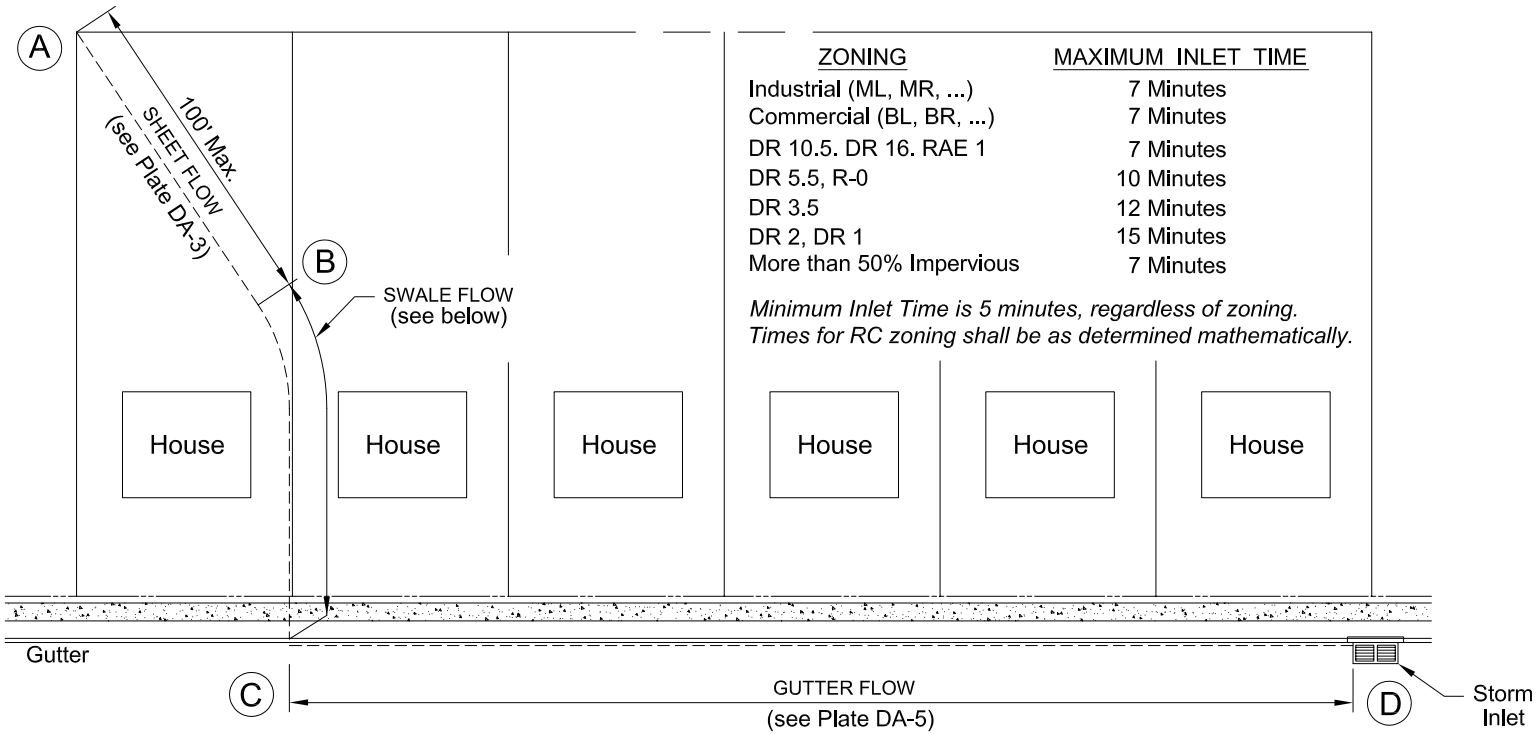

ZONING	MAXIMUM INLET TIME
Industrial (ML, MR, ...)	7 Minutes
Commercial (BL, BR, ...)	7 Minutes
DR 10.5. DR 16. RAE 1	7 Minutes
DR 5.5, R-0	10 Minutes
DR 3.5	12 Minutes
DR 2, DR 1	15 Minutes
More than 50% Impervious	7 Minutes

Minimum Inlet Time is 5 minutes, regardless of zoning.
Times for RC zoning shall be as determined mathematically.

VELOCITY OF SWALE FLOW	
Slope of Lawn (%)	Velocity (ft / sec.) (Clay or Sandy Lawn)
0.5	0.4
1.0	0.5
2.0	0.6
3.0	0.7
4.0	0.8
5.0	0.9
6.0	1.0
8.0	1.1

Note:
1. *Velocities shown for swale flow where Q is about 0.1 cfs in a 6:1 Vee ditch.*
2. *Compute velocities for other conditions.*

EXAMPLE FOR DR 5.5 ZONING

Reach	Slope	Distance	Velocity	Time
A to B	2.0%	75'	-	9.7 min.[1]
B to C	2.0%	70'	0.6 fps	1.9 min.[2]
C to D	5.5%	305'	5.2 fps	1.0 min.[3]
			Total Inlet Time =	12.6 min.

Use 10 minute Maximum Inlet Time (DR 5.5 zoning)

[1] *See SHEET Flow Time, Design Plate DA-4.*
[2] *See Velocity of Swale Flow Table, this Design Plate.*
[3] *See Gutter Flow Chart, Design Plate DA-5*

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

INLET TIME SOLUTION

RATIONAL AND TR-55 METHODS

ISSUED: February 7, 2008
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PLATE
DA-1
(HYDROLOGY)

2/7/2008 5:04 PM
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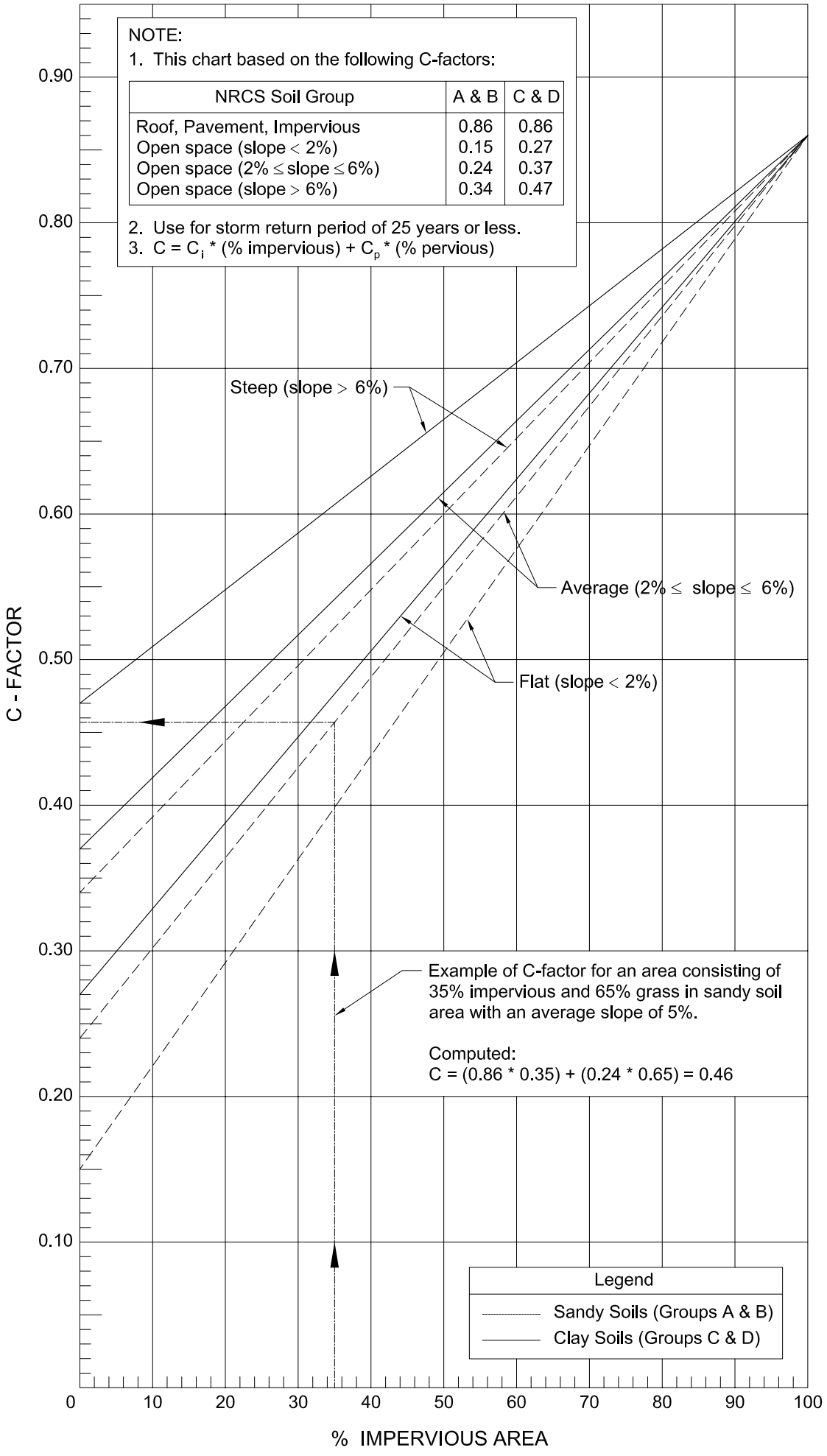
NOTE:
1. This chart based on the following C-factors:

NRCS Soil Group	A & B	C & D
Roof, Pavement, Impervious	0.86	0.86
Open space (slope < 2%)	0.15	0.27
Open space (2% ≤ slope ≤ 6%)	0.24	0.37
Open space (slope > 6%)	0.34	0.47

2. Use for storm return period of 25 years or less.
3. $C = C_i * (\%\ \text{impervious}) + C_p * (\%\ \text{pervious})$



ISSUED: FEBRUARY 7, 2008
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REVISED:

PLATE **DA-2** (HYDROLOGY)

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

RATIONAL METHOD *C* - FACTORS
BY PERCENT IMPERVIOUS

BALTIMORE COUNTY MARYLAND

Runoff Coefficients for the Rational Formula by Hydrologic Soil Group and Slope Range

For Storm Return Period of 25 years or Less

	A			B			C			D		
LAND USE	**0-2%**	**2-6%**	**6%+**	**0-2%**	**2-6%**	**6%+**	**0-2%**	**2-6%**	**6%+**	**0-2%**	**2-6%**	**6%+**
Crop land [1]	0.14	0.23	0.35	0.17	0.26	0.34	0.21	0.30	0.39	0.26	0.34	0.43
Pasture / Open Space [1]	0.12	0.20	0.30	0.18	0.28	0.37	0.24	0.34	0.44	0.30	0.40	0.50
Meadow	0.10	0.16	0.25	0.14	0.22	0.30	0.20	0.28	0.36	0.24	0.30	0.40
Woods [1]	0.12	0.18	0.28	0.16	0.25	0.34	0.22	0.31	0.40	0.28	0.35	0.47
Resident Lot Size 1/8 acre [2]	0.60	0.63	0.66	0.62	0.66	0.69	0.64	0.68	0.71	0.66	0.70	0.73
Lot Size 1/4 acre [2]	0.40	0.45	0.51	0.44	0.50	0.56	0.48	0.54	0.60	0.51	0.57	0.64
Lot Size 1/3 acre [2]	0.34	0.40	0.47	0.38	0.45	0.52	0.43	0.50	0.57	0.47	0.54	0.61
Lot Size 1/2 acre [2]	0.31	0.37	0.44	0.35	0.43	0.49	0.40	0.47	0.55	0.44	0.52	0.59
Lot Size 1 acre [2]	0.27	0.33	0.41	0.32	0.40	0.47	0.36	0.44	0.52	0.41	0.49	0.57
Institutional [3,4]	0.61	0.64	0.67	0.63	0.66	0.69	0.65	0.68	0.72	0.67	0.70	0.74
Industrial [2,4]	0.65	0.68	0.70	0.67	0.70	0.72	0.69	0.71	0.74	0.70	0.73	0.76
Commercial [2,4]	0.75	0.76	0.78	0.76	0.77	0.79	0.77	0.78	0.80	0.78	0.79	0.81
Streets including R/W	0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.73	0.76	0.73	0.75	0.78
Parking	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87

Source: Kibler, D.F. et at. 1982. Recommended Hydrologic Procedures for Computing Urban Runoff in Pennsylvania Commonwealth of Pa. Harrisburg Pa.: Dept. of Environmental Resources (Revised as noted)

Note: [1] Adjusted to reflect NRCS RCN values.

[2] Adjusted to reflect new Open Space runoff coefficients.

[3] Values derived from aerial photograph of University of Maryland, College Park Campus.

[4] Because of the variety of these types of land use, for more accurate runoff coefficient, calculate the percentage of impervious area and open space area and use the C-Factor chart on sheet DA-2 to find the correct C value.

HYDROLOGIC SOIL GROUPS

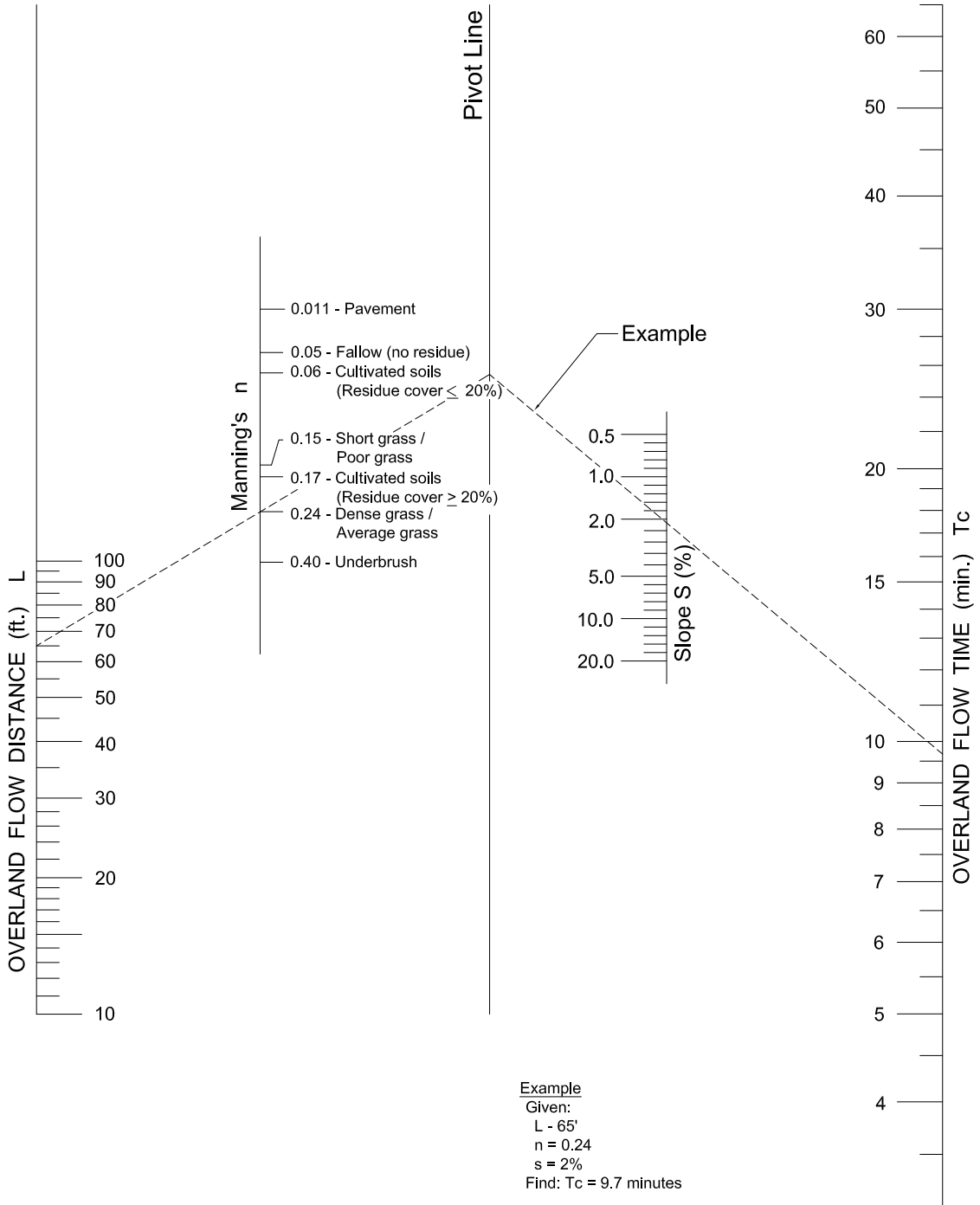
(by U.S. Soil Conservation Service 1986)

A Soils with high infiltration rates even when thoroughly wetted; consist chiefly of deep and well drained sands or gravels.

B Soils with moderate infiltration rates when thoroughly wetted; consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

C Soils with slow infiltration rates when thoroughly wetted; consist chiefly of soils with a layer that impeded downward movement of water, and soils with moderately fine to fine texture.

D Soils with very slow infiltration rates when thoroughly wetted; consist chiefly clay soils with high swelling potential, soils with permanent high water table, soils with a clay layer at or near the surface, and shallow soils over nearly impervious material.



Example
Given:
L - 65'
n = 0.24
s = 2%
Find: Tc = 9.7 minutes

Note:

1. *Maximum sheet flow distance of 100 feet shall be used.*
2. *This nomograph was based on the Manning's kinematic solution:*

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}}$$

, P_2 = *2-year, 24-hour rainfall (in.) = 3.38 in.*

T_t = *Travel time (hr)*
n = *Manning's roughness coefficient*
L = *Flow length (ft)*
s = *Slope of hydraulic grade line (ft/ft)*

(See equation for Sheet Flow, Chapter 3, in SCS TR-55 document).

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

SHEET FLOW TIME

RATIONAL AND TR-55 METHODS

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PLATE
DA-4
(HYDROLOGY)

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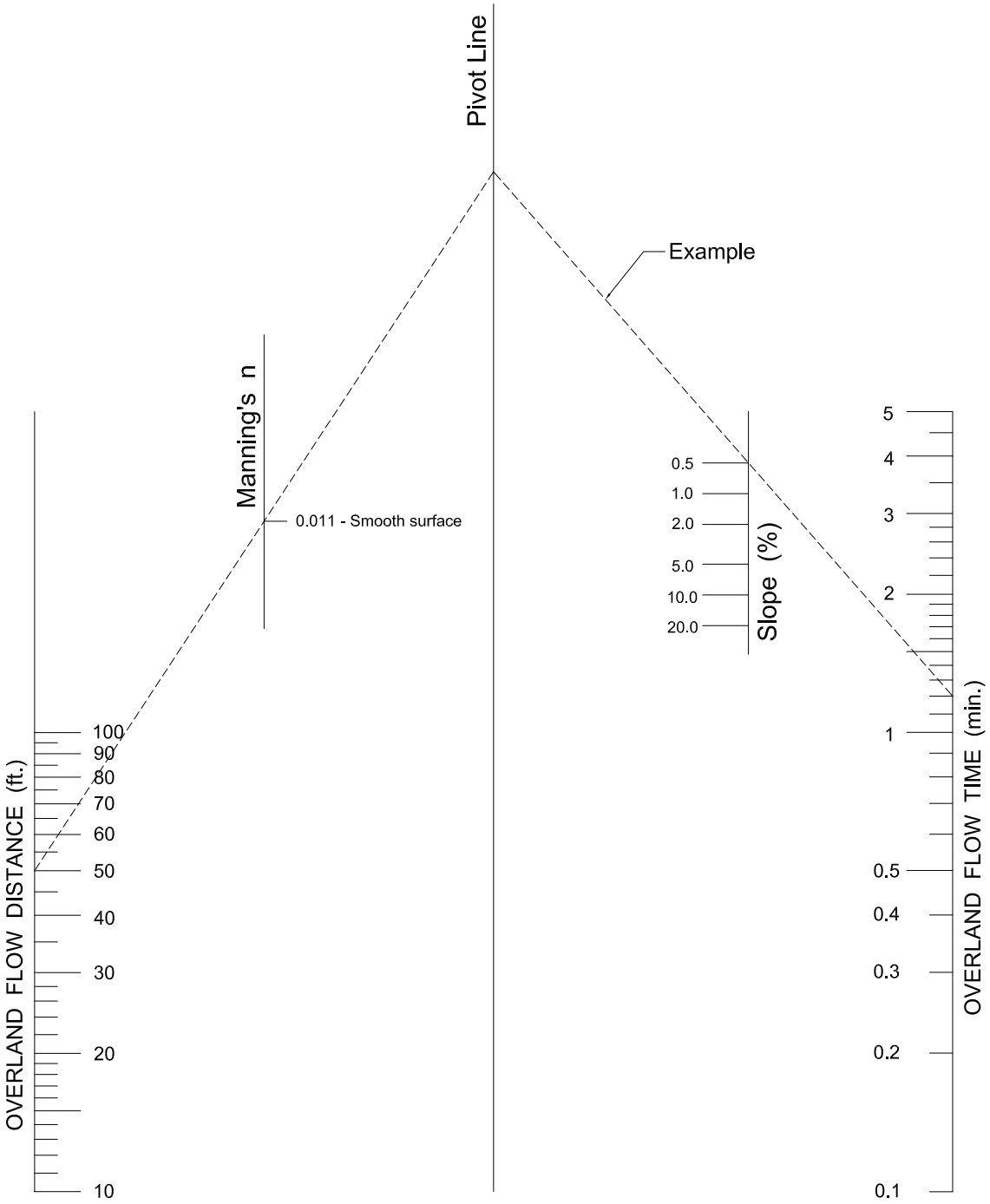

Note:

1. *For n ≥ 0.011, see sheet DA-3a.*
2. *Maximum overland flow distance of 100 feet shall be used.*
3. *This nomograph was based on the Manning's kinematic solution:*

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}}$$

, P_2 = *2-year, 24-hour rainfall (in.)*
= *3.38 in.*

(See equation for Sheet Flow, Chapter 3, in SCS TR-55 document).

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

OVERLAND FLOW TIME

RATIONAL METHOD

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PLATE
DA-4B
(HYDROLOGY)

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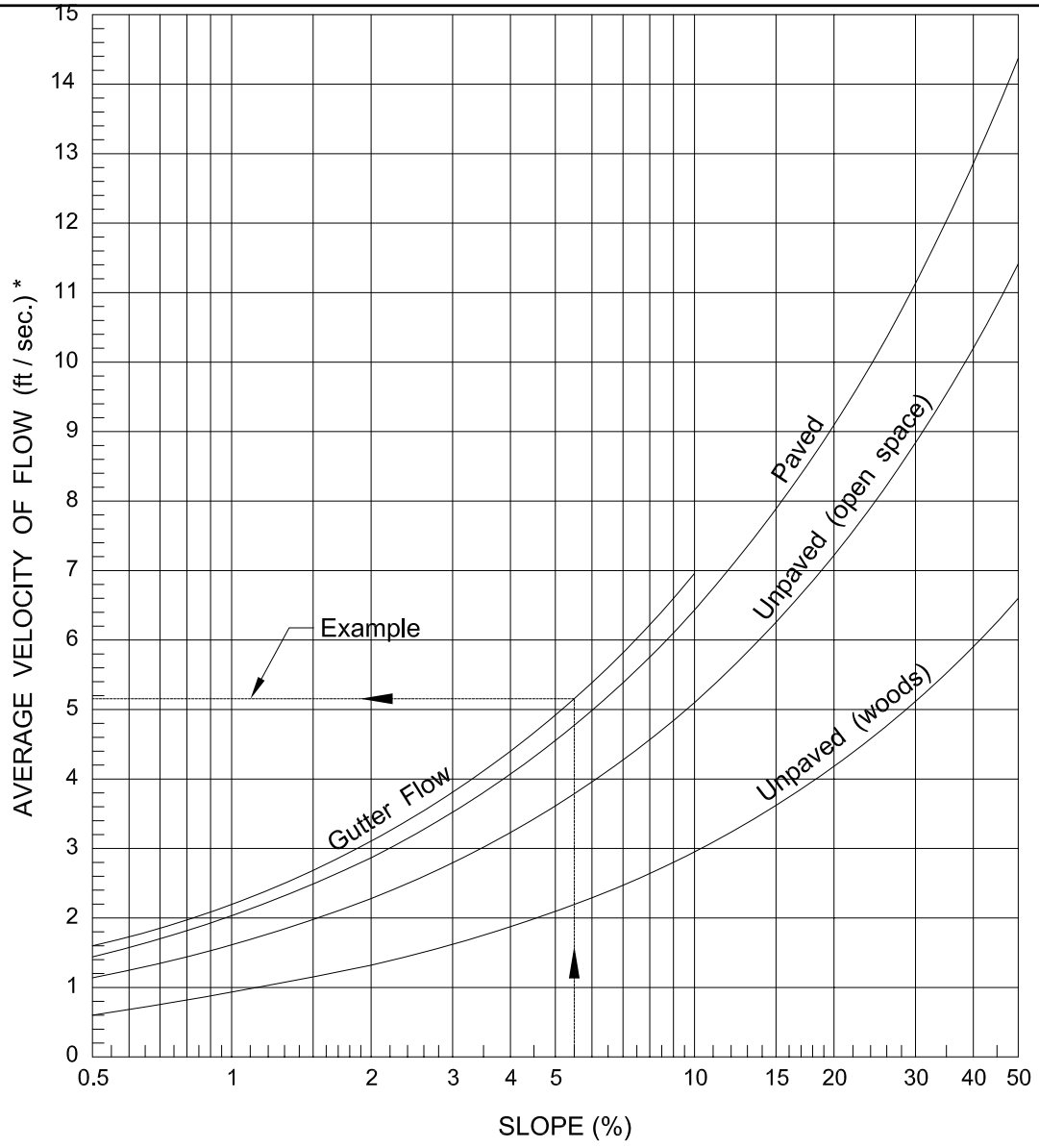
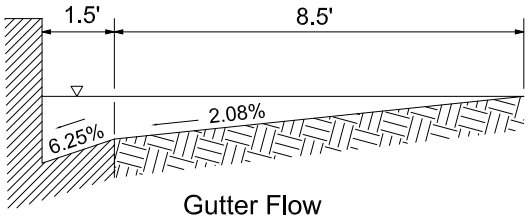


Note:
** For gutter flow, this is the average velocity of flow from point where it enters gutter to inlet.*



Gutter Flow

Manning's Equation:

1. Gutter Flow: $V = \frac{1.486\ R^{2/3} s^{1/2}}{n}$, n = 0.015

   Note: This chart is for flow at allowable spread of 10 feet.

2. Shallow Concentrated Flow:

   a. Unpaved: $V = 16.1345\ s^{1/2}$, n = 0.05 & R = 0.4
   b. Unpaved woods: $V = 9.3612\ s^{1/2}$, n = 0.1 & R = 0.5
   b. Paved: $V = 20.3282\ s^{1/2}$, n = 0.025 & R = 0.2

V = average velocity (ft/s)
R = hydraulic radius (ft) = a / p_w
a = cross sectional flow area (ft^2)
p_w = wetted perimeter (ft)
s = longitudinal slope, watercourse slope (ft/ft)
n = Manning's roughness coefficient for open channel flow

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

SHALLOW CONCENTRATED & GUTTER FLOWS

FOR RATIONAL AND TR-55 METHODS

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PLATE
DA-5
(HYDROLOGY)

2/7/2008 5:26 PM
DA-5.dwg

Baltimore County Rainfall Intensity - Frequency - Duration Table *

Duration		Intensity (inches/hour)						
Min.	Hrs	2 Yr	5 Yr	10 Yr	20 Yr	25 Yr	50 Yr	100 Yr
5	0.0833	5.0	6.0	6.7	7.3	7.6	8.2	8.8
6	0.1000	4.8	5.7	6.4	7.0	7.2	7.8	8.4
7	0.1167	4.6	5.5	6.1	6.7	6.9	7.5	8.0
8	0.1333	4.4	5.3	5.9	6.4	6.6	7.1	7.7
9	0.1500	4.2	5.0	5.6	6.1	6.3	6.8	7.4
10	0.1667	4.0	4.8	5.3	5.8	6.0	6.5	7.0
11	0.1833	3.9	4.6	5.1	5.6	5.8	6.3	6.8
12	0.2000	3.7	4.4	5.0	5.4	5.6	6.1	6.5
13	0.2167	3.6	4.3	4.8	5.2	5.4	5.9	6.3
14	0.2333	3.5	4.2	4.7	5.1	5.2	5.7	6.1
15	0.2500	3.4	4.0	4.5	4.9	5.1	5.5	5.9
16	0.2667	3.3	3.9	4.4	4.8	5.0	5.4	5.8
17	0.2833	3.2	3.8	4.3	4.7	4.9	5.3	5.7
18	0.3000	3.1	3.8	4.2	4.6	4.8	5.2	5.5
19	0.3167	3.0	3.7	4.1	4.5	4.6	5.1	5.4
20	0.3333	3.0	3.6	4.0	4.4	4.5	4.9	5.3
21	0.3500	2.9	3.5	3.9	4.3	4.4	4.8	5.2
22	0.3667	2.8	3.4	3.8	4.2	4.4	4.8	5.1
23	0.3833	2.7	3.3	3.7	4.1	4.3	4.7	5.1
24	0.4000	2.7	3.2	3.7	4.0	4.2	4.6	5.0
25	0.4167	2.6	3.2	3.6	3.9	4.1	4.5	4.9
26	0.4333	2.5	3.1	3.5	3.9	4.0	4.4	4.8
27	0.4500	2.5	3.0	3.4	3.8	4.0	4.3	4.7
28	0.4667	2.4	3.0	3.4	3.7	3.9	4.3	4.7
29	0.4833	2.4	2.9	3.3	3.7	3.8	4.2	4.6
30	0.5000	2.3	2.9	3.3	3.6	3.8	4.1	4.5
31	0.5167	2.3	2.8	3.2	3.5	3.7	4.1	4.5
32	0.5333	2.3	2.8	3.1	3.5	3.6	4.0	4.4
33	0.5500	2.2	2.7	3.1	3.4	3.6	3.9	4.3
34	0.5667	2.2	2.7	3.0	3.4	3.5	3.9	4.3
35	0.5833	2.1	2.6	3.0	3.3	3.5	3.8	4.2
36	0.6000	2.1	2.6	2.9	3.3	3.4	3.8	4.1
37	0.6167	2.1	2.6	2.9	3.2	3.4	3.7	4.1
38	0.6333	2.0	2.5	2.8	3.2	3.3	3.7	4.0
39	0.6500	2.0	2.5	2.8	3.1	3.3	3.6	4.0
40	0.6667	2.0	2.4	2.8	3.1	3.2	3.6	3.9

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PLATE
DA-6A
(HYDROLOGY)

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

INTENSITY - FREQUENCY - DURATION CURVES

BALTIMORE COUNTY, MD

Baltimore County Rainfall Intensity - Frequency - Duration Table *

Duration		Intensity (inches/hour)						
Min.	Hrs	2 Yr	5 Yr	10 Yr	20 Yr	25 Yr	50 Yr	100 Yr
41	0.6833	1.9	2.4	2.7	3.0	3.2	3.5	3.9
42	0.7000	1.9	2.4	2.7	3.0	3.1	3.5	3.8
43	0.7167	1.9	2.3	2.7	2.9	3.1	3.4	3.8
44	0.7333	1.8	2.3	2.6	2.9	3.0	3.4	3.7
45	0.7500	1.8	2.3	2.6	2.9	3.0	3.3	3.7
46	0.7667	1.8	2.2	2.5	2.8	2.9	3.3	3.6
47	0.7833	1.7	2.2	2.5	2.8	2.9	3.2	3.6
48	0.8000	1.7	2.2	2.5	2.7	2.9	3.2	3.6
49	0.8167	1.7	2.1	2.4	2.7	2.8	3.2	3.5
50	0.8333	1.7	2.1	2.4	2.7	2.8	3.1	3.5
51	0.8500	1.6	2.1	2.4	2.7	2.8	3.1	3.4
52	0.8667	1.6	2.0	2.3	2.6	2.7	3.1	3.4
53	0.8833	1.6	2.0	2.3	2.6	2.7	3.0	3.4
54	0.9000	1.6	2.0	2.3	2.6	2.7	3.0	3.3
55	0.9167	1.6	2.0	2.3	2.5	2.7	3.0	3.3
56	0.9333	1.5	1.9	2.2	2.5	2.6	2.9	3.2
57	0.9500	1.5	1.9	2.2	2.5	2.6	2.9	3.2
58	0.9667	1.5	1.9	2.2	2.4	2.6	2.9	3.2
59	0.9833	1.5	1.9	2.2	2.4	2.5	2.8	3.1
60	1.0000	1.5	1.8	2.1	2.4	2.5	2.8	3.1
61	1.0167	1.5	1.8	2.1	2.4	2.5	2.8	3.1
62	1.0333	1.4	1.8	2.1	2.3	2.5	2.8	3.1
63	1.0500	1.4	1.8	2.1	2.3	2.4	2.7	3.0
64	1.0667	1.4	1.8	2.1	2.3	2.4	2.7	3.0
65	1.0833	1.4	1.8	2.0	2.3	2.4	2.7	3.0
66	1.1000	1.4	1.8	2.0	2.3	2.4	2.7	2.9
67	1.1167	1.4	1.7	2.0	2.2	2.4	2.7	2.9
68	1.1333	1.4	1.7	2.0	2.2	2.4	2.6	2.9
69	1.1500	1.3	1.7	2.0	2.2	2.3	2.6	2.9
70	1.1667	1.3	1.7	1.9	2.2	2.3	2.6	2.9
71	1.1833	1.3	1.7	1.9	2.2	2.3	2.6	2.8
72	1.2000	1.3	1.7	1.9	2.2	2.3	2.6	2.8
73	1.2167	1.3	1.7	1.9	2.2	2.2	2.5	2.8
74	1.2333	1.3	1.6	1.9	2.1	2.2	2.5	2.8
75	1.2500	1.3	1.6	1.9	2.1	2.2	2.5	2.8
76	1.2667	1.3	1.6	1.9	2.1	2.2	2.5	2.8
77	1.2833	1.3	1.6	1.8	2.1	2.2	2.5	2.7
78	1.3000	1.2	1.6	1.8	2.1	2.2	2.4	2.7
79	1.3167	1.2	1.6	1.8	2.1	2.2	2.4	2.7
80	1.3333	1.2	1.6	1.8	2.0	2.1	2.4	2.7

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DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

INTENSITY - FREQUENCY - DURATION CURVES
BALTIMORE COUNTY, MD

Baltimore County Rainfall Intensity - Frequency - Duration Table *

Duration		Intensity (inches/hour)						
Min.	Hrs	2 Yr	5 Yr	10 Yr	20 Yr	25 Yr	50 Yr	100 Yr
81	1.3500	1.2	1.5	1.8	2.0	2.1	2.4	2.7
82	1.3667	1.2	1.5	1.8	2.0	2.1	2.4	2.6
83	1.3833	1.2	1.5	1.8	2.0	2.1	2.4	2.6
84	1.4000	1.2	1.5	1.8	2.0	2.1	2.3	2.6
85	1.4167	1.2	1.5	1.7	2.0	2.1	2.3	2.6
86	1.4333	1.2	1.5	1.7	2.0	2.0	2.3	2.6
87	1.4500	1.2	1.5	1.7	1.9	2.0	2.3	2.6
88	1.4667	1.2	1.5	1.7	1.9	2.0	2.3	2.5
89	1.4833	1.1	1.4	1.7	1.9	2.0	2.3	2.5
90	1.5000	1.1	1.4	1.7	1.9	2.0	2.2	2.5
91	1.5167	1.1	1.4	1.7	1.9	2.0	2.2	2.5
92	1.5333	1.1	1.4	1.7	1.9	1.9	2.2	2.5
93	1.5500	1.1	1.4	1.6	1.8	1.9	2.2	2.4
94	1.5667	1.1	1.4	1.6	1.8	1.9	2.2	2.4
95	1.5833	1.1	1.4	1.6	1.8	1.9	2.2	2.4
96	1.6000	1.1	1.4	1.6	1.8	1.9	2.2	2.4
97	1.6167	1.1	1.4	1.6	1.8	1.9	2.1	2.4
98	1.6333	1.1	1.3	1.6	1.8	1.9	2.1	2.4
99	1.6500	1.1	1.3	1.6	1.8	1.8	2.1	2.3
100	1.6667	1.1	1.3	1.6	1.8	1.8	2.1	2.3
101	1.6833	1.0	1.3	1.5	1.7	1.8	2.1	2.3
102	1.7000	1.0	1.3	1.5	1.7	1.8	2.1	2.3
103	1.7167	1.0	1.3	1.5	1.7	1.8	2.0	2.3
104	1.7333	1.0	1.3	1.5	1.7	1.8	2.0	2.3
105	1.7500	1.0	1.3	1.5	1.7	1.8	2.0	2.2
106	1.7667	1.0	1.3	1.5	1.7	1.7	2.0	2.2
107	1.7833	1.0	1.3	1.5	1.7	1.7	2.0	2.2
108	1.8000	1.0	1.2	1.4	1.6	1.7	2.0	2.2
109	1.8167	1.0	1.2	1.4	1.6	1.7	1.9	2.2
110	1.8333	1.0	1.2	1.4	1.6	1.7	1.9	2.2
111	1.8500	1.0	1.2	1.4	1.6	1.7	1.9	2.2
112	1.8667	1.0	1.2	1.4	1.6	1.7	1.9	2.1
113	1.8833	0.9	1.2	1.4	1.6	1.6	1.9	2.1
114	1.9000	0.9	1.2	1.4	1.6	1.6	1.9	2.1
115	1.9167	0.9	1.2	1.4	1.6	1.6	1.8	2.1
116	1.9333	0.9	1.2	1.4	1.5	1.6	1.8	2.1
117	1.9500	0.9	1.1	1.3	1.5	1.6	1.8	2.0
118	1.9667	0.9	1.1	1.3	1.5	1.6	1.8	2.0
119	1.9833	0.9	1.1	1.3	1.5	1.6	1.8	2.0
120	2.0000	0.9	1.1	1.3	1.5	1.6	1.8	2.0

* NOAA Atlas 14, November 2004.

ISSUED: FEBRUARY 7, 2008
REVISED:
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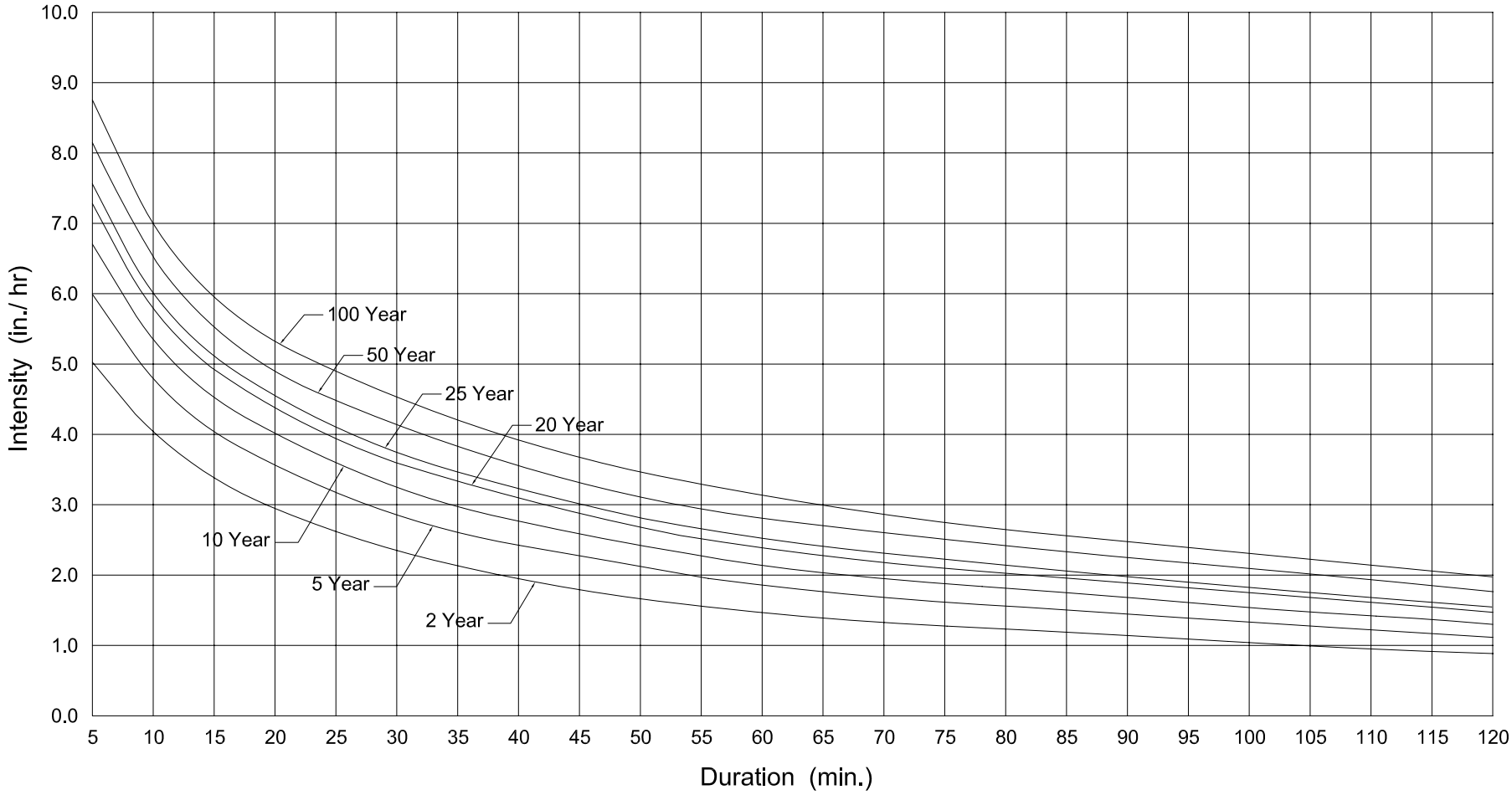
PLATE
DA-6C
(HYDROLOGY)

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

INTENSITY - FREQUENCY - DURATION CURVES
BALTIMORE COUNTY, MD



DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

INTENSITY - FREQUENCY - DURATION CURVES

BALTIMORE COUNTY, MD

ISSUED: FEBRUARY 7, 2008

REVISED:

REVISED:

PLATE

DA-7

(HYDROLOGY)

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