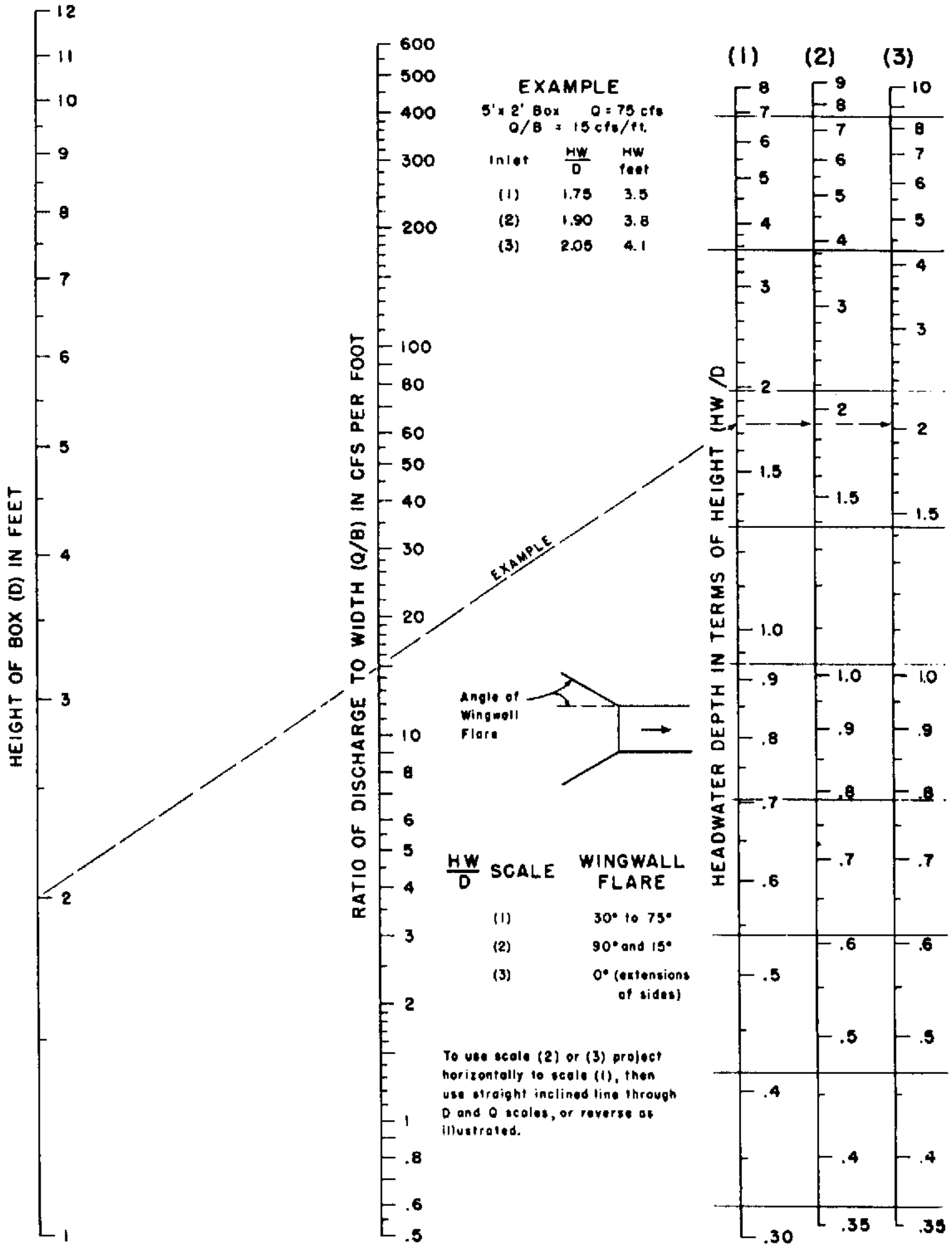
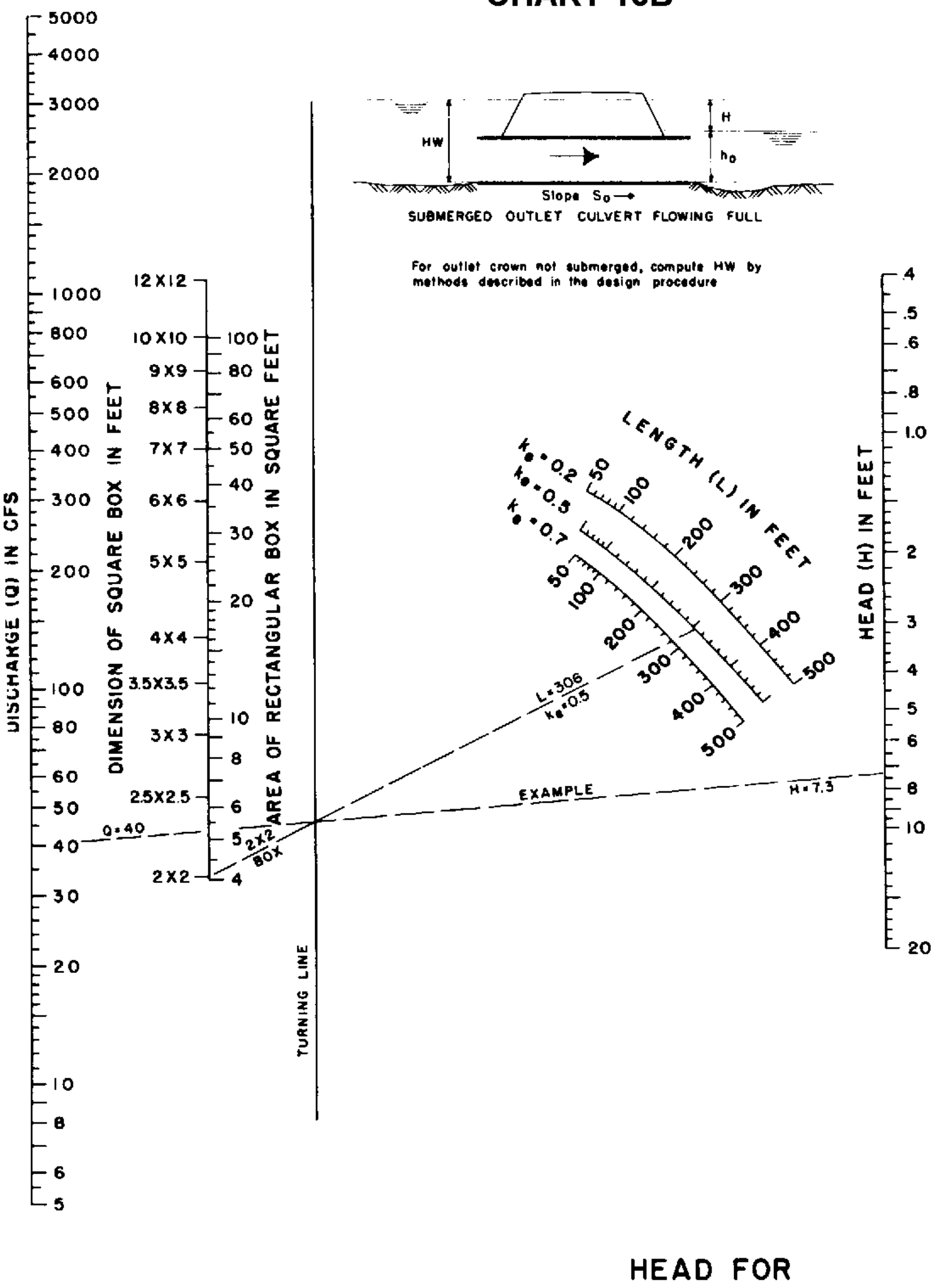
CHART 8B



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

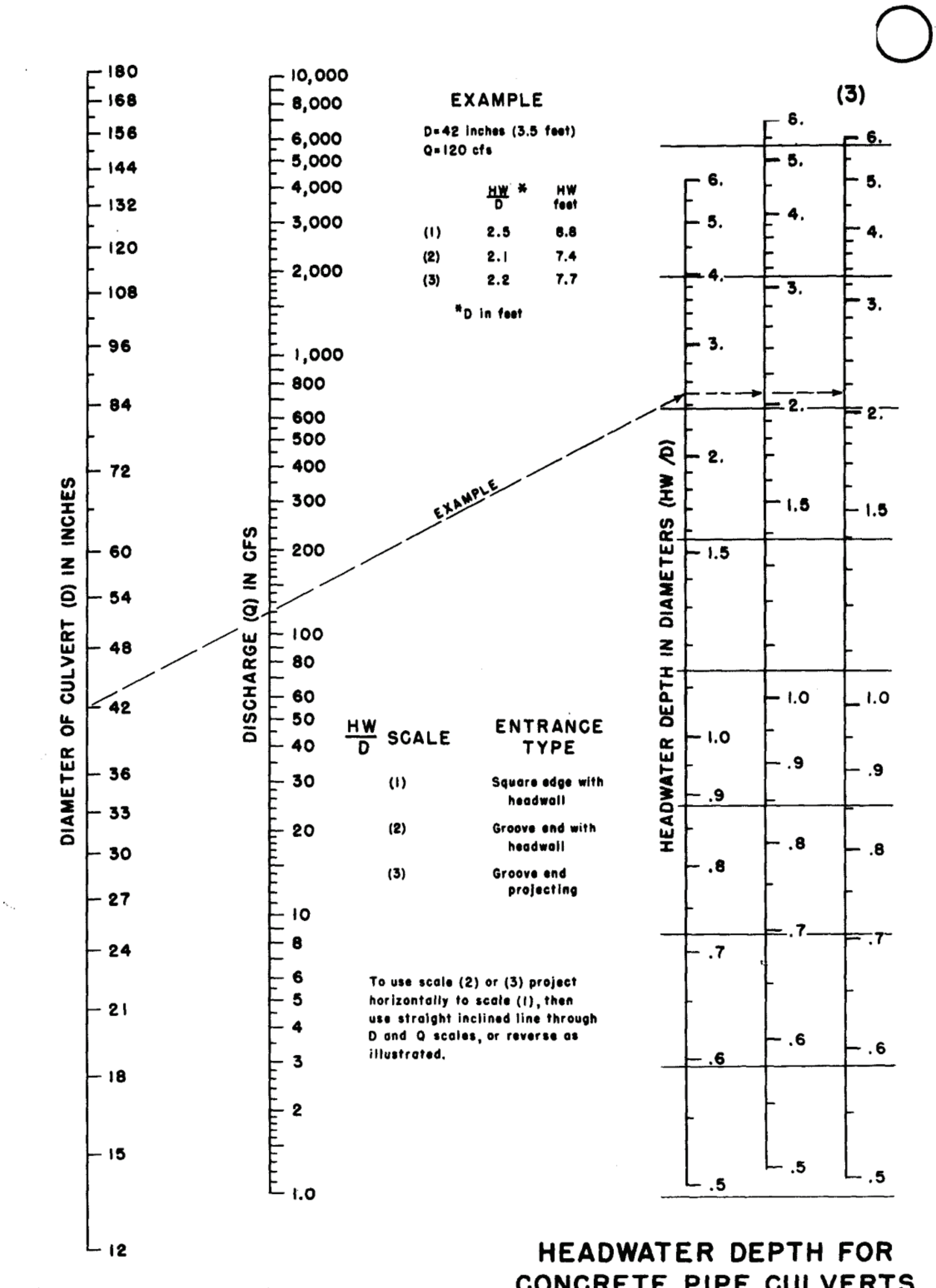
CHART 15B



HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

AU OF PUBLIC ROADS JAN. 1963

CHART 1B



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2&3 REVISED MAY 1964

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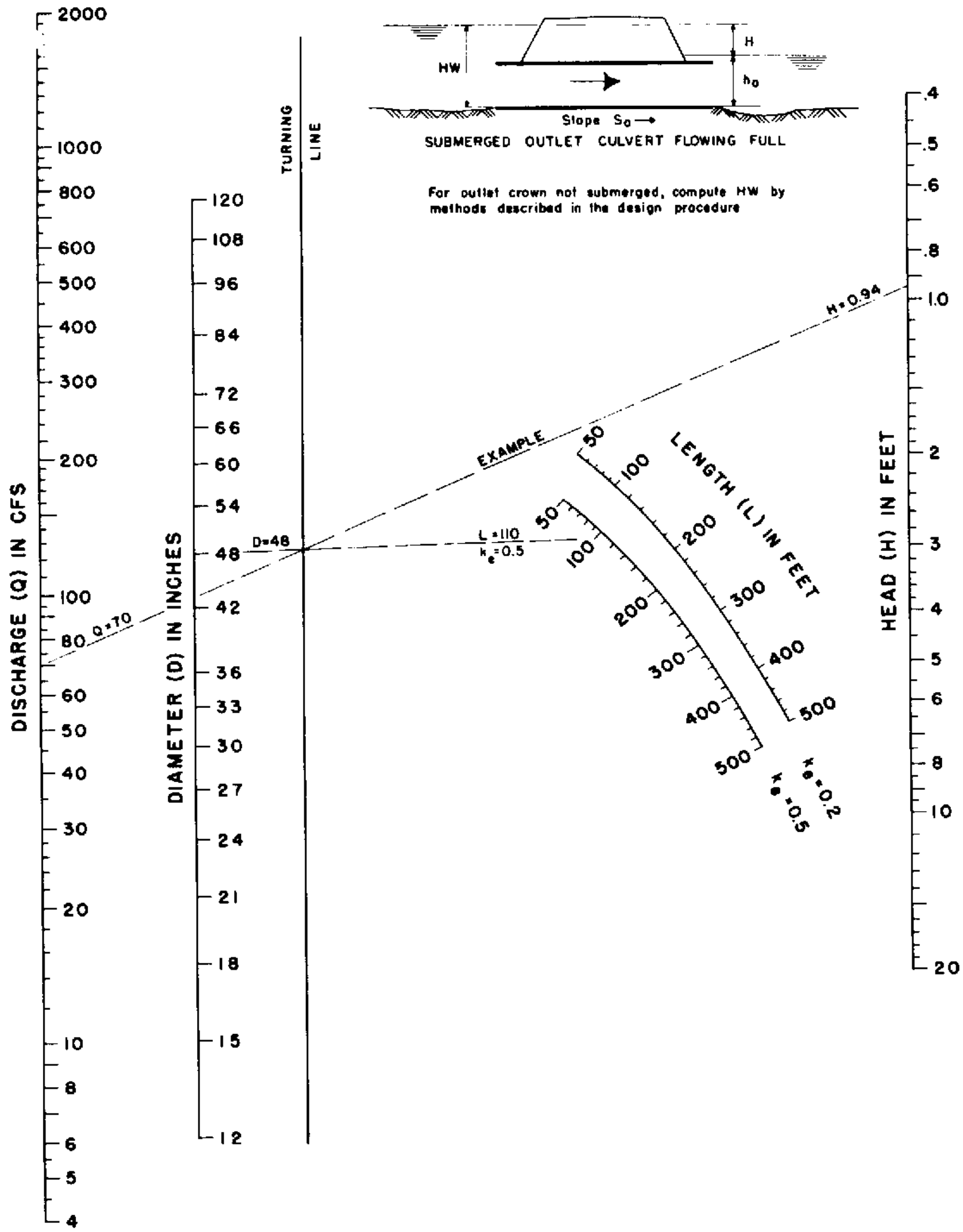
CHART 5B



HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

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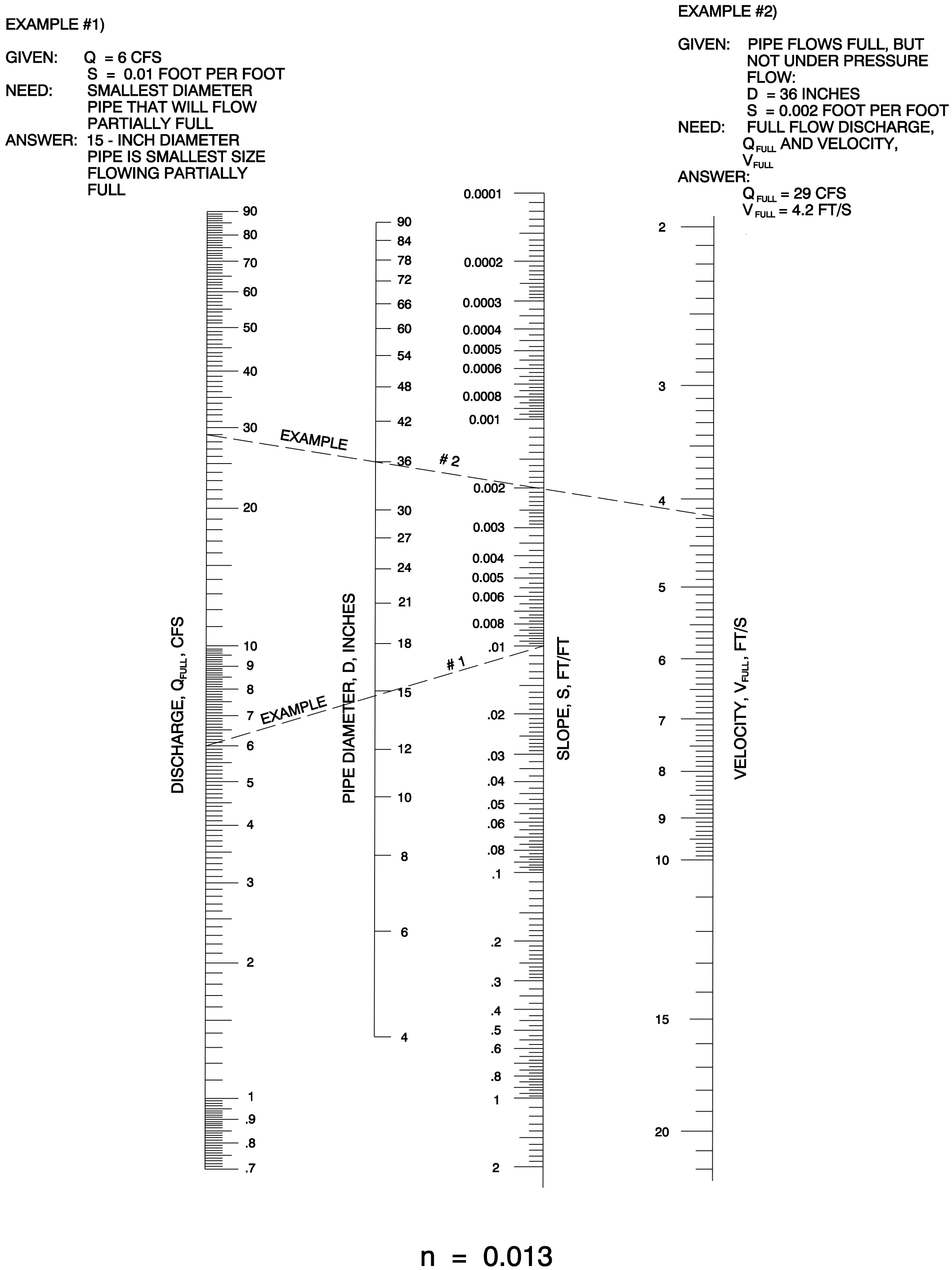


Figure 8-19 Capacity and Velocity Nomograph for Circular Concrete Pipes Flowing Full

EXAMPLE
GIVEN: Q = 15 CFS
D = 24 INCHES
NEED: ESTIMATE OF FRICTION
SLOPE IN FEET PER FOOT
ANSWER: FRICTION SLOPE = 0.015 FOOT
PER FOOT

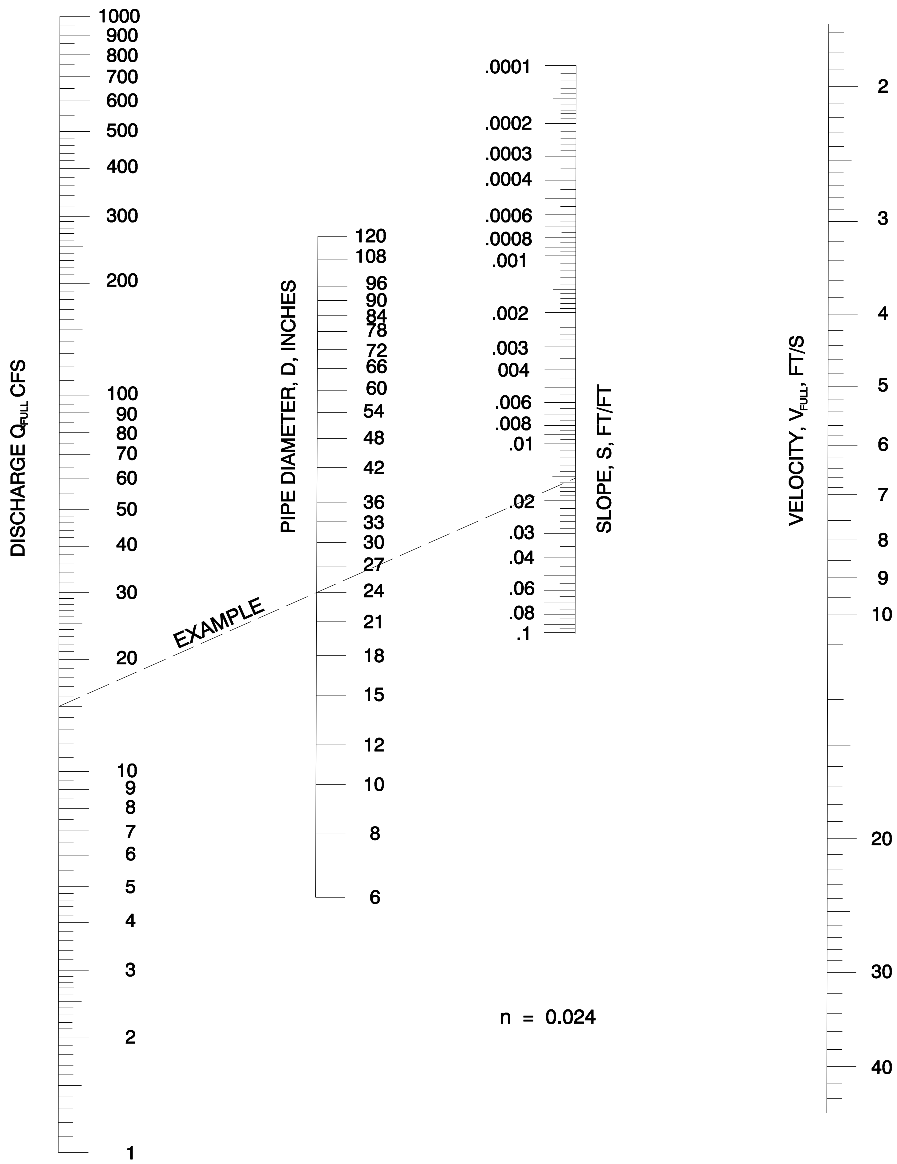
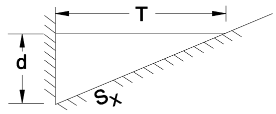


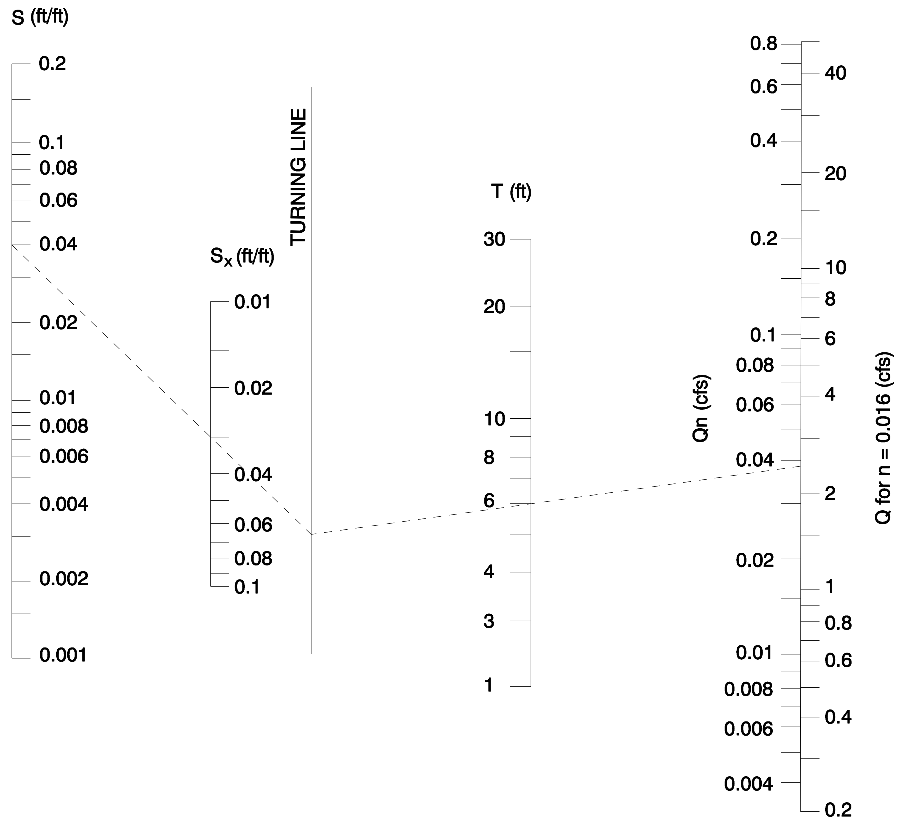
Figure 8-20 Capacity and Velocity Nomograph for Circular Corrugated Metal Pipes Flowing Full



$$Q = \frac{0.56}{n} S_x^{1.67} S^{0.5} T^{2.67}$$

$$d = TS_x$$

Example: Given:
$n = 0.016$, $S_x = 0.03$ ft/ft
$S = 0.04$ ft/ft, $T = 6$ ft
Find:
$Q = 2.4$ cfs
$d = (6)(0.03) = 0.18$ ft



S = longitudinal gutter slope (ft/ft)

S_x = gutter cross-slope (ft/ft)

T = flow width in gutter (ft)

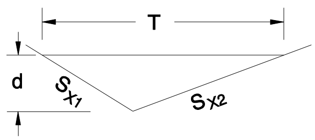
Q = total gutter flow (cfs)

n = Manning's "n"

d = flow depth at curb (ft)

Example: Given:
$n = 0.012$, $S_x = 0.03$ ft/ft
$S = 0.04$ ft/ft, $T = 6$ ft
Find:
$Q_n = 0.038$ cfs
$Q = \frac{Q_n}{n} = \frac{0.038}{0.012} = 3.2$ cfs

Figure 8-14 Discharge Nomograph for Gutter with Near Vertical Curb and Single Gutter Cross Slope

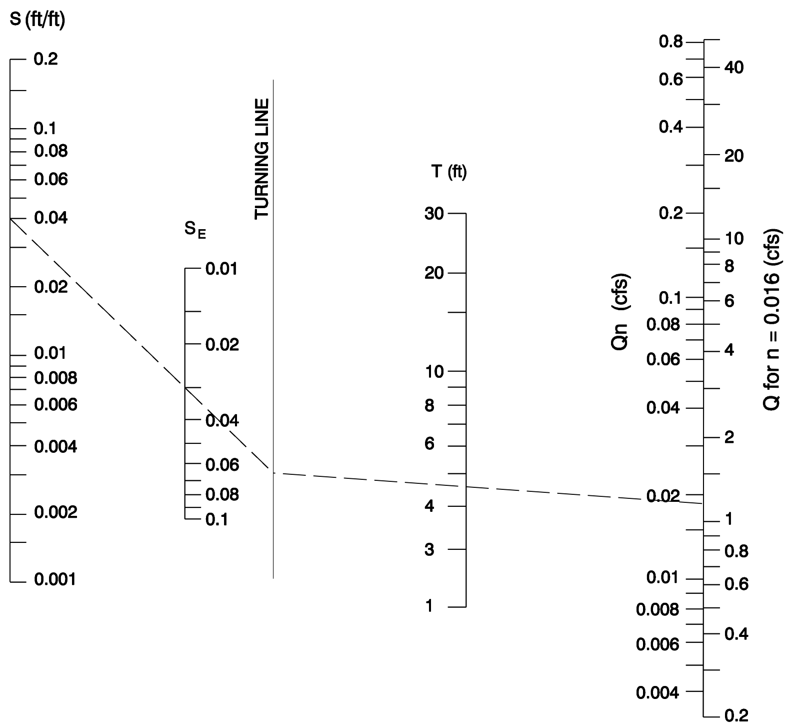


$$Q = \frac{0.56}{n} S_E^{1.67} S^{0.5} T^{2.67}$$

$$S_E = S_{X1} S_{X2} / (S_{X1} + S_{X2})$$

$$d = TS_E$$

Example: Given:
n = 0.016, S_{X1} = 0.50 ft/ft, S_{X2} = 0.02 ft/ft
S = 0.04 ft/ft, T = 6 ft
Find:
S_E = (0.50)(0.02)/(0.50 + 0.02)
S_E = 0.019
Q = 1.2 cfs
d = (6)(0.019) = 0.11 ft



S = longitudinal gutter slope (ft/ft)

S_{X1}, S_{X2} = gutter cross-slope (ft/ft)

S_E = equivalent gutter cross-slope (ft/ft)

T = flow width in gutter (ft)

Q = total gutter flow (cfs)

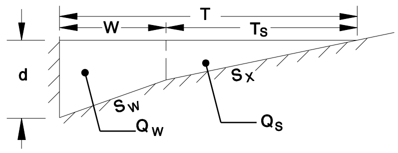
n = Manning's "n"

d = flow depth at curb (ft)

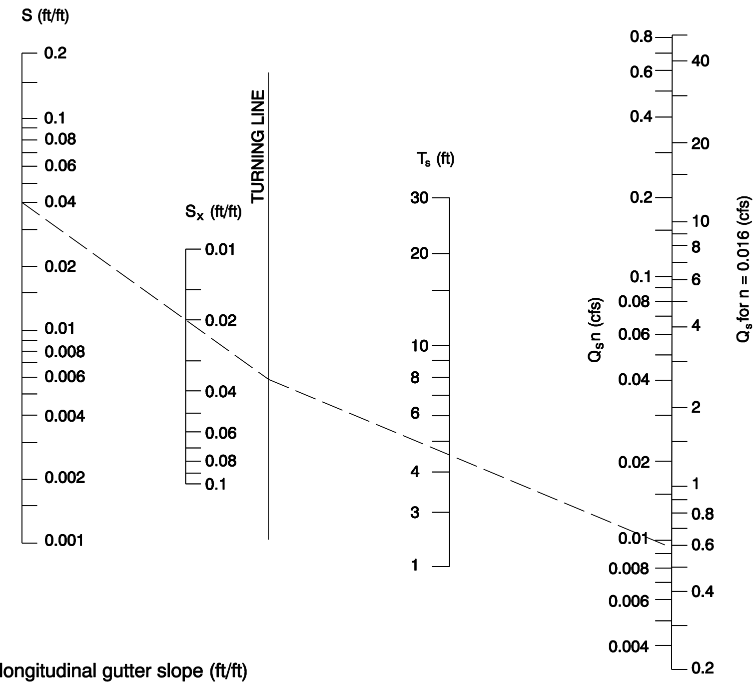
Example: Given:
n = 0.012, S_{X1} = 0.50 ft/ft,
S_{X2} = 0.02 ft/ft, S = 0.04 ft/ft
T = 6 ft
Need:
S_E = (0.50)(0.02)/(0.50 + 0.02)
S_E = 0.019 ft/ft
Q_n = 0.019 cfs
$Q = \frac{Q_n}{n} = \frac{0.019}{0.012}$ = 1.6 cfs

Figure 8-16 Discharge Nomograph for Gutter with Two Cross Slopes

To determine discharge in gutter with composite cross slopes, find Q_S using T_S and S_X. Then, use Figure 8-18 to find E_O. The total discharge is $Q = Q_S/(1 - E_O)$, and $Q = Q - Q_S$
$d = WS_W + T_S S_X$



Example: Given:
$n = 0.016$, $S_W = 0.08$ ft/ft, $S_X = 0.02$ ft/ft
$T = 6$ ft, $W = 1.5$ ft, $S = 0.04$ ft/ft
Find:
$T_S = T - W = 6 - 1.5 = 4.5$ ft
$Q_S = 0.59$ cfs
$E_O = 0.67$ (from Figure 8-18)
$Q = 0.59/(1 - 0.67) = 1.8$ cfs



S = longitudinal gutter slope (ft/ft)

S_W = depressed gutter cross slope (ft/ft)

S_X = gutter cross-slope (ft/ft)

T = flow width in gutter (ft)

T_S = flow width outside of depressed gutter (ft)

W = depressed gutter flow width (ft)

Q = total gutter flow (cfs)

Q_S = flow outside of depressed gutter (cfs)

Q_W = depressed gutter flow (cfs)

E_O = ratio of depressed gutter flow to total gutter flow

Example: Given:
$n = 0.012$, $S_W = 0.08$ ft/ft, $S_X = 0.02$ ft/ft
$T = 6$ ft, $W = 1.5$ ft, $S = 0.04$ ft/ft
Find:
$T_S = T - W = 6 - 1.5 = 4.5$ ft
$Q_S n = 0.0093$ cfs
$Q_S = \frac{Q_S n}{n} = \frac{0.0093}{0.012} = 0.77$ cfs
$E_O = 0.67$ (from Figure 8-18)
$Q = 0.77/(1 - 0.67) = 2.3$ cfs

Figure 8-17 Discharge Nomograph for Gutter with Near Vertical Curb and Two Gutter Cross Slopes