17 Attachment 2

Borough of Elizabethtown

APPENDIX B

STORMWATER MANAGEMENT AND BMP CALCULATION COEFFICIENTS

[Ord. 954, 12/19/2013]

APPENDIX NO. B-1

RUNOFF COEFFICIENTS "C" FOR RATIONAL FORMULA

TABLE 5.2
Runoff Coefficients for the Rational Equation*

LAND USE	A Soils[1]			B Soils[1]			C Soils[1]			D Soils[1]		
	< 2%	2-6%	>6%	< 2%	2-6%	>6%	< 2%	2-6%	>6%	< 2%	2-6%	>6%
Cultivated land	0.08	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
Pasture	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
Forest	0.05	0.08	0.11	0.08	0.11	0.14	0.10	0.13	0.16	0.12	0.16	0.20
Residential lot size 1/8 acre	0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
Residential lot size 1/4 acre	0.22	0.26	0.29	0.24	0.29	0.33	0.27	0.31	0.36	0.30	0.34	0.40
Residential lot size 1/3 acre	0.19	0.23	0.26	0.22	0.26	0.30	0.25	0.29	0.34	0.28	0.32	0.39
Residential lot size 1/2 acre	0.16	0.20	0.24	0.19	0.23	0.28	0.22	0.27	0.32	0.26	0.30	0.37
Residential lot size 1 acre	0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.29	0.35
Industrial	0.67	0.68	0.68	0.68	0.68	0.69	0.68	0.68	0.69	0.69	0.69	0.70
Commercial	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Streets	0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.73	0.76	0.73	0.75	0.78
Open Space	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.15	0.21	0.28
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
Construction Sites - Bare packed soil, smooth	0.30	0.35	.040	0.35	.040	0.45	0.40	0.45	0.50	0.50	0.55	0.60
Construction Sites - Bare packed soil, rough	.020	0.25	0.30	0.25	0.30	0.35	0.30	0.35	0.40	0.40	0.45	0.50

* Runoff Coefficients for storm recurrence intervals less than 25 years

Adapted from McCuen, R.H., Hydrologic Analysis and Design (2004)

1. According to the USDA NRCS Hydrologic Soils Classification System

APPENDIX NO. B-2

RUNOFF CURVE NUMBERS "CN" FOR SCS METHOD*

Runoff Curve Numbers "CN" for SCS Method												
Soil Group	**A**			**B**			**C**			**D**		
Slope / **Land Use**	**0-2%**	**2-6%**	**6%+**	**0-2%**	**2-6%**	**6%+**	**0-2%**	**2-6%**	**6%+**	**0-2%**	**2-6%**	**6%+**
Cultivated Land												
winter conditions	48	60	75	62	73	82	68	78	90	77	88	95
summer conditions	35	51	58	48	55	65	57	65	73	64	69	79
Fallowed Fields	45	54	65	56	63	73	64	74	81	69	77	87
poor conditions	30	44	48	43	48	55	48	54	63	56	60	68
good conditions	30	40	43	42	46	50	45	50	53	50	56	61
Forest/Woodland												
Grass Areas	35	51	53	48	54	63	56	59	73	62	63	79
good conditions	45	53	58	52	55	65	60	63	75	65	69	82
average conditions	48	55	67	56	67	77	66	74	85	73	81	90
poor conditions	96	97	98	96	97	98	96	97	98	96	97	98
Impervious Areas												
Weighted Residential												
Lot size 1/8 acre	71	75	78	74	76	82	78	80	87	81	83	90
Lot size 1/4 acre	62	67	71	66	69	76	67	69	76	75	78	88
Lot size 1/3 acre	59	65	69	64	66	74	65	66	75	74	77	87
Lot size 1/2 acre	57	63	68	62	64	73	63	65	73	72	76	86
Lot size 1 acre	55	62	67	61	63	72	61	64	72	71	75	85

APPENDIX NO. B-3

NOAA Atlas 14, Volume 2, Version 3
Location name: Pequea, Pennsylvania, US*
Coordinates: 39.8957, -76.3157
Elevation: 454 ft*
source Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M., Bonnin, D. Martin, B. Lin, T. Parzybok, M. Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	3.88 (3.46-4.37)	4.61 (4.12-5.20)	5.45 (4.86-6.13)	6.05 (5.38-6.79)	6.77 (6.00-7.60)	7.28 (6.43-8.16)	7.76 (6.83-8.70)	8.22 (7.19-9.23)	8.76 (7.60-9.83)	9.14 (7.90-10.3)
10-min	3.10 (2.76-3.49)	3.68 (3.29-4.15)	4.36 (3.89-4.91)	4.84 (4.30-5.43)	5.39 (4.78-6.05)	5.80 (5.12-6.50)	6.17 (5.42-6.91)	6.52 (5.69-7.31)	6.92 (6.01-7.77)	7.21 (6.22-8.09)
15-min	2.58 (2.30-2.90)	3.09 (2.76-3.48)	3.68 (3.28-4.14)	4.08 (3.62-4.58)	4.56 (4.04-5.11)	4.89 (4.32-5.48)	5.20 (4.57-5.83)	5.48 (4.79-6.15)	5.81 (5.04-6.52)	6.03 (5.20-6.78)
30-min	1.77 (1.58-1.99)	2.13 (1.90-2.40)	2.61 (2.33-2.94)	2.96 (2.63-3.32)	3.38 (2.99-3.79)	3.68 (3.25-4.13)	3.98 (3.50-4.46)	4.27 (3.73-4.79)	4.62 (4.01-5.19)	4.88 (4.21-5.49)
60-min	1.10 (0.983-1.24)	1.34 (1.19-1.51)	1.68 (1.49-1.89)	1.92 (1.71-2.16)	2.25 (1.99-2.52)	2.50 (2.20-2.80)	2.74 (2.41-3.07)	2.99 (2.62-3.36)	3.32 (2.88-3.72)	3.56 (3.07-4.00)
2-hr	0.659 (0.590-0.739)	0.800 (0.716-0.896)	1.01 (0.904-1.13)	1.18 (1.05-1.32)	1.41 (1.25-1.57)	1.60 (1.41-1.78)	1.80 (1.58-2.00)	2.01 (1.75-2.24)	2.30 (1.98-2.56)	2.53 (2.16-2.83)
3-hr	0.476 (0.428-0.533)	0.578 (0.520-0.648)	0.733 (0.658-0.820)	0.854 (0.764-0.954)	1.02 (0.909-1.14)	1.16 (1.03-1.29)	1.30 (1.15-1.45)	1.45 (1.27-1.61)	1.67 (1.44-1.85)	1.83 (1.57-2.04)
6-hr	0.294 (0.265-0.329)	0.356 (0.321-0.398)	0.449 (0.405-0.502)	0.527 (0.473-0.587)	0.638 (0.569-0.709)	0.732 (0.648-0.811)	0.833 (0.731-0.921)	0.941 (0.818-1.04)	1.10 (0.942-1.21)	1.23 (1.04-1.36)
12-hr	0.175 (0.158-0.197)	0.211 (0.191-0.237)	0.269 (0.241-0.301)	0.317 (0.284-0.355)	0.390 (0.346-0.435)	0.453 (0.398-0.503)	0.522 (0.454-0.579)	0.598 (0.514-0.663)	0.713 (0.601-0.789)	0.810 (0.673-0.896)
24-hr	0.101 (0.093-0.110)	0.122 (0.112-0.134)	0.156 (0.143-0.170)	0.185 (0.169-0.202)	0.229 (0.208-0.249)	0.268 (0.241-0.288)	0.311 (0.277-0.335)	0.359 (0.316-0.386)	0.432 (0.374-0.463)	0.495 (0.422-0.530)
2-day	0.058 (0.053-0.063)	0.070 (0.065-0.076)	0.089 (0.082-0.097)	0.105 (0.097-0.115)	0.129 (0.118-0.140)	0.150 (0.136-0.162)	0.173 (0.155-0.186)	0.197 (0.175-0.213)	0.234 (0.205-0.253)	0.265 (0.229-0.286)
3-day	0.041 (0.038-0.044)	0.049 (0.046-0.054)	0.063 (0.058-0.068)	0.074 (0.069-0.081)	0.091 (0.084-0.099)	0.106 (0.096-0.114)	0.122 (0.110-0.131)	0.140 (0.125-0.150)	0.166 (0.146-0.178)	0.188 (0.163-0.202)
4-day	0.032 (0.030-0.035)	0.039 (0.036-0.042)	0.050 (0.046-0.054)	0.059 (0.054-0.064)	0.072 (0.066-0.078)	0.084 (0.076-0.090)	0.097 (0.087-0.104)	0.111 (0.099-0.119)	0.131 (0.116-0.141)	0.149 (0.131-0.161)
7-day	0.022 (0.020-0.023)	0.026 (0.024-0.028)	0.033 (0.030-0.035)	0.038 (0.035-0.041)	0.047 (0.043-0.050)	0.054 (0.049-0.058)	0.062 (0.056-0.067)	0.071 (0.064-0.076)	0.083 (0.074-0.090)	0.094 (0.083-0.101)
10-day	0.017 (0.016-0.018)	0.021 (0.019-0.022)	0.026 (0.024-0.028)	0.030 (0.028-0.032)	0.036 (0.033-0.038)	0.041 (0.037-0.044)	0.046 (0.042-0.049)	0.052 (0.047-0.055)	0.060 (0.054-0.064)	0.067 (0.059-0.072)
20-day	0.012 (0.011-0.012)	0.014 (0.013-0.015)	0.017 (0.016-0.018)	0.019 (0.018-0.020)	0.022 (0.021-0.024)	0.025 (0.023-0.026)	0.027 (0.026-0.029)	0.030 (0.028-0.032)	0.034 (0.031-0.036)	0.037 (0.034-0.039)
30-day	0.010 (0.009-0.010)	0.011 (0.011-0.012)	0.013 (0.013-0.014)	0.015 (0.014-0.016)	0.017 (0.016-0.018)	0.019 (0.018-0.020)	0.021 (0.020-0.022)	0.023 (0.021-0.024)	0.026 (0.024-0.027)	0.027 (0.025-0.029)
45-day	0.008 (0.008-0.009)	0.010 (0.009-0.010)	0.011 (0.011-0.012)	0.012 (0.012-0.013)	0.014 (0.013-0.015)	0.015 (0.014-0.016)	0.016 (0.015-0.017)	0.017 (0.015-0.018)	0.019 (0.018-0.020)	0.020 (0.019-0.021)
60-day	0.007 (0.007-0.008)	0.009 (0.008-0.009)	0.010 (0.009-0.010)	0.011 (0.010-0.011)	0.012 (0.011-0.013)	0.013 (0.012-0.014)	0.014 (0.013-0.015)	0.015 (0.014-0.015)	0.016 (0.015-0.017)	0.017 (0.016-0.017)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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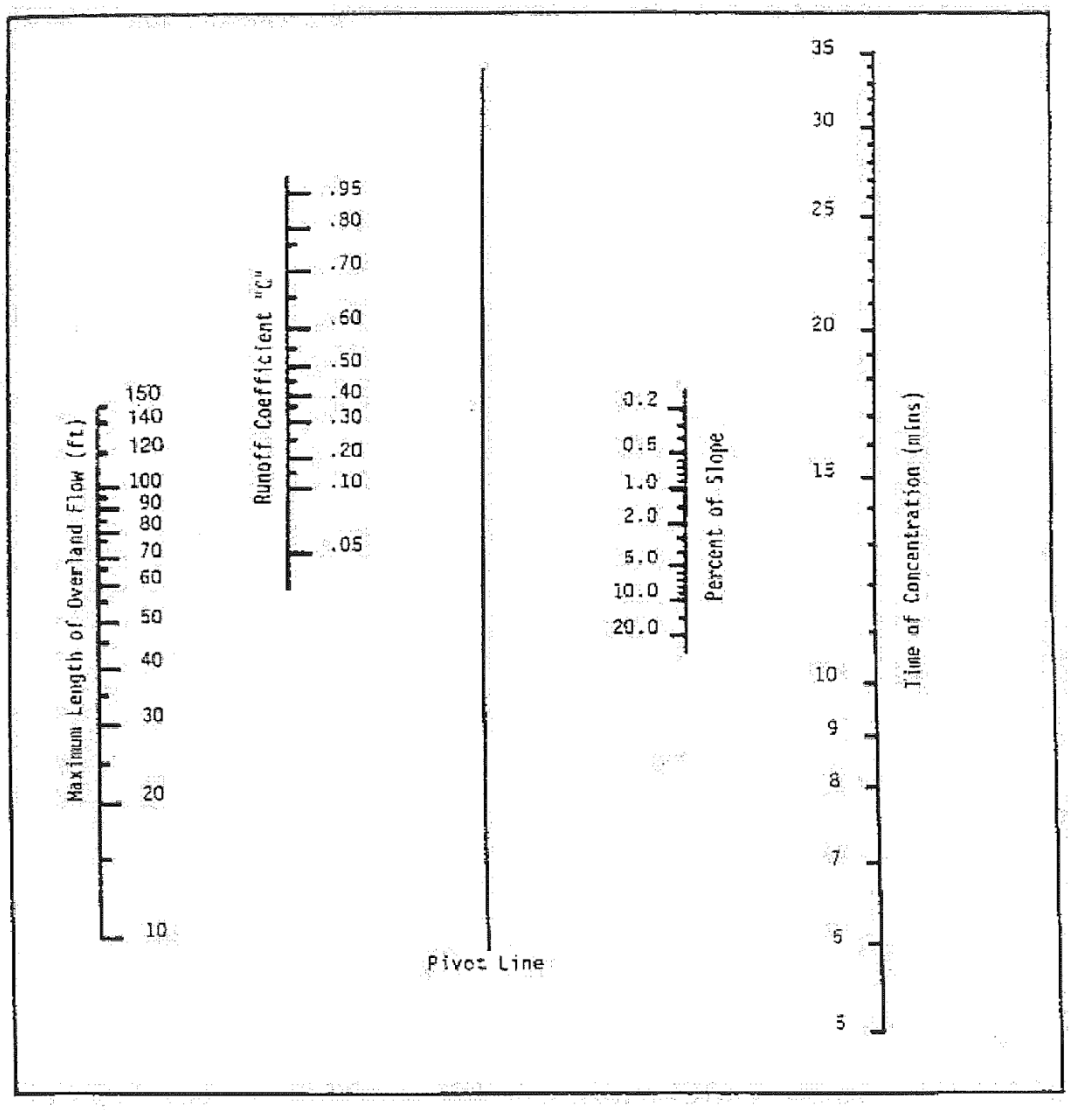
PF graphical

APPENDIX NO. B-4

NOMOGRAPH FOR DETERMINING SHEET FLOW

(for use with the Rational Method)



APPENDIX NO. B-5

Worksheet #1: Time of concentration (Tc) or travel time (Tt)

Project _____ By _____ Date _____
Location _____ Checked _____ Date _____
Circle One: Present Developed _____
Circle One: Tc Tt through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic or description of flow segments.

Sheet Flow (Applicable to Tc Only)		**Segment ID**					
1. Surface description (Table 3-1)							
2. Manning's roughness coefficient, n (Table 3-1)							
3. Flow length, L (total L ≤** 150 feet)		ft					
4. Two-year 24-hour rainfall, P_2		in					
5. Land slope, s		ft/ft					
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5} \times S^{0.4}}$	Compute T_t	hr		+		=	

Shallow Concentrated Flow		**Segment ID**					
7. Surface description (paved or unpaved)							
8. Flow Length, L		ft					
9. Watercourse slope, s		ft/ft					
10. Average velocity, V (Figure 3-1)		ft/s					
11. $T_t = \frac{L}{3600\ V}$	Compute T_t	hr		+		=	

Channel Flow		**Segment ID**					
12. Cross sectional flow area, a		ft^2					
13. Wetted perimeter, P_w		ft					
14. Hydraulic radius, $r = \frac{a}{P_w}$	Compute r	ft					
15. Channel slope, s		ft/ft					
16. Manning's roughness coefficient, n							
17. $V = \frac{1.49 \times r^{r} n \times s^{1} n}{n}$	Compute V	ft/s					
18. Flow Length, L		ft					
19. $T_t = \frac{L}{3600V}$	Compute T_t	hr		+		=	
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11 and 19)						hr	

* Table 3-1 per latest TR-55, Urban Hydrology for Small Watersheds
** 150' sheet flow length per latest TR-55 revision

APPENDIX NO. B-6

AVERAGE VELOCITIES FOR ESTIMATING TRAVEL TIME FOR SHALLOW CONCENTRATED FLOW

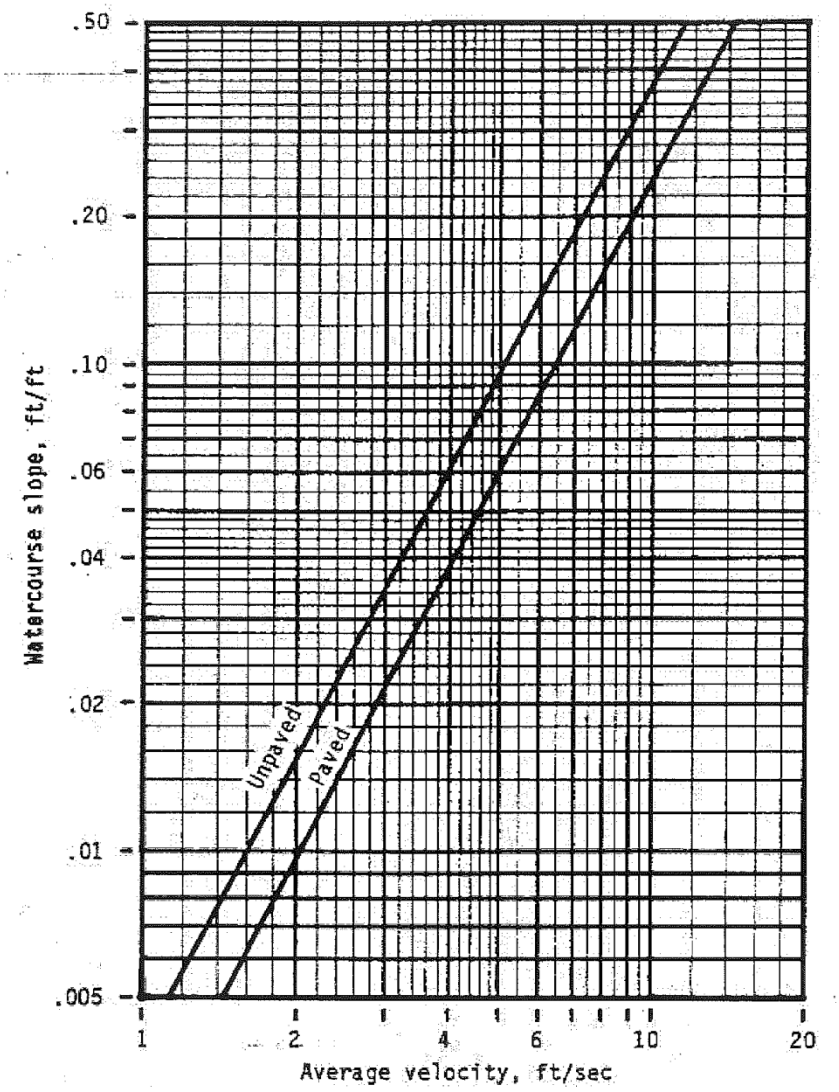


Figure 3-1. — Average velocities for estimating travel time for shallow concentrated flow.

(210-V1-TR-55, Second Ed., June 1986)