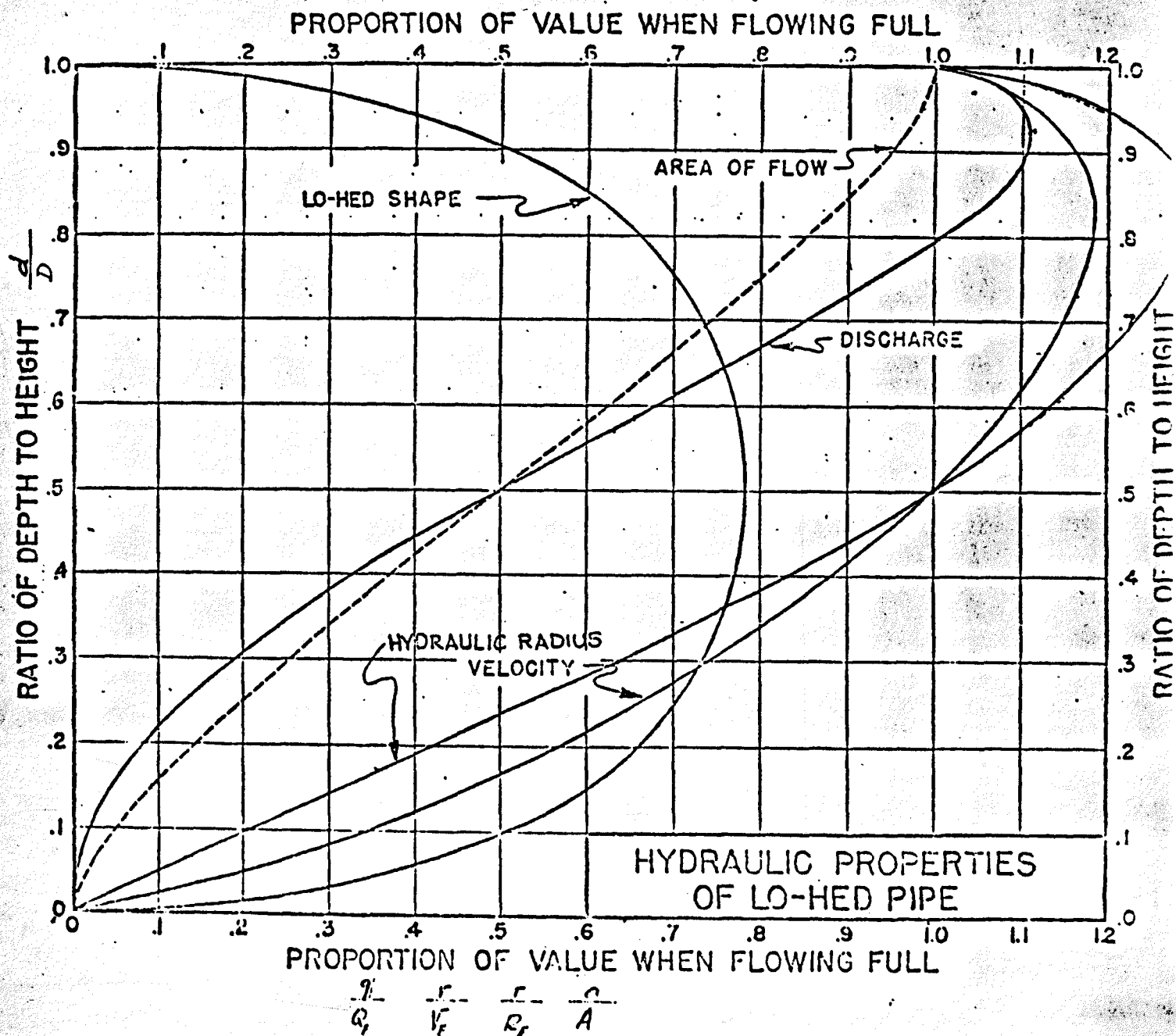
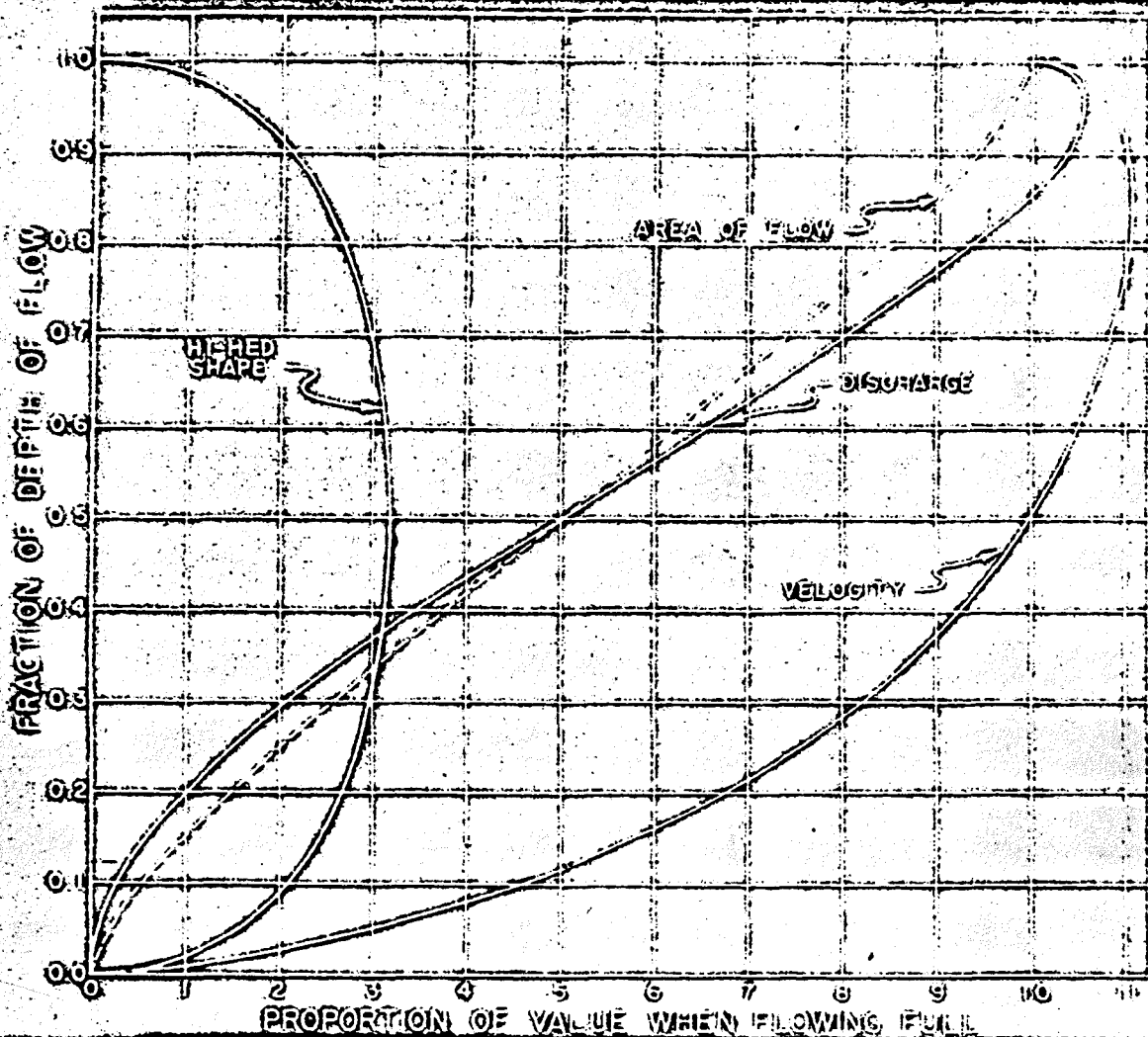


HYDRAULIC PROPERTIES OF LO-HED CONCRETE PIPE

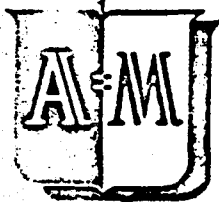


Wished

Hydraulic Properties



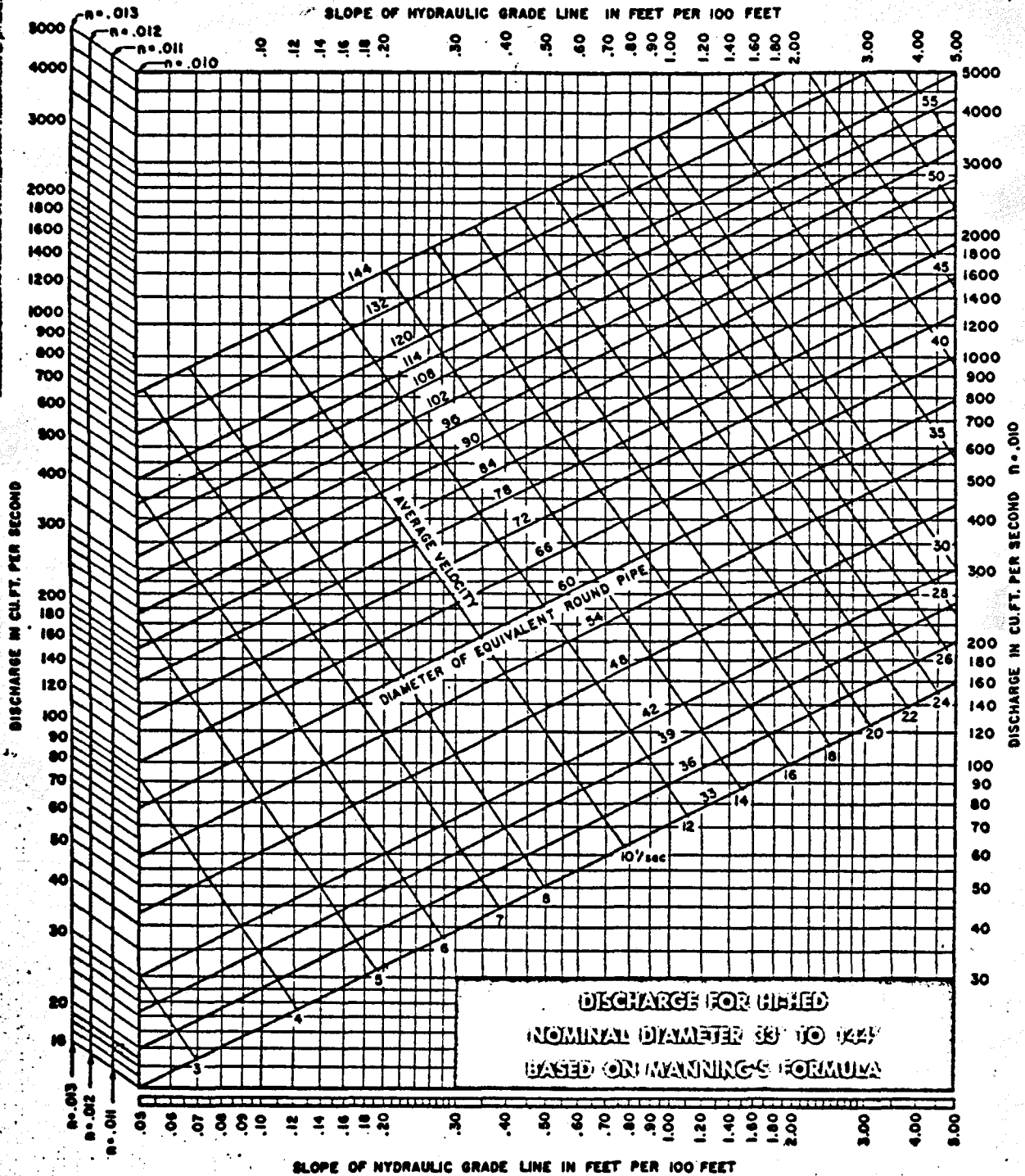
Our technical staff will be pleased to assist you with your pipe problems.



AMERICAN-MARIETTA COMPANY
CONCRETE PRODUCTS DIVISION

GENERAL OFFICES: AMERICAN-MARIETTA BUILDING, 101 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS • PHONE WHITEHALL 4-5600

HI-HED REINFORCED CONCRETE PIPE



XEROX THIS SIDE ONLY

Physical Characteristics

(ELLIPTICAL) H1-HED REINFORCED CONCRETE PIPE

CIRCULAR EQUIVALENT DIAMETER	INSIDE HEIGHT	INSIDE WIDTH	WALL THICKNESS	OUTSIDE HEIGHT	OUTSIDE WIDTH	LAYING LENGTH	AREA OF CROSS SECTION	WEIGHT PER FOOT
18"	23 in.	14 in.	2¾ in.	28½ in.	19½ in.	4 Ft.	1.8 Sq. Ft.	195 #
24	30	19	3¼	36½	25½	6	3.3	300
27	34	22	3½	41	29	6	4.1	365
30	38	24	3¾	45½	31½	6	5.1	430
33	42	27	3¾	49½	34½	6	6.3	475
36	45	29	4½	54	38	6	7.4	625
39	49	32	4¾	58½	41½	6	8.8	720
42	53	34	5	63	44	6	10.2	815
48	60	38	5½	71	49	6	12.9	1000
54	68	43	6	80	55	6	16.6	1235
60	76	48	6½	89	61	6	20.5	1475
66	83	53	7	97	67	6	24.8	1745
72	91	58	7½	106	73	6	29.5	2040
78	98	63	8	114	79	6	34.6	2350
84	106	68	8½	123	85	6	40.1	2680
90	113	72	9	131	90	6	46.1	3050
96	121	77	9½	140	96	6	52.4	3420
102	128	82	9¾	147½	101½	6	59.2	3725
108	136	87	10	156	107	6	66.4	4050
114	143	92	10½	164	113	6	74.0	4470
120	151	97	11	173	119	6	82.0	4930
132	166	106	12	190	130	6	99.2	5900
144	180	116	13	206	142	6	118.6	7000

R. SHABUNIA

Figure 7

**Brooklyn Sewers
Equivalent Sewer Sizes**

Size of Sewer
(HxD)
Egg Shaped Sewers

Equivalent
Circular Section
(Diameters)

22.33" x 14.89"

18"

28.77" x 19.85"

24"

44.66" x 29.77"

36"

52.12" x 34.75"

42"

59.54" x 39.69"

48"

66.98" x 44.66"

54"

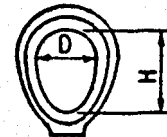
74.48" x 49.62"

60"

Circular Arch & Bottom

7'-3" x 4'-6"

72"



Circular Arch

5'-8" x 7'-0"

72"

5'-8½" x 7'-0"

78"

6'-3" x 7'-9"

84"

7'-2½" x 9'-0"

96"

7'-7" x 9'-6"

102"

8'-0" x 10'-0"

108"

8'-10½" x 11'-0"

120"

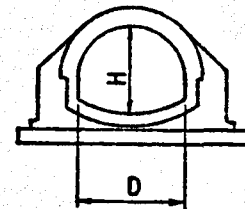


Figure 8

New York City
Transit Authority
Equivalent Sewer Sizes

Egg Shaped Inverts

<u>Size of Sewer (H x D)</u>	<u>Equivalent Egg-Shaped Section</u>
3'-6" x 2'-4"	3'-6" x 2'-4"
3'-9" x 2'-4"	3'-9" x 2'-6"
4'-0" x 2'-6"	4'-0" x 2'-8"
4'-3" x 2'-8"	4'-3" x 2'-10"
4'-6" x 2'-10"	4'-6" x 3'-0"
4'-9" x 3'-0"	4'-9" x 3'-2"
5'-0" x 3'-2"	5'-0" x 3'-4"
5'-3" x 3'-4"	5'-3" x 3'-6"

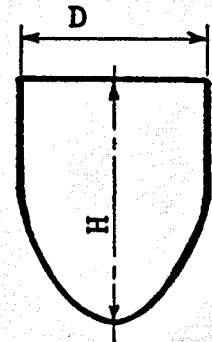
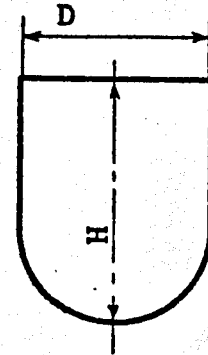


Figure 9

New York City
Transit Authority
Equivalent Sewer Sizes

Circular Shaped Inverts

<u>Size of Sewer (H x D)</u>	<u>Equivalent Circular Section</u>
3'-6" x 3'-2"	3'-6"
3'-9" x 3'-5"	3'-9"
4'-0" x 3'-8"	4'-0"
4'-3" x 3'-10"	4'-3"
4'-6" x 4'-1"	4'-6"
4'-9" x 4'-3"	4'-9"
5'-0" x 4'-6"	5'-0"
5'-3" x 4'-9"	5'-3"
5'-6" x 5'-0"	5'-6"
5'-9" x 5'-2"	5'-9"
6'-0" x 5'-5"	6'-0"
6'-3" x 5'-8"	6'-3"
6'-6" x 5'-11"	6'-6"

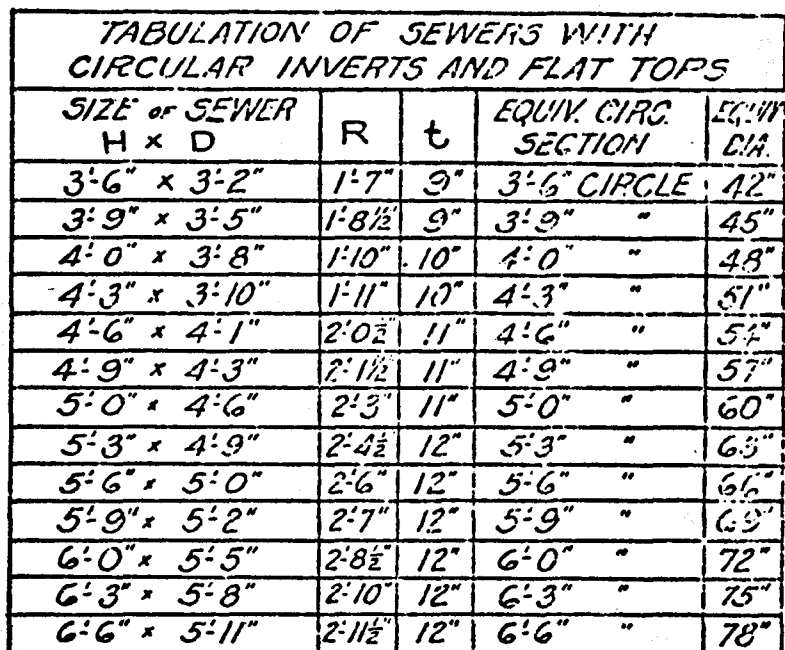


R. SHABUNIA

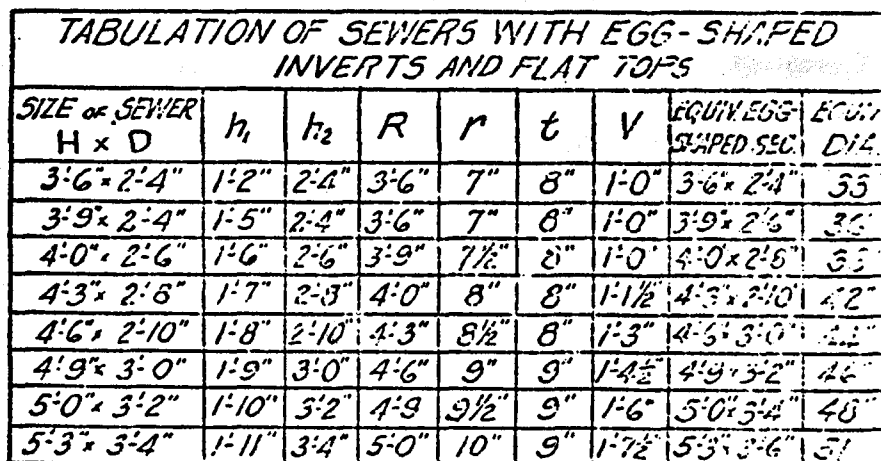
LO-HED REINFORCED CONCRETE PIPE

I.D. ROUND PIPE EQUIVALENT	INSIDE HEIGHT "RISE"	INSIDE WIDTH "SPAN"	END AREA A	WETTED PERIMETER	HYDRAULIC RADIUS R	$\frac{1406 R^{3/2}}{0.015}$	$\frac{1406 A R^{3/2}}{0.015}$ $\times S^{1/2} = Q_{CAP}$
18	14	23	1.6	5.01	0.368	52.002	93.604
24	19	30	3.3	6.67	0.490	61.063	201.508
27	22	34	4.1	7.51	0.546	66.091	270.930
30	24	38	5.1	8.34	0.613	71.558	364.947
33	27	42	6.3	9.18	0.695	77.068	485.525
36	29	45	7.4	10.01	0.736	80.322	594.393
39	32	49	8.8	10.84	0.812	86.197	759.536
42	34	53	10.2	11.67	0.875	90.664	924.769
48	38	60	12.9	13.32	0.969	97.034	1252.382
54	43	68	16.6	15.00	1.103	105.831	1756.801
60	48	76	20.5	16.67	1.229	113.559	2327.956
66	53	83	24.8	18.33	1.352	121.058	3002.249
72	58	91	29.5	20.00	1.475	128.389	3787.479
78	63	98	34.6	21.66	1.598	135.416	4685.330
84	68	106	40.1	23.33	1.721	142.433	5711.553
90	72	113	46.1	24.99	1.845	148.993	6868.593
96	77	121	52.4	26.65	1.967	155.526	8149.590
102	82	120	59.2	28.32	2.091	161.935	9586.569
108	87	136	66.4	29.98	2.215	168.341	11177.830
114	92	143	74.0	31.64	2.340	174.628	12922.497
120	97	151	82.0	33.31	2.461	180.443	14796.302
132	106	166	99.2	36.64	2.707	192.395	19005.601
144	116	180	118.6	39.97	2.968	204.646	24271.067

CIRCULAR EQUIVALENTS



EGG-SHAPED EQUIVALENTS

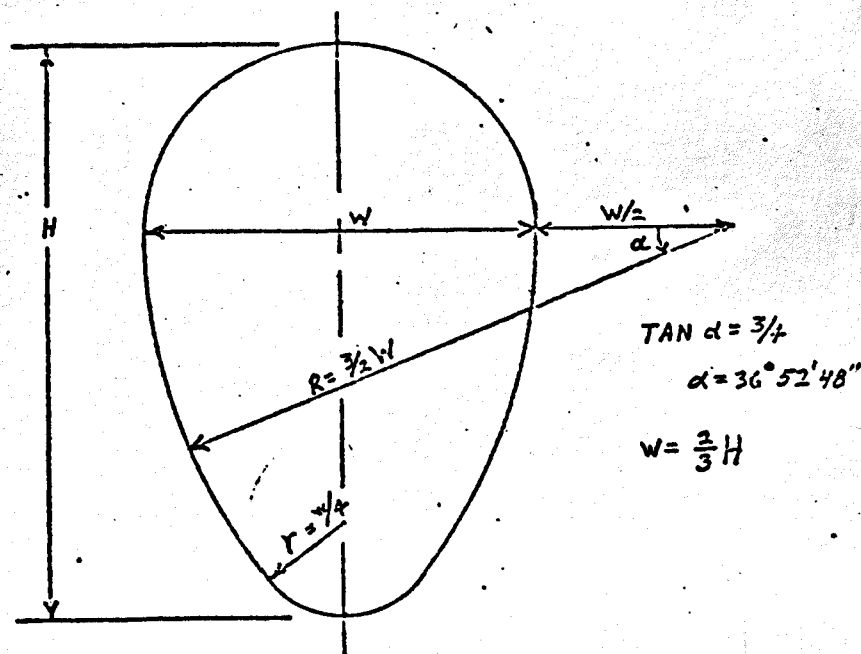


R. SHABUNIA

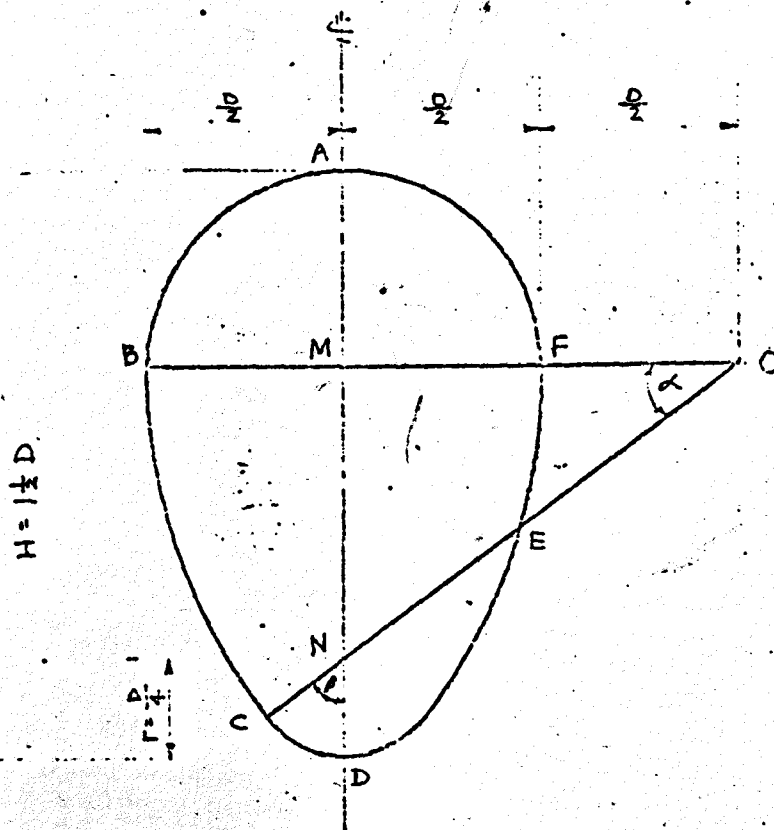
GEOMETRY OF EGG-SHAPED SEWERS

SIZE H x W	AREA (A)	HYDRAULIC RADIUS (R)	DIAMETER OF EQUI- VALENT CIRCLE
3'0" x 2'0"	4.67	0.578	29.0"
3'6" x 2'4"	6.28	0.678	33.1"
3'9" x 2'6"	7.18	0.724	35.5"
4'0" x 2'8"	8.14	0.771	38.4"
4'3" x 2'10"	9.27	0.823	40.5"
4'6" x 3'0"	10.34	0.87	43.2"
4'9" x 3'2"	11.48	0.918	45.4"
5'0" x 3'4"	12.83	0.968	48.0"
5'3" x 3'6"	14.10	1.017	50.4"

GEOMETRY OF STANDARD EGG-SHAPED SEWER



R. SHABUNIA



$$\tan \alpha = \frac{3}{4} ; \alpha = 36^\circ - 52' - 36''$$

$$\beta = 53^\circ - 07' - 24''$$

$$\frac{\alpha}{360} = 0.1024 ; \frac{\beta}{360} = 0.1476$$

$$\text{Arc } \widehat{AB} = 0.7854 \times D = \frac{\pi D}{4}$$

$$\widehat{BC} = 0.7442 \times D = 0.7442 D$$

$$\widehat{CD} = 0.2518 \times D = 0.2518 D$$

$$\text{Total Perimeter} = 3.963 \times D$$

$$\text{Area } ABM = 0.1964 \times D^2$$

$$MBcN = 0.3487 \times D^2$$

$$NcD = 0.0289 \times D^2$$

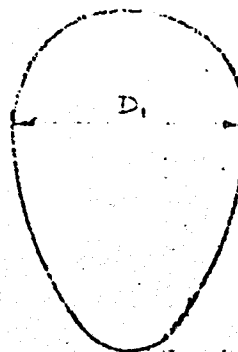
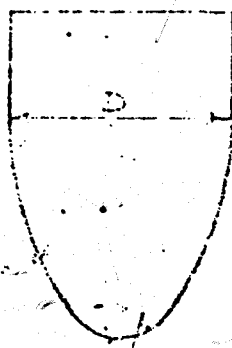
$$\text{Total Area} = 1.1480 \times D^2$$

P. 1.977

DIMENSIONS OF EQUIVALENT EGG SHAPE SEWERS

SIZE	HORIZONTAL DIAM.		VERTICAL DIAM.		HORIZONTAL DIAM.		AREA OF
INCHES	FEET*	INCHES	FEET	INCHES	FEET	INCHES	SEWER SECTION
							sq.-ft. R
12	0.844	10 1/8	1.266	15 3/16	0.211	2 17/32	0.818
15	1.052	12 5/8	1.578	18 15/16	0.263	3 5/32	1.271
18	1.261	15 1/8	1.891	22 11/16	0.315	3 55/32	1.826
20	1.396	16 3/4	2.094	25 1/8	0.349	4 3/16	2.238
24	1.677	20 1/8	2.516	30 3/8	0.419	5 1/32	3.230
30	2.094	25 1/8	3.141	37 11/16	0.524	6 3/32	5.086
36	2.511	30 1/8	3.766	45 3/8	0.628	7 5/32	7.293
42	2.927	35 1/8	4.391	52 11/16	0.732	8 3/16	9.940
48	3.354	40 1/4	5.031	60 3/8	0.839	10 1/16	12.900
54	3.771	45 1/2	5.656	67 7/8	0.943	11 5/16	16.330
60	4.188	50 1/2	6.281	75 3/8	1.047	12 9/16	20.140
66	4.604	55 1/2	6.906	82 1/8	1.151	13 13/16	24.345
72	5.021	60 1/2	7.531	90 3/8	1.255	14 11/16	29.000
78	5.438	65 1/2	8.156	97 7/8	1.359	15 5/8	34.000
84	5.854	70 1/2	8.781	105 3/8	1.463	16 3/4	39.300
90	6.271	75 1/2	9.406	112 7/8	1.567	17 1/2	44.900
96	6.688	80 1/2	10.031	120 3/8	1.671	18 1/4	50.800
102	7.104	85 1/2	10.656	127 7/8	1.775	19 1/8	56.900
108	7.521	90 1/2	11.281	135 3/8	1.879	20 1/4	63.300
114	7.938	95 1/2	11.906	142 7/8	1.983	21 1/8	69.900
120	8.354	100 1/2	12.531	150 3/8	2.087	22 1/4	76.800
126	8.771	105 1/2	13.156	157 7/8	2.191	23 1/8	83.900
132	9.188	110 1/2	13.781	165 3/8	2.295	24 1/4	91.300
138	9.604	115 1/2	14.406	172 7/8	2.399	25 1/8	98.900
144	10.021	120 1/2	15.031	180 3/8	2.503	26 1/4	106.800
150	10.438	125 1/2	15.656	187 7/8	2.607	27 1/8	114.900
156	10.854	130 1/2	16.281	195 3/8	2.711	28 1/4	123.300
162	11.271	135 1/2	16.906	202 7/8	2.815	29 1/8	131.900
168	11.688	140 1/2	17.531	210 3/8	2.919	30 1/4	140.800
174	12.104	145 1/2	18.156	217 7/8	3.023	31 1/8	149.900
180	12.521	150 1/2	18.781	225 3/8	3.127	32 1/4	159.300
186	12.938	155 1/2	19.406	232 7/8	3.231	33 1/8	168.900
192	13.354	160 1/2	20.031	240 3/8	3.335	34 1/4	178.800
198	13.771	165 1/2	20.656	247 7/8	3.439	35 1/8	188.900
204	14.188	170 1/2	21.281	255 3/8	3.543	36 1/4	199.300
210	14.604	175 1/2	21.906	262 7/8	3.647	37 1/8	209.900
216	15.021	180 1/2	22.531	270 3/8	3.751	38 1/4	220.800
222	15.438	185 1/2	23.156	277 7/8	3.855	4 5/8	2.722

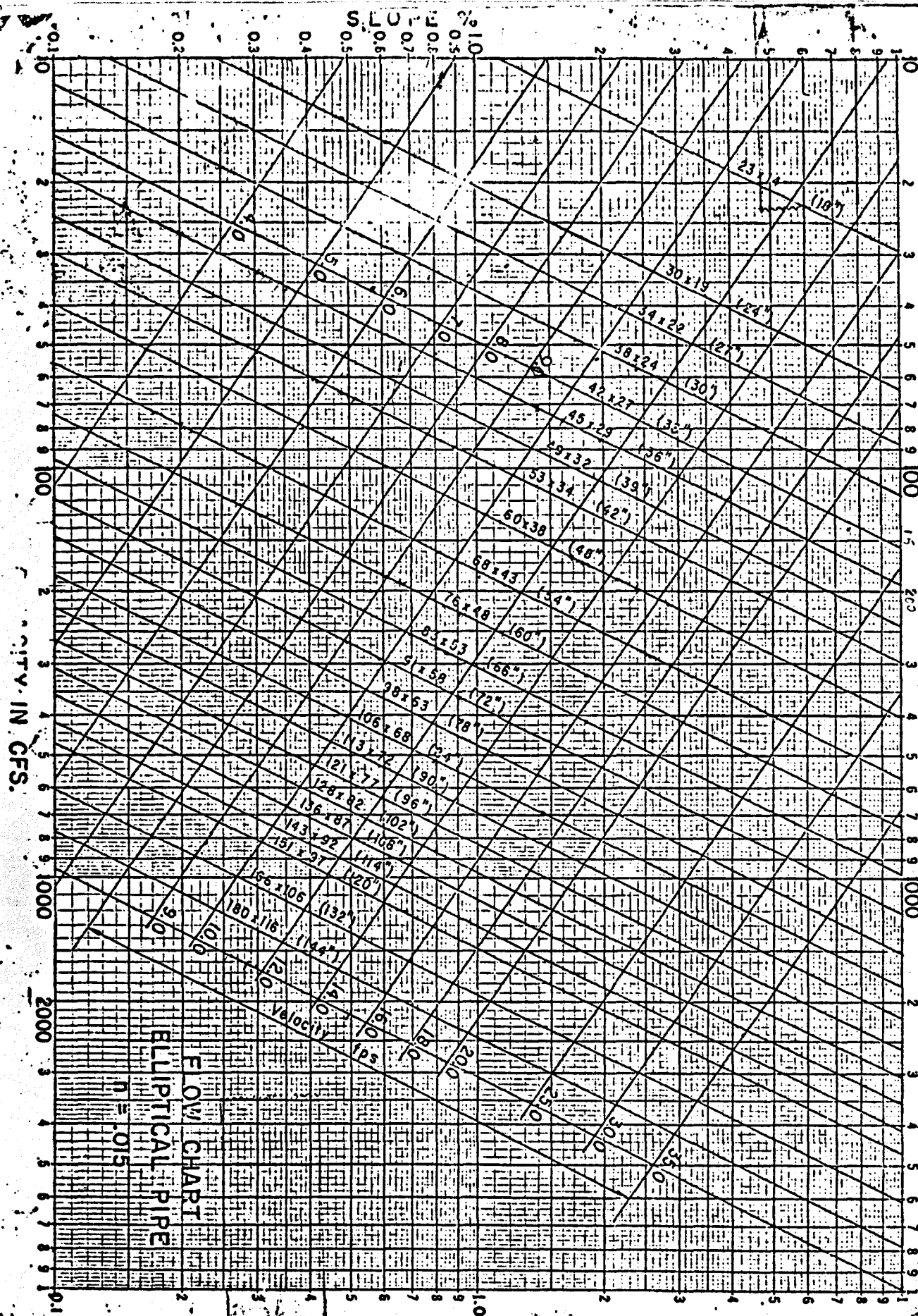
HYDRAULIC ELEMENTS OF SEWERS WITH EGG SHAPED INVERTS



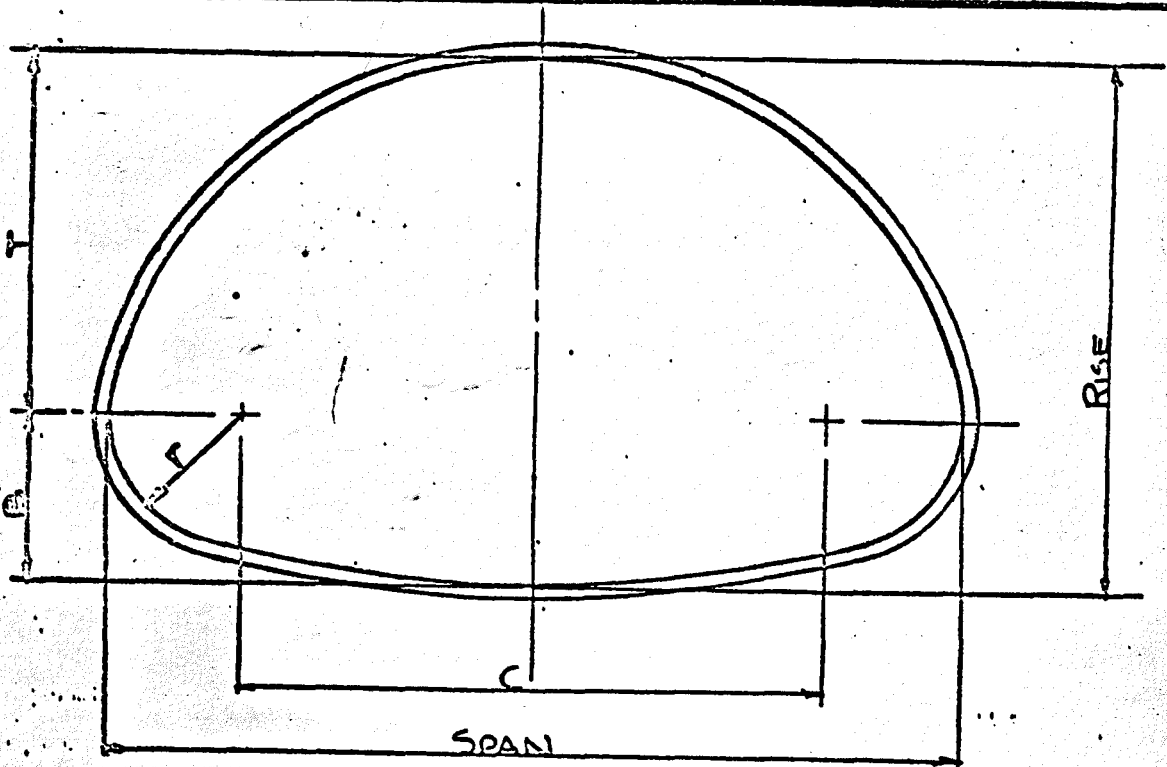
A = Area
P = Wetted Per.
r = Hydr. Rad.
C = Coefficient
Q = Discharge Cu. ft. sec.
S = Slope ft./ft.

Egg Shaped Inverts-Flat Tops						Equivalent Egg Shaped Sewers					
SIZE OF SEWER H x D	A (sq. ft.)	P (ft.)	r (ft.)	C	Q/√S	SIZE OF SEWER H ₁ x D ₁	A (sq. ft.)	P (ft.)	r (ft.)	C	Q/√S
3'-6" x 2'-4"	6.84	10.26	0.667	91	508	3'-6" x 2'-4"	6.28	9.28	0.678	91	470
3'-9" x 2'-4"	7.45	10.76	0.691	91.5	569	3'-9" x 2'-6"	7.18	9.92	0.724	92	562
4'-0" x 2'-6"	8.47	11.49	0.737	93	675	4'-0" x 2'-8"	8.14	10.56	0.771	94	670
4'-3" x 2'-8"	9.62	12.21	0.786	94	801	4'-3" x 2'-10"	9.27	11.23	0.823	95	800
4'-6" x 2'-10"	10.83	12.99	0.834	95	940	4'-6" x 3'-0"	10.34	11.91	0.87	97	935
4'-9" x 3'-0"	12.06	13.68	0.882	97	1100	4'-9" x 3'-2"	11.48	12.5	0.918	98	1080
5'-0" x 3'-2"	13.37	14.40	0.927	97.8	1250	5'-0" x 3'-4"	12.83	13.28	0.968	98.5	1240
5'-3" x 3'-4"	14.34	15.17	0.98	98	1450	5'-3" x 3'-6"	14.10	13.99	1.017	99	1410

Slope 1.36% Cap. = 145.0 C.F.S.



R. SHABUNIA


circular CMP $n = 0.024$

SPAN	RISE	EQUIV. PIPE	AREA	r	T	B	C
18	11	15	11	3½	6½	4½	11
22	13	18	16	4	8¼	4¾	14
25	16	21	22	4	10¾	5¼	17
29	18	24	28	4½	12½	5½	20
36	22	30	44	5	15¾	6¼	26
43	27	36	64	5½	20	7	32
50	31	42	87	6	23	8	38
58	36	48	114	7	26¾	9¼	44
65	40	54	143	8	29½	10½	49
72	44	60	176	9	32¼	11¾	54
79	49	66	213	10	35¾	13¼	59
85	54	72	253	11	39½	14½	63
94	58	78	294	12	42¼	15¾	70

DRAWN 2-6-63

BY D.J.W.

ARMCO CORRUGATED METAL

PIPE-ARCH

METAL PRODUCTS DIVISION
EASTERN REGION • BALTIMORE, MARYLAND

SCALE

ORDER NO.

DRAWING NO.

CE-015-PA