SECTION 104 - STORMWATER RUNOFF COMPUTATIONS

SECTION 104 - STORMWATER RUNOFF COMPUTATIONS

104.1 GENERAL

This policy describes methods which can be used to determine rates and volumes of stormwater runoff. It is important to remember that the physical relationship between precipitation and the rate and amount of runoff is very complex, and that computational methods which have been developed are empirical. When applying any hydrologic technique, the designer must be aware of its basic assumptions and limitations. Experience and good judgement must be used to evaluate the results.

Numerous methods have been published for determining runoff rates and volumes. The designer may choose to use other methods than those described herein provided that the method is documented in generally accepted engineering literature and is used within the limitations stated for the method. An overview of recognized methods is given in the ASCE manual of practice for stormwater design (Reference 104.13).

104.1.1 Key Terms

The following key terms should be used in describing runoff computations:

Pre-project conditions - the topography, surface cover, and other hydrologic conditions in the watershed being considered as they exist prior to the proposed development.

Post-project conditions - the topography, surface cover, and other hydrologic conditions in the watershed as they will be after construction of the proposed development.

Fully urbanized conditions - the topography, surface cover, and other hydrologic conditions in the watershed as they will be after all areas in the watershed have been developed in accordance with current zoning designations, as provided in the Greene County Comprehensive Plan, or as can otherwise be reasonably anticipated.

104.2 PRECIPITATION DATA

Precipitation data used for computing runoff rates and volumes for use in the design of stormwater management facilities in Greene County are derived from data published by the National Weather Service (NWS) (References 104.1 and 104.2). These data are summarized in Tables 104.1 and 104.2, and Figures 104.1, 104.2 and 104.3.

Data obtained from other reliable sources, such as the Rainfall Atlas of the Midwest (Reference 104.3) may also be used with the written approval of the Stormwater Engineer.

104.3 TOPOGRAPHIC DATA

Topographic data utilized in determining drainage areas must be sufficiently detailed to allow computation of runoff with a reasonable degree of accuracy.

104.3.1 On-site Drainage Areas

Topographic maps with a maximum contour interval of not more than two feet five inches (2'5") for A-1 and A-R zoning districts must be utilized for determining drainage areas within the development site. Topographic maps must show existing and proposed drainage facilities such as storm drains, culverts, road cuts, ditches and other physical features which affect the patterns of runoff on the site.

104.3.2 Off-site Drainage Areas

Maps published by the U.S. Geological Survey having a maximum contour interval of ten feet (10') will generally be considered sufficiently accurate for use in determining drainage areas where no development has occurred. For small drainage areas where U.S.G.S. maps do not have a sufficient level of accuracy or where drainage patterns have been altered by development, the best available data should be used.

NOTE: Topographic information (five foot (5') contour intervals) is available for certain portions of the area around the City of Springfield on the 1976 Springfield Planning Area maps. These maps should be used in determining off-site drainage areas, where more detailed maps are not available. Where no other topographic maps having sufficient detail to determine the drainage area in question are available, aerial photo maps available from the County Assessor's office should be used with drainage area limits and paths of flow determined in the field.

Regardless of the data used, it is the designer's responsibility to field verify that the drainage areas used are reasonably accurate.

104.4 METHODS FOR COMPUTING RUNOFF

104.4.1 Peak Runoff Rates

A. Drainage areas less than 200 acres.

Where the tributary drainage area is less than two hundred (200) acres, and only the peak runoff rate is needed, the peak runoff rate may be computed by the Rational Method (Reference 104.4) as described below. Peak flow rates for designing inlets and conveyance facilities (storm drains and open channels) for most developments can be computed by this method.

B. Urban drainage areas equal to or greater than 200 acres.

Where the tributary drainage area is two hundred (200) acres or more, and only the peak flow rate is needed, the peak runoff rate shall be computed by any of the following methods:

1) Soil Conservation Service TR-55, Graphical Peak Discharge Method (Reference 104.5). Hydrologic soil groups for soils listed in the Greene County soil survey are shown in Table 104.4.

2) Unit hydrograph methods (See Section 104.4.3).

C. Rural drainage areas equal to or greater than 200 acres.

Peak runoff rates for rural watersheds equal to or greater than two hundred (200) acres shall be computed by any of the following methods:

1) Soil Conservation Service TR-55 Graphical Peak Discharge Method (Reference 104.5).

NOTE: This method is limited to a maximum time of concentration of ten (10) hours.

2) U.S. Geological Survey Technique for Estimating the 2- to 500-year Flood Discharges on Unregulated Streams in Rural Missouri (Reference 104.6).

3) Unit hydrograph methods (See Section 104.4.3).

104.4.2 Runoff Volumes

Runoff volumes shall be computed using Soil Conservation Service TR-55 (Reference 104.5), or any of the unit hydrograph methods listed below.

104.4.3 Hydrograph Methods

When runoff rates must be known as a function of time, such as for reservoir routing computations or when the limitations of the methods listed above are exceeded, hydrograph methods must be used. Commonly accepted hydrograph methods are as follows:

U.S. Army Corps of Engineers HEC-1 Flood Hydrograph Package (Reference 104.7).

Soil Conservation Service TR-55 and TR-20 (Reference 104.5 and 104.8).

USEPA Storm Water Management Model (SWMM) (Reference 104.9 and 104.10).

Other methods may be used upon written approval of the Stormwater Engineer, provided that they are documented in accepted engineering literature and are used within the limitations stated.

Methods used for distribution of rainfall, determining precipitation losses, accounting for channel and reservoir storage effects, etc., shall be as prescribed in the literature for the selected method.

Where the method gives the designer the choice of precipitation distribution, use of the Pilgrim-Cordery distribution is preferred (Reference 104.11). Synthetic rainfall mass curve data for this distribution is shown in Table 104.5.

104.4.4 Accuracy

Runoff computations are based upon empirical methods and cannot be expected to give precise results. Results should always be rounded off or shown with a limited number of significant digits to avoid implying an accuracy greater than that which can be expected. Runoff rates and volumes should be rounded up to the nearest ten percent (10%) of the computed value.

104.5 RATIONAL METHOD

The rational formula may be used to compute peak runoff rates only for drainage areas less than two hundred (200) acres. The rational method or variations of the rational method are not reliable for use in determining runoff volumes.

The formula for the rational method is as follows:

Q = C I A, where

Q = peak runoff rate for a design storm of recurrence interval, T, in cubic feet per second (cfs);

C = dimensionless runoff coefficient; recommended runoff coefficient values are given in Table 104.3. The value used shall be the composite value based upon the type of surface coverage in the drainage area for the runoff condition being considered.

I = average rainfall intensity for a storm of recurrence interval, T, over a duration equal to or greater than the time of concentration for the contributing drainage area.

The time of concentration utilized shall be determined for conditions under which the peak flow rate is calculated; i.e. pre-project conditions for the pre-project peak flow rate and post-project conditions for the post-project peak flow rate, etc.

A = tributary watershed area in acres

NOTE: 1 acre-inch per hour = 1.008 cfs; therefore, the unit conversion factor is typically ignored.

104.6 TIME OF CONCENTRATION

The time of concentration is defined as the travel time from the hydraulically most distant point in the contributing drainage area to the point under study, or, the rainfall intensity averaging time. Time of concentration for use with the Rational Method may be computed by either of the two methods described below. The minimum time of concentration which shall be used is five (5) minutes.

The Soil Conservation Service Method, or other methods for which there is documentation in commonly accepted literature, shall be used in computing peak runoff rates for other methods.

104.6.1 Kirpich Formula (Reference 104.12)

$$t_c = 0.0078\left[\frac{L}{\sqrt{S}}\right]^{0.77}$$

t_c = time of concentration in minutes
L = length of travel in feet
S = slope of the flow path from the remote part of the basin to the calculation point divided by the horizontal distance between the two points (ft./ft.)

104.6.2 Soil Conservation Service Method

The method given in Chapter 3 of Soil Conservation Service TR-55 (Reference 104.5) may be used to compute times of concentration. In using this method it must be remembered that overland flow elements are limited to three hundred feet (300') in rural areas, and generally to one hundred feet (100') in urban areas. The designer must consider whether calculated runoff rate from directly connected impervious areas having a shorter time of concentration will exceed the runoff rate for the entire drainage area when pervious areas are included.

104.7 REFERENCES

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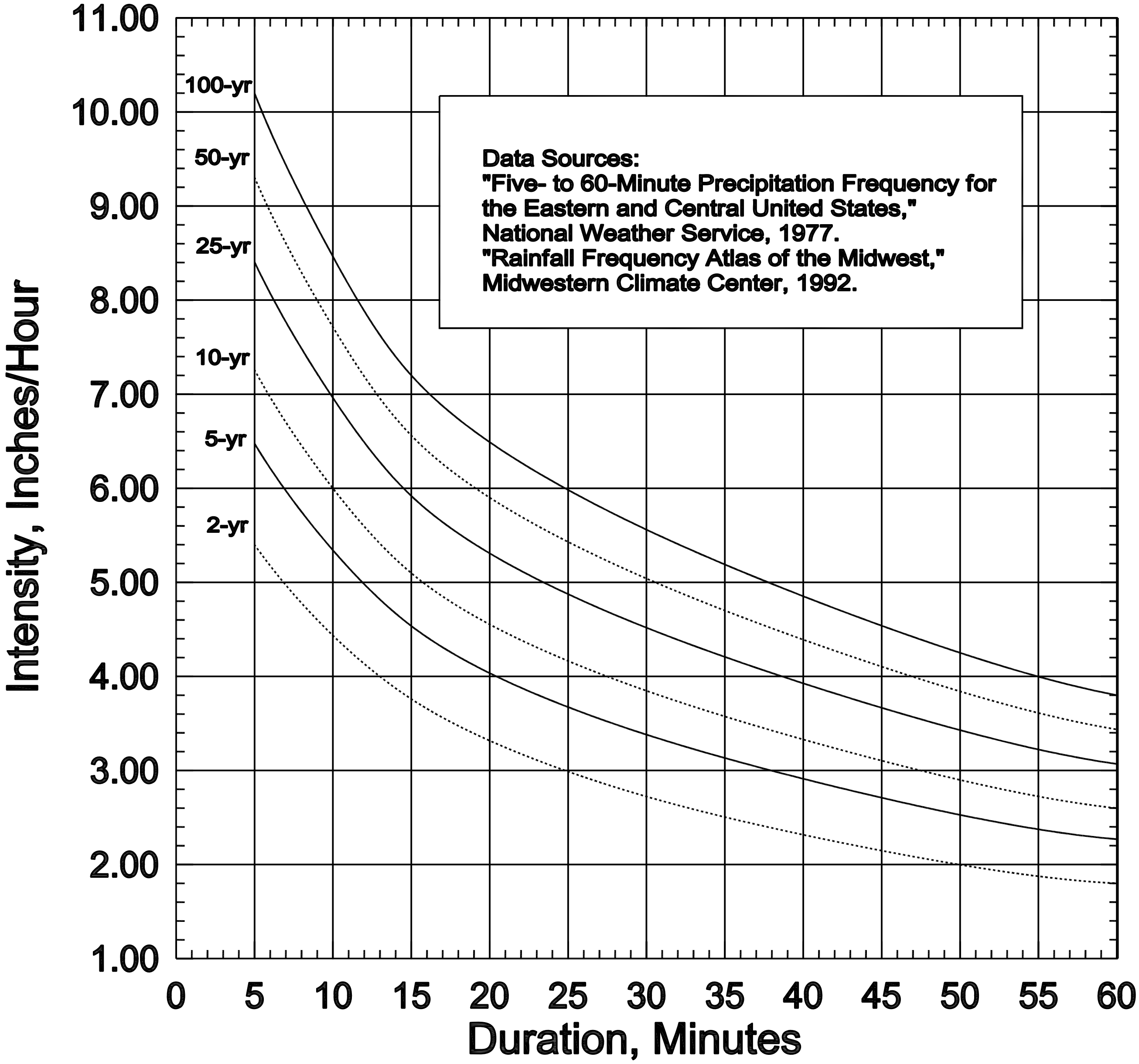

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

RAINFALL
INTENSITY – DURATION – FREQUENCY
5 – 60 MINUTES

FIGURE 104.1

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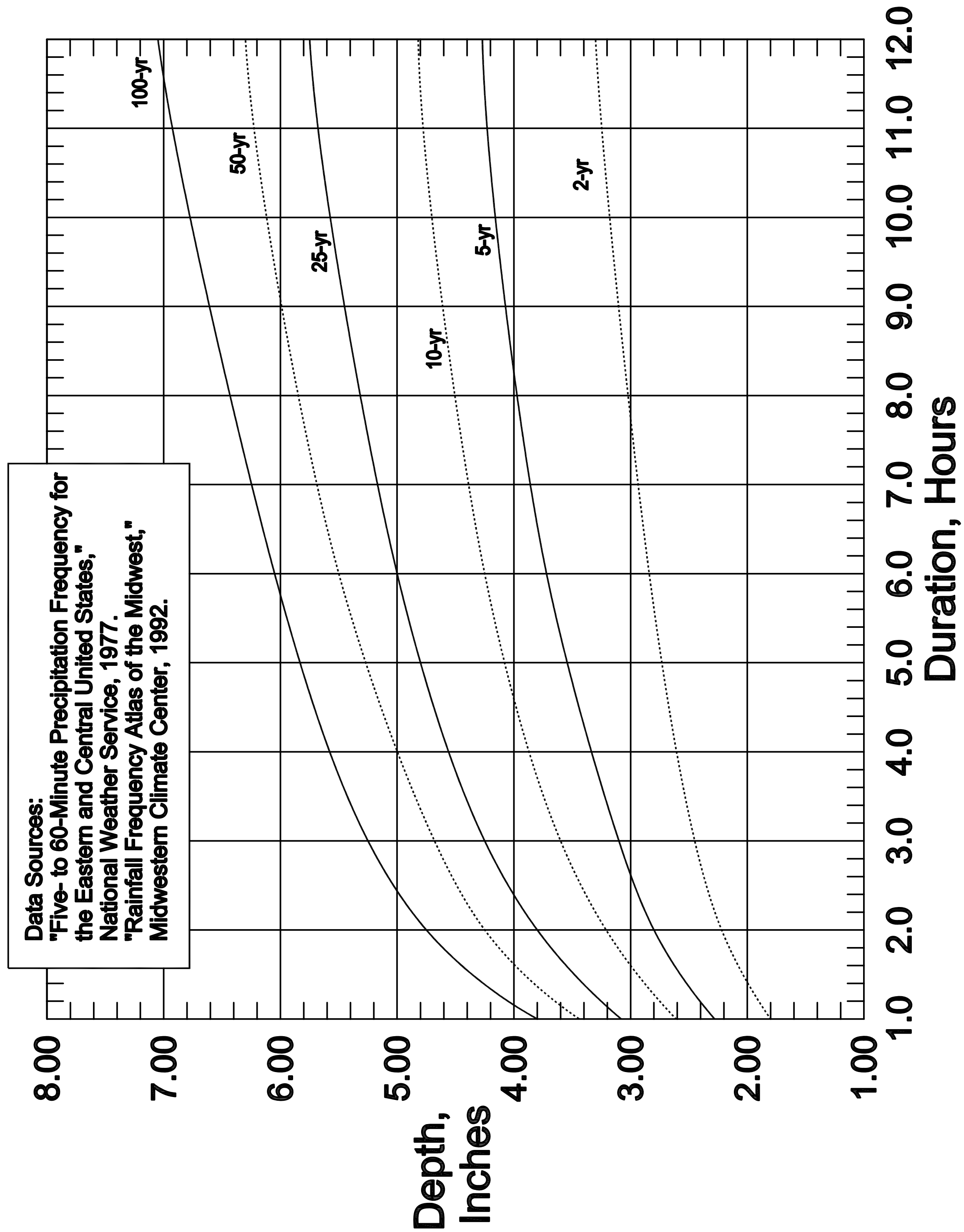

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

RAINFALL
DEPTH – DURATION – FREQUENCY
DURATION, 1 – 12 HOURS

FIGURE 104.2

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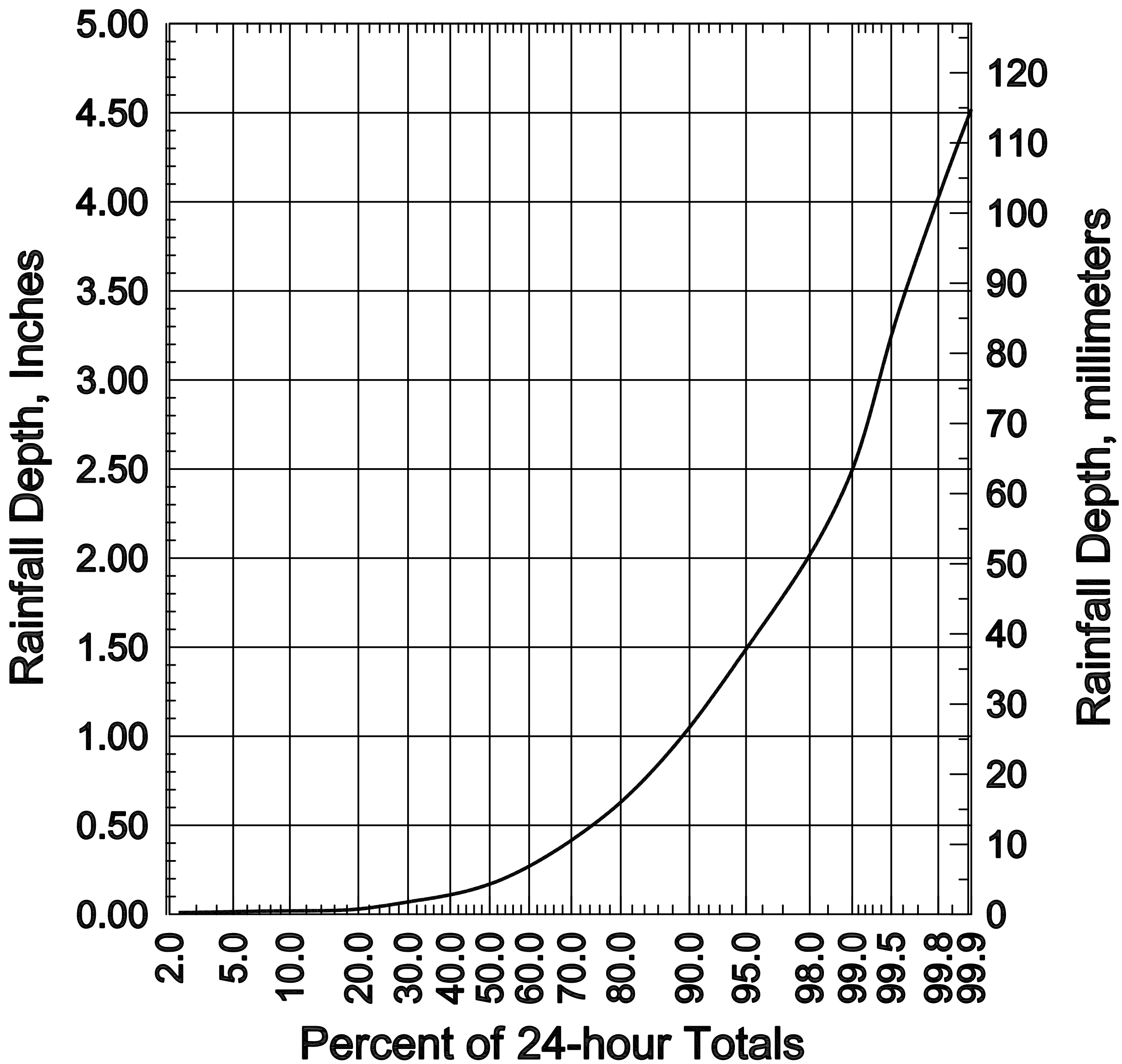

National Weather Service, Hourly Precipitation, Springfield, Missouri.
Period of record January 1958 - December 1994.

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

RAINFALL
RAINFALL DEPTH vs. PERCENT OF
24 – HOUR TOTALS

FIGURE 104.3

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Table 104.1

MONTHLY & ANNUAL
PRECIPITATION AND EVAPORATION DATA

Greene County, Missouri, Average Precipitation and Evaporation. Source: National Weather Climatological Data Annual Summary, Missouri 1995.

Month	Jan.	Feb.	Mar.	Apr.	May	June	July
Precipitation	1.79	2.17	3.89	4.18	4.38	5.09	2.92
Evaporation	0.30	0.50	2.80	4.30	5.00	6.00	6.80
Precipitation - Evaporation	1.49	1.67	1.09	- 0.12	- 0.62	- 0.91	- 3.88

Month	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Precipitation	3.51	4.62	3.58	3.75	3.16	43.04
Evaporation	6.20	4.00	3.00	2.70	0.40	42.00
Precipitation - Evaporation	- 2.69	0.62	0.58	1.05	2.76	1.04

file:m:\storm2\swregs\section 104 table 104.1

Table 104.2

RAINFALL DEPTH & DURATION DATA

Greene County, Missouri

Duration Minutes	Rainfall Intensity, Inches/Hour 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
5	5.40	6.48	7.23	8.40	9.30	10.20
6	5.19	6.21	6.99	8.08	8.82	9.82
7	4.99	5.98	6.70	7.78	8.60	9.46
8	4.80	5.75	6.46	7.50	8.30	9.10
9	4.60	5.54	6.22	7.22	8.01	8.78
10	4.42	5.34	6.00	6.97	7.71	8.46
11	4.29	5.16	5.79	6.71	7.44	8.16
12	4.13	4.98	5.58	6.48	7.18	7.88
13	4.00	4.81	5.40	6.27	6.94	7.62
14	3.88	4.78	5.24	6.08	6.83	7.40
15	3.75	4.53	5.10	5.91	6.55	7.20
16	3.66	4.42	4.98	5.78	6.41	7.03
17	3.56	4.31	4.86	5.65	6.27	6.89
18	3.48	4.21	4.75	5.53	6.13	6.75
19	3.40	4.13	4.66	5.42	6.02	6.62
20	3.32	4.04	4.56	5.32	5.91	6.51
25	3.00	3.78	4.17	4.89	5.44	5.99
30	2.72	3.38	3.84	4.52	5.03	5.56
35	2.51	3.13	3.57	4.20	4.70	5.18
40	2.32	2.91	3.32	3.92	4.39	4.84
45	2.16	2.71	3.11	3.68	4.11	4.54
50	2.01	2.52	2.91	3.44	3.85	4.26
55	1.88	2.39	2.74	3.23	3.62	4.02
60	1.80	2.28	2.61	3.08	3.44	3.80

Duration Minutes	Rainfall Depth, Inches 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
15	0.94	1.13	1.28	1.48	1.64	1.80
20	1.11	1.35	1.52	1.77	1.97	2.17
25	1.25	1.58	1.74	2.04	2.27	2.50
30	1.36	1.69	1.92	2.26	2.52	2.78
35	1.46	1.83	2.08	2.45	2.74	3.02
40	1.55	1.94	2.21	2.61	2.93	3.23
45	1.62	2.03	2.33	2.76	3.08	3.41
50	1.68	2.10	2.43	2.87	3.21	3.55
55	1.72	2.19	2.51	2.96	3.32	3.69

Duration Hours	Rainfall Depth, Inches 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
1	1.80	2.28	2.61	3.08	3.44	3.80
2	2.22	2.80	3.21	3.80	4.25	4.75
3	2.45	3.10	3.60	4.25	4.68	5.25
6	2.84	3.72	4.25	5.00	5.50	6.05
12	3.30	4.27	4.82	5.75	6.30	7.05
24	3.90	4.90	5.65	6.78	7.45	8.00
48	4.20	5.25	6.05	7.10	8.00	8.95
72	4.65	5.90	6.75	7.80	8.80	10.00
120	5.25	6.50	7.50	8.60	9.65	11.00
240	6.70	8.10	9.20	10.50	11.65	12.80

Source: "Five-to 60-Minute Precipitation Frequency for the Eastern and Central United States", National Weather Service, 1977. "Rainfall Frequency Atlas of the Midwest", Midwestern Climate Center, 1992.

TABLE 104.3

RUNOFF COEFFICIENTS FOR USE IN THE RATIONAL FORMULA

Surface Type	Runoff Coefficient	Notes
Asphalt, concrete pavement	0.95	(1,3)
Roofs	0.95	(1,3)
Gravel	0.70	(2,3)
Lawns, pasture, hayfields		
Flat (<2% slopes)	0.15	(1,3)
Average (2-7% slopes)	0.20	(1,3)
Steep (>7% slopes)	0.30	(1,3)
Woods	0.10	(2,3)

COMPOSITE RUNOFF COEFFICIENTS FOR SINGLE FAMILY RESIDENTIAL AREAS
(using recommended values for runoff coefficients and estimates of impervious area given in this table)

	Terrain		
	Flat	Average	Steep
Avg. Lot size, 1/4 acre	0.45	0.49	0.55
Avg. Lot size, 1/3 acre	0.40	0.43	0.50
Avg. Lot size, ½ acre	0.35	0.40	0.46
Avg. Lot size, 1 acre	0.25	0.30	0.38
Avg. Lot size, 3 acres	0.20	0.24	0.33

IMPERVIOUS COVERAGE FOR TYPICAL DEVELOPMENTS
FOR USE IN COMPUTING COMPOSITE RUNOFF COEFFICIENTS

Type of Development	Zoning District	% Impervious Cover
Single FamilyResidential		
Avg. Lot size, 1/4 acre	R1	38 (Note 5)
Avg. Lot size, 1/3 acre	R1	30 (Note 5)
Avg. Lot size, 1/2 acre	R1	25 (Note 5)
Avg. Lot size, 1 acre	R1	13
Avg. Lot size, 3 acres	A-R	5
Duplex, patio homes	R2	(Note 6)
Multifamily	R3	(Note 7)
Office	O1, O2	(Note 7)
Commercial	C1, C2	70 (Note 8)
Commercial	C3	60 (Note 8)
Industrial, Manufacturing	M1, M2	(Note 7)

(***NOTES FOR TABLE 104.3 ON NEXT PAGE***)

NOTES FOR TABLE 104.3:

Greene County Design Standards - Adopted April 5, 1999
SECTION 104 - STORMWATER RUNOFF COMPUTATIONS
Table 104.3 - Runoff Coefficients For Use In The Rational Formula

(1) From ASCE Manual of Practice, Table 5.5, p. 91. (Reference 104.13)
(2) From Ritter & Paquette, Highway Engineering, as referenced in The Rational Method Revisited, by Ronald L. Rosmiller, Poceedings of the International Symposium on Urban Runoff, University of Kentucky, Lexington, KY, June 28-31, 1980.
(3) Each of the above references suggests a range of values for each type of cover. The values given in this table reflect prevailing local practice.
(4) The ASCE manual of practice (Reference 104.13) notes that the normal range of runoff coefficients given in the manual are typical for return periods of 2 to 10 years. Because infiltration and other losses have a proportionately less effect, higher values are recommended for storms with larger return periods. Debo and Reese recommend increasing runoff coefficients by 10% for a 25-year return period and 25% for a 100-year return period (maximum value of 1.0). (Reference 104.14)
(5) Values from SCS TR-55 Table 2-2a. (Reference 104.5)
(6) Typical value used locally.
(7) % impervious area should be determined on a case by case basis from the site plan.
(8) Maximum impervious area coverage permitted by the Zoning Code for this district.

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TABLE 104.4

HYDROLOGIC SOIL GROUPS FOR GREENE COUNTY SOILS

MAP SYMBOL	NAME	HYDROLOGIC GROUP
1B	Newtonia silt loam	B
2B	Pembroke silt loam	B
3D	Eldon cherty silt loam	B
5C	Wilderness cherty silt loam	C
6B	Creldon silt loam	C
9B	Needleye silte loam	C
10	Bado silt loam	D
11B	Sampsel silty clay loam	D
16B	Barco fine sandy loam	B
21B	Peridge silt loam	B
23B	Bolivar fine sandy loam	B
24	Parsons silt loam	D
26D	Collinsville fine sandy loam	D
27D	Basehor stony fine sandy loam	D
30C	Keeno cherty silt loam	C
32C	Freeburg & Alsup silt loams	C
33B	Keeno & Eldon cherty silt loams	60%C/40%B*
35D	Clarksville-Nixa cherty silt Loam	75%B/25%C*
40E	Alsup very stony silt loam	C
43D	Goss cherty silt loam	B
44E	Goss-Gasconade complex	80%B/20%D*
45E	Clarksville cherty silt loam	B
50C	Nixa cherty silt loam	C
53B	Wilderness & Goss cherty silt loam	60%C/40%B*

(***Table 104.4 Continued Next Page***)

TABLE 104.4 *continued*

MAP SYMBOL	NAME	HYDROLOGIC GROUP
54	Lanton silt loam	D
55	Huntington silt loam	B
56	Osage silty clay loam	D
61B	Hoberg silt loam	C
76	Hepler silt loam	C
81B	Viraton silt loam	C
83D	Gasconade-rock outcrop complex	D
94	Cedargap cherty silt loam	B
95	Cedargap silt loam	B
240	Gerald silt loam	D
241B	Parsons & Sampsel silt loams	D
245	Carytown silt loam	D
921	Secesh-Cedargap silt loams	B
931	Waben-Cedargap silt loams	B

* Based on relative percent of each soil given in the Soil Survey.

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TABLE 104.5

Pilgrim-Cordery Method
Cumulative Depth vs. Duration Data

Cumulative Fraction of Storm Duration	Cumulative Fraction of Depth				
	1-Hour	2-Hour	3-Hour	4-Hour	6-Hour
.00	.00	.00	.00	.00	.00
.05	.03	.03	.03	.02	.05
.10	.07	.05	.05	.03	.09
.15	.11	.10	.06	.05	.14
.20	.14	.17	.09	.06	.20
.25	.17	.22	.11	.08	.28
.30	.23	.25	.13	.14	.35
.35	.29	.27	.19	.20	.41
.40	.35	.29	.31	.27	.43
.45	.41	.30	.39	.33	.46
.50	.47	.31	.44	.38	.49
.55	.56	.41	.47	.47	.60
.60	.65	.51	.54	.56	.70
.65	.73	.60	.64	.64	.80
.70	.82	.69	.70	.74	.86
.75	.91	.78	.73	.83	.89
.80	.93	.82	.81	.87	.93
.85	.95	.87	.89	.90	.96
.90	.97	.92	.94	.93	.97
.95	.99	.96	.98	.97	.98
1.00	1.00	1.00	1.00	1.00	1.00