1810.4	119
	118	55.99	69.90	103.68	46.55	6.54	1762.2	118
	117	54.63	68.54	102.32	45.38	6.36	1715.7	117
	116	53.31	67.21	100.99	44.26	6.18	1670.8	116
	115	52.02	65.93	99.71	43.17	6.01	1627.4	115
	114	50.77	64.67	98.45	42.12	5.84	1585.5	114
	113	49.55	63.46	97.23	41.10	5.67	1545.0	113

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	128	60.62	71.76	97.74	49.84	7.78	1553.4	128
SU	127	59.07	70.20	96.18	48.44	7.60	1506.7	127
	126	57.56	68.69	94.67	47.09	7.43	1461.7	126
R1 = 100'	125	56.10	67.23	93.22	45.80	7.26	1418.6	125
R2 = 30'	124	54.69	65.82	91.81	44.55	7.09	1377.1	124
	123	53.33	64.46	90.44	43.35	6.92	1337.3	123
° = 5.0'	122	52.01	63.14	89.12	42.19	6.76	1298.9	122
	121	50.73	61.86	87.84	41.08	6.59	1262.0	121
Θ = 21°47.22'								
	120	49.49	60.62	86.60	40.00	6.43	1226.4	120
y = 7.14'	119	48.28	59.42	85.40	38.96	6.27	1192.1	119
	118	47.12	58.25	84.23	37.96	6.11	1159.1	118
	117	45.98	57.12	83.10	36.99	5.95	1127.2	117
	116	44.88	56.01	81.99	36.05	5.80	1096.5	116
	115	43.80	54.94	80.92	35.14	5.64	1066.8	115
	114	42.76	53.90	79.88	34.26	5.49	1038.1	114
	113	41.75	52.88	78.86	33.41	5.34	1010.4	113

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	113	29.03	33.99	53.84	20.77	5.17	394.9	113
P	112	28.40	33.36	53.20	20.24	5.05	384.1	112
	111	27.78	32.74	52.58	19.72	4.94	373.6	111
R1 = 100'	110	27.17	32.13	51.98	19.23	4.82	363.5	110
R2 = 20'	109	26.58	31.54	51.39	18.75	4.71	353.7	109
	108	26.01	30.97	50.81	18.28	4.60	344.3	108
° = 2.5'	107	25.45	30.41	50.25	17.83	4.49	335.1	107
	106	24.90	29.86	49.70	17.39	4.38	326.3	106
Θ = 14°21.72'								
	105	24.36	29.32	49.17	16.96	4.27	317.7	105
y = 3.13'	104	23.84	28.80	48.64	16.55	4.16	309.4	104
	103	23.33	28.29	48.13	16.14	4.06	301.4	103
	102	22.82	27.79	47.63	15.75	3.95	293.6	102
	101	22.33	27.30	47.14	15.37	3.85	286.1	101
	100	21.85	26.81	46.66	15.00	3.75	278.8	100
	99	21.38	26.34	46.19	14.64	3.64	271.7	99
	98	20.92	25.88	45.73	14.30	3.54	264.8	98

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	128	61.13	72.79	99.98	50.98	7.40	1632.6	128
C43	127	59.55	71.20	98.40	49.56	7.23	1584.2	127
	126	58.02	69.67	96.87	48.20	7.06	1537.7	126
R1 = 100'	125	56.54	68.20	95.39	46.88	6.90	1493.1	125
R2 = 30'	124	55.11	66.77	93.96	45.62	6.73	1450.3	124
	123	53.73	65.38	92.58	44.40	6.57	1409.0	123
° = 5.5'	122	52.39	64.04	91.24	43.23	6.40	1369.3	122
	121	51.09	62.75	89.94	42.09	6.24	1331.1	121
Θ = 22°51.84'								
	120	49.83	61.49	88.69	41.00	6.08	1294.3	120
y = 7.86'	119	48.61	60.27	87.47	39.95	5.93	1258.8	119
	118	47.43	59.08	86.28	38.93	5.77	1224.6	118
	117	46.27	57.93	85.13	37.94	5.62	1191.6	117
	116	45.16	56.81	84.01	36.99	5.47	1159.7	116
	115	44.07	55.72	82.92	36.07	5.32	1129.0	115
	114	43.01	54.67	81.86	35.18	5.17	1099.2	114
	113	41.98	53.64	80.83	34.32	5.02	1070.5	113

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	113	46.90	57.41	76.93	33.85	7.81	990.9	113
SU	112	45.83	56.34	75.86	32.96	7.62	960.8	112
	111	44.78	55.29	74.81	32.09	7.43	931.7	111
R1 = 100'	110	43.76	54.27	73.79	31.25	7.24	903.6	110
R2 = 35'	109	42.76	53.27	72.79	30.44	7.06	876.5	109
	108	41.79	52.30	71.82	29.65	6.87	850.2	108
° = 3.0'	107	40.84	51.35	70.87	28.89	6.69	824.9	107
	106	39.92	50.43	69.95	28.14	6.51	800.4	106
Θ = 17°28.50'								
	105	39.01	49.52	69.04	27.42	6.34	776.7	105
y = 4.62'	104	38.13	48.64	68.16	26.72	6.16	753.7	104
	103	37.26	47.77	67.29	26.04	5.99	731.5	103
	102	36.42	46.93	66.44	25.38	5.82	710.1	102
	101	35.59	46.10	65.62	24.74	5.65	689.3	101
	100	34.78	45.29	64.81	24.12	5.49	669.1	100
	99	33.98	44.49	64.01	23.51	5.33	649.6	99
	98	33.20	43.71	63.23	22.92	5.17	630.8	98

TABLE 4 (continued)

VARIABLE DIMENSIONS OF 3-CENTERED CURVES WITHOUT ISLANDS (Refer to 9-2 Table 3)

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	83	18.15	23.89	41.09	11.05	2.98	207.4	83
P	82	17.74	23.47	40.68	10.78	2.87	201.6	82
	81	17.33	23.06	40.27	10.51	2.77	195.9	81
R1 = 100'	80	16.92	22.66	39.86	10.25	2.67	190.5	80
R2 = 25'	79	16.52	22.26	39.46	9.99	2.58	185.2	79
	78	16.13	21.86	39.07	9.74	2.48	180.0	78
* = 2.0'	77	15.74	21.48	38.68	9.50	2.39	175.0	77
	76	15.36	21.10	38.30	9.26	2.29	170.1	76
Θ = 13°15.66'								
	75	14.98	20.72	37.92	9.03	2.20	165.4	75
y = 2.67'	74	14.61	20.35	37.55	8.81	2.12	160.8	74
	73	14.24	19.98	37.18	8.59	2.03	156.4	73
	72	13.88	19.62	36.82	8.37	1.94	152.1	72
	71	13.52	19.26	36.46	8.16	1.86	147.8	71
	70	13.17	18.91	36.11	7.96	1.78	143.8	70
	69	12.82	18.56	35.76	7.76	1.70	139.8	69
	68	12.48	18.21	35.42	7.57	1.62	135.9	68

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	83	32.75	49.10	81.81	24.10	3.78	971.7	83
C50	82	31.89	48.25	80.95	23.54	3.61	945.9	82
	81	31.05	47.40	80.11	22.99	3.45	920.9	81
R1 = 150'	80	30.22	46.57	79.28	22.45	3.29	896.6	80
R2 = 50'	79	29.40	45.75	78.46	21.93	3.14	872.9	79
	78	28.59	44.94	77.65	21.42	2.99	849.9	78
* = 5.5'	77	27.79	44.15	76.85	20.92	2.84	827.5	77
	76	27.01	43.36	76.07	20.43	2 70	805.8	76
Θ = 19°05.46'								
	75	26.23	42.59	75.29	19.96	2.56	784.6	75
y = 8.25'	74	25.47	41.82	74.53	19.49	2.42	764.0	74
	73	24.71	41.07	73.78	19.04	2.29	743.9	73
	72	23.97	40.32	73.03	18.60	2.16	724.4	72
	71	23.23	39.59	72.30	18.17	2.04	705.4	71
	70	22.51	38.86	71.57	17.75	1.92	686.9	70
	69	21.79	38.14	70.85	17.34	1.80	668.9	69
	68	21.08	37.44	70.14	16.95	1.68	651.4	68

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	83	31.26	41.58	58.79	17.75	5.36	496.5	83
SU	82	30.53	40.86	58.06	17.28	5.17	480.1	82
	81	29.82	40.14	57.35	16.81	4.99	464.2	81
R1 = 120'	80	29.12	39.44	56.64	16.35	4.81	448.8	80
R2 = 45'	79	28.42	38.74	55.95	15.91	4.64	433.8	79
	78	27.74	38.06	55.26	15.48	4.46	419.4	78
* = 2.0'	77	27.06	37.39	54.59	15.06	4.30	405.3	77
	76	26.40	36.72	53.93	14.64	4.13	391.8	76
Θ = 13°15.66'								
	75	25.74	36.06	53.27	14.24	3.97	378.6	75
y = 3.20'	74	25.09	35.42	52.62	13.85	3.81	365.8	74
	73	24.46	34.78	51.98	13.47	3.65	353.5	73
	72	23.83	34.15	51.35	13.10	3.50	341.5	72
	71	23.20	33.53	50.73	12.73	3.35	329.9	71
	70	22.59	32.91	50.11	12.38	3.20	318.7	70
	69	21.98	32.30	49.51	12.03	3.06	307.8	69
	68	21.38	31.70	48.91	11.69	2.92	297.2	68

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	68	35.33	52.95	82.32	19.69	4.71	845.1	68
C50	67	34.34	51.96	81.33	19.14	4.48	816.4	67
	66	33.36	50.98	80.35	18.60	4.26	788.6	66
R1 = 200'	65	32.39	50.01	79.38	18.08	4.05	761.7	65
R2 = 75'	64	31.43	49.05	78.43	17.57	3.84	735.6	64
	63	30.48	48.11	77.48	17.07	3.63	710.3	63
* = 3.5'	62	29.54	47.17	76.54	16.58	3.44	685.8	62
	61	28.62	46.24	75.61	16.11	3.24	662.1	61
Θ = 13°35.40'								
	60	27.70	45.32	74.70	15.64	8.05	639.1	60
y = 5.60'	59	26.79	44.41	73.79	15.19	2.87	616.9	59
	58	25.89	43.51	72.89	14.75	2.70	595.3	58
	57	25.00	42.62	72.00	14.32	2.53	574.4	57
	56	24.12	41.74	71.11	13.91	2.36	554.2	56
	55	23.24	40.87	70.24	13.50	2.20	534.6	55
	54	22.37	40.00	69.37	13.10	2.04	515.7	54
	53	21.52	39.14	68.51	12.72	1.90	497.3	53

Constants	Δ	T2	T1	T	E	M	Area	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	83	28.85	43.35	67.52	20.42	3.49	681.8	83
C43	82	28.10	42.60	66.76	19.93	3.34	662.4	82
	81	27.35	41.85	66.02	19.44	3.19	643.5	81
R1 = 120'	80	26.62	41.12	65.28	18.97	3.05	625.2	80
R2 = 45'	79	25.89	40.39	64.56	18.50	2.91	607.4	79
	78	25.18	39.68	63.85	18.05	2.77	590.2	78
* = 4.0'	77	24.48	38.98	63.14	17.61	2.63	573.4	77
	76	23.78	38.28	62.45	17.18	2.50	557.1	76
Θ = 18°47.82'								
	75	23.10	37.60	61.77	16.76	2.38	541.2	75
y = 6.40'	74	22.43	36.92	61.09	16.36	2.25	525.9	74
	73	21.76	36.26	60.42	15.96	2.13	510.9	73
	72	21.10	35.60	59.77	15.57	2.01	496.3	72
	71	20.45	34.95	59.12	15.19	1.90	482.2	71
	70	19.81	34.31	58.48	14.82	1.79	468.5	70
	69	19.18	33.68	57.84	14.46	1.68	455.1	69
	68	18.55	33.05	57.22	14.11	1.57	442.1	68

TABLE 5 ***9 - 2***
T - 5

VARIABLE DIMENSIONS OF 3-CENTERED CURVES WITHOUT ISLANDS (Refer to 9-2 Table 2)

Constants	Δ	T2	T1	T	E	M	Area *	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	128	58.69	66.64	85.18	44.14	10.18	1177.6	128
P or	127	57.24	65.19	83.73	42.84	9.98	1138.3	127
occasional SU	126	55.84	63.79	82.33	41.59	9.79	1100.7	126
	125	54.49	62.43	80.97	40.39	9.59	1064.5	125
R1 = 100'								
	124	53.18	61.12	79.66	39.23	9.40	1029.9	124
R2 = 30'	123	51.91	59.86	78.40	38.11	9.21	996.6	123
	122	50.69	58.63	77.17	37.04	9.03	964.6	122
° = 2.5'	121	49.50	57.44	75.98	36.00	8.84	933.8	121
Θ = 15°21.54'	120	48.35	56.29	74.83	35.00	8.65	904.2	120
	119	47.23	55.17	73.72	34.04	8.47	875.8	119
y = 3.57'	118	46.14	54.09	72.63	33.10	8.29	848.4	118
	117	45.09	53.04	71.58	32.20	8.11	822.0	117
	116	44.07	52.01	70.55	31.33	7.93	796.5	116
	115	43.07	51.02	69.56	30.49	7.76	772.0	115
	114	42.10	50.05	68.59	29.67	7.58	748.4	114
	113	41.16	49.10	67.64	28.88	7.40	725.6	113

Constants	Δ	T2	T1	T	E	M	Area *	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	113	54.57	63.46	81.23	36.10	11.06	1098.9	113
P or	112	53.38	62.27	80.04	35.11	10.82	1063.0	112
occasional SU	111	52.22	61.11	78.89	34.15	10.59	1028.4	111
	110	51.09	59.98	77.76	33.23	10.35	995.0	110
R1 = 120'								
	109	49.99	58.88	76.66	32.33	10.12	962.7	109
R2 = 40'	108	48.92	57.81	75.58	31.46	9.89	931.6	108
	107	47.87	56.76	74.54	30.61	9.66	901.5	107
° = 2.0'	106	46.85	55.74	73.51	29.79	9.43	872.5	106
Θ = 12°50.34'	105	45.85	54.74	72.51	28.99	9.21	844.4	105
	104	44.87	53.76	71.53	28.22	8.99	817.3	104
y = 3.00'	103	43.91	52.80	70.58	27.47	8.77	791.1	103
	102	42.98	51.87	69.64	26.74	8.55	765.8	102
	101	42.06	50.95	68.73	26.03	8.33	741.3	101
	100	41.17	50.05	67.83	25.34	8.12	717.6	100
	99	40.29	49.18	66.95	24.67	7.91	694.7	99
	98	39.43	48.32	66.09	24.02	7.11	672.5	98

Constants	Δ	T2	T1	T	E	M	Area *	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	128	60.63	71.76	97.74	49.84	7.78	1553.4	128
SU or	127	59.07	70.20	96.18	48.44	7.61	1506.7	127
occasional C50	126	57.56	68.69	94.67	47.09	7.43	1461.7	126
	125	56.10	67.24	93.22	45.80	7.26	1418.6	125
R1 = 100'								
	124	54.69	65.83	91.81	44.55	7.09	1377.1	124
R2 = 30'	123	53.33	64.46	90.44	43.35	6.92	1337.3	123
	122	52.01	63.14	89.12	42.19	6.76	1298.9	122
° = 5.0'	121	50.73	61.86	87.84	41.08	6.59	1262.0	121
Θ = 21°47.22'	120	49.49	60.62	86.60	40.00	6.43	1226.4	120
	119	48.28	59.42	85.40	38.96	6.27	1192.1	119
y = 7.14'	118	47.12	58.25	84.23	37.96	6.11	1159.1	118
	117	45.98	57.12	83.10	36.99	5.95	1127.2	117
	116	44.88	56.01	81.99	36.05	5.80	1096.5	116
	115	43.80	54.94	80.92	35.14	5.64	1066.8	115
	114	42.76	53.90	79.88	34.26	5.49	1038.1	114
	113	41.75	52.88	78.86	33.41	5.34	1010.4	113

Constants	Δ	T2	T1	T	E	M	Area *	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	113	54.01	67.23	93.69	40.63	8.14	1451.9	113
SU or	112	52.75	65.97	92.43	39.58	7.93	1409.9	112
occasional C50	111	51.52	64.75	91.20	38.57	7.72	1369.3	111
	110	50.33	63.55	90.01	37.58	7.51	1330.0	110
R1 = 120'								
	109	49.16	62.39	88.84	36.63	7.31	1292.1	109
R2 = 40'	108	48.02	61.25	87.70	35.71	7.11	1255.5	108
	107	46.91	60.14	86.59	34.81	6.91	1220.0	107
° = 4.5'	106	45.83	59.05	85.51	33.94	6.72	1185.7	106
Θ = 19°18.54'	105	44.77	57.99	84.45	33.10	6.53	1152.5	105
	104	43.73	56.96	83.41	32.28	6.34	1120.3	104
y = 6.75'	103	42.72	55.94	82.40	31.48	6.15	1089.2	103
	102	41.73	54.95	81.41	30.71	5.96	1059.1	102
	101	40.76	53.98	80.44	29.96	5.78	1029.9	101
	100	39.81	53.03	79.49	29.23	5.60	1001.6	100
	99	38.88	52.10	78.56	28.52	5.43	974.1	99
	98	37.97	51.19	77.64	27.83	5.25	947.5	98

Constants	Δ	T2	T1	T	E	M	Area *	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	128	72.20	86.11	119.89	60.81	8.42	2336.2	128
C50	127	70.33	84.24	118.02	59.13	8.22	2268.2	127
	126	68.52	82.43	116.21	57.51	8.03	2202.9	126
R1 = 120'	125	66.77	80.68	114.46	55.96	7.83	2140.2	125
R2 = 35'	124	65.08	78.99	112.77	54.46	7.64	2079.9	124
	123	63.45	77.35	111.13	53.02	7.45	2021.8	123
° = 7.0'	122	61.86	75.77	109.55	51.63	7.26	1966.0	122
	121	60.33	74.24	108.01	50.29	7.08	1912.2	121
Θ = 23°24.90'								
	120	58.84	72.75	106.53	49.00	6.90	1860.4	120
y = 9.88'	119	57.39	71.30	105.08	47.75	6.71	1810.4	119
	118	55.99	69.90	103.68	46.55	6.54	1762.2	118
	117	54.63	68.54	102.32	45.38	6.36	1715.7	117
	116	53.31	67.21	100.99	44.26	6.18	1670.8	116
	115	52.02	65.93	99.71	43.17	6.01	1627.4	115
	114	50.77	64.67	98.45	42.12	5.84	1585.5	114
	113	49.55	63.46	97.23	41.10	5.67	1545.0	113

Constants	Δ	T2	T1	T	E	M	Area *	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	113	57.25	71.77	111.69	46.06	7.32	1953.2	113
C50	112	55.91	70.42	110.34	44.94	7.12	1903.4	112
	111	54.60	69.11	109.04	43.86	6.92	1855.2	111
R1 = 150'	110	53.32	67.84	107.76	42.81	6.73	1808.5	110
R2 = 40'	109	52.08	66.59	106.51	41.80	6.54	1763.4	109
	108	50.86	65.38	105.30	40.81	6.35	1719.7	108
° = 7.5'	107	49.68	64.19	104.11	39.86	6.16	1677.3	107
	106	48.52	63.04	102.96	38.93	5.97	1636.3	106
Θ = 21°16.80'								
	105	47.39	61.90	101.83	38.03	5.79	1596.5	105
y = 10.23'	104	46.28	60.80	100.72	37.15	5.61	1557.9	104
	103	45.20	59.72	99.64	36.30	5.44	1520.5	103
	102	44.14	58.66	98.58	35.48	5.26	1484.2	102
	101	43.11	57.62	97.54	34.68	5.09	1449.0	101
	100	42.09	56.61	96.53	33.90	4.92	1414.8	100
	99	41.10	55.62	95.54	33.14	4.75	1381.6	99
	98	40.13	54.64	94.56	32.40	4.59	1349.3	98

* Includes Area of Islands

TABLE 5 (continued)

VARIABLE DIMENSIONS OF 3-CENTERED CURVES WITHOUT ISLANDS (Refer to 9-2 Table 2)

Constants	Δ	T2	T1	T	E	M	Area*	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	98	48.81	60.97	85.28	30.79	9.01	1117.1	98
P or	97	47.75	59.91	84.22	29.99	8.76	1082.5	97
occasional SU	96	46.71	58.86	83.17	29.21	8.51	1049.0	96
	95	45.68	57.84	82.15	28.45	8.27	1016.6	95
R1 = 150'	94	44.68	56.84	81.15	27.71	8.03	985.3	94
R2 = 50'	93	43.70	55.85	80.16	27.00	7.80	954.9	93
	92	42.73	54.88	79.19	26.30	7.57	925.4	92
* = 3.0'	91	41.78	53.93	78.24	25.62	7.34	896.9	91
Θ = 14°04.20'	90	40.85	53.00	77.31	24.95	7.11	869.2	90
	89	39.93	52.08	76.39	24.31	6.89	842.5	89
y = 4.50'	88	39.03	51.18	75.49	23.68	6.67	816.5	88
	87	38.14	50.30	74.61	23.07	6.45	791.3	87
	86	37.27	49.42	73.73	22.47	6.24	766.9	86
	85	36.41	48.57	72.88	21.89	6.03	743.3	85
	84	35.57	47.72	72.03	21.32	5.82	720.4	84
	83	34.74	46.89	71.20	20.77	5.62	698.1	83

Constants	Δ	T2	T1	T	E	M	Area*	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	83	46.81	69.45	92.10	29.81	6.45	1376.2	83
P or	82	45.60	68.24	90.88	29.01	6.18	1330.1	82
occasional SU	81	44.40	67.05	89.69	28.23	5.92	1285.5	81
	80	43.23	65.87	88.51	27.47	5.67	1242.3	80
R1 = 150'	79	42.07	64.71	87.35	26.73	5.43	1200.4	79
R2 = 75'	78	40.92	63.57	86.21	26.01	5.18	1159.8	78
	77	39.80	62.44	85.09	25.31	4.95	1120.5	77
* = 3.5'	76	38.69	61.33	83.98	24.62	4.72	1082.4	76
Θ = 17°34.38'	75	37.59	60.24	82.88	23.95	4.49	1045.4	75
	74	36.51	59.15	81.80	23.29	4.27	1009.6	74
y = 7.00'	73	35.44	58.09	80.73	22.65	4.06	975.0	73
	72	34.39	57.03	79.68	22.03	3.85	941.4	72
	71	33.35	55.99	78.64	21.42	3.64	908.8	71
	70	32.32	54.97	77.61	20.83	3.44	877.3	70
	69	31.31	53.95	76.60	20.25	3.25	846.7	69
	68	30.31	52.95	75.59	19.69	3.06	817.1	68

Constants	Δ	T2	T1	T	E	M	Area*	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	98	47.66	63.27	94.50	33.83	7.05	1391.7	98
SU or	97	46.55	62.17	93.39	33.00	6.83	1352.8	97
occasional C50	96	45.47	61.08	92.31	32.20	6.61	1315.1	96
	95	44.41	60.02	91.25	31.41	6.40	1278.5	95
R1 = 150'	94	43.37	58.98	90.21	30.65	6.19	1243.1	94
R2 = 50'	93	42.35	57.96	89.18	29.90	5.98	1208.6	93
	92	41.34	56.95	88.18	29.18	5.77	1175.3	92
* = 5.0'	91	40.36	55.97	87.19	28.47	5.57	1142.8	91
Θ = 18°11.70'	90	39.39	55.00	86.23	27.78	5.37	1111.4	90
	89	38.44	54.05	85.27	27.11	5.18	1080.9	89
y = 7.50'	88	37.50	53.11	84.34	26.46	4.99	1051.3	88
	87	36.58	52.19	83.42	25.82	4.80	1022.5	87
	86	35.68	51.29	82.51	25.20	4.61	994.5	86
	85	34.79	50.40	81.62	24.60	4.43	967.4	85
	84	33.91	49.52	80.75	24.01	4.25	941.0	84
	83	33.05	48.66	79.89	23.44	4.08	915.4	83

Constants	Δ	T2	T1	T	E	M	Area*	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	83	43.85	70.79	97.70	31.82	4.73	1584.3	83
SU or	82	42.62	69.54	96.47	31.00	4.51	1534.6	82
occasional C50	81	41.40	68.33	95.25	30.21	4.28	1486.4	81
	80	40.20	67.13	94.05	29.43	4.07	1439.6	80
R1 = 150'	79	39.02	65.95	92.87	28.68	3.86	1394.2	79
R2 = 75'	78	37.86	64.78	91.71	27.94	3.65	1350.1	78
	77	36.71	63.64	90.56	27.22	3.46	1307.4	77
* = 5.0'	76	35.58	62.50	89.43	26.52	3.26	1265.9	76
Θ = 21°02.34'	75	34.46	61.39	88.31	25.84	3.07	1225.7	75
	74	33.36	60.28	87.21	25.17	2.89	1186.6	74
y = 10.00'	73	32.27	59.20	86.12	24.52	2.71	1148.7	73
	72	31.20	58.12	85.05	23.89	2.54	1111.9	72
	71	30.14	57.06	83.99	23.27	2.38	1076.2	71
	70	29.09	56.02	82.94	22.66	2.22	1041.5	70
	69	28.06	54.98	81.91	22.07	2.06	1007.9	69
	68	27.04	53.96	80.89	21.50	1.91	975.2	68

Constants	Δ	T2	T1	T	E	M	Area*	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	98	61.95	79.95	111.81	40.94	10.44	1983.2	98
C50	97	60.55	78.56	110.41	39.89	10.13	1923.1	97
	96	59.18	77.19	109.04	38.87	9.83	1864.9	96
R1 = 180'	95	57.84	75.85	107.70	37.87	9.53	1808.6	95
R2 = 65'	94	56.53	74.53	106.38	36.91	9.24	1754.0	94
	93	55.23	73.24	105.09	35.97	8.95	1701.0	93
* = 4.5'	92	53.96	71.97	103.82	35.05	8.66	1649.8	92
	91	52.72	70.72	102.58	34.16	8.38	1600.0	91
Θ = 16°04.86'	90	51.50	69.50	101.36	33.29	8.11	1551.9	90
y = 7.04'	89	50.29	68.30	100.15	32.44	7.83	1505.2	89
	88	49.11	67.12	98.97	31.62	7.57	1459.9	88
	87	47.95	65.95	97.81	30.81	7.30	1416.0	87
	86	46.81	64.81	96.67	30.03	7.04	1373.4	86
	85	45.68	63.69	95.54	29.27	6.79	1332.1	85
	84	44.57	62.58	94.43	28.52	6.54	1292.0	84
	83	43.48	61.49	93.34	27.80	6.29	1253.2	83

Constants	Δ	T2	T1	T	E	M	Area*	Δ
	deg.	Length in feet					sq. feet	deg.
Design Vehicle	83	57.87	82.72	107.58	34.84	8.75	1866.3	83
C50	82	56.42	81.28	106.13	33.89	8.41	1802.0	82
	81	55.00	79.86	104.71	32.96	8.08	1739.7	81
R1 = 180'	80	53.60	78.46	103.31	32.08	7.76	1679.4	80
R2 = 90'	79	52.22	77.08	101.93	31.17	7.45	1621.1	79
	78	50.86	75.72	100.57	30.31	7.14	1564.5	78
* = 3.5'	77	49.52	74.37	99.23	29.47	6.83	1509.8	77
	76	48.20	73.05	97.91	28.65	6.54	1456.8	76
Θ = 16°01.86'	75	46.89	71.75	96.60	27.85	6.24	1405.4	75
y = 7.00'	74	45.60	70.46	95.31	27.08	5.96	1355.7	74
	73	44.33	69.19	94.04	26.31	5.68	1307.6	73
	72	43.08	67.93	92.79	25.57	5.41	1260.9	72
	71	41.84	66.69	91.55	24.85	5.15	1215.8	71
	70	40.62	65.47	90.32	24.14	4.89	1172.1	70
	69	39.41	64.26	89.12	23.45	4.64	1129.7	69
	68	38.21	63.07	87.92	22.78	4.39	1088.8	68

* Includes Area of Islands

In determining the required sight distance at intersections, there are cases listed in A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS (2001) edition. The treatment of these cases are as follows:

Cases I and II are for no stop control or yield control for vehicles on the minor road. Since all intersections are stop signed or signal controlled, these cases do not apply to standard intersection design.

Case III (see Figure 1) is sight distance for stop control on minor roads. This case is further broken down into three basic maneuvers.

Case IIIA is for vehicles on the minor road that cross the intersection. This is the minimum required sight distance at unsignalized intersections. Figure 2 shows the equation for determining this distance. Figure 3 is a graph showing sight distances for various highway types.

Case IIIB and IIIC is for vehicles that turn left and right respectively onto the main roadway. This is a desirable sight distance for intersection design. Figure 4 shows these sight distances.

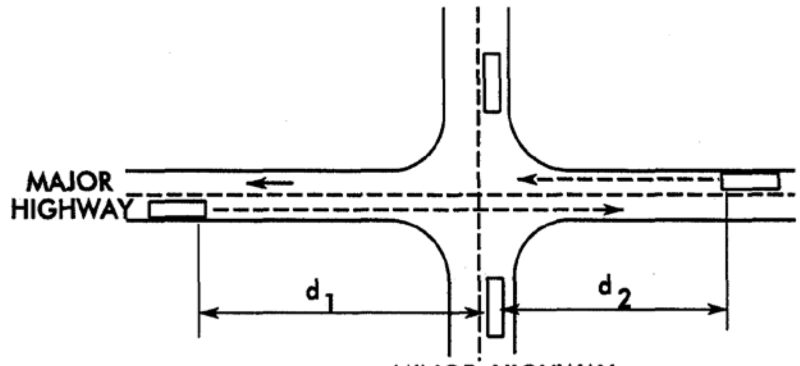
Case IV is sight distance for signalized intersections. It is desirable to determine the sight distance line by using Case III procedures. However, this distance may not be obtainable in heavily urbanized areas.

NOTE: For additional information on sight distance, refer to A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS (2001) edition.

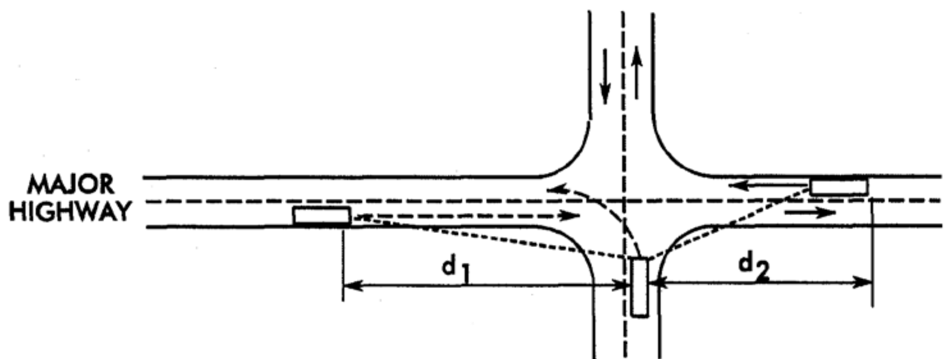
FIGURE 1 **9 – 3 / F – 1**

INTERSECTION SIGHT DISTANCE AT AT–GRADE INTERSECTIONS.

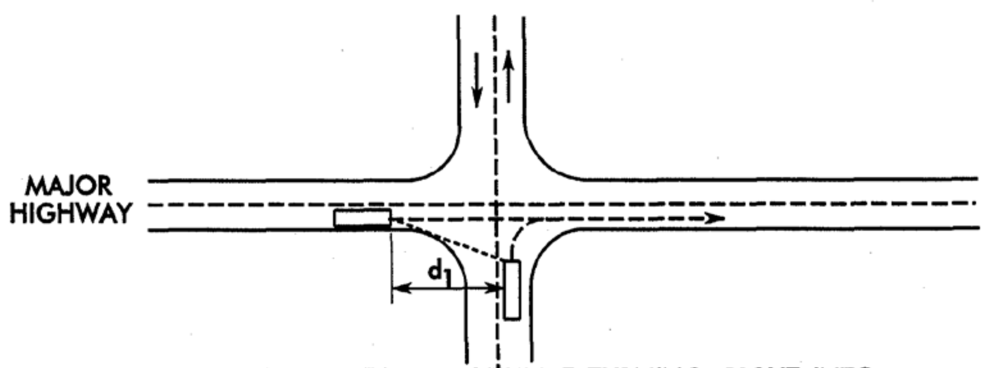
CASE III STOP CONTROL



CASE IIIA – STOPPED VEHICLE CROSSING A MAJOR HIGHWAY



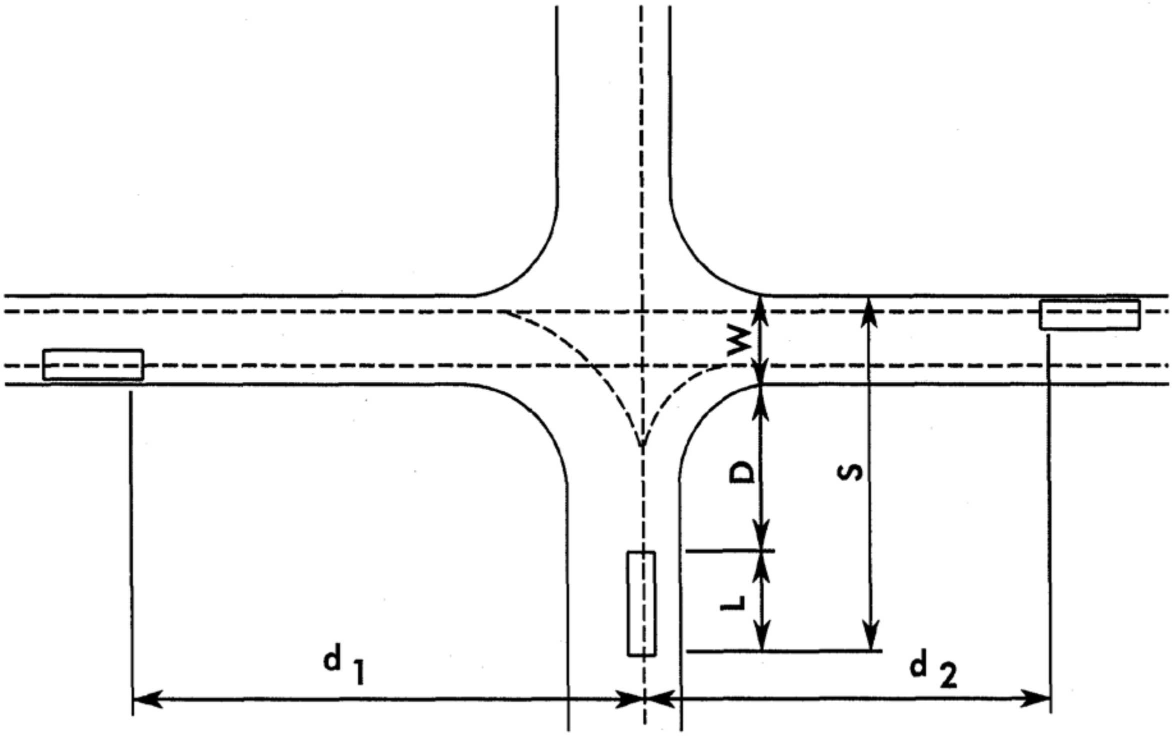
CASE IIIB – STOPPED VEHICLE TURNING LEFT INTO TWO–LANE MAJOR HIGHWAY



CASE IIIC – STOPPED VEHICLE TURNING RIGHT INTO TWO– LANE MAJOR HIGHWAY OR RIGHT TURN ON RED SIGNAL

FIGURE 2 **9 - 3 / F - 2**

DETERMINING SIGHT DISTANCE FOR CASE III A



CASE III
STOP CONTROL ON MINOR ROAD

IN THE ABOVE FIGURE, THE DISTANCE S THAT THE CROSSING VEHICLE MUST TRAVEL TO CLEAR THE MAJOR HIGHWAY IS THE SUM OF THE FOLLOWING THREE DISTANCES (IN FEET):

$$S = D + W + L$$

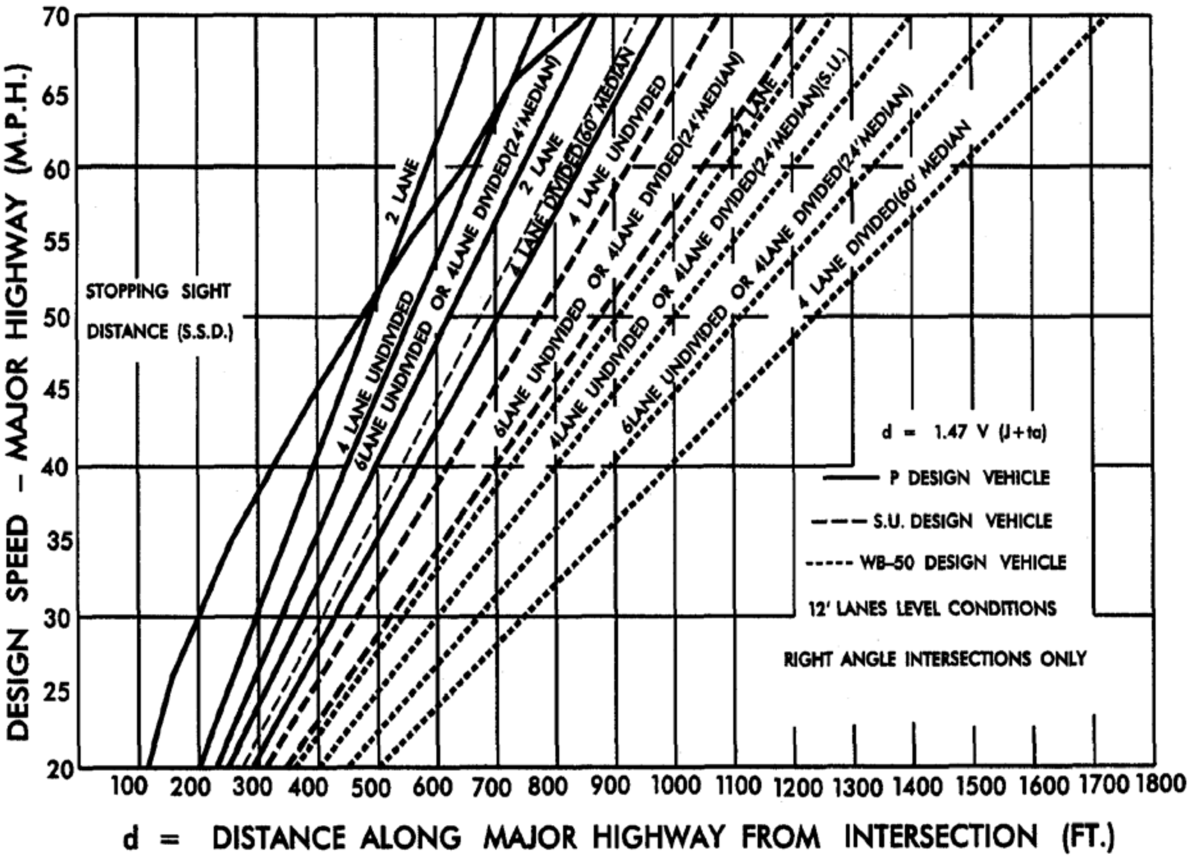
WHERE: D = DISTANCE FROM NEAR EDGE OF PAVEMENT TO FRONT OF A STOPPED VEHICLE, FT.
W = PAVEMENT WIDTH ALONG PATH OF CROSSING VEHICLE, FT.
L = OVERALL LENGTH OF VEHICLE, FT.

THE SIGHT DISTANCE FOR A CROSSING MANEUVER IS BASED ON THE TIME IT TAKES FOR THE STOPPED VEHICLE TO CLEAR THE INTERSECTION AND THE DISTANCE THAT A VEHICLE WILL TRAVEL ALONG THE MAJOR ROAD AT IT'S DESIGN SPEED IN THAT AMOUNT OF TIME. THIS DISTANCE MAY BE CALCULATED FROM THE EQUATION:

$$d = 1.47\ V\ (J + t_a)$$

WHERE: d = SIGHT DISTANCE ALONG THE MAJOR HIGHWAY FROM THE INTERSECTION, FT.
V = DESIGN SPEED ON THE MAJOR HIGHWAY, MPH.
J = SUM OF THE PERCEPTION TIME AND THE TIME REQUIRED TO ACTUATE THE CLUTCH OR ACTUATE AUTOMATIC SHIFT, SECONDS.
t_a = TIME REQUIRED TO ACCELERATE AND TRAVERSE THE DISTANCE S TO CLEAR THE MAJOR HIGHWAY PAVEMENT, SECONDS.

FIGURE 3 9 – 3 / F – 3



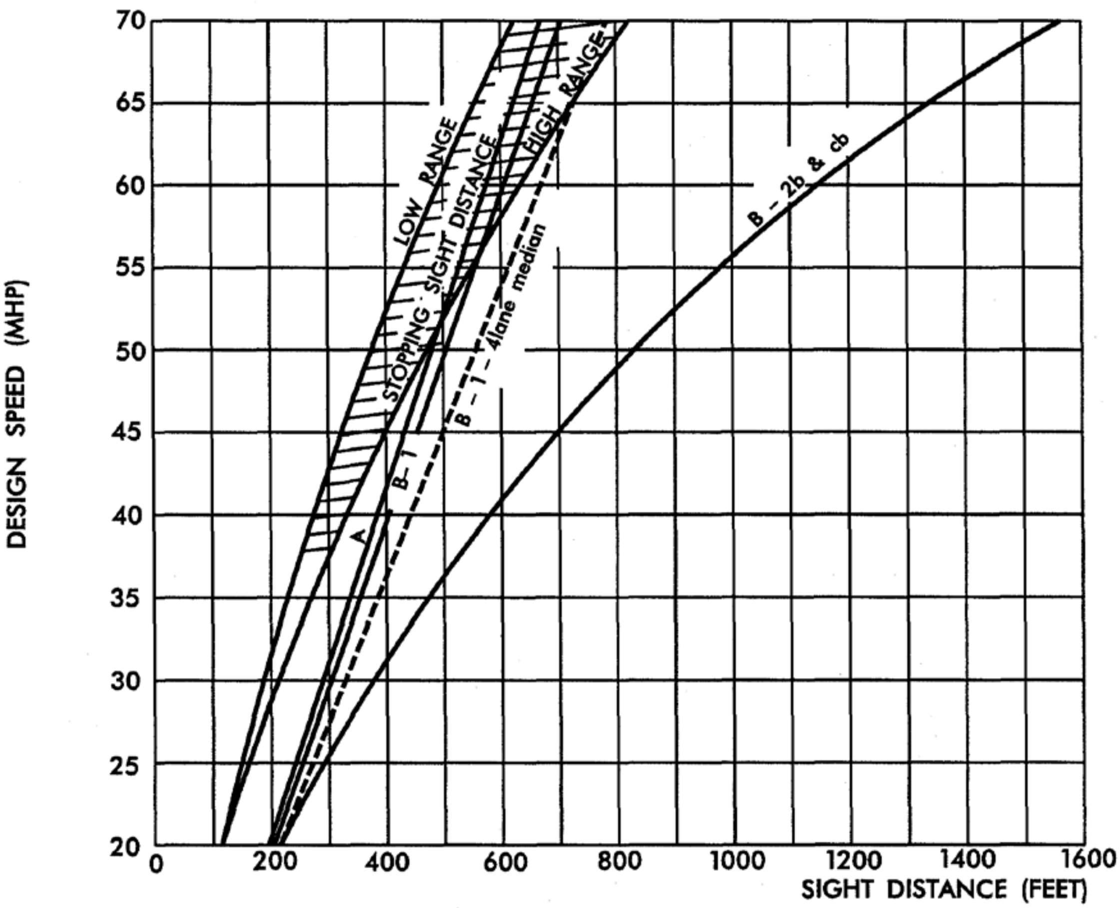
SIGHT DISTANCE AT INTERSECTION

(CASE IIIA, REQUIRED SIGHT DISTANCE ALONG A MAJOR HIGHWAY).

-- THESE DISTANCES ARE BASED ON 90 DEGREE CROSSINGS AND 0% GRADES. THE SIGHT DISTANCE MUST BE ADJUSTED FOR GRADE AND SKEW.

-- IF THE STOPPING SIGHT DISTANCE EXCEEDS THE INTERSECTION SIGHT DISTANCE, THE STOPPING SIGHT DISTANCE WILL GOVERN.

FIGURE 4 **9 – 3 / F – 4**



INTERSECTION SIGHT DISTANCE AT AT–GRADE INTERSECTION
(CASE IIIB AND CASE IIIC).

A – SIGHT DISTANCE FOR P VEHICLE CROSSING 2–LANE HIGHWAY FROM STOP. (SEE DIAGRAM)

B – 1 – SIGHT DISTANCE FOR P VEHICLE TURNING LEFT INTO 2–LANE HIGHWAY ACCROSS P VEHICLE APPROACHING FROM LEFT.(SEE DIAGRAM)

B – 1 –4LANE +MEDIAN SIGHT DISTANCE FOR P VEHICLE TURNING LEEFT INTO 4– LANE HIGHWAY ACCROSS P VEHICLE APPROACHING FROM LEFT. (SEE DIAGRAM)

B – 2b – SIGHT DISTANCE FOR P VEHICLE TO TURN LEFT INTO 2 – LANE HIGHWAY AND ATTAIN 85% OF DESIGN SPEED WITHOUT BEING OVERTAKEN BY A VEHICLE APPROACHING FROM THE RIGHT REDUCING SPEED FROM DESIGN SPEED TO 85% OF DESIGN SPEED.(SEE DIAGRAM)

cb – SIGHT DISTANCE FOR P VEHICLE TO TURN RIGHT INTO 2 – LANE HIGHWAY AND ATTAIN 85% OF DESIGN SPEED WITHOUT BEING OVERTAKEN BY A VEHICLE APPROACHING FROM THE LEFT REDUCING SPEED FROM DESIGN SPEED TO 85% OF DESIGN SPEED.

DIRECTIONAL CROSSOVERS WITH MEDIAN U-TURNS 9-4

Directional Crossovers with Median U-Turns should be considered in the following locations:

- High speed rural median divided facilities
- Strategic Highway Corridors with partial or limited control of access
- Intersections with a documented crash history
- In congested areas where it is desirable to minimize the use of traffic signals.

The directional crossover eliminates full-movement median openings. Traffic on the primary highway is not affected, as all movements (thru, left, right) are still permitted. Traffic on the secondary highway must turn right onto the primary highway. Through and left movements from the secondary highway are directed to a median U-turn crossover located downstream (approximately 800-1000 ft.)

This type of crossover design will be used in various situations. For rural, high speed median divided facilities, full-movement median crossovers have a high crash potential, with the predominate crash-type being the secondary highway far-side angle crash, which has the potential to have the most severe injuries. The directional crossover with median U-turns converts the secondary highway left-turn and through movements to two-stage movements, (right-turn and U-turn) each of which is significantly safer than the full-movement crossover. Because turning movements are separated the need for signalization at intersections is reduced.

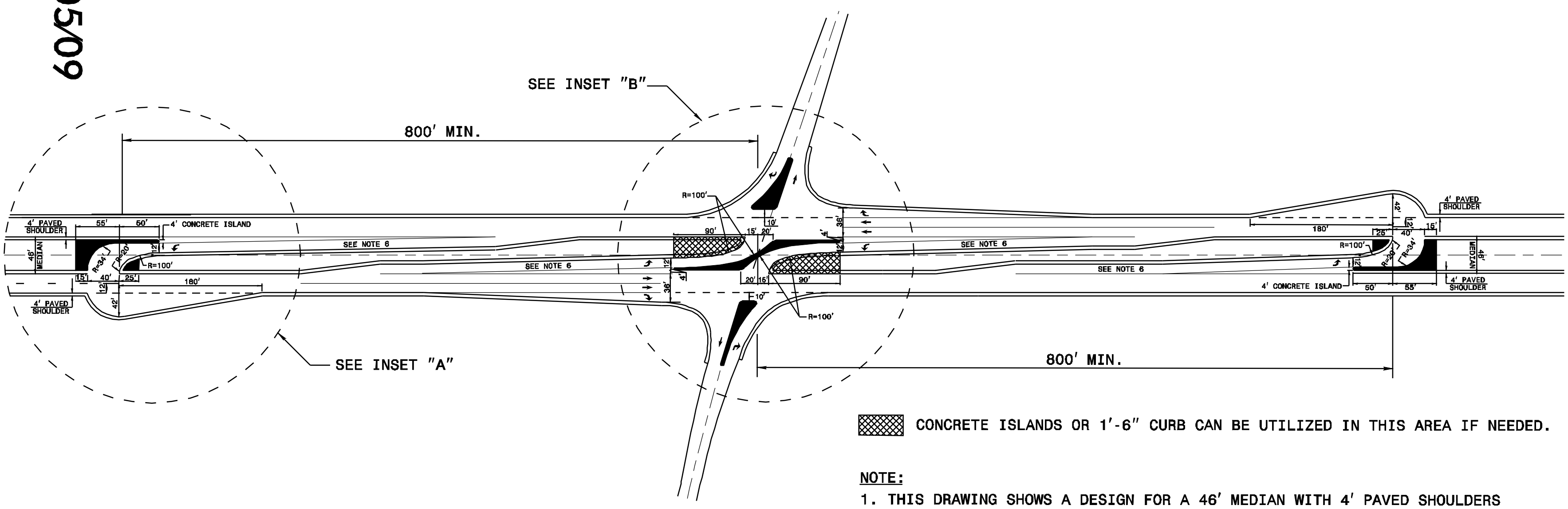
For high-mobility corridors, including strategic highway corridors, the use of directional crossovers with median U-turns converts four-leg, multi-phase signalized intersections into four independent two-phase signalized intersections. The reduced number of signalized phases provides for more green time to be allocated to the primary movements, and allows for shorter cycle lengths, which reduce queuing. Each two-phase signal only impacts one direction of traffic on the primary highway. Because the primary highway's through movements operate independently, signal coordination is simpler and more effective, as the primary highway has effectively been converted to two parallel one-way streets.

Variations include not permitting the primary highway left-turn to turn directly to the secondary highway, diverting that movement to the median U-turn. This may occur where shorts weaving and merging distances at the directional crossover may create a safety or capacity problem. For higher volume secondary highways, or for intersections of two primary highways, another variation would permit the through and right movements from each highway to occur at a two-phase signal, but direct all left-turn movements to median U-turns. This is commonly known as a "Michigan Left" intersection.

DIRECTIONAL CROSSOVERS WITH MEDIAN U-TURNS(continued) 9-4

Each intersection on a corridor must be evaluated individually, to determine the optimum type of median opening. On current TIP projects, the locations where Directional Crossovers with Median U-turns are proposed should be thoroughly discussed during the public hearing map review, presented at the public hearing, and the details of the design features should be discussed during the Final Design Field Inspection. Potential retrofit locations should be reviewed by the Division Traffic Engineer and by Transportation Mobility and Safety.

DIRECTIONAL CROSSOVER WITH MEDIAN U-TURNS



PLAN

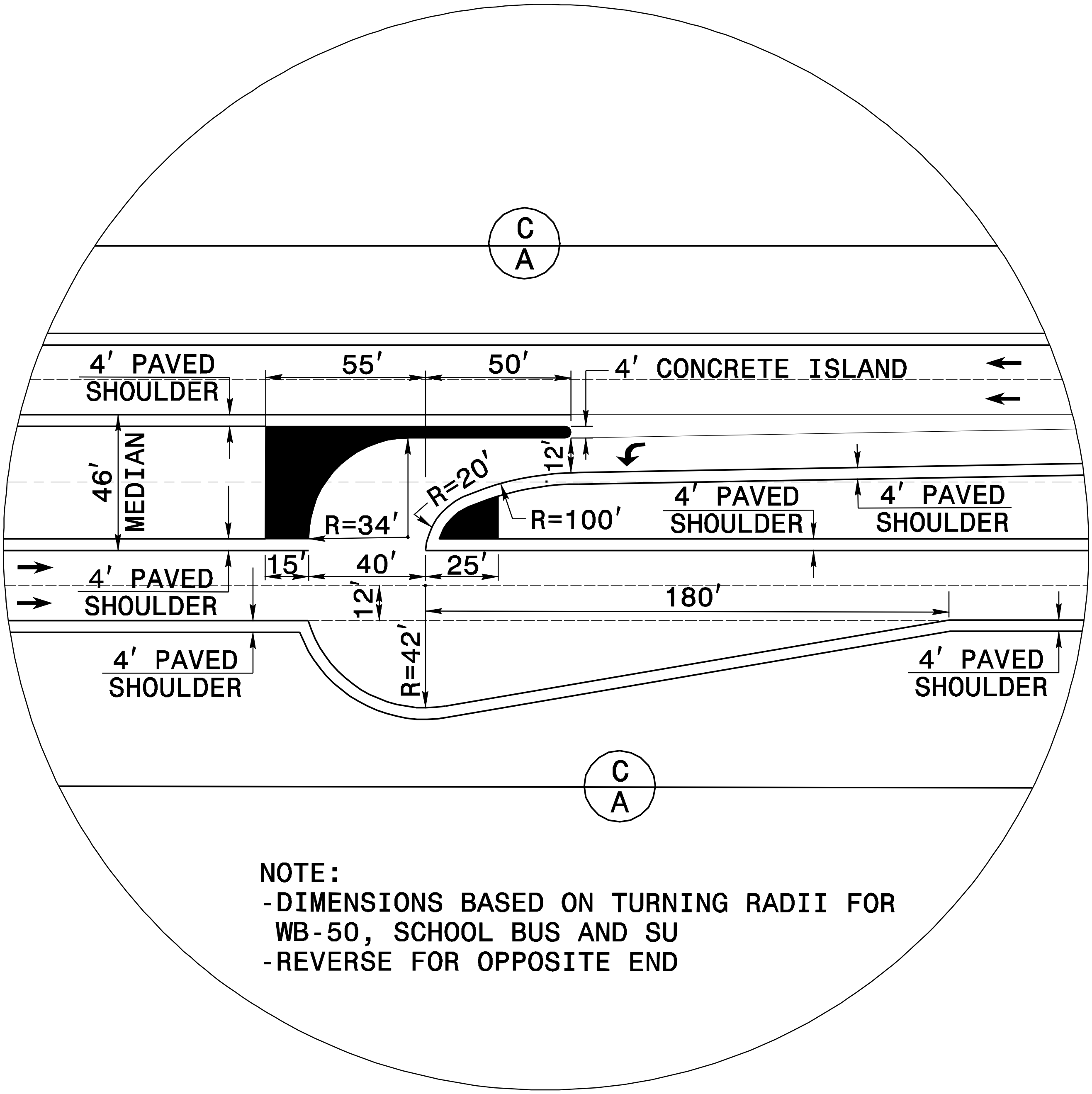
CONCRETE ISLANDS OR 1′-6″ CURB CAN BE UTILIZED IN THIS AREA IF NEEDED.

NOTE:

1. THIS DRAWING SHOWS A DESIGN FOR A 46′ MEDIAN WITH 4′ PAVED SHOULDERS (MEDIAN AND OUTSIDE) ASSUMING A 55 MPH POSTED SPEED. WHEN OTHER MEDIAN WIDTHS, PAVED SHOULDERS, AND POSTED SPEEDS ARE USED, ENGINEERING JUDGEMENT SHOULD BE USED TO ESTABLISH APPROPRIATE GEOMETRY.
2. AT -Y- LINES ONLY PASSENGER CAR U-TURNS ARE ACCOMMODATED.
3. DESIGN BULB OUTS TO ACCOMODATE WB-50. IN AREAS WHERE THERE ARE R/W OR ENVIRONMENTAL CONSTRAINTS, BULB OUT DIMENSIONS MAY BE REDUCED.
4. ALL DIMENSIONS ARE SUBJECT TO FIELD CONDITIONS.
5. FULL CONTROL OF ACCESS SHOULD BE OBTAINED THROUGHOUT LIMITS OF THE BULB OUT ON BOTH SIDES OF ROADWAY.
6. USE 575′ MINIMUM LENGTH FOR ALL LEFT TURN LANES (INCLUDES TAPER AND FULL STORAGE LENGTH).

REV. DATE : 02/05/09
REV. NO. 6

INSET "A"

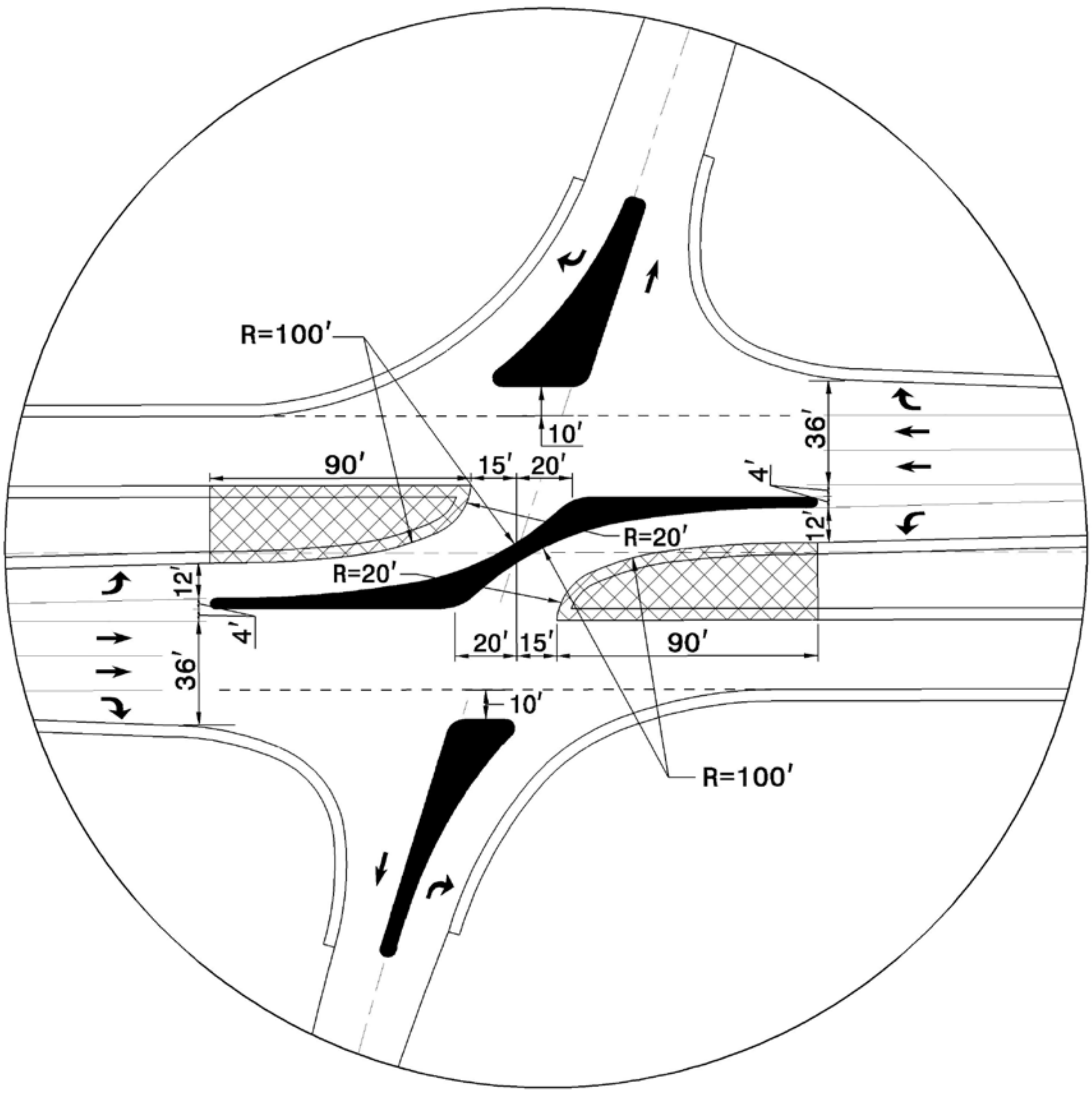


INSET "A"

REV. DATE : 02/05/09
REV. NO. 6

INSET "B" **9 - 4**

INSET "B"



INSET "B"