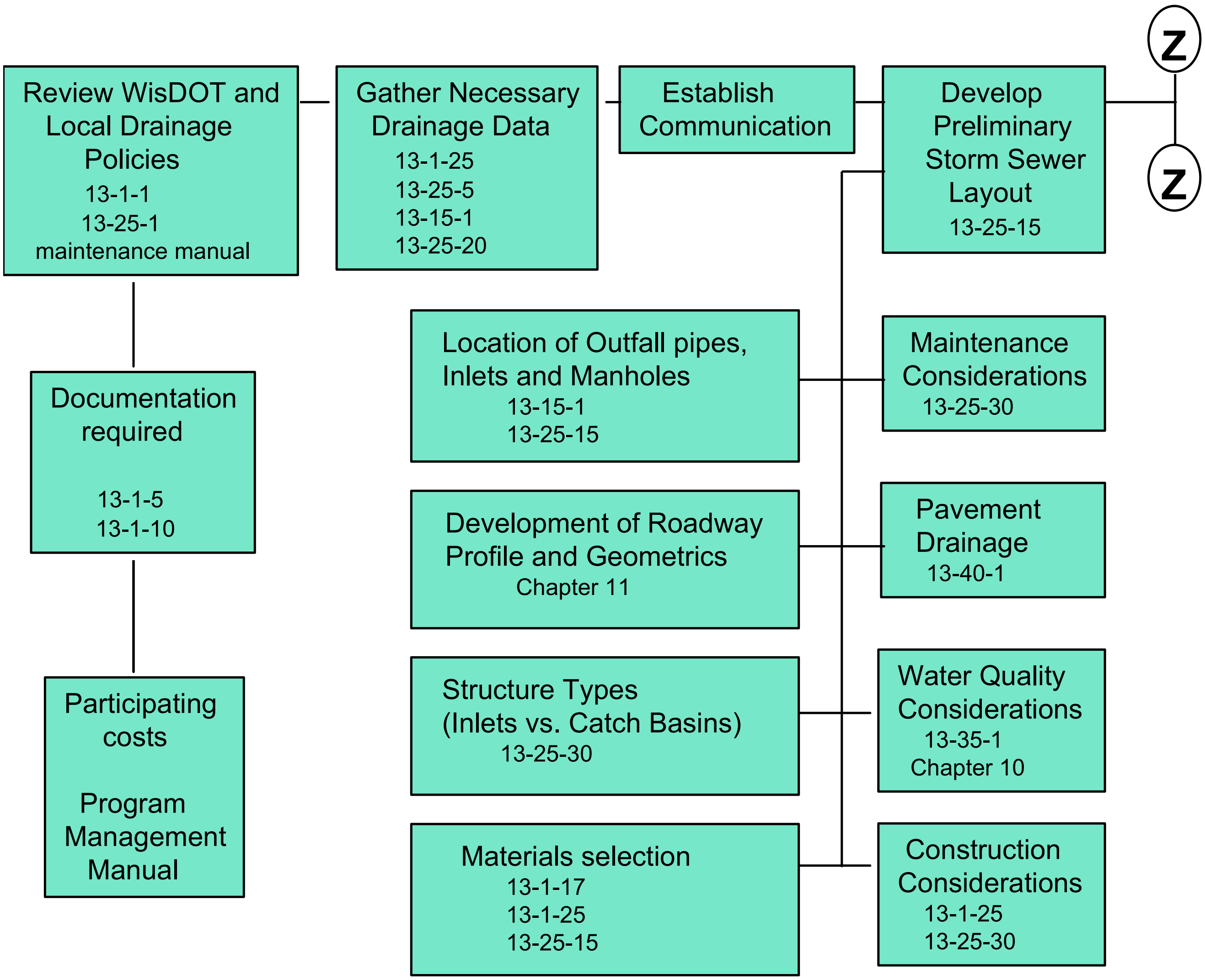
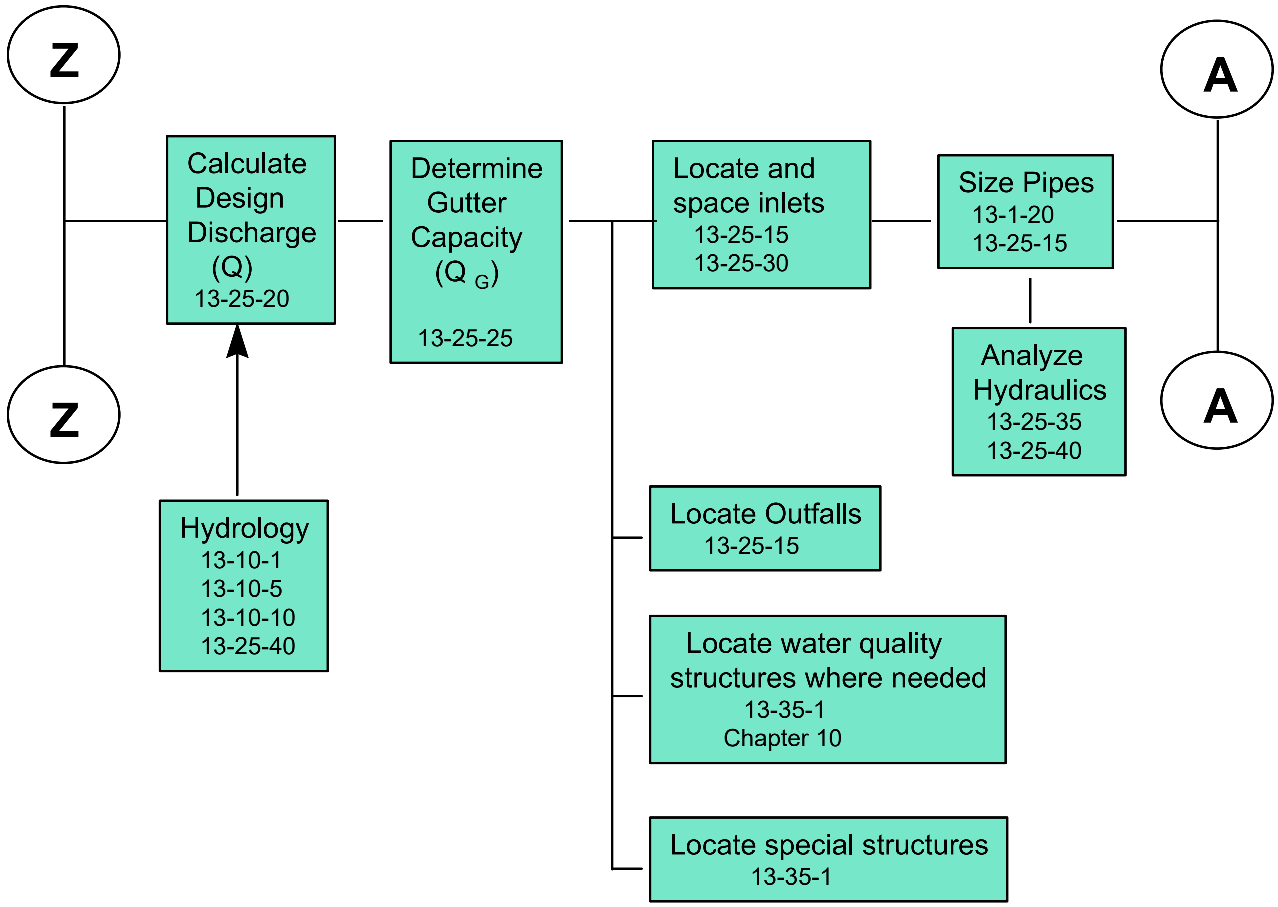
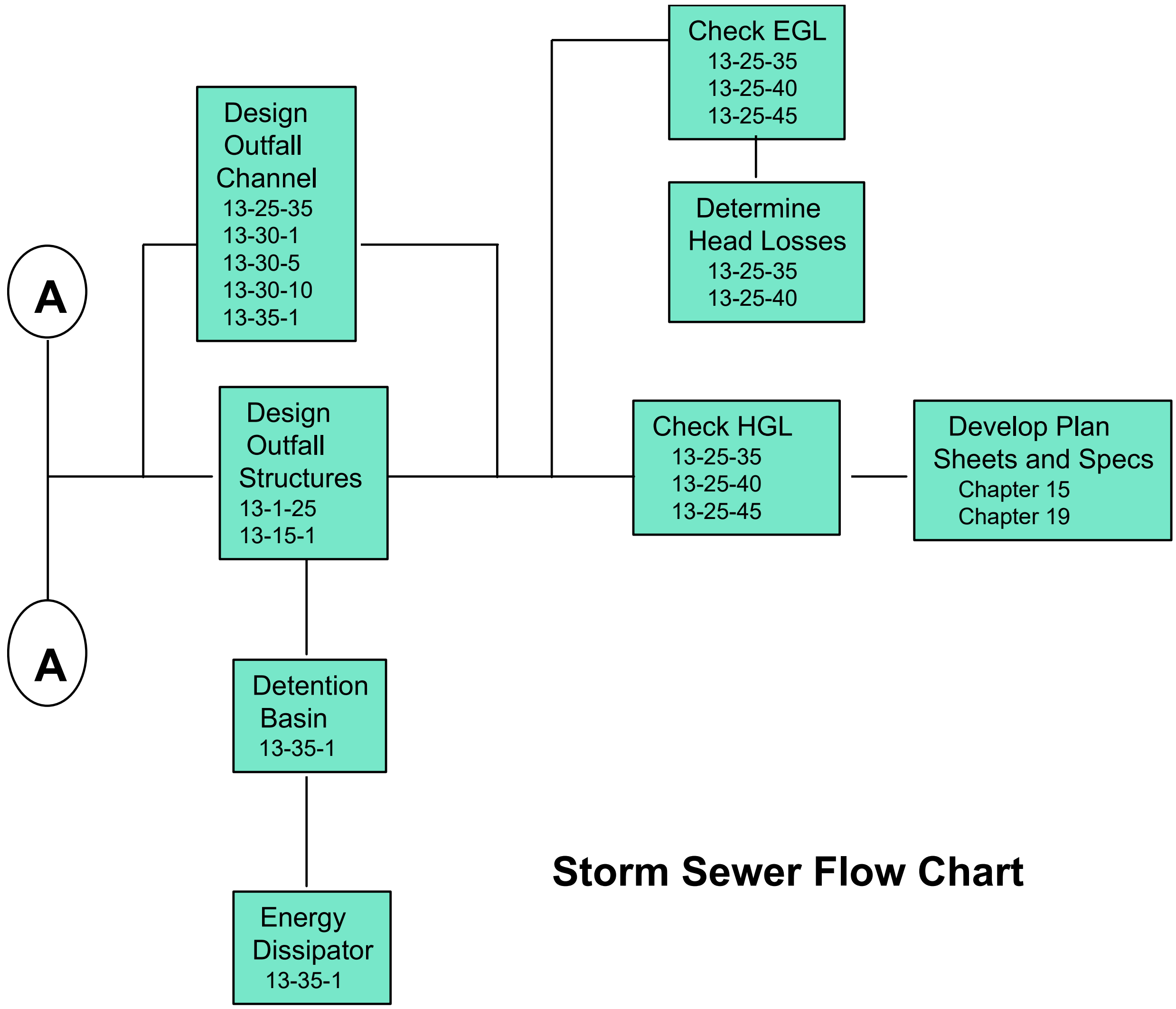


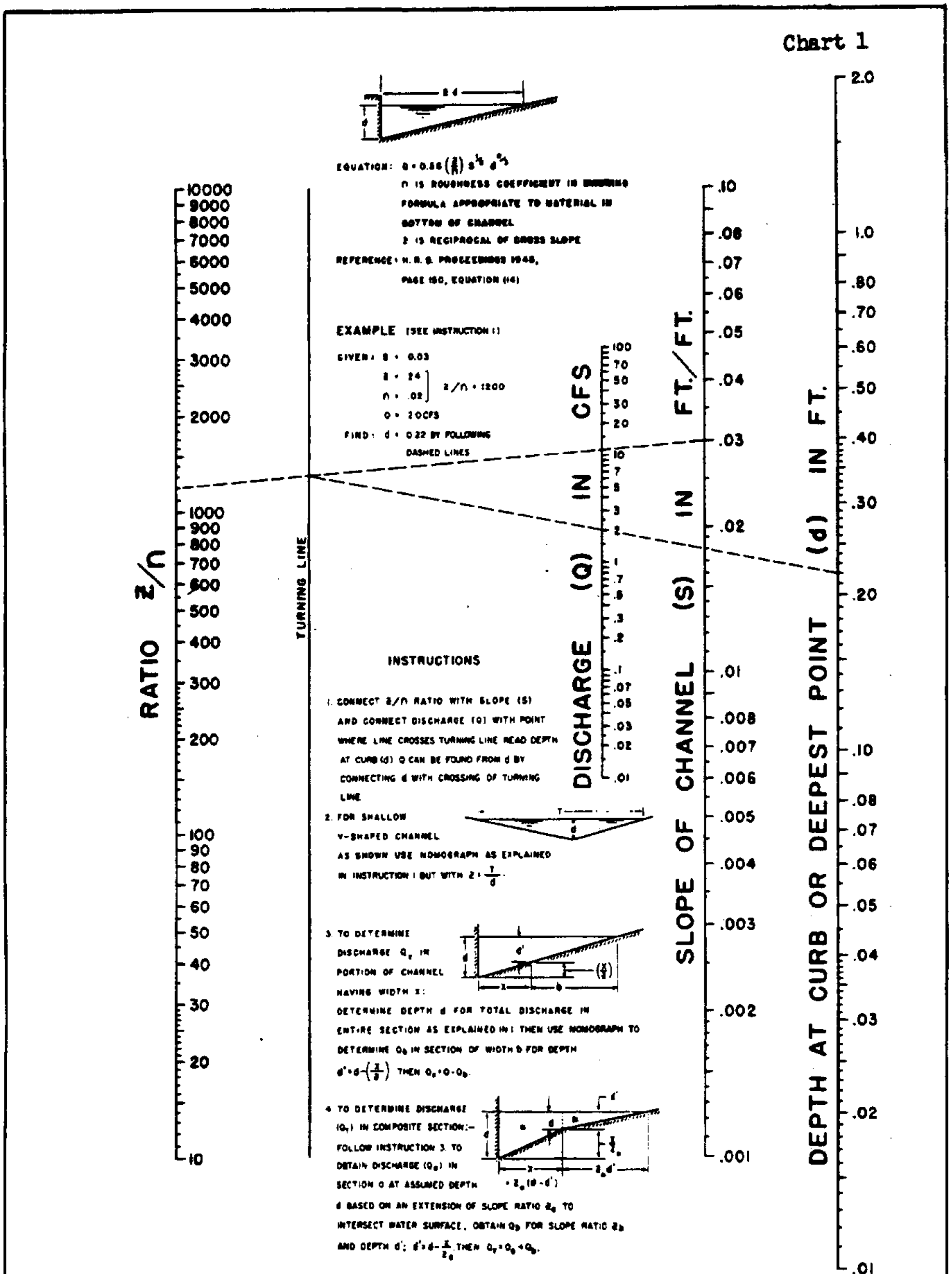
Storm Sewer Flow Chart



Storm Sewer Flow Chart

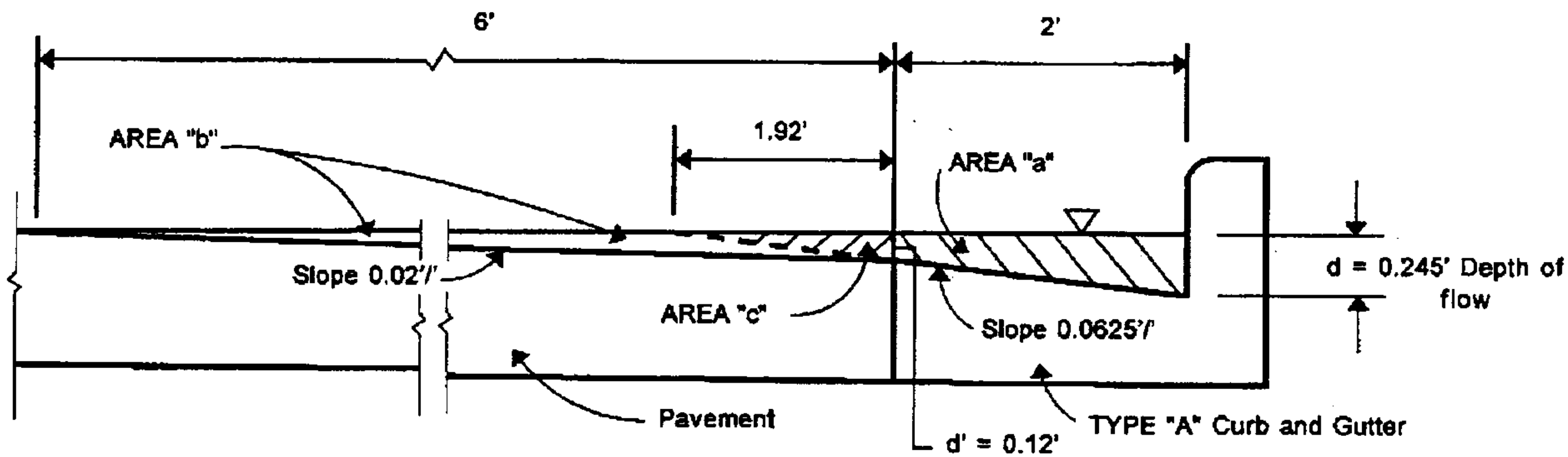


Storm Sewer Flow Chart



NOMOGRAPH FOR FLOW IN TRIANGULAR CHANNELS

Example Problem
Gutter Design



REDUCTION FACTORS TO APPLY TO INLETS

Condition	Inlet Type	Percentage of Theoretical Capacity Allowed
Sump	Curb Opening	80%
Sump	Grated	50%
Sump	Combination	65%
Continuous Grade	Curb opening	80%
Continuous Grade	Deflector	75%
Continuous Grade	Longitudinal Bar Grated	60%
Continuous Grade	Transverse Bar Grate or Longitudinal Bar Grate incorporating transverse bars	50%
Continuous Grade	Combination	110% of that listed for type of grate utilized

Source: Denver Regional Council of Governments, Urban Storm Drainage-Criteria Manual, Volume 1.

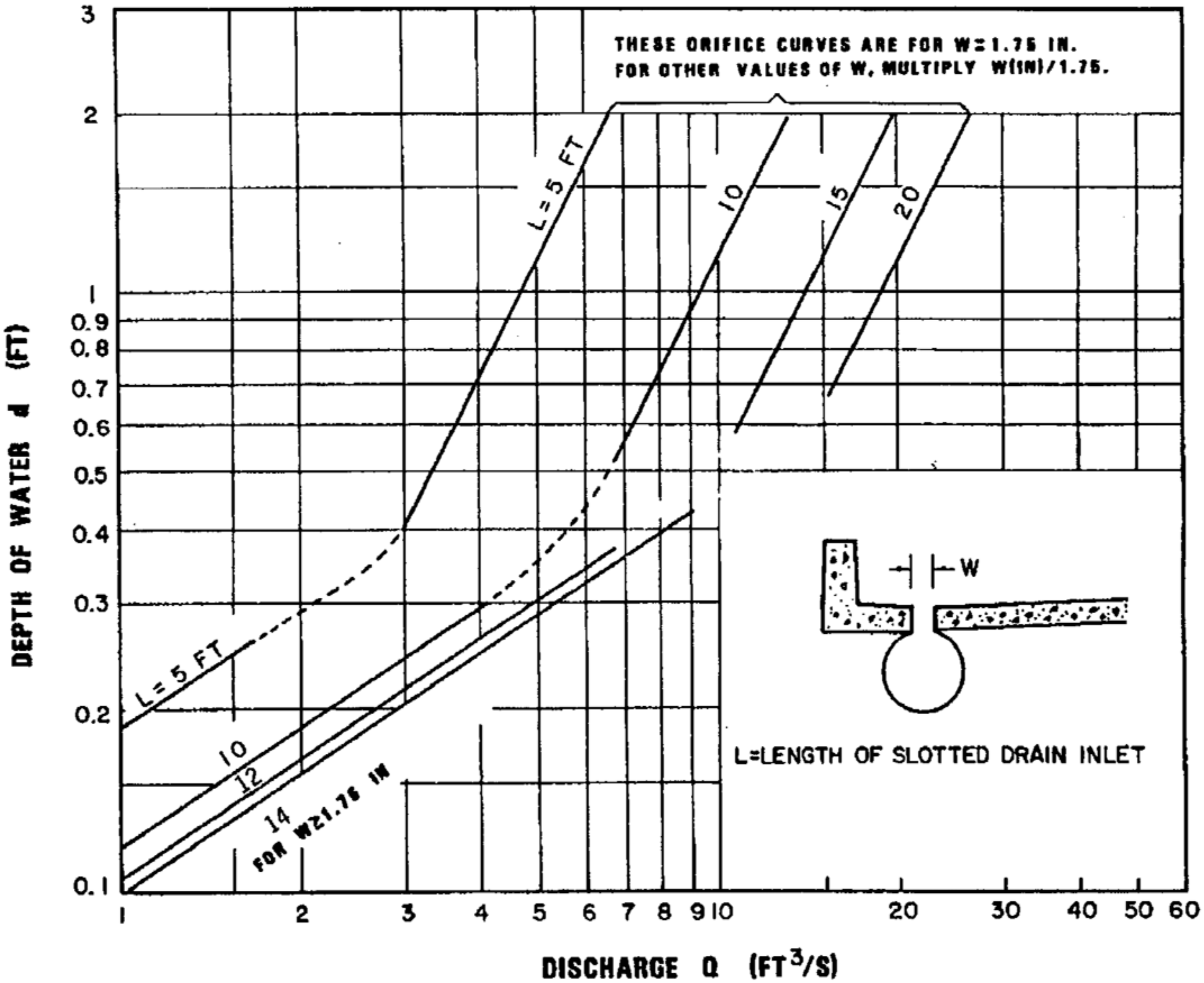

THESE ORIFICE CURVES ARE FOR W = 1.75 IN.
FOR OTHER VALUES OF W, MULTIPLY W(IN)/1.75.
L = 5 FT
10
15
20
L = 5 FT
10
12
14
FOR W = 1.75 IN
W
L=LENGTH OF SLOTTED DRAIN INLET
DEPTH OF WATER d (FT)
DISCHARGE Q (FT³/S)
3
2
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60

Table 1.—Manning roughness coefficients, *n* [1]

	Manning's n range [2]
I. Closed conduits:	
A. Concrete pipe	0.011–0.013
B. Corrugated-metal pipe or pipe-arch:	
1. 2⅔ by ½-in. corrugation (riveted pipe): [3]	
a. Plain or fully coated	0.024
b. Paved invert (range values are for 25 and 50 percent of circumference paved):	
(1) Flow full depth	0.021–0.018
(2) Flow 0.8 depth	0.021–0.016
(3) Flow 0.6 depth	0.019–0.013
2. 6 by 2-in. corrugation (field bolted)	0.03
C. Vitrified clay pipe	0.012–0.014
D. Cast-iron pipe, uncoated	0.013
E. Steel pipe	0.009–0.011
F. Brick	0.014–0.017
G. Monolithic concrete:	
1. Wood forms, rough	0.015–0.017
2. Wood forms, smooth	0.012–0.014
3. Steel forms	0.012–0.013
H. Cemented rubble masonry walls:	
1. Concrete floor and top	0.017–0.022
2. Natural floor	0.019–0.025
I. Laminated treated wood	0.015–0.017
J. Vitrified clay liner plates	0.015
II. Open channels, lined [4] (straight alinement): [5]	
A. Concrete, with surfaces as indicated:	
1. Formed, no finish	0.013–0.017
2. Trowel finish	0.012–0.014
3. Float finish	0.013–0.015
4. Float finish, some gravel on bottom	0.015–0.017
5. Gunite, good section	0.016–0.019
6. Gunite, wavy section	0.018–0.022
B. Concrete, bottom float finished, sides as indicated:	
1. Dressed stone in mortar	0.015–0.017
2. Random stone in mortar	0.017–0.020
3. Cement rubble masonry	0.020–0.025
4. Cement rubble masonry, plastered	0.016–0.020
5. Dry rubble (riprap)	0.020–0.030
C. Gravel bottom, sides as indicated:	
1. Formed concrete	0.017–0.020
2. Random stone in mortar	0.020–0.023
3. Dry rubble (riprap)	0.023–0.033
D. Brick	0.014–0.017
E. Asphalt:	
1. Smooth	0.013
2. Rough	0.016
F. Wood, planed, clean	0.011–0.013
G. Concrete-lined excavated rock:	
1. Good section	0.017–0.020
2. Irregular section	0.022–0.027
III. Open channels, excavated [4] (straight alinement, [5] natural lining):	
A. Earth, uniform section:	
1. Clean, recently completed	0.016–0.018
2. Clean, after weathering	0.018–0.020
3. With short grass, few weeds	0.022–0.027
4. In gravelly soil, uniform section, clean	0.022–0.025
B. Earth, fairly uniform section:	
1. No vegetation	0.022–0.025
2. Grass, some weeds	0.025–0.030
3. Dense weeds or aquatic plants in deep channels	0.030–0.035
4. Sides clean, gravel bottom	0.025–0.030
5. Sides clean, cobble bottom	0.030–0.040
C. Dragline excavated or dredged:	
1. No vegetation	0.028–0.033
2. Light brush on banks	0.035–0.050
D. Rock:	
1. Based on design section	0.035
2. Based on actual mean section:	
a. Smooth and uniform	0.035–0.040
b. Jagged and irregular	0.040–0.045
E. Channels not maintained, weeds and brush uncut:	
1. Dense weeds, high as flow depth	0.08–0.12
2. Clean bottom, brush on sides	0.05–0.08
3. Clean bottom, brush on sides, highest stage of flow	0.07–0.11
4. Dense brush, high stage	0.10–0.14
IV. Highway channels and swales with maintained vegetation [6, 7] (values shown are for velocities of 2 and 6 f.p.s.):	
A. Depth of flow up to 0.7 foot:	
1. Bermudagrass, Kentucky bluegrass, buffalograss:	
a. Mowed to 2 inches	0.07–0.045
b. Length 4–6 inches	0.09–0.05
2. Good stand, any grass:	
a. Length about 12 inches	0.18–0.09
b. Length about 24 inches	0.30–0.15
3. Fair stand, any grass:	
a. Length about 12 inches	0.14–0.08
b. Length about 24 inches	0.25–0.13
B. Depth of flow 0.7–1.5 feet:	
1. Bermudagrass, Kentucky bluegrass, buffalograss:	
a. Mowed to 2 inches	0.05–0.035
b. Length 4 to 6 inches	0.06–0.04
2. Good stand, any grass:	
a. Length about 12 inches	0.12–0.07
b. Length about 24 inches	0.20–0.10
3. Fair stand, any grass:	
a. Length about 12 inches	0.10–0.06
b. Length about 24 inches	0.17–0.09
V. Street and expressway gutters:	
A. Concrete gutter, troweled finish	0.012
B. Asphalt pavement:	
1. Smooth texture	0.013
2. Rough texture	0.016
C. Concrete gutter with asphalt pavement:	
1. Smooth	0.013
2. Rough	0.015
D. Concrete pavement:	
1. Float finish	0.014
2. Broom finish	0.016
E. For gutters with small slope, where sediment may accumulate, increase above values of *n* by	*0.002*
VI. Natural stream channels: [8]	
A. Minor streams [9] (surface width at flood stage less than 100 ft.):	
1. Fairly regular section:	
a. Some grass and weeds, little or no brush	0.030–0.035
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035–0.05
c. Some weeds, light brush on banks	0.035–0.05
d. Some weeds, heavy brush on banks	0.05–0.07
e. Some weeds, dense willows on banks	0.06–0.08
f. For trees within channel, with branches submerged at high stage, increase all above values by	*0.01–0.02*
2. Irregular sections, with pools, slight channel meander; increase values given in 1a–e about	*0.01–0.02*
3. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage:	
a. Bottom of gravel, cobbles, and few boulders	0.04–0.05
b. Bottom of cobbles, with large boulders	0.05–0.07
B. Flood plains (adjacent to natural streams):	
1. Pasture, no brush:	
a. Short grass	0.030–0.035
b. High grass	0.035–0.05
2. Cultivated areas:	
a. No crop	0.03–0.04
b. Mature row crops	0.035–0.045
c. Mature field crops	0.04–0.05
3. Heavy weeds, scattered brush	0.05–0.07
4. Light brush and trees: [10]	
a. Winter	0.05–0.06
b. Summer	0.06–0.08
5. Medium to dense brush: [10]	
a. Winter	0.07–0.11
b. Summer	0.10–0.16
6. Dense willows, summer, not bent over by current	0.15–0.20
7. Cleared land with tree stumps, 100–150 per acre:	
a. No sprouts	0.04–0.05
b. With heavy growth of sprouts	0.06–0.08
8. Heavy stand of timber, a few down trees, little undergrowth:	
a. Flood depth below branches	0.10–0.12
b. Flood depth reaches branches	0.12–0.16
C. Major streams (surface width at flood stage more than 100 ft.): Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of *n* may be somewhat reduced. Follow recommendation in publication cited [5] if possible. The value of *n* for larger streams of most regular section, with no boulders or brush, may be in the range of	0.028–0.033

from Hydraulic Design Series No. 3, "Design Charts for Open-Channel Flow"

Footnotes to Table 1 appear on page 2 of this figure

Footnotes to Table 1

[1] Estimates are by Bureau of Public Roads unless otherwise noted.

[2] Ranges indicated for closed conduits and for open channels, lined or excavated, are for good to fair construction (unless otherwise stated). For poor quality construction, use larger values of *n*.

[3] *Friction Factors in Corrugated Metal Pipe*, by M. J. Webster and L. R. Metcalf, Corps of Engineers, Department of the Army; published in Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers, vol. 85, No. HY9, Sept. 1959, Paper No. 2148, pp. 35–67.

[4] For important work and where accurate determination of water profiles is necessary, the designer is urged to consult the following references and to select *n* by comparison of the specific conditions with the channels tested:

Flow of Water in Irrigation and Similar Channels, by F. C. Scobey, Division of Irrigation, Soil Conservation Service, U.S. Department of Agriculture, Tech. Bull. No. 652, Feb. 1939; and

Flow of Water in Drainage Channels, by C. E. Ramser, Division of Agricultural Engineering, Bureau of Public Roads, U.S. Department of Agriculture, Tech. Bull. No. 129, Nov. 1929.

[5] With channel of an alinement other than straight, loss of head by resistance forces will be increased. A small increase in value of *n* may be made, to allow for the additional loss of energy.

[6] *Handbook of Channel Design for Soil and Water Conservation*, prepared by the Stillwater Outdoor Hydraulic Laboratory in cooperation with the Oklahoma Agricultural Experiment Station; published by the Soil Conservation Service, U.S. Department of Agriculture, Publ. No. SCS-TP-61, Mar. 1947, rev. June 1954.

[7] *Flow of Water in Channels Protected by Vegetative Linings*, by W. O. Ree and V. J. Palmer, Division of Drainage and Water Control, Research, Soil Conservation Service, U.S. Department of Agriculture, Tech. Bull. No. 967, Feb. 1949.

[8] For calculation of stage or discharge in natural stream channels, it is recommended that the designer consult the local District Office of the Surface Water Branch of the U.S. Geological Survey, to obtain data regarding values of *n* applicable to streams of any specific locality. Where this procedure is not followed, the table may be used as a guide. The values of *n* tabulated have been derived from data reported by C. E. Ramser (see footnote 4) and from other incomplete data.

[9] The tentative values of *n* cited are principally derived from measurements made on fairly short but straight reaches of natural streams. Where slopes calculated from flood elevations along a considerable length of channel, involving meanders and bends, are to be used in velocity calculations by the Manning formula, the value of *n* must be increased to provide for the additional loss of energy caused by bends. The increase may be in the range of perhaps 3 to 15 percent.

[10] The presence of foliage on trees and brush under flood stage will materially increase the value of *n*. Therefore, roughness coefficients for vegetation in leaf will be larger than for bare branches. For trees in channel or on banks, and for brush on banks where submergence of branches increases with depth of flow, *n* will increase with rising stage.

Table 2.—Permissible velocities for channels with erodible linings, based on uniform flow in continuously wet, aged channels [1]

Soil type or lining (earth; no vegetation)	Maximum permissible velocities for—		
	Clear water	Water carrying fine silts	Water carrying sand and gravel
	F.p.s.	*F.p.s.*	*F.p.s.*
Fine sand (noncolloidal)	1.5	2.5	1.5
Sandy loam (noncolloidal)	1.7	2.5	2.0
Silt loam (noncolloidal)	2.0	3.0	2.0
Ordinary firm loam	2.5	3.5	2.2
Volcanic ash	2.5	3.5	2.0
Fine gravel	2.5	5.0	3.7
Stiff clay (very colloidal)	3.7	5.0	3.0
Graded, loam to cobbles (noncolloidal)	3.7	5.0	5.0
Graded, silt to cobbles (colloidal)	4.0	5.5	5.0
Alluvial silts (noncolloidal)	2.0	3.5	2.0
Alluvial silts (colloidal)	3.7	5.0	3.0
Coarse gravel (noncolloidal)	4.0	6.0	6.5
Cobbles and shingles	5.0	5.5	6.5
Shales and hard pans	6.0	6.0	5.0

[1] As recommended by Special Committee on Irrigation Research, American Society of Civil Engineers, 1926.

Table 3.—Permissible velocities for channels lined with uniform stands of various grass covers, well maintained [1] [2]

Cover	Slope range	Permissible velocity on—	
		Erosion resistant soils	Easily eroded soils
	Percent	*F.p.s.*	*F.p.s.*
Bermudagrass	0–5	8	6
	5–10	7	5
	Over 10	6	4
Buffalograss Kentucky bluegrass Smooth brome Blue grama	0–5	7	5
	5–10	6	4
	Over 10	5	3
Grass mixture	0–5	5	4
	5–10	4	3
Lespedeza sericea Weeping lovegrass Yellow bluestem Kudzu Alfalfa Crabgrass	0–5	3.5	2.5
Common lespedeza [3] Sudangrass [3]	[4] 0–5	3.5	2.5

[1] From *Handbook of Channel Design for Soil and Water Conservation* (see footnote 6, table 1, above).

[2] Use velocities over 5 f.p.s. only where good covers and proper maintenance can be obtained.

[3] Annuals, used on mild slopes or as temporary protection until permanent covers are established.

[4] Use on slopes steeper than 5 percent is not recommended.

Table 4.—Factors for adjustment of discharge to allow for increased resistance caused by friction against the top of a closed rectangular conduit [1]

D/B	Factor
1.00	1.21
.80	1.24
.75	1.25
.667	1.27
.60	1.28
.50	1.31
.40	1.34

[1] Interpolations may be made.

Table 5.—Guide to selection of retardance curve

Average length of vegetation	Retardance curve for—	
	Good stand	Fair stand
6–10 inches	C	D.
2–6 inches	D	D.

from Hydraulic Design Series No. 3, "Design Charts for Open-Channel Flow"

Graphic Solution of the Manning Equation

FIGURE 2 is a nomograph for the solution of the Manning equation:

$$V=\frac{1.49}{n} R^{2/3} S^{1/2}.$$

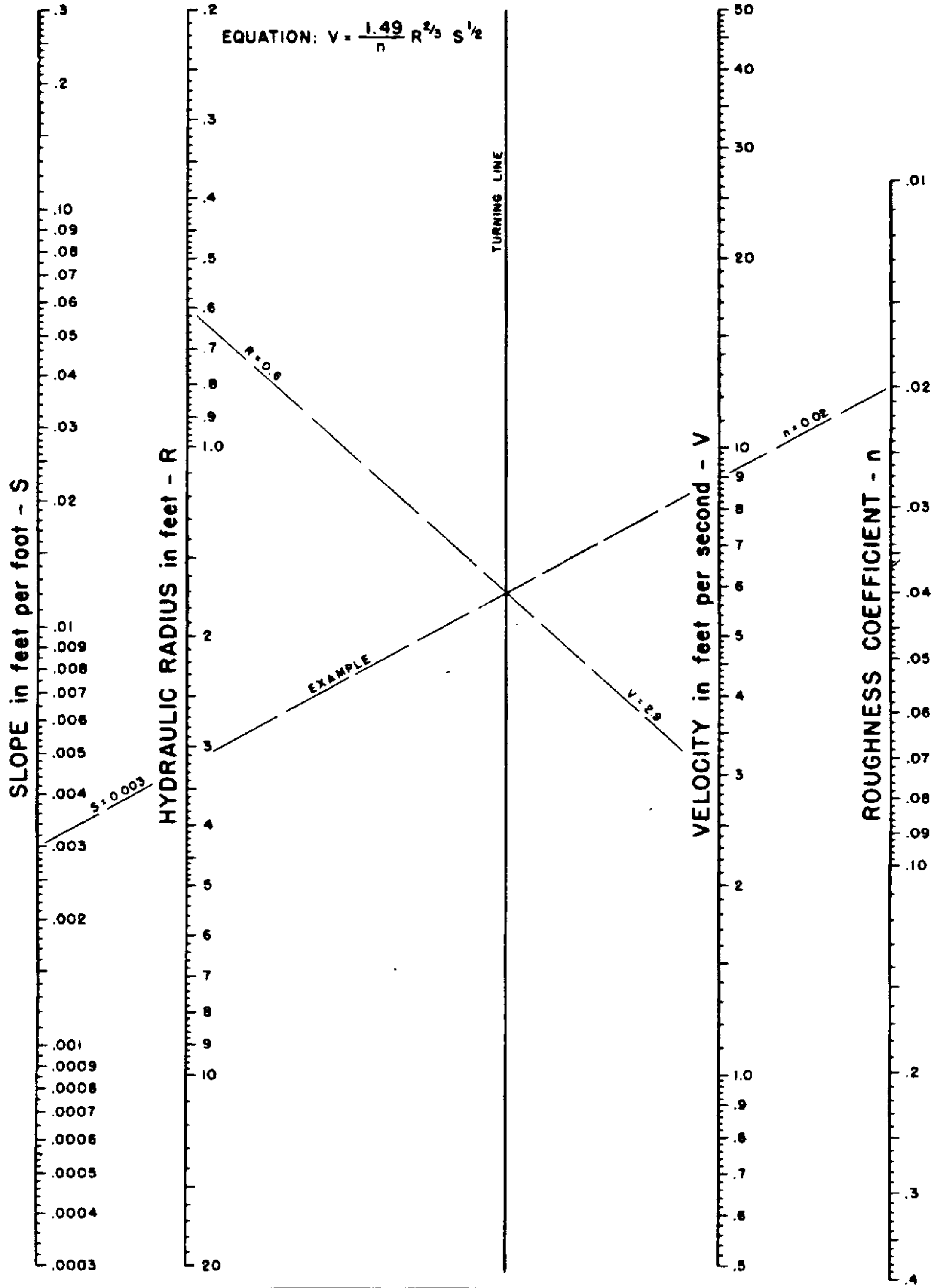
This chart will be found useful when an open-channel flow chart is not available for the particular channel cross section under consideration. Values of n will be found in table 1, and slope S and hydraulic radius $R=A/WP$, where A is the area of cross section and WP is the wetted perimeter, are dimensions of the channel.

Use of the chart is demonstrated by the example shown on the chart itself. Given is a channel with rectangular cross section, 6 feet wide, flowing at a depth of 0.75 foot, with a 0.3-percent slope ($S=0.003$), and $n=0.02$. Area $A=6\times 0.75=4.50$ sq. ft.; wetted perimeter $WP=6+2\times 0.75=7.50$ ft.; then $R=A/WP=4.50/7.50=0.6$.

A straight line is laid on the chart, connecting $S=0.003$ and $n=0.02$. Another straight line is then laid on the chart, connecting $R=0.6$ and the intersection of the first line and the "turning line," and extending to the velocity scale. Reading this scale, $V=2.9$.

The chart may, of course, be used to find any one of the four values represented, given the other three; and may also be used for channels with cross sections other than rectangular.

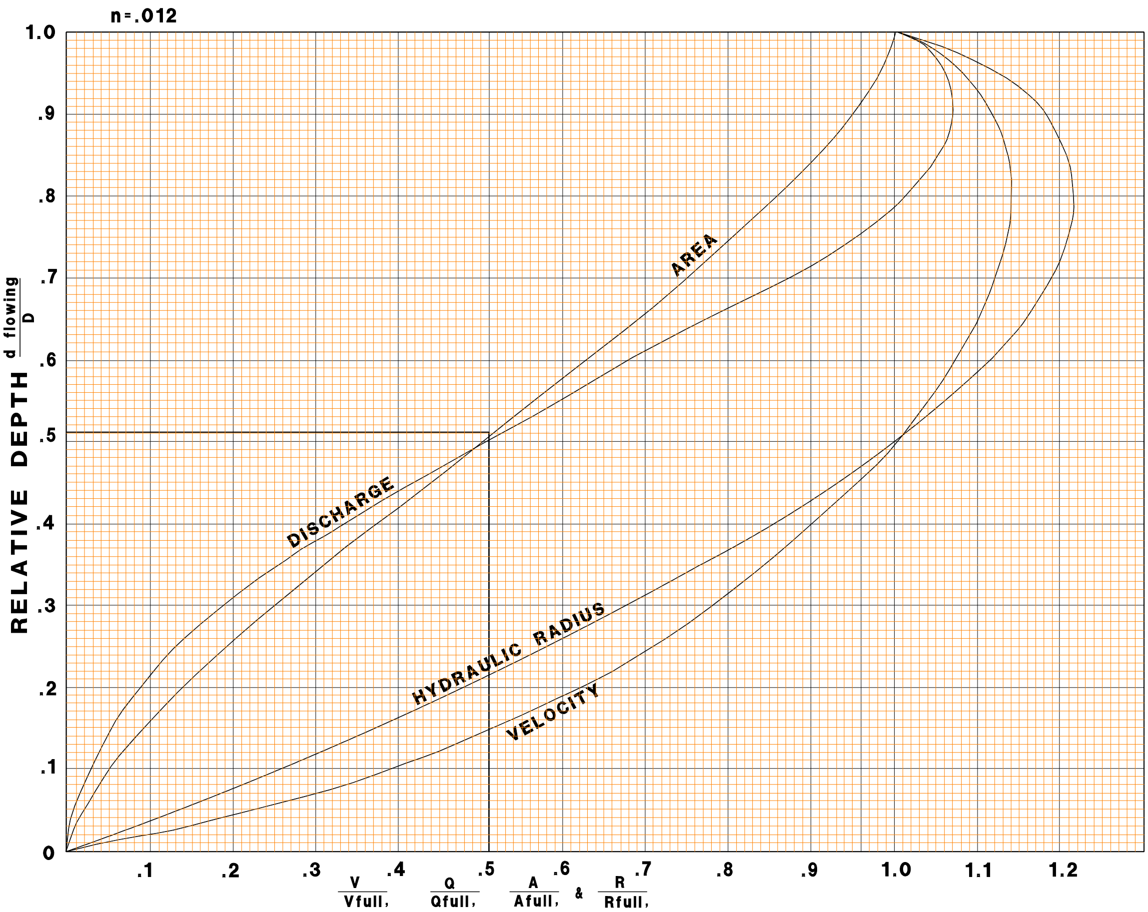
Source: Hydraulic Design Series No. 3, "Design Charts for Open-Channel Flow"



NOMOGRAPH FOR SOLUTION OF MANNING EQUATION

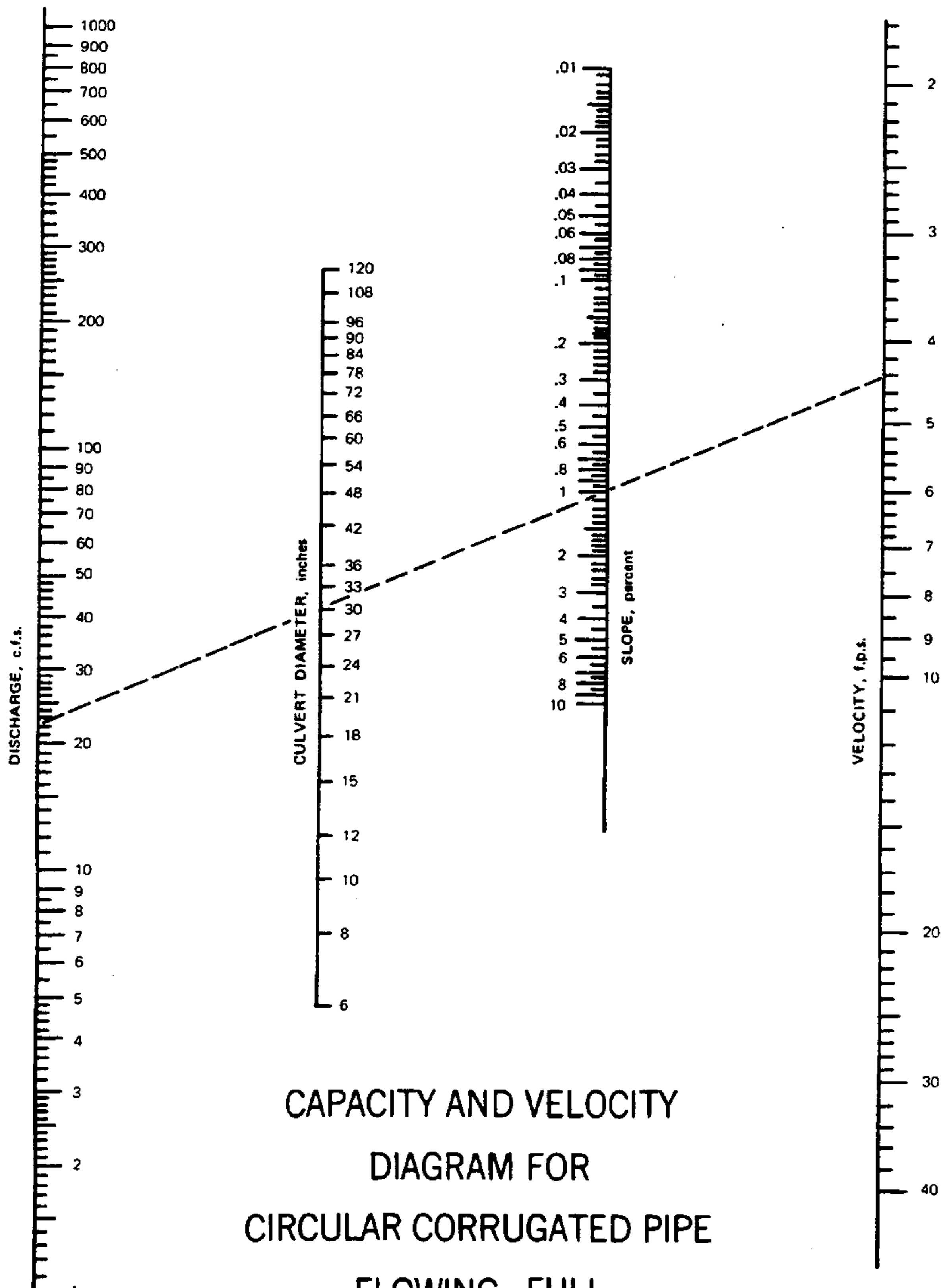
☆ U. S. GOVERNMENT PRINTING OFFICE : 1961 O - 597083

Source: Hydraulic Design Series No. 3, "Design Charts for Open-Channel Flow



HYDRAULIC ELEMENTS

CIRCULAR SECTION



CAPACITY AND VELOCITY

DIAGRAM FOR

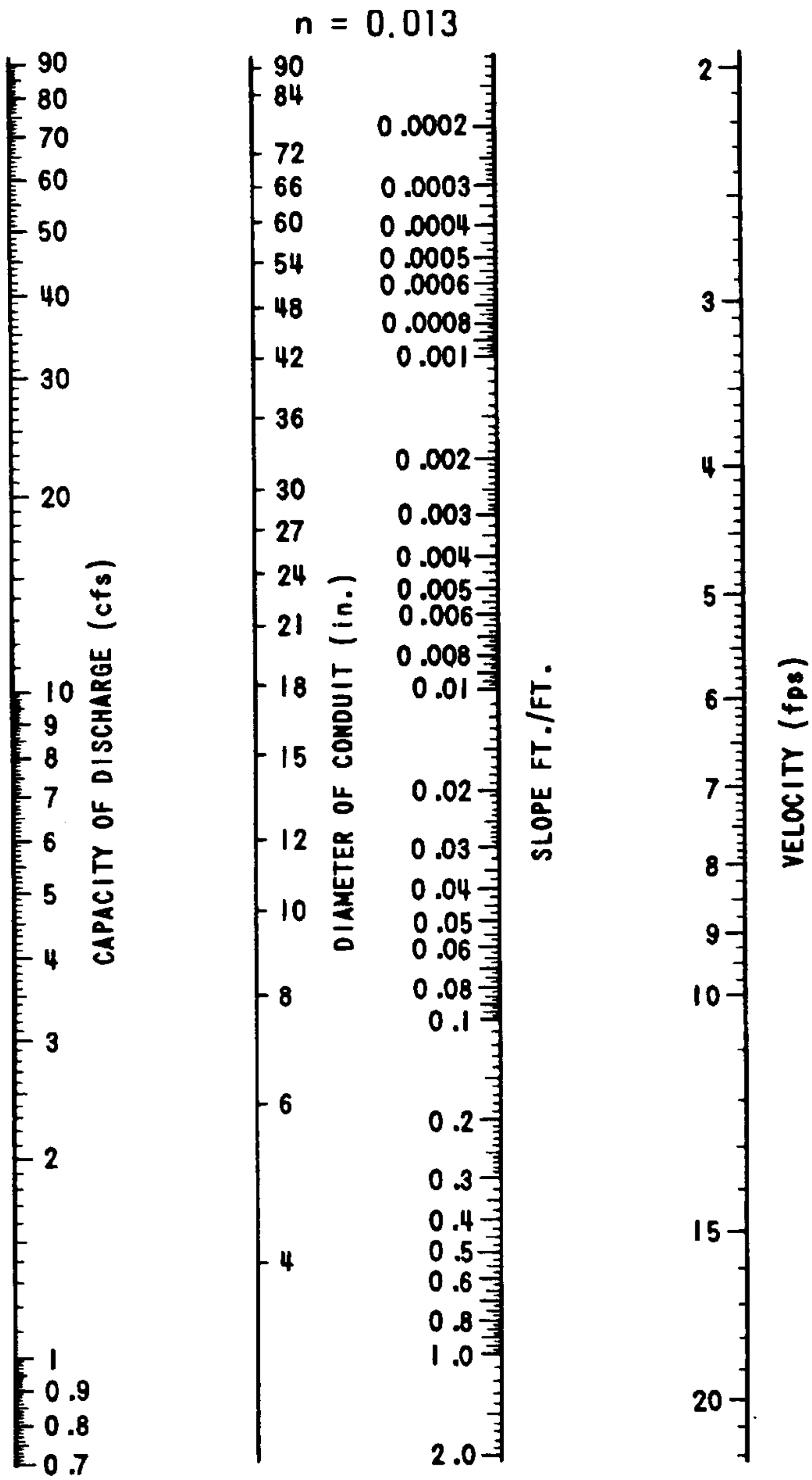
CIRCULAR CORRUGATED PIPE

FLOWING FULL

n = 0.024

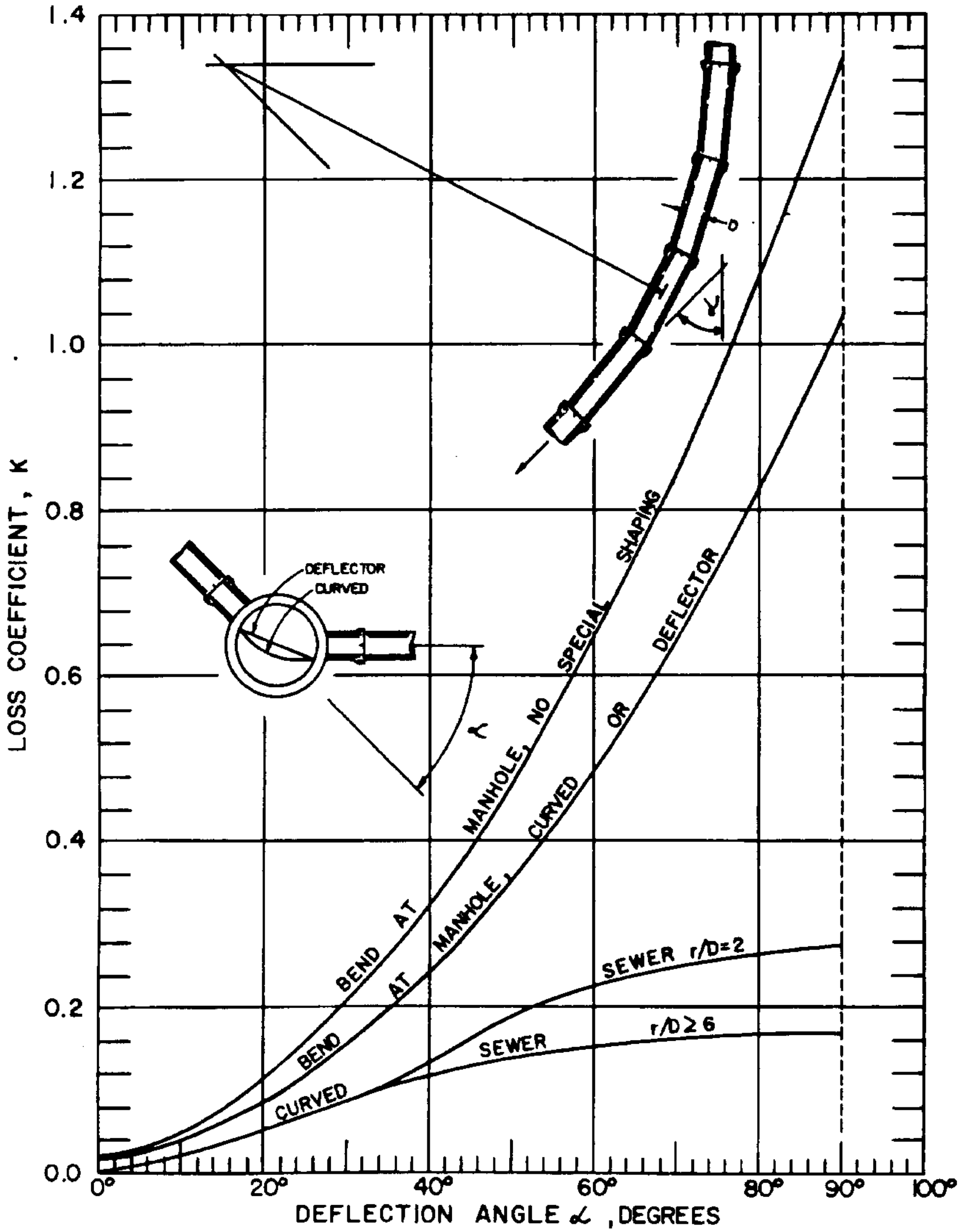
Capacity and Velocity Diagram

For Circular Concrete Pipe Flowing Full

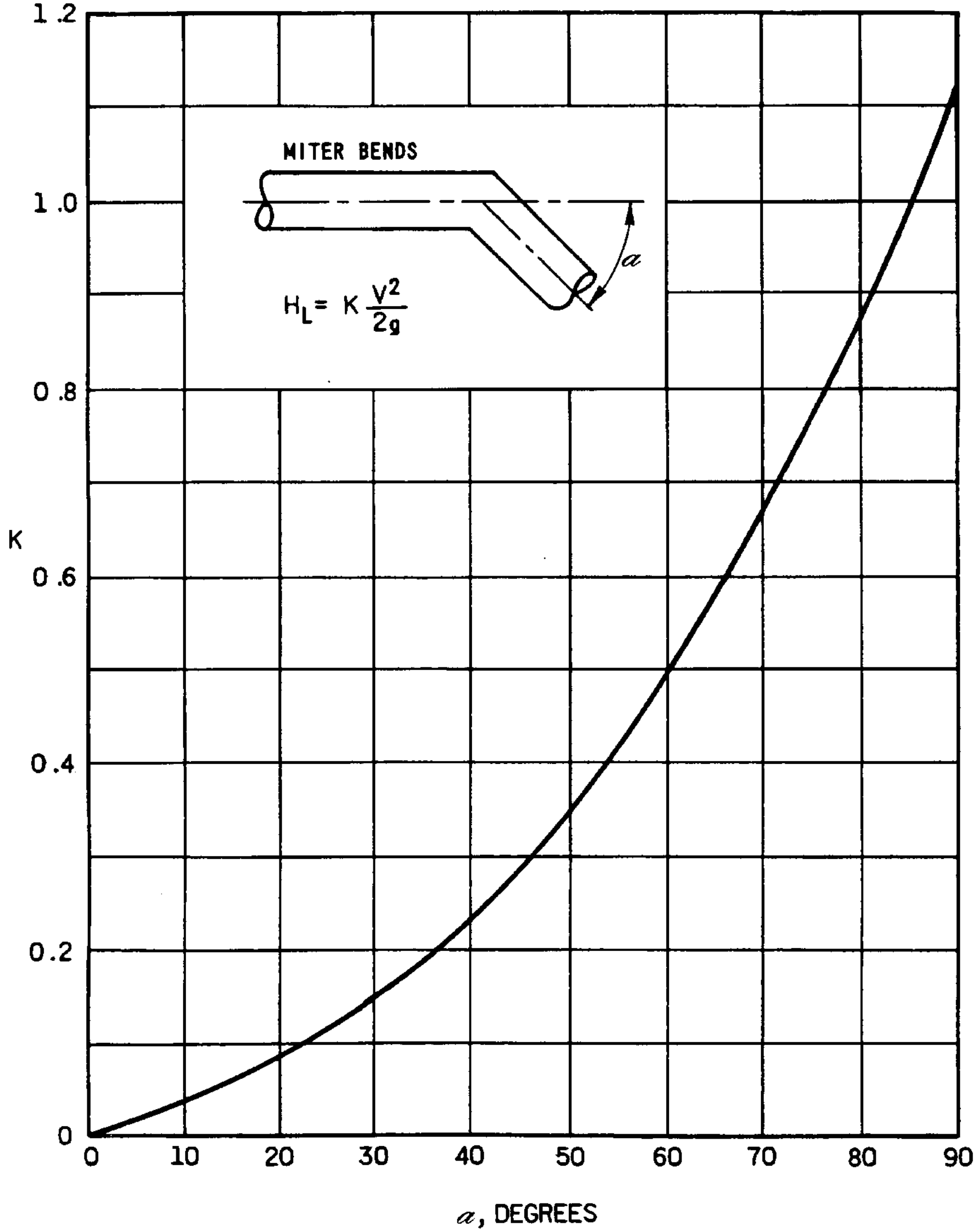


Nomograph based on Manning's formula for circular pipes flowing full in which n=0.013

Sewer Bend Loss Coefficient



Source: Denver Regional Council of Governments, "Urban Storm Drainage"



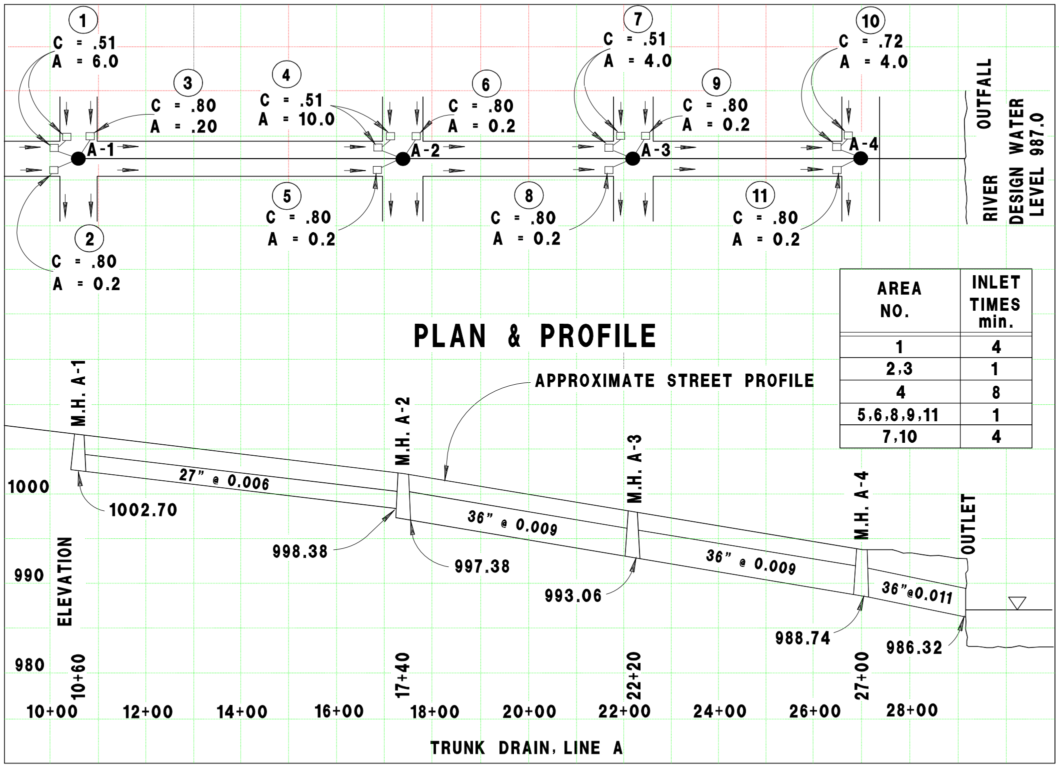
LOSS COEFFICIENTS FOR MITER BENDS

WORK SHEET FOR STORM SEWER DESIGN

PROJECT __________________ ROAD __________________________ COUNTY __________________________ DESIGN FREQUENCY _____________ YR

COMPUTED BY _______________ DATE ___________________ CHECKED BY __________________________ DATE ___________________

Location			Tributary Area					Travel Time				Rainfall-Runoff				Flow in Conduit						Vertical Control			
	Struc-tures								Flow Time													Invert Elev.		Top of Structures	
Station of Upstream Structure	from	to	Index No.	Area	Runoff Coeff.	Equiv. Area for 100 Runoff		Inlet Time	Street	Pipe	Time of Concentration	Ave. Rainfall Intensity	Direct Runoff	Other Runoff	Design Runoff	Slope of Sewer	Pipe Size	Capacity Flowing Full	Mean Velocity Flowing Full	Length of Pipe	Fall of Pipe	Upper	Lower	Upper	Lower
				A	C	ΔCA	ΣCA																		
				Acres		Acres	Acre	Min.	Min.	Min.	Min.	In/Hr	Cfs	Cfs	Cfs	Ft/Ft	In.	Cfs	Fps	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26



Detail A

WORK SHEET FOR STORM SEWER DESIGN

PROJECT 1001-7-00 ROAD OMEGA ROAD COUNTY DANE DESIGN FREQUENCY 10 YR

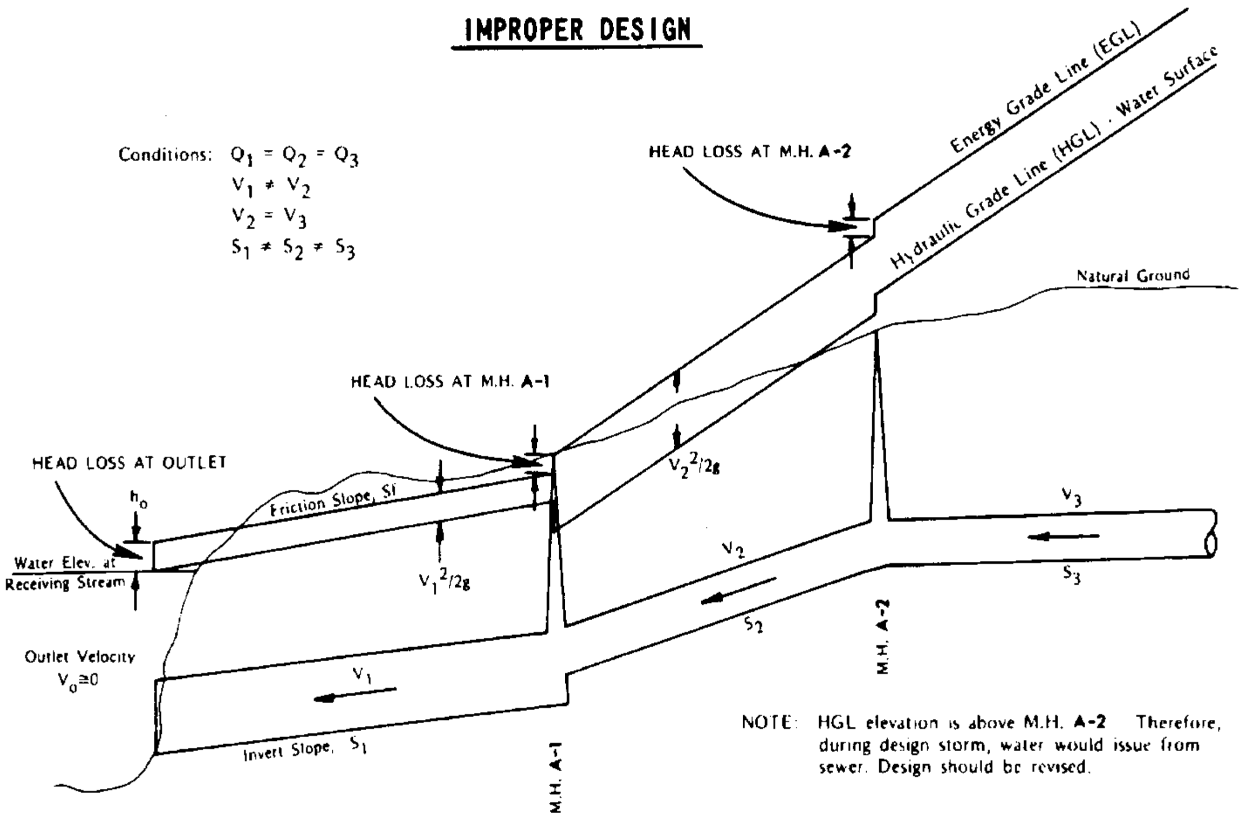
COMPUTED BY ______ DATE 12/24/95 CHECKED BY J.F.K. DATE 12/25/95

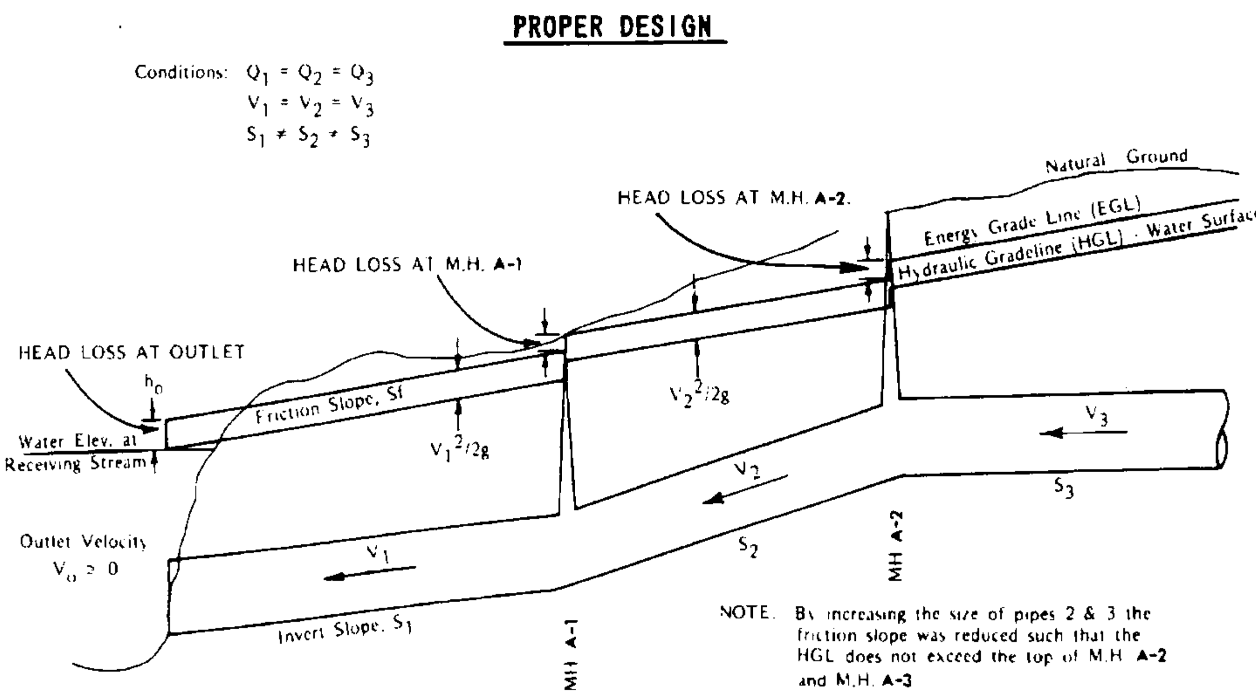
Location: Station of Upstream Structure	Location: Structures from	Location: Structures to	Tributary Area: Index No.	Tributary Area: Area	Tributary Area: Runoff Coeff.	Tributary Area: Equiv. Area for 100 Runoff	Tributary Area: Equiv. Area for 100 Runoff	Travel Time: Inlet Time	Travel Time: Flow Time Street	Travel Time: Flow Time Pipe	Travel Time: Time of Concentration	Rainfall-Runoff: Ave. Rainfall Intensity	Rainfall-Runoff: Direct Runoff	Rainfall-Runoff: Other Runoff	Rainfall-Runoff: Design Runoff	Flow in Conduit: Slope of Sewer	Flow in Conduit: Pipe Size	Flow in Conduit: Capacity Flowing Full	Flow in Conduit: Mean Velocity Flowing Full	Flow in Conduit: Length of Pipe	Flow in Conduit: Fall of Pipe	Vertical Control: Invert Elev. Upper	Vertical Control: Invert Elev. Lower	Vertical Control: Top of Structures Upper	Vertical Control: Top of Structures Lower
				A	C	△CA	ΣCA																		
				Acres		Acres	Acre	Min.	Min.	Min.	Min.	In/Hr	Cfs	Cfs	Cfs	Ft/Ft	In.	Cfs	Fps	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	MH	MH																							
10+60	A-1	A-2	1	6.0	0.51	3.06	3.06	4																	
			2	0.2	0.80	0.16	3.22	1																	
			3	0.2	0.80	0.16	3.38	1	-	1.9	5(1)	6.2	21.	-	21.	.006	27	23	6.1	680	4.32	1002.7	998.38	1006.7	1002.3
	MH	MH																							
17+40	A-2	A-3	4	10.0	0.51	5.10	8.48	8																	
			5	0.2	0.80	0.16	8.64	1																	
			6	0.2	0.80	0.16	8.80	1	-	0.9	8(2)	5.5	48.	-	48.	.009	36	64.0	9.0	480	4.32	997.38	993.06	1002.3	998.20
	MH	MH																							
22+20	A-3	A-4	7	4.0	0.51	2.04	10.84	4																	
			8	0.2	0.80	0.16	11.0	1																	
			9	0.2	0.80	0.16	11.16	1	-	0.9	8.9	5.3	59.	-	59.	.009	36	64.0	9.0	480	4.32	993.06	988.74	998.20	994.00
	MH	out-																							
27+00	A-4	fall	10	4.0	0.72	2.88	14.04	4																	
			11	0.2	0.80	0.16	14.2	1	-	0.8	9.8	5.0	71.	-	71.	.011	36	72.0	10.0	220	2.42	988.20	986.32	994.00	993.00

(1) Minimum design T_c (2) Maximum of (5.0 + 1.9) or 8.0

Detail B

Energy and Hydraulic Grade Lines for a Properly and Improperly Designed Storm Sewer





WORK SHEET FOR STORM SEWER DESIGN

SURCHARGED FLOW

PROJECT__________________ ROAD__________________ COUNTY__________________ DESIGN FREQUENCY __________________YR

COMPUTED BY______________ DATE____________CHECKED BY__________________ DATE__________________

Location		Pipe Data			Velocity Head				Pipe Head Losses				Structure Head Losses		Gradeline Elev. at Structure		Vertical Control		
Station of Structure	Structure Type & No.	Discharge	Pipe Size	Pipe Length	Mean Pipe Velocity	Pipe Velocity Head	Mean Channel Velocity	Channel Velocity Head	Coeff. K Bend Loss	Bend Energy Loss	Friction Slope	Friction Head Loss	Coeff. K Structure	Structure Energy Losses	E.G.L. Down-stream / Up-stream	H.G.L. Down-stream / Up-* stream	Invert Elev. Down-stream / Up-stream	Top of Struc. Elev.	Free-board
		Q			V1	$V_1^2/2g$	V_2	$V_2^2/2g$	K_b		S_o		K						
		cfs	in.	ft.	fps	ft.	fps	ft.		ft.	ft/ft	ft.		ft.	ft.	ft.	ft.	ft.	ft.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

* water surface elevation in structure.

SURCHARGED FULL SEWER DESIGN PROBLEM

WORK SHEET FOR STORM SEWER DESIGN

SURCHARGED FLOW

PROJECT 2400-1-00 ROAD ALMA DRIVE COUNTY MILWAUKEE DESIGN FREQUENCY 10 YR

COMPUTED BY D. J. S. DATE 10-16-78 CHECKED BY F. D. S. DATE 10-17-78

Location		Pipe Data			Velocity Head				Pipe Head Losses				Structure Head Losses		Gradeline Elev. at Structure		Vertical Control		
Station of Structure	Structure Type & No.	Discharge	Pipe Size	Pipe Length	Mean Pipe Velocity	Pipe Velocity Head	Mean Channel Velocity	Channel Velocity Head	Coeff. K Bend Loss	Bend Energy Loss	Friction Slope	Friction Head Loss	Coeff. K Structure	Structure Energy Losses	E.G.L. Down-stream Up-stream	H.G.L. Down-stream Up-stream*	Invert Elev. Down-stream Up-stream	Top of Struc. Elev.	Free-board
		Q			V_1	$V_1^2/2g$	V_2	$V_2^2/2g$	K_b		S_o		K						
		cfs	in.	ft.	fps	ft.	fps	ft.		ft.	ft/ft	ft.		ft.	ft.	ft.	ft.	ft.	ft.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
29+20	River Outlet												1.00	1.55	990.50 992.05	990.50 990.50	986.32 "	-	-
		71	36	220	10.0	1.55	-	-	-	-	.0109	2.40							
27+00	M.H. A-4												0.71	1.10	994.45 995.55	992.90 994.47	988.74 "		
		59	36	480	8.3	1.08	-	-	-	-	.0077	3.70							
22+20	M.H. A-3																		
29+20	River Outlet												1.00	1.55	990.50 992.05	990.50 990.50	986.32 "		
		71	42	220	7.4	0.85	-	-	-	-	.0047	1.30							
27+00	M.H. A-4												0.30	0.26	993.08 993.34	992.23 992.26	988.74 "	994.00	1.74
		59	36	480	8.3	1.08	-	-	-	-	.0077	3.70							
22+20	M.H. A-3												0.71	0.77	997.04 997.81	995.96 997.09	993.06 "	998.20	1.11
		48	36	480	6.8	0.72	-	-	-	-	.0048	2.30							
17+40	M.H. A-2												0.71	0.51	1000.11 1000.62	999.39 999.92	997.38 998.38	1002.3	(3)
		21	24	480	6.7	0.71	-	-	-	-	.0081	3.89							

* water surface elevation in structure.

(1) K Coeff's obtained from Ref. 2, FDM 13-25-35.

(2) Water surface above M H. Cover A-4. Replace downstream pipe with next larger pipe.

(3) Free water surface within conduit. Discontinue calculations or use normal depth of flow within conduit for further calculations.