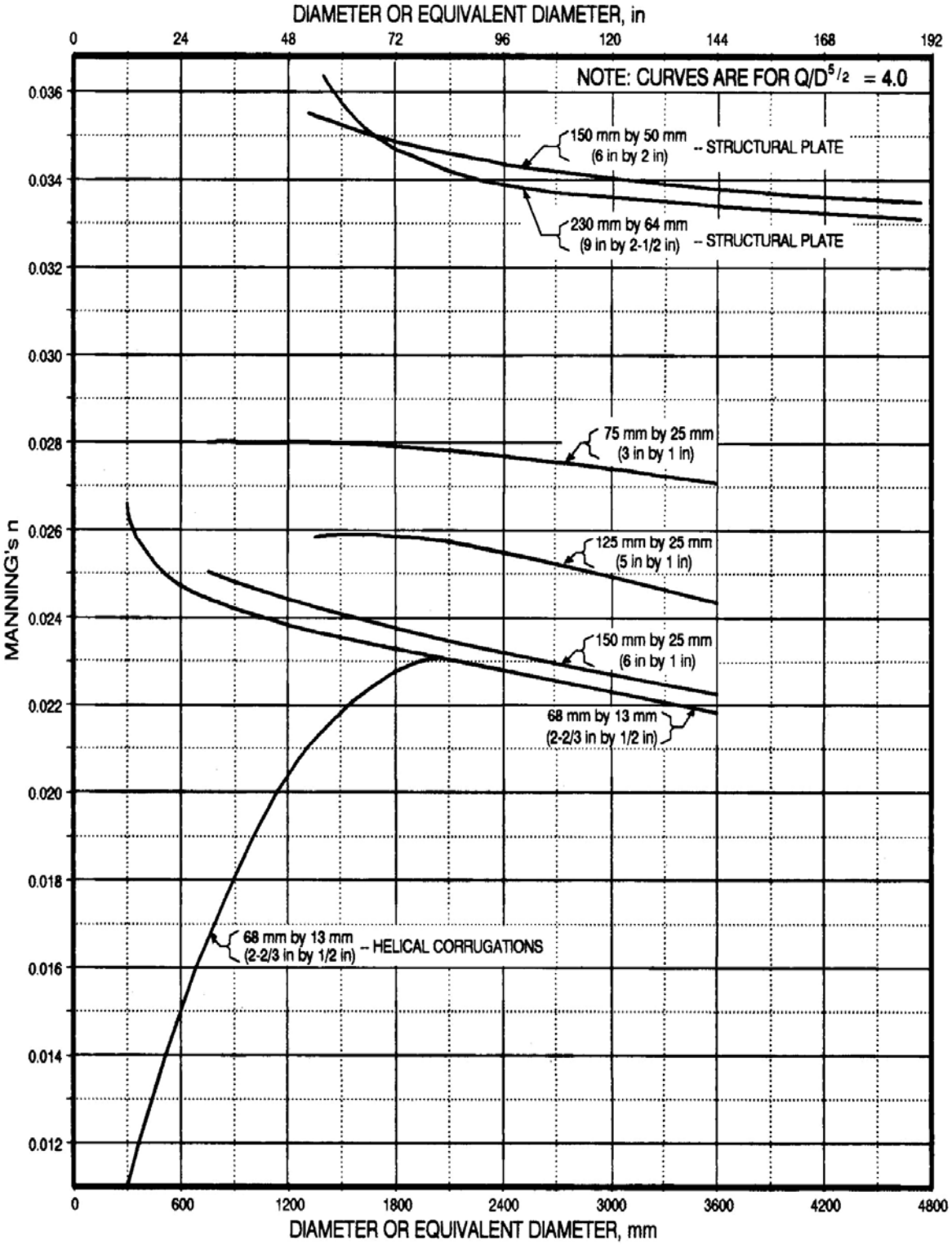
Appendix 5-B
Tables of Manning's n, Loss Coefficients, and Worksheets

Recommended Manning n Values

Type of Conduit	Wall Description	MDOT Manning Design Value
Concrete Pipe	Smooth	0.013
Concrete Boxes	Smooth	0.013
Corrugated Metal Pipe, Pipe-Arch and Box (For Annular and Helical corrugations, see 5-B-3: Manning's "n" varies with barrel size)	2 2/3 inch by ½ inch corrugations Annular	0.027
	2 2/3 inch by ½ inch corrugations Helical	0.012 - 0.024
	6 inch by 1 inch corrugations Helical	0.025
	5 inch by 1 inch corrugations	0.026
	3 inch by 1 inch corrugations	0.028
	6 inch by 2 inch structural plate	0.035
	9 inch by 2 ½ inch structural plate	0.037
Spiral Rib Metal	Smooth	0.013
Corrugated Polyethylene	Smooth	0.013
Corrugated Polyethylene	Corrugated	0.025
Polyvinyl Chloride (PVC)	Smooth	0.011

Note 1: The values indicated in this table are recommended Manning n design values. Actual field values for older existing pipelines may vary depending on the effects of abrasion, corrosion, deflection, and joint conditions. Concrete pipe with poor joints and deteriorated walls may have n values of 0.014 to 0.018. Corrugated metal pipe with joint and wall problems may also have higher n values and, in addition, may experience shape changes that could adversely affect the general hydraulic characteristics of the culvert.

Manning's "n" versus Diameter for Corrugated Metal Conduits



Entrance Loss Coefficients
(Outlet Control, Full or Partly Full)

$$H_e = k_e (y^2/2g)$$

Type of Structure and Design of Entrance	Coefficient k_e
Pipe, Concrete	
Mitered to conform to fill slope	0.7
* End-Section conforming to fill slope	0.5
Projecting from fill, sq. cut end	0.5
Headwall or headwall and wingwalls	
Square-edge	0.5
Rounded (radius = 1/12D)	0.2
Socket end of pipe (groove-end)	0.2
Projecting from fill, socket end (groove-end)	0.2
Beveled edges, 33.7E or 45E bevels	0.2
Side- or slope-tapered inlet	0.2
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Mitered to conform to fill slope, paved or unpaved slope	0.7
Headwall or headwall and wingwalls square-edge	0.5
* End-Section conforming to fill slope	0.5
Beveled edges, 33.7E or 45E bevels	0.2
Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Wingwalls at 10E to 25E or 30E to 75E to barrel	
Square-edged at crown	0.5
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2
Wingwalls at 30E to 75E to barrel	
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2
Side- or slope-tapered inlet	0.2

* Note: "End Section conforming to fill slope," made of either metal or concrete, are the sections commonly available from manufacturers. From limited hydraulic tests, they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections, incorporating a closed taper in their design have a superior hydraulic performance. These latter sections can be designed using the information given for the beveled inlet.

PROJECT : _____

STATION : _____

SHEET _____ OF _____

CULVERT DESIGN FORM

DESIGNER / DATE : _____ / _____

REVIEWER / DATE : _____ / _____

HYDROLOGICAL DATA

SEE ADD'L SHTS.

☐ METHOD : _____

☐ DRAINAGE AREA : _____ ☐ STREAM SLOPE : _____

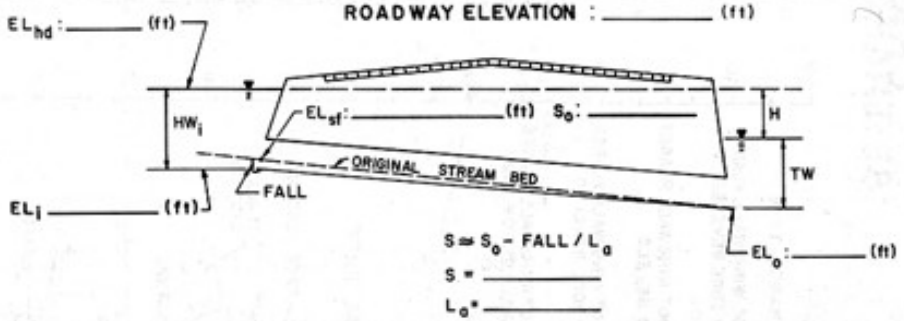
☐ CHANNEL SHAPE : _____

☐ ROUTING : _____ ☐ OTHER : _____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION : _____ (ft)



$S \simeq S_o - FALL / L_a$

$S =$ _____

$L_a =$ _____

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW i/D (2)	HW i	FALL (3)	EL hi (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c + D}{2}$	h_o (6)	k_e	H (7)	EL ho (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_t/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L) / R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS :

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION :

CULVERT BARREL SELECTED :

SIZE : _____

SHAPE : _____

MATERIAL : _____

ENTRANCE : _____

PROJECT : _____

_____

STATION : _____

SHEET _____ OF _____

TAPERED INLET DESIGN FORM

DESIGNER / DATE: _____ / _____

REVIEWER / DATE: _____ / _____

DESIGN DATA :

Q _____ = _____ cfs ; EL_{hi} _____ ft

EL. THROAT INVERT _____ ft

EL. STREAM BED AT FACE _____ ft

FALL _____ ft TAPER _____ : 1 (4 : 1 TO 6 : 1)

STREAM SLOPE , So = _____ ft/ft

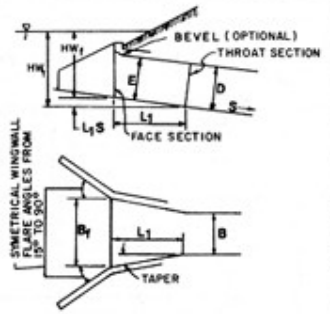
SLOPE OF BARREL , S = _____ ft/ft

S_f _____ : 1 (2 : 1 TO 3 : 1)

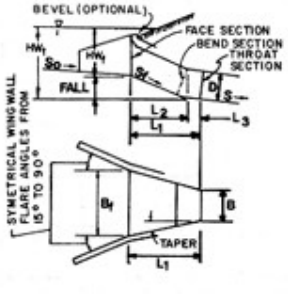
BARREL SHAPE AND MATERIAL : _____

N = _____ , B = _____ , D = _____

INLET EDGE DESCRIPTION _____



SIDE - TAPERED



SLOPE - TAPERED

COMMENTS

Q (cfs)	EL_{hi}	EL. THROAT INVERT	EL. FACE INVERT (1)	HW_f (2)	HW_f/E (3)	Q/B_f (4)	MIN. B_f (5)	SELECTED B_f	SLOPE-TAPERED ONLY: MIN. L_3 (6)	L_2 (7)	CHECK L_2 (8)	ADJ. L_3 (9)	ADJ. TAPER (10)	L_1 (11)	SIDE-TAPERED W/ FALL: EL. CREST INV.	HW_c (12)	MIN. W (13)

(1) SIDE - TAPERED : EL. FACE INVERT = EL. THROAT INVERT + 1 ft (APPROX.)
SLOPE - TAPERED : EL. FACE INVERT = EL. STREAM BED AT FACE

(2) $HW_f = EL_{hi}$ - EL. FACE INVERT

(3) I.I D ≥ E ≥ D

(4) FROM DESIGN CHARTS

(5) MIN. $B_f = Q/(Q/B_f)$

(6) MIN. $L_3 = 0.5\,NB$

(7) L_2 = (EL. FACE INVERT - EL. THROAT INVERT) S_f

(8) CHECK $L_2 = \left[\frac{B_f - NB}{2}\right] \cdot TAPER - L_3$

(9) IF (8)>(7), ADJ. $L_3 = \left[\frac{B_f - NB}{2}\right] \cdot TAPER - L_2$

(10) IF (7)>(8), ADJ. TAPER = $(L_2 + L_3) \Big/ \left[\frac{B_f - NB}{2}\right]$

(11) SIDE - TAPERED : $L = \left[\frac{B_f - NB}{2}\right] \cdot TAPER$

SLOPE - TAPERED : $L_1 = L_2 + L_3$

(12) $HW_c = EL_{hi}$ - EL. CREST INVERT

(13) MIN. $W = 0.35\,Q / HW_c^{1.5}$

SELECTED DESIGN

B_f _____

L_1 _____

L_2 _____

L_3 _____

BEVELS ANGLE ____°

b = ____ in ; d = ____ in

TAPER _____ : 1

S_f = _____ : 1

PROJECT : _____

_____

STATION : _____

SHEET _____ OF _____

MITERED INLET DESIGN FORM

DESIGNER / DATE : _____ / _____

REVIEWER / DATE : _____ / _____

DESIGN DATA : N _____ ; B _____ ; D _____

Q _____ = _____ cfs ; EL_{hi} _____ ft

EL. THROAT INVERT _____ ft EL. STREAM BED AT CREST _____ ft

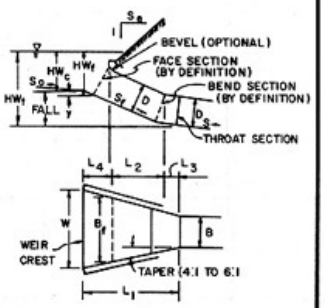
FALL _____ ft ; TAPER _____ : (4:1 TO 6:1)

STREAM SLOPE , S_o _____ ft/ft ; BARREL SLOPE , S = _____ ft/ft

SLOPE OF THE EMBANKMENT S_e = _____ : 1 ; S_f _____ : 1 (2:1 TO 3:1)

BARREL SHAPE AND MATERIAL : _____

INLET EDGE DESCRIPTION : _____



SLOPE - TAPERED INLET / MITERED FACE

COMMENTS

Q (cfs)	EL_{hi}	EL. THROAT INVERT	y (1)	EL. FACE INVERT (2)	HW_f (3)	HW_f/E (4)	Q/B_f (5)	MIN. B_f (6)	SELECTED B_f	MIN. L_3 (7)	L_4 (8)	L_2 (9)	CHECK L_2 (10)	ADJ. L_3 (11)	ADJ. TAPER (12)	L_1 (13)	EL. CREST INV.	HW_c (14)	MIN. W (15)	W (16)

(1) $y = \left[\frac{(S_e \cdot S_f) - 1}{(S_e + S_f)(S_f^2 + 1)^{0.5}}\right] \cdot D$

(2) EL. FACE INVERT = EL. STREAM BED AT CREST - y

(3) $HW_f = EL_{hi}$ - EL. FACE INVERT

(4) I.I D ≥ E ≥ D

(5) FROM DESIGN CHARTS

(6) MIN. $B_f = Q/(Q/B_f)$

(7) MIN. L_3 = 0.5 NB

(8) $L_4 = S_f y + D/S_f$

(9) L_2 = (EL. CREST INVERT - EL. THROAT INVERT) $S_f - L_4$

*** IF L_2 IS NEGATIVE DO NOT USE THIS INLET

(10) CHECK $L_2 = \left[\frac{B_f - NB}{2}\right]$ TAPER - L_3.

(11) IF (10)>(9), ADJ. $L_3 = \left[\frac{B_f - NB}{2}\right]$ TAPER - L_2

(12) IF (9)>(10), ADJ. TAPER = $(L_2 + L_3) / \left[\frac{B - NB}{2}\right]$

(13) $L_1 = L_2 + L_3 + L_4$

(14) HW_c = EL_{hi} - EL. CREST INVERT

(15) MIN. W = $0.35 Q / (HW_c)^{1.5}$

(16) $W = NB + 2\left[\frac{L_1}{TAPER}\right]$

IF W<MIN. W, ADJUST TAPER

SELECTED DESIGN

B_f _____

L_1 _____

L_2 _____

L_3 _____

L_4 _____

BEVELS ANGLE _____°

b = _____ in; d = _____ in

TAPER _____ : 1

S_f _____ : 1