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**Soil
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Service**

**Engineering
Division**

Technical
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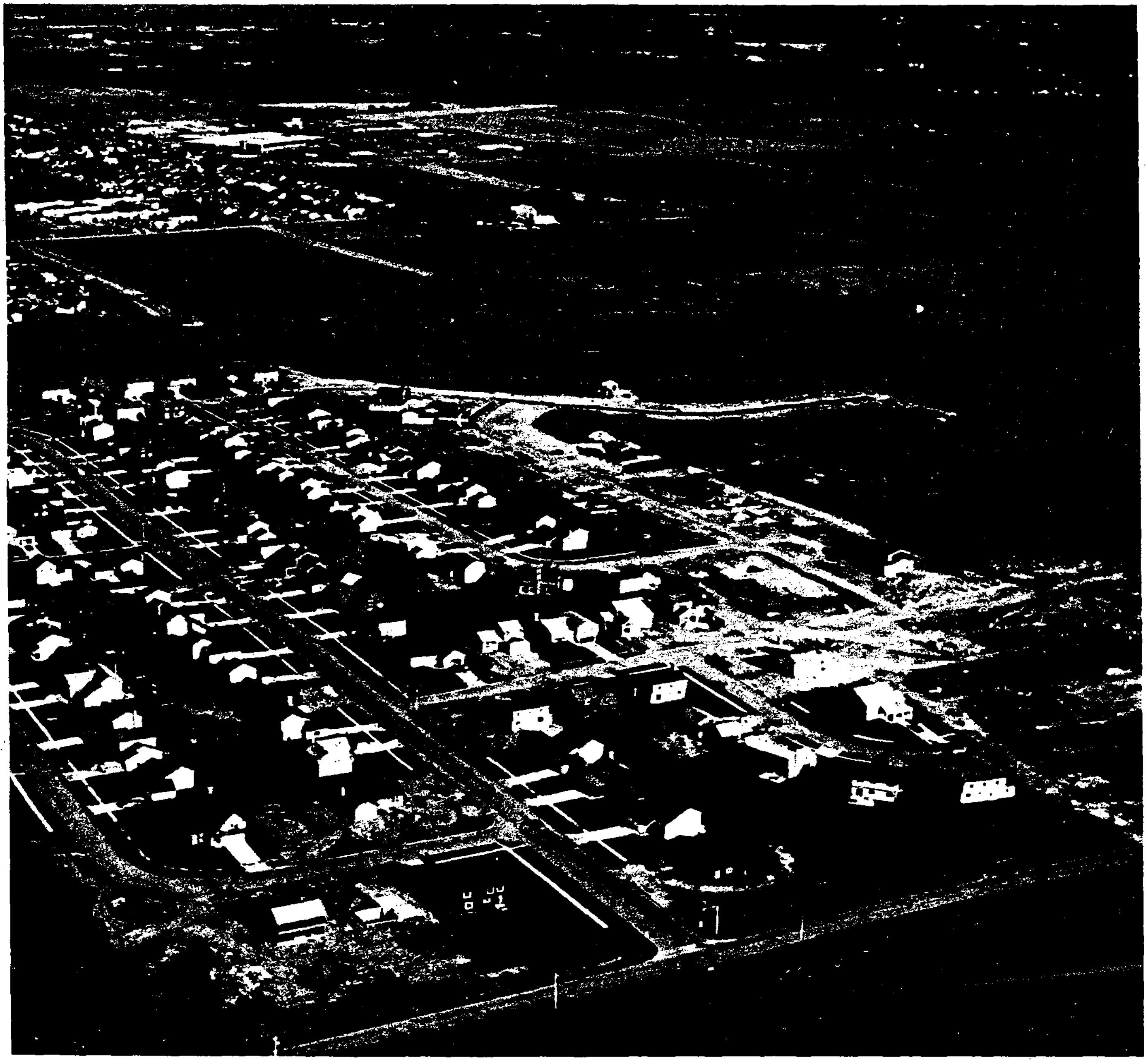
June 1986

Urban Hydrology for Small Watersheds



Preface

Technical Release 55 (TR-55) presents simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for floodwater reservoirs. These procedures are applicable in small watersheds, especially urbanizing watersheds, in the United States. First issued by the Soil Conservation Service (SCS) in January 1975, TR-55 incorporates current SCS procedures. This revision includes results of recent research and other changes based on experience with use of the original edition.

The major revisions and additions are—

1. A flow chart for selecting the appropriate procedure;
2. Three additional rain distributions;
3. Expansion of the chapter on runoff curve numbers;
4. A procedure for calculating travel times of sheet flow;
5. Deletion of a chapter on peak discharges;
6. Modifications to the Graphical Peak Discharge method and Tabular Hydrograph method;
7. A new storage routing procedure;
8. Features of the TR-55 computer program; and
9. Worksheets.

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Contents

Figures

Tables

Exhibits

Worksheets

Metric conversions

The English system of units is used in this TR. To convert to the International System of units (metric), use the following factors:

From English unit	To metric unit	Multiply by
Acre	Hectare	0.405
Square mile	Square kilometer	2.59
Cubic feet per second	Cubic meters per second	0.0283
Inch	Millimeter	25.4
Feet per second	Meters per second	0.3048
Acre-foot	Cubic meter	1233.489
Cubic foot	Cubic meter	0.0283

Perform rounding operations as appropriate to indicate the same level of precision as that of the original measurement. For example:

1. A stream discharge is recorded in cubic feet per second with three significant digits.
2. Convert stream discharge to cubic meters per second by multiplying by 0.0283.
3. Round to enough significant digits so that, when converting back to cubic feet per second, you obtain the original value (step 1) with three significant digits.

Definitions of symbols

Symbol	Unit	Definition
a	ft^2	Cross sectional flow area
A_m	mi^2	Drainage area
CN		Runoff curve number
CN_c		Composite runoff curve number
CN_p		Pervious runoff curve number
E_{max}		Maximum stage
F_p		Pond and swamp adjustment factor
H_w	ft	Head over weir crest
I_a	in	Initial abstraction
L	ft	Flow length
L_w	ft	Weir crest length
m		Number of flow segments
n		Manning's roughness coefficient
P	in	Rainfall
P_{imp}		Percent imperviousness
P_2	in	Two-year frequency, 24-hour rainfall
p_w	ft	Wetted perimeter
q	cfs	Hydrograph coordinate
q_i	cfs	Peak inflow discharge
q_o	cfs	Peak outflow discharge
q_p	cfs	Peak discharge
q_t	csm/in	Tabular hydrograph unit discharge
q_u	csm/in	Unit peak discharge
Q	in	Runoff
r	ft	Hydraulic radius
R		Ratio of unconnected impervious area to total impervious area
s	ft/ft	Slope of hydraulic grade line
S	in	Potential maximum retention after runoff begins
t	hr	Hydrograph time
T_c	hr	Time of concentration
T_p	hr	Time to peak
T_t	hr	Travel time
V	ft/s	Average velocity
V_r	acre-ft, ft^3, or watershed-inch	Runoff volume
V_s	acre-ft, ft^3, or watershed-inch	Storage volume

Chapter 1: Introduction

The conversion of rural land to urban land usually increases erosion and the discharge and volume of storm runoff in a watershed. It also causes other problems that affect soil and water. As part of programs established to alleviate these problems, engineers increasingly must assess the probable effects of urban development, as well as design and implement measures that will minimize its adverse effects.

Technical Release 55 (TR-55) presents simplified procedures for estimating runoff and peak discharges in small watersheds. In selecting the appropriate procedure, consider the scope and complexity of the problem, the available data, and the acceptable level of error. While this TR gives special emphasis to urban and urbanizing watersheds, the procedures apply to any small watershed in which certain limitations are met.

Effects of urban development

An urban or urbanizing watershed is one in which impervious surfaces cover or will soon cover a considerable area. Impervious surfaces include roads, sidewalks, parking lots, and buildings. Natural flow paths in the watershed may be replaced or supplemented by paved gutters, storm sewers, or other elements of artificial drainage.

Hydrologic studies to determine runoff and peak discharge should ideally be based on long-term stationary streamflow records for the area. Such records are seldom available for small drainage areas. Even where they are available, accurate statistical analysis of them is usually impossible because of the conversion of land to urban uses during the period of record. It therefore is necessary to estimate peak discharges with hydrologic models based on measurable watershed characteristics. Only through an understanding of these characteristics and experience in using these models can we make sound judgments on how to alter model parameters to reflect changing watershed conditions.

Urbanization changes a watershed's response to precipitation. The most common effects are reduced infiltration and decreased travel time, which significantly increase peak discharges and runoff. Runoff is determined primarily by the amount of precipitation and by infiltration characteristics related to soil type, soil moisture, antecedent rainfall, cover type, impervious surfaces, and surface retention. Travel time is determined primarily by slope, length of flow path, depth of flow, and roughness of flow surfaces. Peak discharges are based on the relationship of these parameters and on the total drainage area of the watershed, the location of the development, the effect of any flood control works or other natural or manmade storage, and the time distribution of rainfall during a given storm event.

The model described in TR-55 begins with a rainfall amount uniformly imposed on the watershed over a specified time distribution. Mass rainfall is converted to mass runoff by using a runoff curve number (CN). CN is based on soils, plant cover, amount of impervious areas, interception, and surface storage. Runoff is then transformed into a hydrograph by using unit hydrograph theory and routing procedures that depend on runoff travel time through segments of the watershed.

For a description of the hydrograph development method used by SCS, see chapter 16 of the SCS National Engineering Handbook, Section 4—Hydrology (NEH-4) (SCS 1985). The routing method (Modified Att-Kin) is explained in appendixes G and H of draft Technical Release 20 (TR-20) (SCS 1983).

Rainfall

TR-55 includes four regional rainfall time distributions. See appendix B for a discussion of how these distributions were developed.

All four distributions are for a 24-hour period. This period was chosen because of the general availability of daily rainfall data that were used to estimate 24-hour rainfall amounts. The 24-hour duration spans most of the applications of TR-55.

One critical parameter in the model is time of concentration (T_c), which is the time it takes for runoff to travel to a point of interest from the hydraulically most distant point. Normally a rainfall duration equal to or greater than T_c is used. Therefore, the rainfall distributions were designed to contain the intensity of any duration of rainfall for the frequency of the event chosen. That is, if the 10-year frequency, 24-hour rainfall is used, the most intense hour will approximate the 10-year, 1-hour rainfall volume.

Runoff

To estimate runoff from storm rainfall, SCS uses the Runoff Curve Number (CN) method (see chapters 4 through 10 of NEH-4, SCS 1985). Determination of CN depends on the watershed's soil and cover conditions, which the model represents as hydrologic soil group, cover type, treatment, and hydrologic condition. Chapter 2 of this TR discusses the effect of urban development on CN and explains how to use CN to estimate runoff.

Time parameters

Chapter 3 describes a method for estimating the parameters used to distribute the runoff into a hydrograph. The method is based on velocities of flow through segments of the watershed. Two major parameters are time of concentration (T_c) and travel time of flow through the segments (T_t). These and the other parameters used are the same as those used in accepted hydraulic analyses of open channels.

Many methods are empirically derived from actual runoff hydrographs and watershed characteristics. The method in chapter 3 was chosen because it is basic; however, other methods may be used.

Peak discharge and hydrographs

Chapter 4 describes a method for approximating peak rates of discharge, and chapter 5 describes a method for obtaining or routing hydrographs. Both methods were derived from hydrographs prepared by procedures outlined in chapter 16 of NEH-4 (SCS 1985). The computations were made with a computerized SCS hydrologic model, TR-20 (SCS 1983).

The methods in chapters 4 and 5 should be used in accordance with specific guidelines. If basic data are improperly prepared or adjustments not properly used, errors will result.

Storage effects

Chapter 6 outlines procedures to account for the effect of detention-type storage. It provides a shortcut method to estimate temporary flood storage based on hydrologic data developed from the Graphical Peak Discharge or Tabular Hydrograph methods.

By increasing runoff and decreasing travel times, urbanization can be expected to increase downstream peak discharges. Chapter 6 discusses how flood detention can modify the hydrograph so that, ideally, downstream peak discharge is reduced approximately to the predevelopment condition. The shortcuts in chapter 6 are useful in sizing a basin even though the final design may require a more detailed analysis.

Selecting the appropriate procedures

Figure 1-1 is a flow chart that shows how to select the appropriate procedures to use in TR-55. In the figure, the diamond-shaped box labeled "Subareas required?" directs the user to the appropriate method based on whether the watershed needs to be divided into subareas. Watershed subdivision is required when significantly different conditions affecting runoff or timing are present in the watershed—for example, if the watershed has widely differing curve numbers or nonhomogeneous slope patterns.

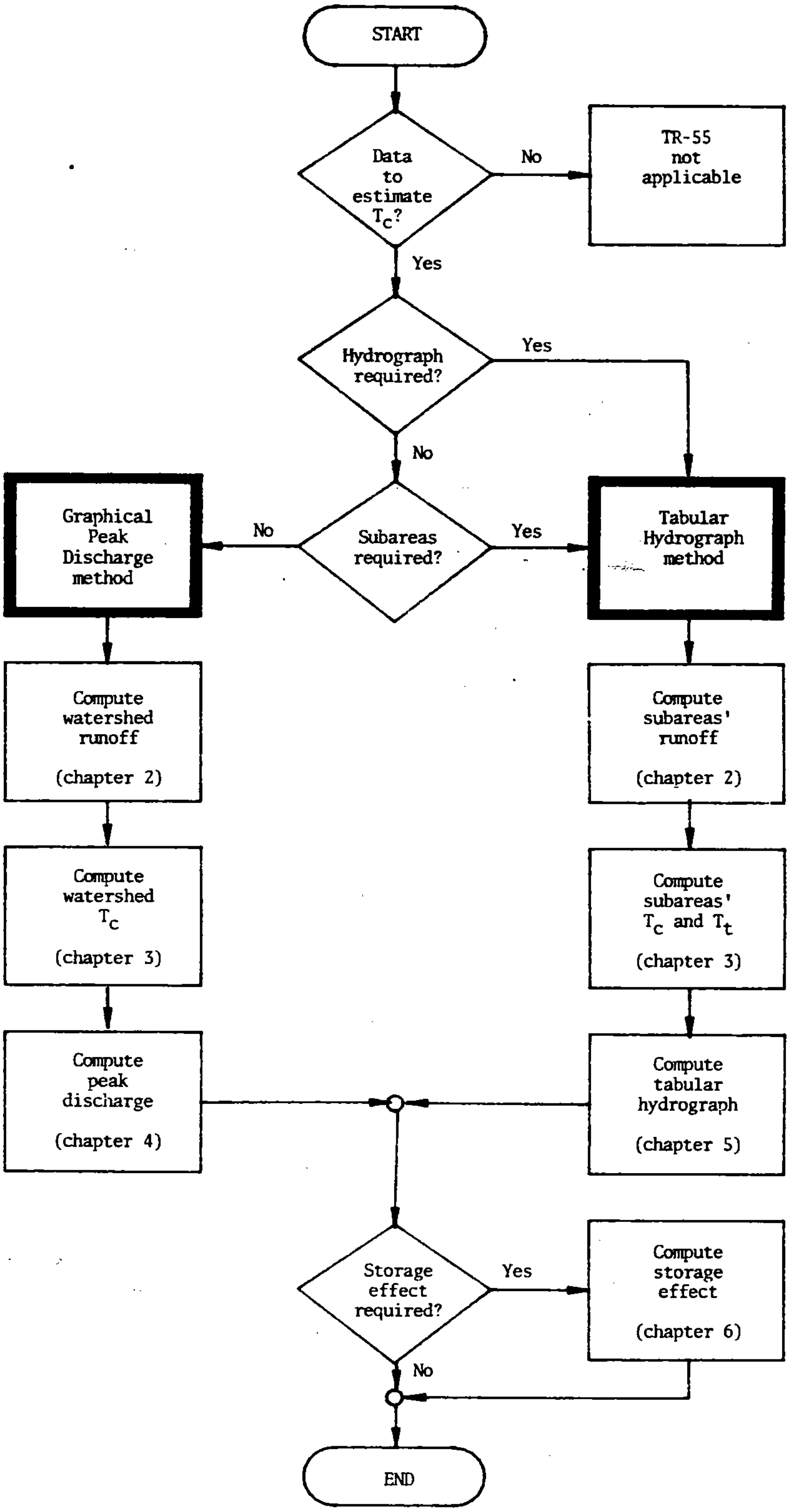

Figure 1-1.—Flow chart for selecting the appropriate procedures in TR-55.

Limitations

To save time, the procedures in TR-55 are simplified by assumptions about some parameters. These simplifications, however, limit the use of the procedures and can provide results that are less accurate than more detailed methods. The user should examine the sensitivity of the analysis being conducted to a variation of the peak discharge or hydrograph. To ensure that the degree of error is tolerable, specific limitations are given in chapters 2 through 6. Additional general constraints to the use of TR-55 are as follows:

- The methods in this TR are based on open and unconfined flow over land or in channels. For large events during which flow is divided between sewer and overland flow, more information about hydraulics than is presented here is needed to determine T_c. After flow enters a closed system, the discharge can be assumed constant until another flow is encountered at a junction or another inlet.

- Both the Graphical Peak Discharge and Tabular Hydrograph methods are derived from TR-20 (SCS 1983) output. Their accuracy is comparable; they differ only in their products. The use of T_c permits them to be used for any size watershed within the scope of the curves or tables. The Graphical method (chapter 4) is used only for hydrologically homogeneous watersheds because the procedure is limited to a single watershed subarea. The Tabular method (chapter 5) can be used for a heterogeneous watershed that is divided into a number of homogeneous subwatersheds. Hydrographs for the subwatersheds can be routed and added.

- The approximate storage-routing curves (chapter 6) should not be used if the adjustment for ponding (chapter 4) is used. These storage-routing curves, like the peak discharge and hydrograph procedures, are generalizations derived from TR-20 routings.

Chapter 2: Estimating runoff

SCS Runoff Curve Number method

The SCS Runoff Curve Number (CN) method is described in detail in NEH-4 (SCS 1985). The SCS runoff equation is

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad \text{[Eq. 2-1]}$$

where

Q = runoff (in),
P = rainfall (in),
S = potential maximum retention after runoff begins (in), and
I_a = initial abstraction (in).

Initial abstraction (I_a) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. I_a is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation:

$$I_a = 0.2S. \qquad \text{[Eq. 2-2]}$$

By removing I_a as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation 2-2 into equation 2-1 gives

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}. \qquad \text{[Eq. 2-3]}$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by

$$S = \frac{1000}{CN} - 10. \qquad \text{[Eq. 2-4]}$$

Figure 2-1 and table 2-1 solve equations 2-3 and 2-4 for a range of CN's and rainfall.

Factors considered in determining runoff curve numbers

The major factors that determine CN are the hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected). Figure 2-2 is provided to aid in selecting the appropriate figure or table for determining curve numbers.

CN's in table 2-2 (*a* to *d*) represent average antecedent runoff condition for urban, cultivated agricultural, other agricultural, and arid and semiarid rangeland uses. Table 2-2 assumes impervious areas are directly connected. The following sections explain how to determine CN's and how to modify them for urban conditions.

Hydrologic soil groups

Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four HSG's (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. Appendix A defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of interest may be identified from a soil survey report, which can be obtained from local SCS offices or soil and water conservation district offices.

Most urban areas are only partially covered by impervious surfaces: the soil remains an important factor in runoff estimates. Urbanization has a greater effect on runoff in watersheds with soils having high infiltration rates (sands and gravels) than in watersheds predominantly of silts and clays, which generally have low infiltration rates.

Any disturbance of a soil profile can significantly change its infiltration characteristics. With urbanization, native soil profiles may be mixed or removed or fill material from other areas may be introduced. Therefore, a method based on soil

Solution for runoff equation

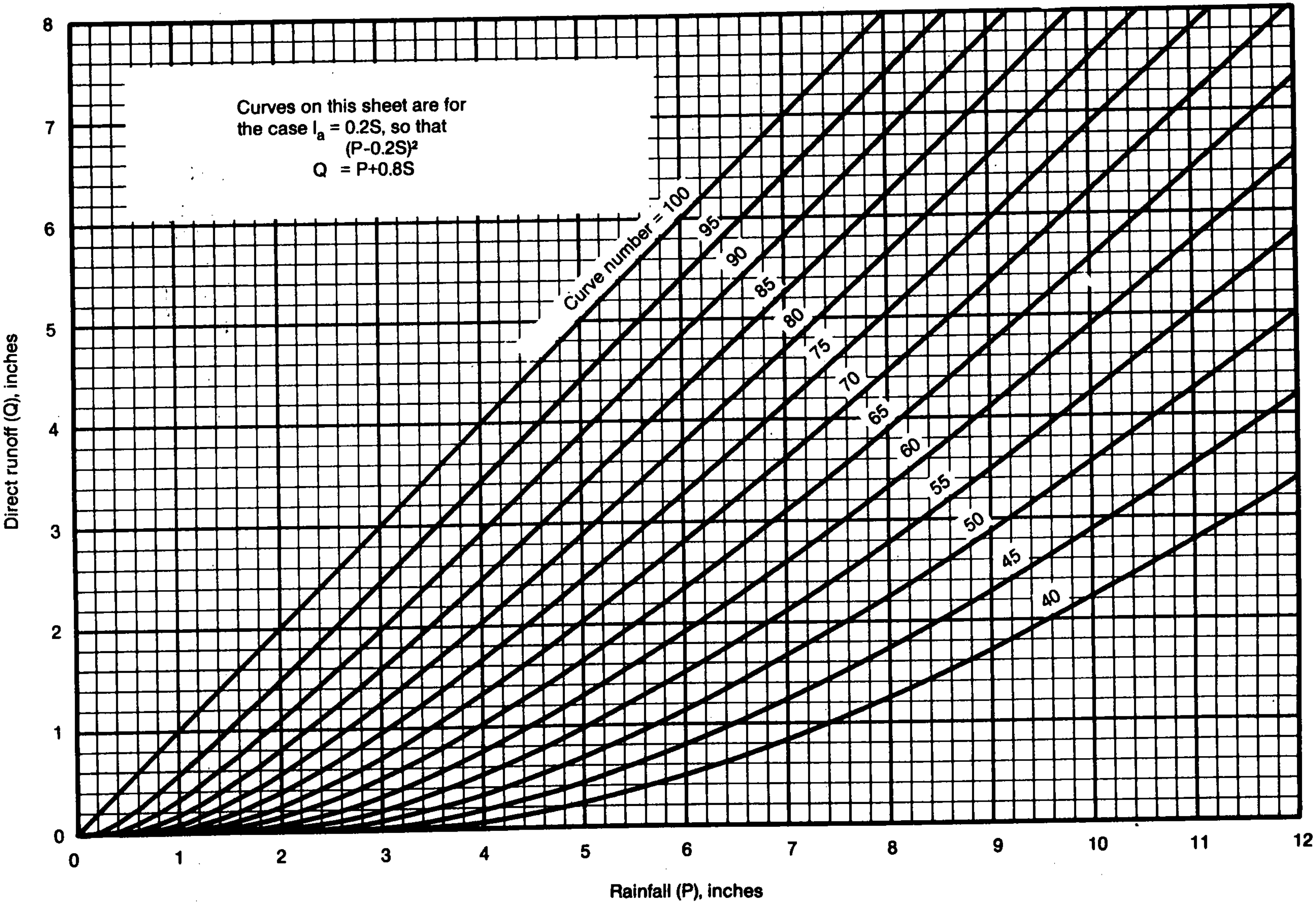

Figure 2-1.—Solution of runoff equation.

texture is given in appendix A for determining the HSG classification for disturbed soils.

Cover type

Table 2-2 addresses most cover types, such as vegetation, bare soil, and impervious surfaces. There are a number of methods for determining cover type. The most common are field reconnaissance, aerial photographs, and land use maps.

Treatment

Treatment is a cover type modifier (used only in table 2-2b) to describe the management of cultivated agricultural lands. It includes mechanical practices, such as contouring and terracing, and management practices, such as crop rotations and reduced or no tillage.

Hydrologic condition

Hydrologic condition indicates the effects of cover type and treatment on infiltration and runoff and is generally estimated from density of plant and residue cover on sample areas. *Good* hydrologic condition indicates that the soil usually has a low runoff potential for that specific hydrologic soil group, cover type, and treatment. Some factors to consider in estimating the effect of cover on infiltration and runoff are (a) canopy or density of lawns, crops, or other vegetative areas; (b) amount of year-round cover; (c) amount of grass or close-seeded legumes in rotations; (d) percent of residue cover; and (e) degree of surface roughness.

Table 2-1.—Runoff depth for selected CN's and rainfall amounts[1]

	Runoff depth for curve number of—												
Rainfall	40	45	50	55	60	65	70	75	80	85	90	95	98
	inches												
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.17	0.32	0.56	0.79
1.2	.00	.00	.00	.00	.00	.00	.03	.07	.15	.27	.46	.74	.99
1.4	.00	.00	.00	.00	.00	.02	.06	.13	.24	.39	.61	.92	1.18
1.6	.00	.00	.00	.00	.01	.05	.11	.20	.34	.52	.76	1.11	1.38
1.8	.00	.00	.00	.00	.03	.09	.17	.29	.44	.65	.93	1.29	1.58
2.0	.00	.00	.00	.02	.06	.14	.24	.38	.56	.80	1.09	1.48	1.77
2.5	.00	.00	.02	.08	.17	.30	.46	.65	.89	1.18	1.53	1.96	2.27
3.0	.00	.02	.09	.19	.33	.51	.71	.96	1.25	1.59	1.98	2.45	2.77
3.5	.02	.08	.20	.35	.53	.75	1.01	1.30	1.64	2.02	2.45	2.94	3.27
4.0	.06	.18	.33	.53	.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
4.5	.14	.30	.50	.74	1.02	1.33	1.67	2.05	2.46	2.91	3.40	3.92	4.26
5.0	.24	.44	.69	.98	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	.50	.80	1.14	1.52	1.92	2.35	2.81	3.28	3.78	4.30	4.85	5.41	5.76
7.0	.84	1.24	1.68	2.12	2.60	3.10	3.62	4.15	4.69	5.25	5.82	6.41	6.76
8.0	1.25	1.74	2.25	2.78	3.33	3.89	4.46	5.04	5.63	6.21	6.81	7.40	7.76
9.0	1.71	2.29	2.88	3.49	4.10	4.72	5.33	5.95	6.57	7.18	7.79	8.40	8.76
10.0	2.23	2.89	3.56	4.23	4.90	5.56	6.22	6.88	7.52	8.16	8.78	9.40	9.76
11.0	2.78	3.52	4.26	5.00	5.72	6.43	7.13	7.81	8.48	9.13	9.77	10.39	10.76
12.0	3.38	4.19	5.00	5.79	6.56	7.32	8.05	8.76	9.45	10.11	10.76	11.39	11.76
13.0	4.00	4.89	5.76	6.61	7.42	8.21	8.98	9.71	10.42	11.10	11.76	12.39	12.76
14.0	4.65	5.62	6.55	7.44	8.30	9.12	9.91	10.67	11.39	12.08	12.75	13.39	13.76
15.0	5.33	6.36	7.35	8.29	9.19	10.04	10.85	11.63	12.37	13.07	13.74	14.39	14.76

[1] Interpolate the values shown to obtain runoff depths for CN's or rainfall amounts not shown.

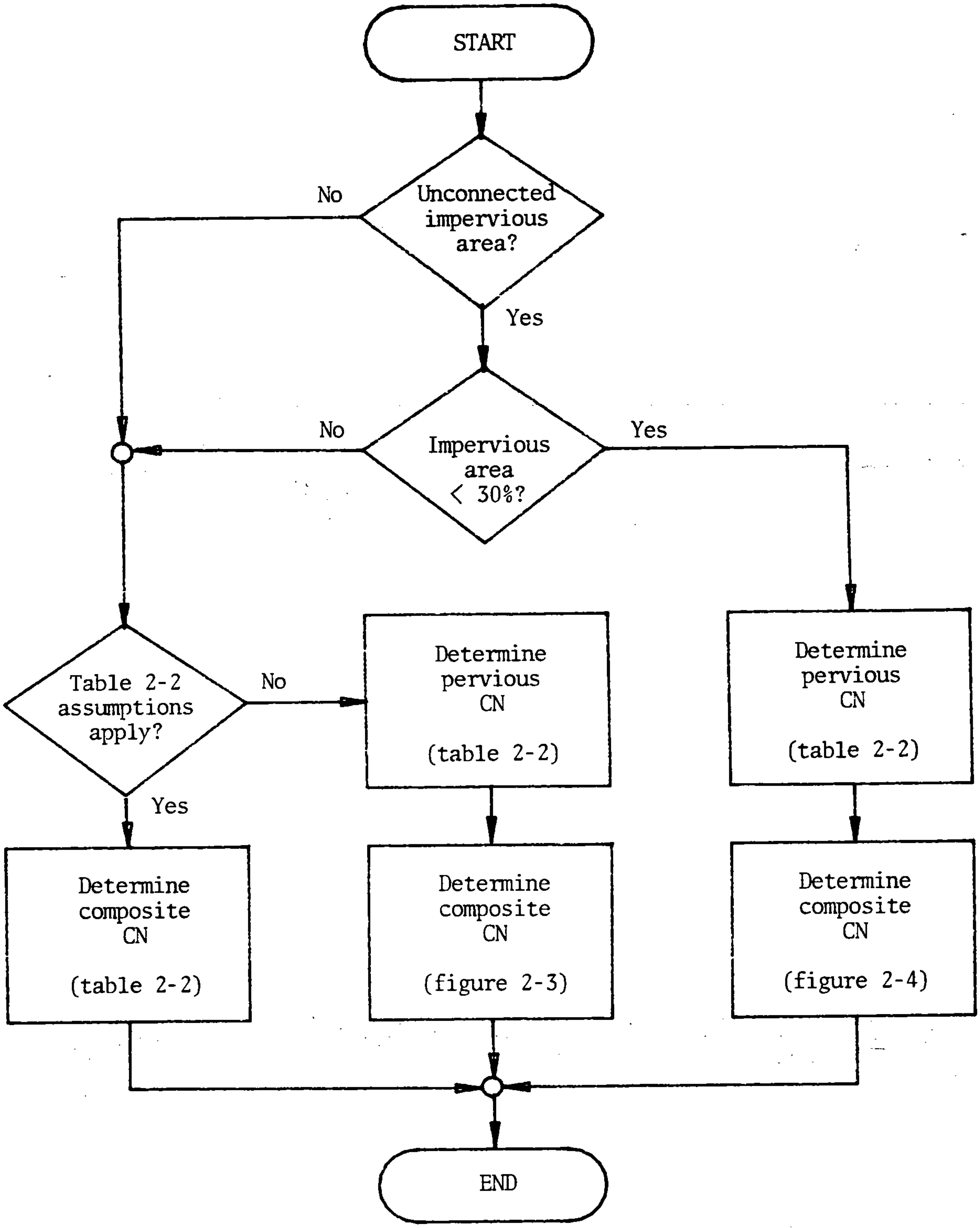

Figure 2-2.—Flow chart for selecting the appropriate figure or table for determining runoff curve numbers.

Table 2-2a.—Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

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[1] Average runoff condition, and $I_a = 0.2S$.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b.—Runoff curve numbers for cultivated agricultural lands[1]

Cover description			Curve numbers for hydrologic soil group—			
Cover type	Treatment[2]	Hydrologic condition[3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1] Average runoff condition, and $I_a = 0.2S$.

[2] *Crop residue cover* applies only if residue is on at least 5% of the surface throughout the year.

[3] Hydrologic condition is based on combination of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes in rotations, (d) percent of residue cover on the land surface (good ⩾ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c.—Runoff curve numbers for other agricultural lands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing.[2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element.[3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	[4]30	48	65	73
Woods—grass combination (orchard or tree farm).[5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	[4]30	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

[1] Average runoff condition, and $I_a = 0.2S$.

[2] *Poor:* <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: >75% ground cover and lightly or only occasionally grazed.

[3] *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

[4] Actual curve number is less than 30; use CN = 30 for runoff computations.

[5] CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6] *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2d.—Runoff curve numbers for arid and semiarid rangelands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition[2]	A[3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

[1] Average runoff condition, and $I_a = 0.2S$. For range in humid regions, use table 2-2c.

[2] *Poor:* <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: >70% ground cover.

[3] Curve numbers for group A have been developed only for desert shrub.

Antecedent runoff condition

The index of runoff potential before a storm event is the antecedent runoff condition (ARC). ARC is an attempt to account for the variation in CN at a site from storm to storm. CN for the average ARC at a site is the median value as taken from sample rainfall and runoff data. The CN's in table 2-2 are for the average ARC, which is used primarily for design applications. See NEH-4 (SCS 1985) and Rallison and Miller (1981) for more detailed discussion of storm-to-storm variation and a demonstration of upper and lower enveloping curves.

Urban impervious area modifications

Several factors, such as the percentage of impervious area and the means of conveying runoff from impervious areas to the drainage system, should be considered in computing CN for urban areas (Rawls et al., 1981). For example, do the impervious areas connect directly to the drainage system, or do they outlet onto lawns or other pervious areas where infiltration can occur?

Connected impervious areas

An impervious area is considered connected if runoff from it flows directly into the drainage system. It is also considered connected if runoff from it occurs as concentrated shallow flow that runs over a pervious area and then into a drainage system.

Urban CN's (table 2-2a) were developed for typical land use relationships based on specific assumed percentages of impervious area. These CN values were developed on the assumptions that (a) pervious urban areas are equivalent to pasture in good hydrologic condition and (b) impervious areas have a CN of 98 and are directly connected to the drainage system. Some assumed percentages of impervious area are shown in table 2-2a.

If all of the impervious area is directly connected to the drainage system, but the impervious area percentages or the pervious land use assumptions in table 2-2a are not applicable, use figure 2-3 to compute a composite CN. For example, table 2-2a gives a CN of 70 for a ½-acre lot in HSG B, with an assumed impervious area of 25 percent. However, if the lot has 20 percent impervious area and a pervious area CN of 61, the composite CN obtained from figure 2-3 is 68. The CN difference between 70 and 68 reflects the difference in percent impervious area.

Unconnected impervious areas

Runoff from these areas is spread over a pervious area as sheet flow. To determine CN when all or part of the impervious area is not directly connected to the drainage system, (1) use figure 2-4 if total impervious area is less than 30 percent or (2) use figure 2-3 if the total impervious area is equal to or greater than 30 percent, because the absorptive capacity of the remaining pervious areas will not significantly affect runoff.

When impervious area is less than 30 percent, obtain the composite CN by entering the right half of figure 2-4 with the percentage of total impervious area and the ratio of total unconnected impervious area to total impervious area. Then move left to the appropriate pervious CN and read down to find the composite CN. For example, for a ½-acre lot with 20 percent total impervious area (75 percent of which is unconnected) and pervious CN of 61, the composite CN from figure 2-4 is 66. If all of the impervious area is connected, the resulting CN (from figure 2-3) would be 68.

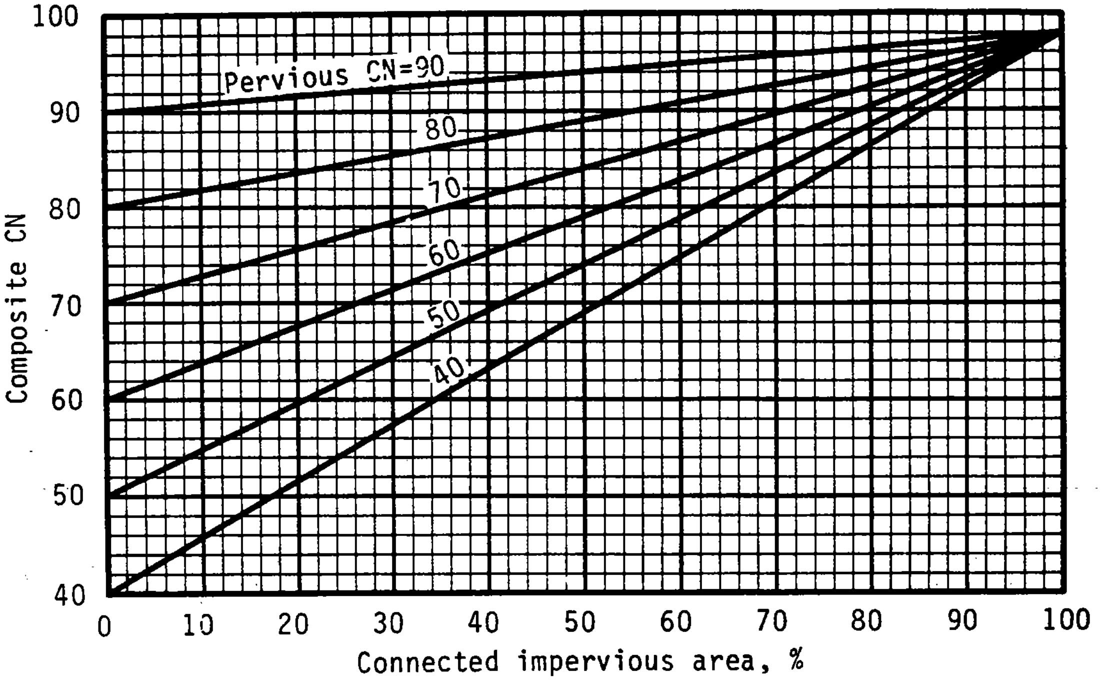


Figure 2-3.—Composite CN with connected impervious area.

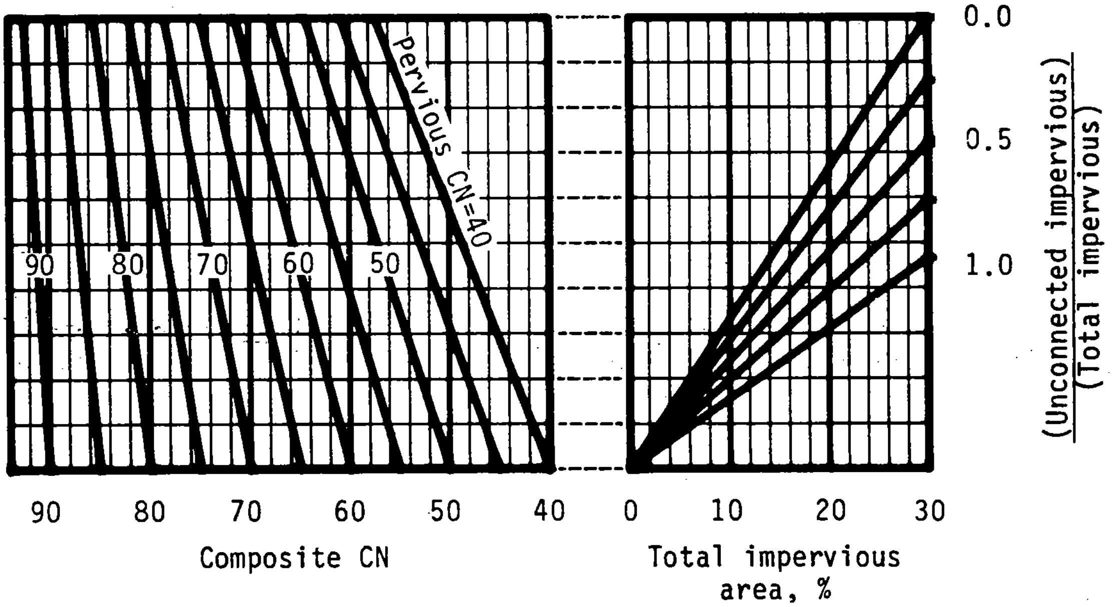


Figure 2-4.—Composite CN with unconnected impervious areas and total impervious area less than 30%.

Runoff

When CN and the amount of rainfall have been determined for the watershed, determine runoff by using figure 2-1, table 2-1, or equations 2-3 and 2-4. The runoff is usually rounded to the nearest hundredth of an inch.

Limitations

- Curve numbers describe average conditions that are useful for design purposes. If the rainfall event used is a historical storm, the modeling accuracy decreases.

- Use the runoff curve number equation with caution when recreating specific features of an actual storm. The equation does not contain an expression for time and, therefore, does not account for rainfall duration or intensity.

- The user should understand the assumption reflected in the initial abstraction term (I_a) and should ascertain that the assumption applies to the situation. I_a, which consists of interception, initial infiltration, surface depression storage, evapotranspiration, and other factors, was generalized as 0.2S based on data from agricultural watersheds (S is the potential maximum retention after runoff begins). This approximation can be especially important in an urban application because the combination of impervious areas with pervious areas can imply a significant initial loss that may not take place. The opposite effect, a greater initial loss, can occur if the impervious areas have surface depressions that store some runoff. To use a relationship other than $I_a = 0.2S$, one must redevelop equation 2-3, figure 2-1, table 2-1, and table 2-2 by using the original rainfall-runoff data to establish new S or CN relationships for each cover and hydrologic soil group.

- Runoff from snowmelt or rain on frozen ground cannot be estimated using these procedures.

- The CN procedure is less accurate when runoff is less than 0.5 inch. As a check, use another procedure to determine runoff.

- The SCS runoff procedures apply only to direct surface runoff: do not overlook large sources of subsurface flow or high ground water levels that contribute to runoff. These conditions are often related to HSG A soils and forest areas that have been assigned relatively low CN's in table 2-2. Good judgment and experience based on stream gage records are needed to adjust CN's as conditions warrant.

- When the weighted CN is less than 40, use another procedure to determine runoff.

Examples

Four examples illustrate the procedure for computing runoff curve number (CN) and runoff (Q) in inches. Worksheet 2 in appendix D is provided to assist TR-55 users. Figures 2-5 to 2-8 represent the use of worksheet 2 for each example. All four examples are based on the same watershed and the same storm event.

The watershed covers 250 acres in Dyer County, northwestern Tennessee. Seventy percent (175 acres) is a Loring soil, which is in hydrologic soil group C. Thirty percent (75 acres) is a Memphis soil, which is in group B. The event is a 25-year frequency, 24-hour storm with total rainfall of 6 inches.

Cover type and conditions in the watershed are different for each example. The examples, therefore, illustrate how to compute CN and Q for various situations of proposed, planned, or present development.

Example 2-1

The present cover type is pasture in good hydrologic condition. (See figure 2-5 for worksheet 2 information.)

Example 2-2

Seventy percent (175 acres) of the watershed, consisting of all the Memphis soil and 100 acres of the Loring soil, is ½-acre residential lots with lawns in good hydrologic condition. The rest of the watershed is scattered open space in good hydrologic condition. (See figure 2-6.)

Example 2-3

This example is the same as example 2-2, except that the ½-acre lots have a total impervious area of 35 percent. For these lots, the pervious area is lawns in good hydrologic condition. Since the impervious area percentage differs from the percentage assumed in table 2-2, use figure 2-3 to compute CN. (See figure 2-7.)

Example 2-4

This example is also based on example 2-2, except that 50 percent of the impervious area associated with the ½-acre lots on the Loring soil is "unconnected," that is, it is not directly connected to the drainage system. For these lots, the pervious area CN (lawn, good condition) is 74 and the impervious area is 25 percent. Use figure 2-4 to compute the CN for these lots. CN's for the ½-acre lots on Memphis soil and the open space on Loring soil are the same as those in example 2-2. (See figure 2-8.)

Worksheet 2: Runoff curve number and runoff

Project Heavenly Acres By WJR Date 10/1/85

Location Dyer County, Tennessee Checked NM Date 10/3/85

Circle one: [✓ Present] Developed

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN [1]			Area ☐ acres ☐ mi^2 ☒ %	Product of CN x area
		Table 2-2	Fig. 2-3	Fig. 2-4		
Memphis, B	Pasture, good condition	61			30	1830
Loring, C	Pasture, good condition	74			70	5180
				Totals =	100	7010

[1] Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{7010}{100} = 70.1$; Use CN = $\boxed{70}$

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	25		
Rainfall, P (24-hour)	in	6.0		
Runoff, Q .... (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	2.81		

Figure 2-5.—Worksheet 2 for example 2-1.

Worksheet 2: Runoff curve number and runoff

Project Heavenly Acres By WJR Date 10/1/85
Location Dyer County, Tennessee Checked NM Date 10/3/85
Circle one: Present [✓ Developed] 175 acres residential

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN [1/] Table 2-2	CN [1/] Fig. 2-3	CN [1/] Fig. 2-4	Area ☒ acres ☐ mi^2 ☐ %	Product of CN x area
Memphis, B	25% impervious 1/2 acre lots, good condition	70			75	5250
Loring, C	25% impervious 1/2 acre lots, good condition	80			100	8000
Loring, C	Open space, good condition	74			75	5550
				Totals =	250	18,800

[1/] Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{18,800}{250} = 75.2$; Use CN = $\boxed{75}$

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	25		
Rainfall, P (24-hour)	in	6.0		
Runoff, Q .... (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	3.28		

Figure 2-6.—Worksheet 2 for example 2-2.

Worksheet 2: Runoff curve number and runoff

Project Heavenly Acres By WJR Date 10/1/85

Location Dyer County, Tennessee Checked NM Date 10/3/85

Circle one: Present [✓ Developed]

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 2-2	CN 1/ Fig. 2-3	CN 1/ Fig. 2-4	Area ☒ acres ☐ mi^2 ☐ %	Product of CN x area
Memphis, B	35% impervious 1/2 acre lots, good condition		74		75	5550
Loring, C	35% impervious 1/2 acre lots, good condition		82		1000	8200
Loring, C	Open space, good condition	74			75	5550
				Totals =	250	19,300

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{19{,}300}{250} = 77.2$; Use CN = 77

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	25		
Rainfall, P (24-hour)	in	6.0		
Runoff, Q (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	3.48		

Figure 2-7.—Worksheet 2 for example 2-3.

Worksheet 2: Runoff curve number and runoff

Project Heavenly Acres By WJR Date 10/1/85

Location Dyer County, Tennessee Checked NM Date 10/3/85

Circle one: Present [✓ Developed]

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN [1/] Table 2-2	CN [1/] Fig. 2-3	CN [1/] Fig. 2-4	Area ☒ acres ☐ mi² ☐ %	Product of CN x area
Memphis, B	25% connected impervious 1/2 acre lots, good condition	70			75	5250
Loring, C	25% impervious with 50% unconnected 1/2 acre lots, good condition			78	100	7800
Loring, C	Open space, good condition	74			75	5550
				Totals =	250	18,600

[1/] Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{18,600}{250} = $ 74.4; Use CN = $\boxed{74}$

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	25		
Rainfall, P (24-hour)	in	6.0		
Runoff, Q .... (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	3.19		

Figure 2-8.—Worksheet 2 for example 2-4.

Chapter 3: Time of concentration and travel time

Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of time of concentration (T_c), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system.

T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

Factors affecting time of concentration and travel time

Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600\ V} \qquad \text{[Eq. 3-1]}$$

where

T_t = travel time (hr),
L = flow length (ft),
V = average velocity (ft/s), and
3600 = conversion factor from seconds to hours.

Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \ldots T_{t_m} \qquad \text{[Eq. 3-2]}$$

where

T_c = time of concentration (hr) and
m = number of flow segments.

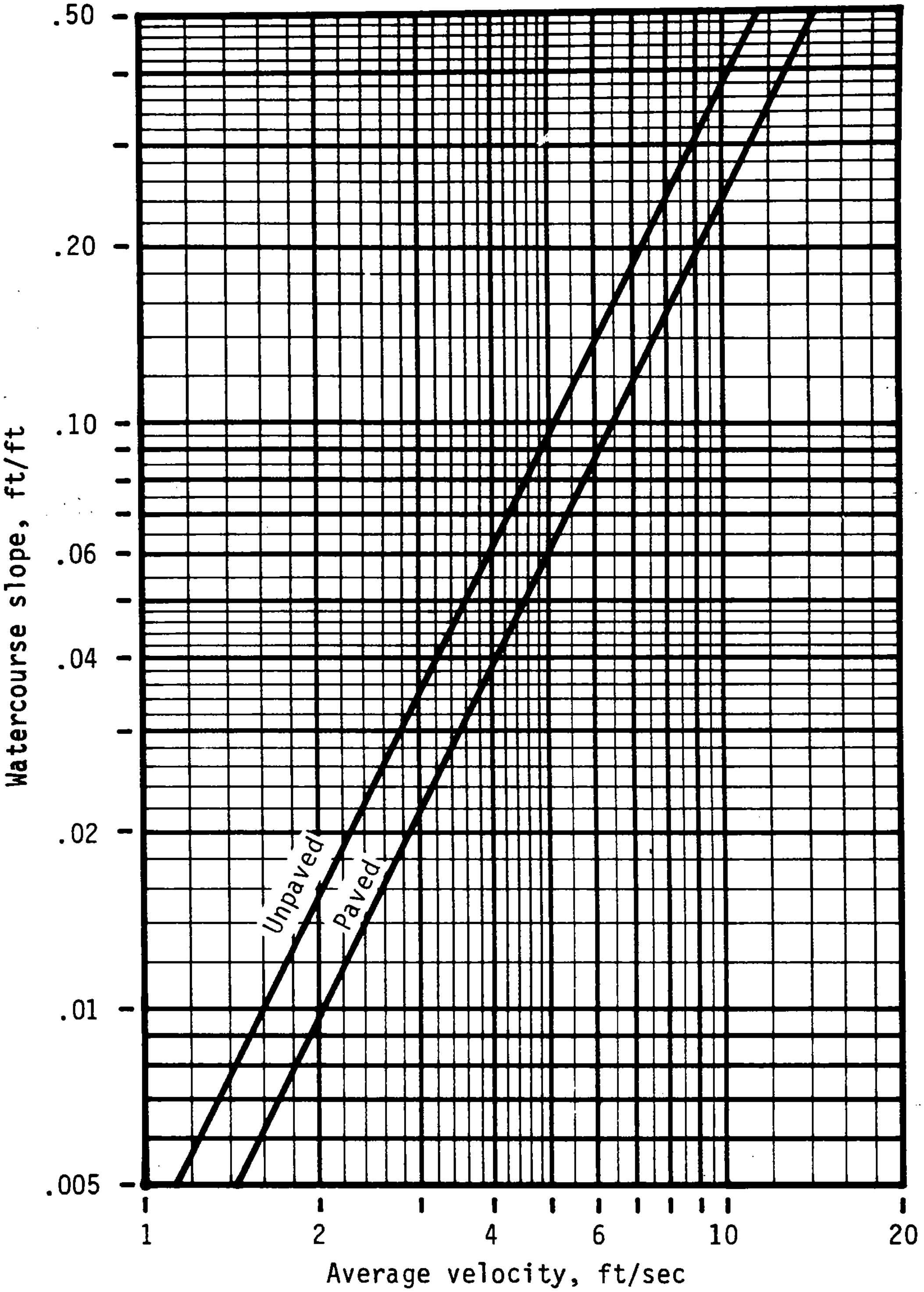


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 3-3]}$$

where

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information compiled by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

Manning's equation is

$$V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n} \quad \text{[Eq. 3-4]}$$

where

V = average velocity (ft/s),
r = hydraulic radius (ft) and is equal to a/p_w,
a = cross sectional flow area (ft^2),
p_w = wetted perimeter (ft),
s = slope of the hydraulic grade line (channel slope, ft/ft), and
n = Manning's roughness coefficient for open channel flow.

Manning's n values for open channel flow can be obtained from standard textbooks such as Chow (1959) or Linsley et al. (1982). After average velocity is computed using equation 3-4, T_t for the channel segment can be estimated using equation 3-1.

Reservoirs or lakes

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed. This travel time is normally very small and can be assumed as zero.

Limitations

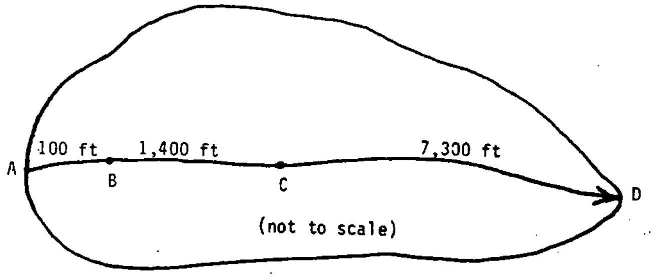
- Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Equation 3-3 was developed for use with the four standard rainfall intensity-duration relationships.
- In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate T_c. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.
- The minimum T_c used in TR-55 is 0.1 hour.
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outflow through the culvert.

Example 3-1

The sketch below shows a watershed in Dyer County, northwestern Tennessee. The problem is to compute T_c at the outlet of the watershed (point D). The 2-year 24-hour rainfall depth is 3.6 inches. All three types of flow occur from the hydraulically most distant point (A) to the point of interest (D). To compute T_c, first determine T_t for each segment from the following information:

Segment AB:	Sheet flow; dense grass; slope (s) = 0.01 ft/ft; and length (L) = 100 ft.
Segment BC:	Shallow concentrated flow; unpaved; s = 0.01 ft/ft; and L = 1400 ft.
Segment CD:	Channel flow; Manning's n = .05; flow area (a) = 27 ft^2; wetted perimeter (p_w) = 28.2 ft; s = 0.005 ft/ft; and L = 7300 ft.

See figure 3-2 for the computations made on worksheet 3.



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Heavenly Acres By DW Date 10/6/85
Location Dyer County, Tennessee Checked Date 10/8/85

Circle one: Present [✓ Developed]
Circle one: [✓ T_c] T_t 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.

<u>Sheet flow</u> (Applicable to T_c only) Segment ID		AB		
1. Surface description (table 3-1)		DENSE GRASS		
2. Manning's roughness coeff., n (table 3-1) ..		0.24		
3. Flow length, L (total L $\leq$ 300 ft)	ft	100		
4. Two-yr 24-hr rainfall, P_2	in	3.6		
5. Land slope, s	ft/ft	0.01		
6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr	0.30	+	= 0.30
<u>Shallow concentrated flow</u> Segment ID		BC		
7. Surface description (paved or unpaved)		Unpaved		
8. Flow length, L	ft	1400		
9. Watercourse slope, s	ft/ft	0.01		
10. Average velocity, V (figure 3-1)	ft/s	1.6		
11. $T_t = \dfrac{L}{3600\ V}$ Compute T_t	hr	0.24	+	= 0.24
<u>Channel flow</u> Segment ID		CD		
12. Cross sectional flow area, a	ft^2	27		
13. Wetted perimeter, p_w	ft	28.2		
14. Hydraulic radius, $r = \dfrac{a}{p_w}$ Compute r	ft	0.957		
15. Channel slope, s	ft/ft	0.005		
16. Manning's roughness coeff., n		0.05		
17. $V = \dfrac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s	2.05		
18. Flow length, L	ft	7300		
19. $T_t = \dfrac{L}{3600\ V}$ Compute T_t	hr	0.99	+	= 0.99
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			1.53

Figure 3-2.—Worksheet 3 for example 3-1.

Chapter 4: Graphical Peak Discharge method

This chapter presents the Graphical Peak Discharge method for computing peak discharge from rural and urban areas. The Graphical method was developed from hydrograph analyses using TR-20, "Computer Program for Project Formulation—Hydrology" (SCS 1983). The peak discharge equation used is

$$q_p = q_u A_m Q F_p \qquad \text{[Eq. 4-1]}$$

where

q_p = peak discharge (cfs);
q_u = unit peak discharge (csm/in);
A_m = drainage area (mi^2);
Q = runoff (in); and
F_p = pond and swamp adjustment factor.

The input requirements for the Graphical method are as follows: (1) T_c (hr), (2) drainage area (mi^2), (3) appropriate rainfall distribution (I, IA, II, or III), (4) 24-hour rainfall (in), and (5) CN. If pond and swamp areas are spread throughout the watershed and are not considered in the T_c computation, an adjustment for pond and swamp areas is also needed.

Peak discharge computation

For a selected rainfall frequency, the 24-hour rainfall (P) is obtained from appendix B or more detailed local precipitation maps. CN and total runoff (Q) for the watershed are computed according to the methods outlined in chapter 2. The CN is used to determine the initial abstraction (I_a) from table 4-1. I_a/P is then computed.

If the computed I_a/P ratio is outside the range shown in exhibit 4 (4-I, 4-IA, 4-II, and 4-III) for the rainfall distribution of interest, then the limiting value should be used. If the ratio falls between the limiting values, use linear interpolation. Figure 4-1 illustrates the sensitivity of I_a/P to CN and P.

Peak discharge per square mile per inch of runoff (q_u) is obtained from exhibit 4-I, 4-IA, 4-II, or 4-III by using T_c (chapter 3), rainfall distribution type, and I_a/P ratio. The pond and swamp adjustment factor is obtained from table 4-2 (rounded to the nearest table value). Use worksheet 4 in appendix D to aid in computing the peak discharge using the Graphical method.

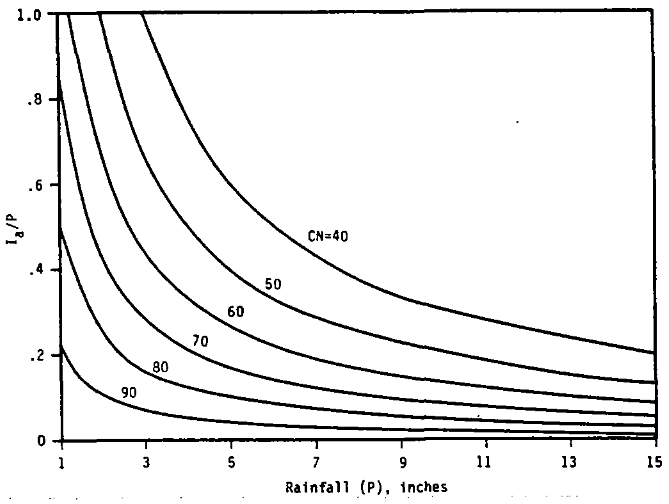


Figure 4-1.—Variation of I_a/P for P and CN.

Table 4-1.—I_a values for runoff curve numbers

Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

Table 4-2.—Adjustment factor (F_p) for pond and swamp areas that are spread throughout the watershed

Percentage of pond and swamp areas	F_p
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

Limitations

The Graphical method provides a determination of peak discharge only. If a hydrograph is needed or watershed subdivision is required, use the Tabular Hydrograph method (chapter 5). Use TR-20 if the watershed is very complex or a higher degree of accuracy is required.

- The watershed must be hydrologically homogeneous, that is, describable by one CN. Land use, soils, and cover are distributed uniformly throughout the watershed.
- The watershed may have only one main stream or, if more than one, the branches must have nearly equal T_c's.
- The method cannot perform valley or reservoir routing.
- The F_p factor can be applied only for ponds or swamps that are not in the T_c flow path.
- Accuracy of peak discharge estimated by this method will be reduced if I_a/P values are used that are outside the range given in exhibit 4. The limiting I_a/P values are recommended for use.
- This method should be used only if the weighted CN is greater than 40.
- When this method is used to develop estimates of peak discharge for both present and developed conditions of a watershed, use the same procedure for estimating T_c.
- T_c values with this method may range from 0.1 to 10 hours.

Example 4-1

Compute the 25-year peak discharge for the 250-acre watershed described in examples 2-2 and 3-1. Figure 4-2 shows how worksheet 4 is used to compute q_p as 345 cfs.

Worksheet 4: Graphical Peak Discharge method

Project Heavenly Acres By RHM Date 10/15/85

Location Dyer County, Tennessee Checked Date 10/17/85

Circle one: Present [✓ Developed]

1. Data:

Drainage area .... A_m = 0.39 mi^2 (acres/640)

Runoff curve number .... CN = 75 (From worksheet 2), Figure 2-6

Time of concentration .. T_c = 1.53 hr (From worksheet 3), Figure 3-2

Rainfall distribution type = II (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = -- percent of A_m (-- acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr	25		
3. Rainfall, P (24-hour)	in	6.0		
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in	0.667		
5. Compute I_a/P		0.11		
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-II)	csm/in	270		
7. Runoff, Q .... (From worksheet 2). Figure 2-6	in	3.28		
8. Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1.0		
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	345		

Figure 4-2.—Worksheet 4 for example 4-1.

Exhibit 4-I: Unit peak discharge (q_u) for SCS type I rainfall distribution

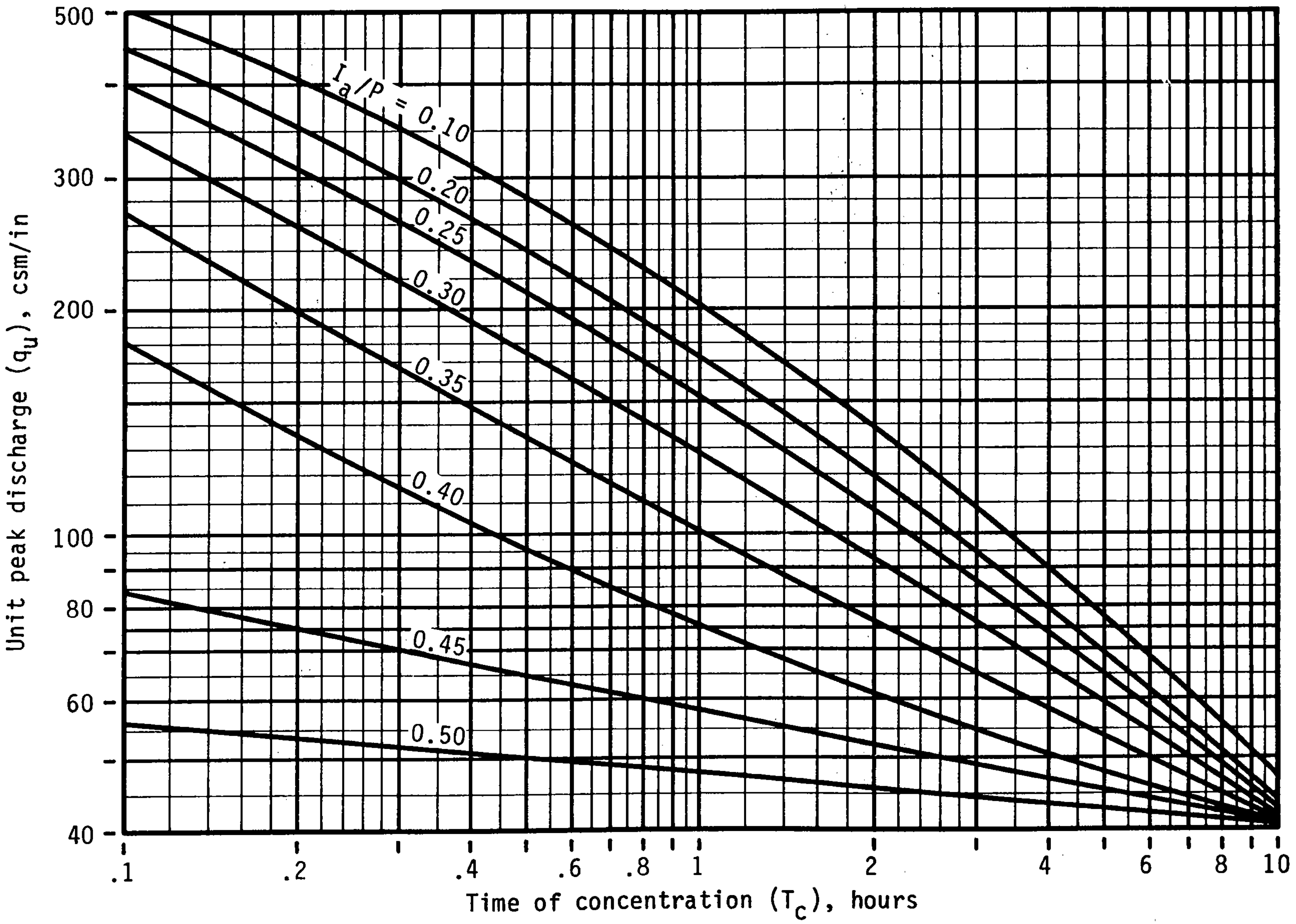


Exhibit 4-IA: Unit peak discharge (q_u) for SCS type IA rainfall distribution

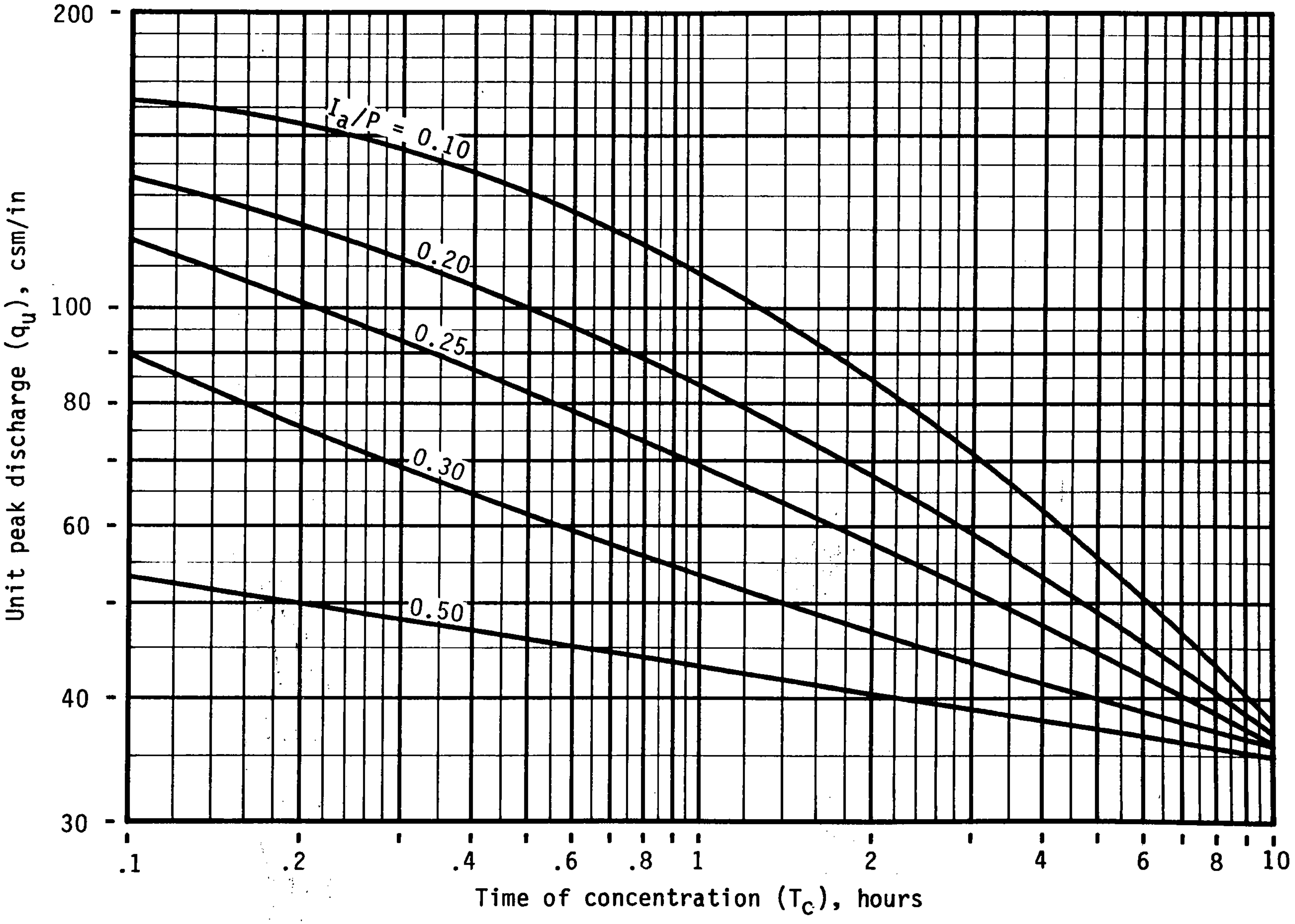


Exhibit 4-II: Unit peak discharge (q_u) for SCS type II rainfall distribution

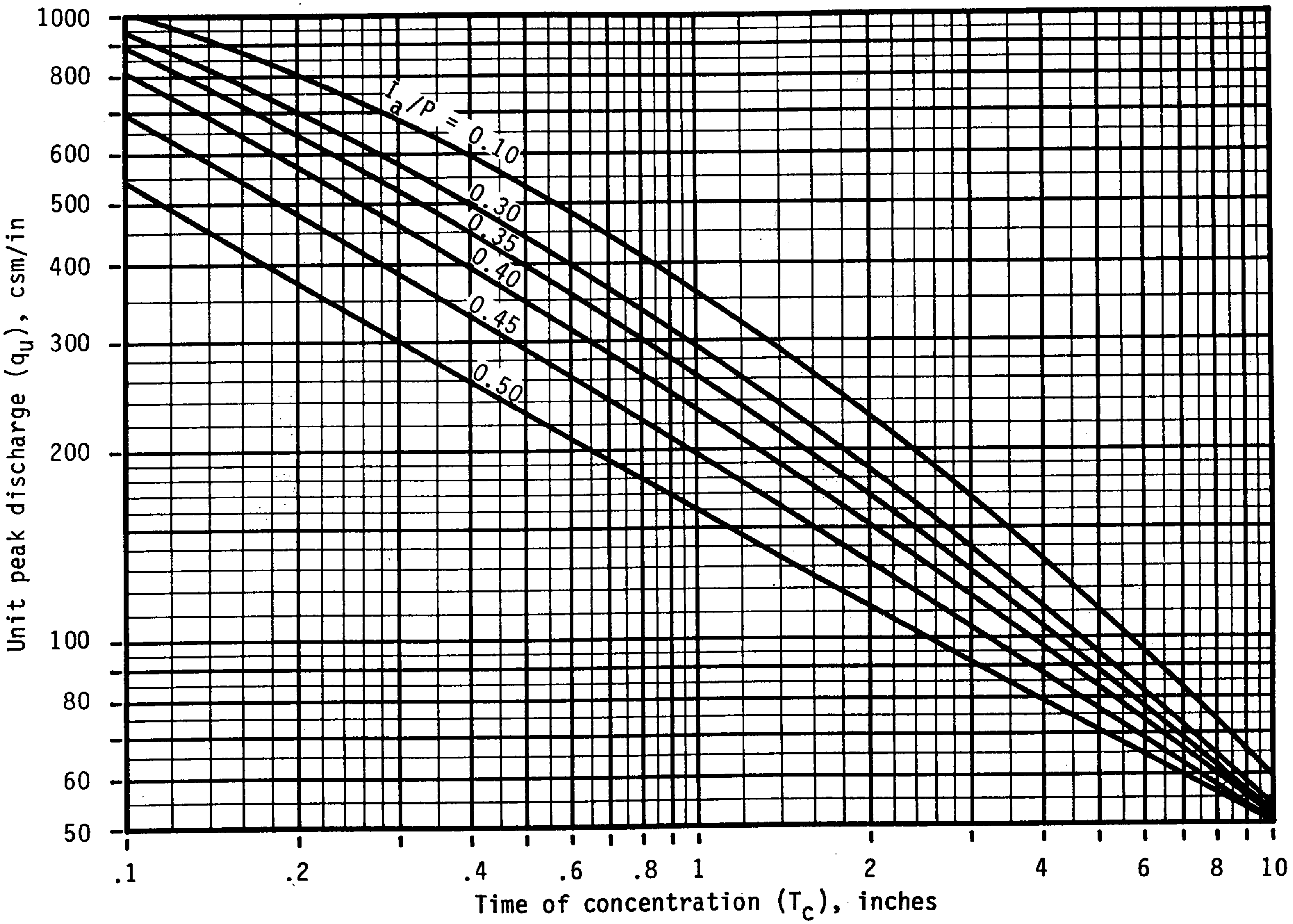
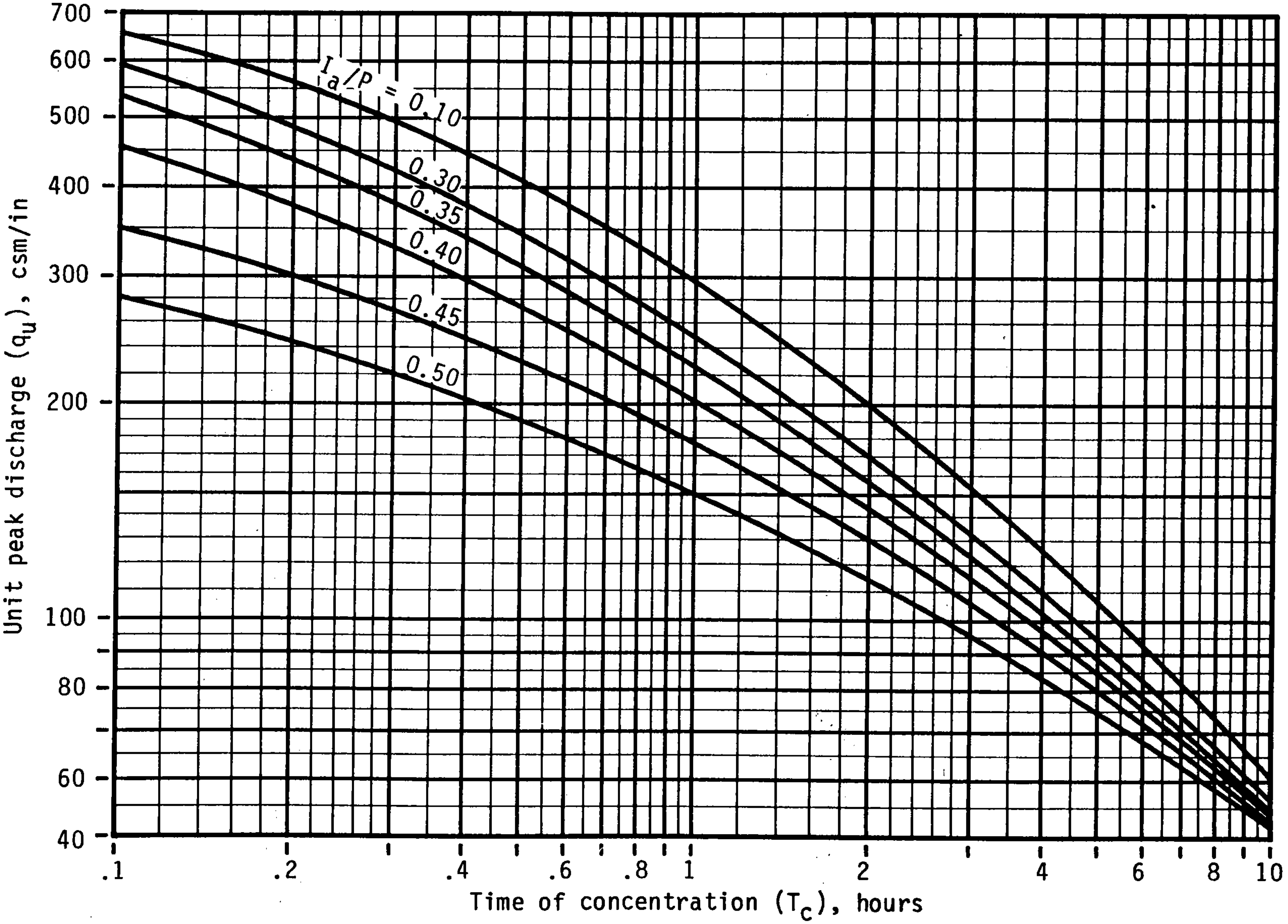


Exhibit 4-III: Unit peak discharge (q_u) for SCS type III rainfall distribution



Chapter 5: Tabular Hydrograph method

This chapter presents the Tabular Hydrograph method of computing peak discharges from rural and urban areas, using time of concentration (T_c) and travel time (T_t) from a subarea as inputs. This method approximates TR-20, a more detailed hydrograph procedure (SCS 1983).

The Tabular method can develop partial composite flood hydrographs at any point in a watershed by dividing the watershed into homogeneous subareas. In this manner, the method can estimate runoff from nonhomogeneous watersheds. The method is especially applicable for estimating the effects of land use change in a portion of a watershed. It can also be used to estimate the effects of proposed structures.

Input data needed to develop a partial composite flood hydrograph include (1) 24-hour rainfall (in), (2) appropriate rainfall distribution (I, IA, II, or III), (3) CN, (4) T_c (hr), (5) T_t (hr), and (6) drainage area (mi^2).

Tabular Hydrograph method exhibits

Exhibit 5 (5-I, 5-IA, 5-II, and 5-III) shows tabular discharge values for the various rainfall distributions. Tabular discharges expressed in csm/in (cubic feet of discharge per second per square mile of watershed per inch of runoff) are given for a range of subarea T_c's from 0.1 to 2 hours and reach T_t's from 0 to 3 hours.

The exhibit was developed by computing hydrographs for 1 square mile of drainage area for selected T_c's and routing them through stream reaches with the range of T_t's indicated. The Modified Att-Kin method for reach routing, formulated by SCS in the late 1970's, was used to compute the tabular hydrographs (Comer et al., 1981). A CN of 75 and rainfall amounts generating appropriate I_a/P ratios were used. The resulting runoff estimate was used to convert the hydrographs in exhibits 5-I through 5-III to cubic feet per second per square mile per inch of runoff.

An assumption in development of the tabular hydrographs is that all discharges for a stream reach flow at the same velocity. By this assumption, the subarea flood hydrographs may be routed separately and added at the reference point. The tabular hydrographs in exhibit 5 are prerouted hydrographs. For T_t's other than zero, the tabular discharge values represent the contribution from a single subarea to the composite hydrograph at T_t downstream.

Information required for Tabular Hydrograph method

The following information is required for the Tabular method:

1. Subdivision of the watershed into areas that are relatively homogeneous and have convenient routing reaches.
2. Drainage area of each subarea in square miles.
3. T_c for each subarea in hours. The procedure for estimating T_c is outlined in chapter 3. Worksheet 3 (appendix D) can be used to calculate T_c.
4. T_t for each routing reach in hours. The procedure for estimating T_t is outlined in chapter 3. Worksheet 3 can be used to calculate T_t through a subarea for shallow concentrated and open channel flow.
5. Weighted CN for each subarea. Table 2-2 shows CN's for individual hydrologic soil cover combinations. Worksheet 2 can be used to calculate the weighted runoff curve number.
6. Appropriate rainfall distribution according to figure B-2 (appendix B).
7. The 24-hour rainfall for the selected frequency. Appendix B contains rainfall maps for various frequencies (figures B-3 to B-8).
8. Total runoff (Q) in inches computed from CN and rainfall.
9. I_a for each subarea from table 5-1, which is the same as table 4-1.
10. Ratio of I_a/P for each subarea. If the ratio for the rainfall distribution of interest is outside the range shown in exhibit 5, use the limiting value.

Development of composite flood hydrograph

This section describes the procedure for developing the peak discharge and selected discharge values of a composite flood hydrograph.

Selecting T_c and T_t

First, use worksheet 5a to develop a summary of basic watershed data by subarea. Then use worksheet 5b to develop a tabular hydrograph discharge summary; this summary displays the effect of individual subarea hydrographs as routed to the watershed point of interest. Use ΣT_t for each subarea as the total reach travel time from that subarea through the watershed to the point of interest. Compute the hydrograph coordinates for selected ΣT_t's using the appropriate sheets in exhibit 5. The flow at any time is

$$q = q_t A_m Q \qquad \text{[Eq. 5-1]}$$

where

q = hydrograph coordinate (cfs) at hydrograph time t;
q_t = tabular hydrograph unit discharge from exhibit 5 (csm/in);
A_m = drainage area of individual subarea (mi^2); and
Q = runoff (in).

Table 5-1.—I_a values for runoff curve numbers

Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

Since the timing of peak discharge changes with T_c and T_t, interpolation of peak discharge for T_c and T_t values for use in exhibit 5 is not recommended. Interpolation may result in an estimate of peak discharge that would be invalid because it would be lower than either of the hydrographs. Therefore, round the actual values of T_c and T_t to values presented in exhibit 5. Perform this rounding so that the sum of the selected table values is close to the sum of actual T_c and T_t. An acceptable procedure is to select the results of one of three rounding operations:

1. Round T_c and T_t separately to the nearest table value and sum;
2. Round T_c down and T_t up to nearest table value and sum; and
3. Round T_c up and T_t down to nearest table value and sum.

From these three alternatives, choose the pair of rounded T_c and T_t values whose sum is closest to the sum of the actual T_c and T_t. If two rounding methods produce sums equally close to the actual sum, use the combination in which rounded T_c is closest to actual T_c. An illustration of the rounding procedure is as follows:

	Actual values	Table values by rounding method—		
		1	2	3
T_c	1.1	1.0	1.0	1.25
T_t	1.7	1.5	2.0	1.5
Sum	2.8	2.5	3.0	2.75

In this instance, the results from method 3 would be selected because the sum 2.75 is closest to the actual sum of 2.8.

Selecting I_a/P

The computed I_a/P value can be rounded to the nearest I_a/P value in exhibits 5-I through 5-III, or the hydrograph values (csm/in) can be linearly interpolated because I_a/P interpolation generally involves peaks that occur at the same time.

Summing for the composite hydrograph

The composite hydrograph is the summation of prerouted individual subarea hydrographs at each time shown on worksheet 5b. Only the times encompassing the expected maximum composite discharge are summed to define a portion of the composite hydrograph.

If desired, the entire composite hydrograph can be approximated by linear extrapolation as follows:

1. Set up a table similar to worksheet 5b. Include on this table the full range of hydrograph times displayed in exhibit 5.
2. Compute the subarea discharge values for those times and insert them in the table.
3. Sum the values to obtain the composite hydrograph.
4. Apply linear extrapolation to the first two points and the last two points of the composite hydrograph. The volume under this approximation of the entire composite hydrograph may differ from the computed runoff volume.

Limitations

The Tabular method is used to determine peak flows and hydrographs within a watershed. However, its accuracy decreases as the complexity of the watershed increases. If you want to compare present and developed conditions of a watershed, use the same procedure for estimating T_c for both conditions.

Use the TR-20 computer program (SCS 1983) instead of the Tabular method if any of the following conditions applies:

- T_t is greater than 3 hours (largest T_t in exhibit 5).
- T_c is greater than 2 hours (largest T_c in exhibit 5).
- Drainage areas of individual subareas differ by a factor of 5 or more.
- The entire composite flood hydrograph or entire runoff volume is required for detailed flood routings. The hydrograph based on extrapolation is only an approximation of the entire hydrograph.
- The time of peak discharge must be more accurate than that obtained through the Tabular method.

The composite flood hydrograph should be compared with actual stream gage data where possible. The instantaneous peak flow value from the composite flood hydrograph can be compared with data from USGS curves of peak flow versus drainage area.

Examples

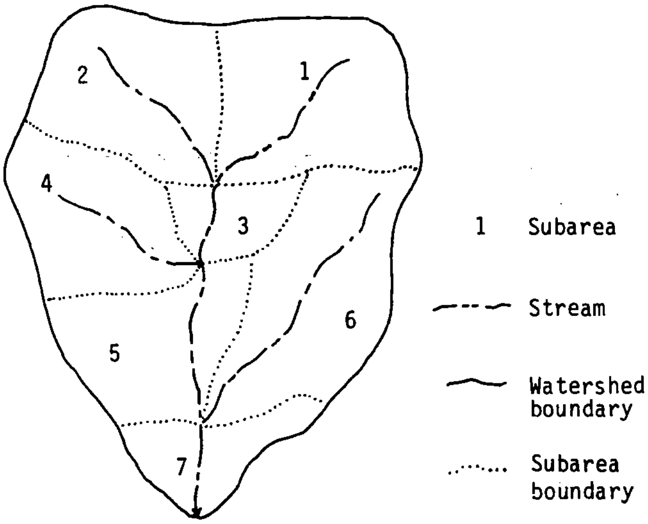
A developer proposes to put a subdivision, Fallswood, in subareas 5, 6, and 7 of a watershed in Dyer County, northwestern Tennessee (see sketch below). Before approving the developer's proposal, the planning board wants to know how the development would affect the 25-year peak discharge at the downstream end of subarea 7. The rainfall distribution is type II (figure B-2), and the 24-hour rainfall (P) is 6.0 inches (figure B-6).

Example 5-1

Compute the 25-year frequency peak discharge at the downstream end of subarea 7 for present conditions, using worksheets 5a and 5b. To do this, first calculate the present condition CN, T_c, and T_t for each subarea, using the procedures in chapters 2 and 3. Enter the values on worksheet 5a (figure 5-1).

Next, compute the prerouted hydrograph points for each subarea hydrograph over a range of time near the peak discharge using worksheet 5b (figure 5-2) and the appropriate exhibit 5. For example, for subarea 4, in which $T_c = 0.75$ hr, refer to sheet 6 of exhibit 5-II. With ΣT_t of 2.00 hr (the sum of downstream travel time through subareas 5 and 7 to the outlet) and I_a/P of 0.1, the routed peak discharge of subarea 4 at the outlet of subarea 7 occurs at 14.6 hr and is 274 csm/in. Solving equation 5-1 with appropriate values provides the peak discharge (q) for subarea 4 at 14.6 hr:

$$q = q_t(A_mQ) = (274)(0.70) = 192 \text{ cfs.}$$



Once all the prerouted subarea hydrographs have been tabulated on worksheet 5b, sum each of the time columns to obtain the composite hydrograph. The resulting 25-year frequency peak discharge is 720 cfs at 14.3 hr (figure 5-2).

Example 5-2

Compute the 25-year frequency peak discharge at the downstream end of subarea 7 for the developed conditions, using worksheets 5a and 5b.

First, calculate the developed condition CN, T_c, and T_t for each subarea, using the procedures in chapters 2 and 3. Enter the values on worksheet 5a (figure 5-3).

Next, compute the prerouted hydrograph points for each subarea hydrograph over a range of time near the peak discharge using worksheet 5b (figure 5-4) and the appropriate exhibit 5. For example, for subarea 6, in which $T_c = 1.0$ hr, refer to sheet 7 of exhibit 5-II. With ΣT_t of 0.5 hr (downstream travel time through subarea 7 to the outlet) and I_a/P of 0.1, the peak discharge of subarea 6 at the outlet of the watershed occurs at 13.2 hr and is 311 csm/in. Solving equation 5-1 provides the peak discharge (q):

$$q = q_t(A_mQ) = (311)(1.31) = 407 \text{ cfs.}$$

Once all the prerouted subarea hydrographs have been tabulated on worksheet 5b, sum each of the time columns to obtain the composite hydrograph. The resulting 25-year frequency peak discharge is 872 cfs at 13.6 hr (figure 5-4).

Comparison

According to the results of the two examples, the proposed subdivision at the downstream end of subarea 7 is expected to increase peak discharge from 720 to 872 cfs and to decrease the time to peak from 14.3 to 13.6 hr.

Worksheet 5a: Basic watershed data

Project Fallswood Location Dyer County, Tennessee By DW Date 10/1/85

Circle one: [✓ Present] Developed Frequency (yr) 25 Checked Date 10/3/85

Subarea name	Drainage area A_m (mi^2)	Time of concentration T_c (hr)	Travel time through subarea T_t (hr)	Downstream subarea names	Travel time summation to outlet ΣT_t (hr)	24-hr Rainfall P (in)	Runoff curve number CN	Runoff Q (in)	A_mQ (mi^2-in)	Initial abstraction I_a (in)	I_a/P
1	0.30	1.50	--	3, 5, 7	2.50	6.0	65	2.35	0.71	1.077	0.18
2	0.20	1.25	--	3, 5, 7	2.50	6.0	70	2.80	0.56	0.857	0.14
3	0.10	0.50	0.50	5, 7	2.00	6.0	75	3.28	0.33	0.667	0.11
4	0.25	0.75	--	5, 7	2.00	6.0	70	2.80	0.70	0.857	0.14
5	0.20	1.50	1.25	7	0.75	6.0	75	3.28	0.66	0.667	0.11
6	0.40	1.50	--	7	0.75	6.0	70	2.80	1.12	0.857	0.14
7	0.20	1.25	0.75	--	0	6.0	75	3.28	0.66	0.667	0.11

↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑
From worksheet 3

↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑
From worksheet 2

↑ ↑ ↑ ↑
From table 5-1

Figure 5-1.—Worksheet 5a for example 5-1.

Worksheet 5b: Tabular hydrograph discharge summary

Project Fallswood Location Dyer County, Tennessee By DW Date 10/1/85

Circle one: [✓ Present] Developed Frequency (yr) 25 Checked Date 10/3/85

Subarea name	Basic watershed data used 1/				Select and enter hydrograph times in hours from exhibit 5-II 2/											
	Subarea T_c (hr)	ΣT_t to outlet (hr)	I_a/P	A_mQ (mi^2-in)	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5
					Discharges at selected hydrograph times 3/ (cfs)											
1	1.50	2.50	0.10	0.71	4	4	5	6	6	8	10	13	24	49	100	149
2	1.25	2.50	0.10	0.56	3	4	4	6	7	8	11	16	32	64	110	127
3	0.50	2.00	0.10	0.33	5	5	6	8	12	21	41	67	98	92	60	29
4	0.75	2.00	0.10	0.70	8	9	11	14	20	34	62	106	172	192	149	81
5	1.50	0.75	0.10	0.66	21	28	50	83	118	147	158	154	127	98	67	44
6	1.50	0.75	0.10	1.12	36	47	85	140	200	249	269	261	216	166	114	75
7	1.25	0	0.10	0.66	169	187	205	176	140	108	85	69	51	40	31	24
Composite hydrograph at outlet					246	284	366	433	503	575	636	686	720	701	631	529

1/ Worksheet 5a. Rounded as needed for use with exhibit 5.
2/ Enter rainfall distribution type used.
3/ Hydrograph discharge for selected times is A_mQ multiplied by tabular discharge from appropriate exhibit 5.

Figure 5-2.—Worksheet 5b for example 5-1.

Worksheet 5a: Basic watershed data

Project Fallswood Location Dyer County, Tennessee By DW Date 10/1/85

Circle one: Present [✓ Developed] ________ Frequency (yr) 25 Checked NM Date 10/3/85

Subarea name	Drainage area A_m (mi^2)	Time of concentration T_c (hr)	Travel time through subarea T_t (hr)	Downstream subarea names	Travel time summation to outlet ΣT_t (hr)	24-hr Rainfall P (in)	Runoff curve number CN	Runoff Q (in)	A_mQ (mi^2-in)	Initial abstraction I_a (in)	I_a/P
1	0.30	1.50	--	3, 5, 7	2.00	6.0	65	2.35	0.71	1.077	0.18
2	0.20	1.25	--	3, 5, 7	2.00	6.0	70	2.80	0.56	0.857	0.14
3	0.10	0.50	0.50	5, 7	1.50	6.0	75	3.28	0.33	0.667	0.11
4	0.25	0.75	--	5, 7	1.50	6.0	70	2.80	0.70	0.857	0.14
5	0.20	1.50	1.00	7	0.50	6.0	85	4.31	0.86	0.353	0.06
6	0.40	1.00	--	7	0.50	6.0	75	3.28	1.31	0.857	0.14
7	0.20	0.75	0.50	--	0	6.0	90	4.85	0.97	0.222	0.04

↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ From worksheet 3

↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ From worksheet 2

↑ ↑ ↑ ↑ From table 5-1

Figure 5-3.—Worksheet 5a for example 5-2.

Worksheet 5b: Tabular hydrograph discharge summary

Project Fallswood Location Dyer County, Tennessee By DW Date 10/1/85

Circle one: Present [✓ Developed] Frequency (yr) 25 Checked XK Date 10/3/85

Subarea name	Basic watershed data used [1/]				Select and enter hydrograph times in hours from exhibit 5-II [2/]											
	Sub-area T_c (hr)	ΣT_t to outlet (hr)	I_a/P	A_mQ (mi^2-in)	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5
					Discharges at selected hydrograph times [3/] (cfs)											
1	1.50	2.00	0.10	0.71	6	6	7	9	11	16	24	40	78	122	155	133
2	1.25	2.00	0.10	0.56	6	6	7	9	12	20	33	55	96	132	132	87
3	0.50	1.50	0.10	0.33	8	9	14	29	58	89	106	102	74	46	25	16
4	0.75	1.50	0.10	0.70	13	14	19	32	63	114	169	207	193	143	83	46
5	1.50	0.50	0.10	0.86	51	69	117	167	205	214	202	175	132	99	70	48
6	1.00	0.50	0.10	1.31	149	208	331	407	393	329	255	195	134	97	69	52
7	0.75	0	0.10	0.97	398	358	244	167	119	90	72	59	48	40	34	30
Composite hydrograph at outlet					631	670	739	820	861	872	861	833	755	679	568	412

1/ Worksheet 5a. Rounded as needed for use with exhibit 5.
2/ Enter rainfall distribution type used.
3/ Hydrograph discharge for selected times is A_mQ multiplied by tabular discharge from appropriate exhibit 5.

Figure 5-4.—Worksheet 5b for example 5-2.

Exhibit 5-I: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																															
	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
			IA/P = 0.10											* * * TC =0.1 HR * * *														IA/P = 0.10				
0.0	30	40	56	183	337	504	326	155	122	107	93	81	73	66	60	56	54	52	49	46	44	40	36	32	30	29	28	27	26	24	20	13
.10	26	35	48	93	153	276	428	360	223	156	123	103	88	72	65	59	56	54	51	47	45	42	37	33	30	29	28	28	26	24	21	13
.20	23	30	41	60	82	129	227	361	360	269	194	147	118	85	71	63	58	55	53	49	46	43	39	35	31	29	29	28	26	24	21	14
.30	22	29	39	56	73	111	188	303	341	293	227	173	136	94	75	65	60	56	54	50	47	43	39	35	31	29	29	28	26	25	21	14
.40	18	25	34	46	53	66	96	157	255	312	300	251	199	126	90	73	64	59	56	52	48	44	40	36	32	30	29	28	26	25	21	14
.50	15	24	32	44	50	61	84	133	214	280	293	265	221	144	99	77	66	60	56	52	49	45	41	37	32	30	29	28	27	25	21	14
.75	14	19	25	34	38	43	49	62	88	134	190	234	252	221	162	115	87	71	63	56	52	47	43	39	35	31	29	29	27	25	22	15
1.0	11	14	19	26	28	31	34	38	44	52	68	98	141	222	238	191	139	101	79	63	56	51	45	41	37	33	30	29	27	26	22	15
1.5	9	10	13	17	18	20	22	25	27	30	34	38	44	74	132	191	211	190	151	101	73	58	50	45	41	37	33	30	28	27	23	16
2.0	6	7	9	11	12	13	14	15	16	18	20	22	24	29	38	58	97	148	193	193	141	89	61	51	46	41	37	33	29	27	24	17
2.5	4	5	7	8	9	9	10	11	11	12	13	14	16	19	23	29	39	58	93	154	181	147	87	61	51	45	41	37	30	28	25	18
3.0	2	3	5	6	6	7	7	8	9	9	10	10	11	13	15	19	23	28	39	72	124	170	138	86	61	50	45	40	33	29	26	19
			IA/P = 0.30											* * * TC =0.1 HR * * *														IA/P = 0.30				
0.0	0	0	0	61	195	343	232	129	113	103	91	81	76	71	66	64	62	61	59	56	54	51	47	43	40	40	39	39	37	36	31	21
.10	0	0	0	12	45	145	277	247	169	131	112	98	87	76	70	65	64	62	60	57	55	53	49	44	40	40	39	39	38	36	32	21
.20	0	0	0	9	33	107	220	238	192	151	125	107	94	79	71	66	64	62	61	58	56	53	49	45	41	40	40	39	38	36	32	21
.30	0	0	0	1	6	24	79	173	216	200	168	139	118	90	77	70	66	64	62	59	57	54	50	46	41	40	40	39	38	36	32	22
.40	0	0	0	1	4	17	59	135	189	196	177	152	129	97	81	72	67	64	63	60	57	54	51	46	42	40	40	39	38	36	32	22
.50	0	0	0	0	0	3	12	43	104	161	185	180	161	121	93	79	71	66	64	61	58	55	52	48	43	40	40	39	38	37	33	22
.75	0	0	0	0	0	1	5	18	49	92	130	153	159	142	114	92	79	71	66	63	60	56	53	49	44	41	40	40	38	37	33	23
1.0	0	0	0	0	0	0	0	0	2	9	27	56	92	144	152	128	103	86	75	67	63	59	55	51	47	43	40	40	39	37	34	24
1.5	0	0	0	0	0	0	0	0	0	0	0	2	6	32	79	121	136	127	109	85	72	64	58	55	51	47	43	40	39	38	34	25
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	33	70	105	126	118	97	75	63	58	54	50	46	42	40	39	35	26
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	32	63	105	118	100	75	63	58	54	50	46	40	39	36	27
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	12	43	84	112	96	74	63	58	54	50	42	40	37	28
			IA/P = 0.50											* * * TC =0.1 HR * * *														IA/P = 0.50				
0.0	0	0	0	0	0	3	13	28	39	44	45	46	46	48	49	51	53	54	54	55	56	55	53	50	50	49	49	49	49	48	45	32
.10	0	0	0	0	0	2	9	22	33	41	44	45	46	48	49	50	52	54	54	54	56	55	53	50	50	49	49	49	49	48	45	32
.20	0	0	0	0	0	0	1	7	17	28	36	41	44	46	48	49	51	53	54	54	56	56	54	51	50	50	49	49	49	48	45	32
.30	0	0	0	0	0	0	0	1	5	13	23	32	38	44	47	48	50	51	53	54	54	55	54	52	50	50	49	49	49	48	46	33
.40	0	0	0	0	0	0	0	0	3	10	18	27	34	43	46	48	49	51	53	54	54	55	54	52	50	50	49	49	49	48	46	33
.50	0	0	0	0	0	0	0	0	0	2	7	15	23	36	43	46	48	50	51	53	54	55	55	53	50	50	49	49	49	48	46	34
.75	0	0	0	0	0	0	0	0	0	1	3	7	13	27	37	43	46	48	50	52	54	55	55	54	51	50	50	49	49	48	46	34
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	20	32	40	45	47	50	52	54	55	54	52	50	50	49	49	49	47	36
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	13	23	33	42	47	51	54	55	54	53	50	50	49	49	48	37
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	12	25	37	46	51	54	55	54	52	50	49	49	48	39
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	15	31	45	51	53	55	54	52	50	49	48	41
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	14	32	45	51	53	54	54	51	49	48	42

RAINFALL TYPE = I * * * TC = 0.1 HR * * * SHEET 1 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																															
	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
			IA/P = 0.10											* * * TC =0.2 HR * * *															IA/P = 0.10			
0.0	28	37	52	126	220	379	405	267	168	129	108	92	80	69	62	58	55	53	50	47	44	41	37	33	30	29	28	27	26	24	21	13
.10	24	32	44	71	108	182	313	375	303	213	157	124	103	78	68	61	57	55	52	49	46	42	38	34	30	29	29	28	26	24	21	14
.20	21	28	38	53	65	94	153	260	336	314	247	137	145	97	77	67	60	57	54	50	47	44	39	35	31	30	29	28	26	25	21	14
.30	20	27	36	50	60	82	129	216	296	308	267	214	168	110	82	69	62	58	55	51	47	44	40	36	32	30	29	28	26	25	21	14
.40	17	23	31	42	47	56	74	111	181	258	291	275	234	152	103	79	68	61	57	53	49	45	41	37	33	30	29	28	27	25	22	14
.50	16	22	30	40	45	52	66	96	153	223	269	273	247	171	115	86	71	63	58	54	50	46	42	37	33	30	29	28	27	25	22	14
.75	13	17	24	32	35	39	44	52	68	99	145	194	229	240	183	132	97	77	[illegible]	58	53	48	44	39	35	31	30	29	27	26	22	15
1.0	11	13	17	24	26	29	32	35	39	45	56	75	107	189	229	206	158	115	[illegible]	67	58	52	46	42	38	34	31	29	28	26	23	15
1.5	8	10	12	15	17	19	21	23	25	28	31	35	39	60	106	166	204	197	[illegible]	112	79	60	51	46	42	37	33	30	28	27	23	16
2.0	5	7	9	10	11	12	13	14	15	17	18	20	22	27	34	49	79	126	[illegible]	188	152	97	64	52	46	42	38	34	29	28	24	17
2.5	3	5	6	8	8	9	10	10	11	12	13	14	15	18	22	26	34	49	[illegible]	136	176	155	95	64	52	46	42	37	31	28	25	18
3.0	2	3	4	5	6	6	7	7	8	8	9	9	10	11	13	16	19	23	[illegible]	49	91	154	167	102	67	53	47	42	34	29	26	19
			IA/P = 0.30											* * * TC =0.2 HR * * *															IA/P = 0.30			
0.0	0	0	0	22	76	206	258	207	144	119	104	92	82	74	68	65	63	62	60	57	55	52	48	44	40	40	39	39	38	36	32	21
.10	0	0	0	3	16	56	156	224	213	167	135	114	99	81	73	67	65	63	61	58	56	53	50	45	41	40	40	39	38	36	32	22
.20	0	0	0	2	11	41	118	189	205	179	150	126	108	85	75	69	65	63	62	59	56	54	50	46	41	40	40	39	38	36	32	22
.30	0	0	0	0	2	8	30	88	155	188	182	161	138	103	83	74	68	65	63	60	57	55	51	47	42	40	40	39	38	36	32	22
.40	0	0	0	0	1	6	22	66	126	167	177	166	147	111	88	76	69	66	63	61	58	55	51	47	43	40	40	39	38	37	33	22
.50	0	0	0	0	0	1	4	16	50	100	145	167	166	136	105	85	75	69	65	62	59	56	53	49	44	41	40	40	38	37	33	23
.75	0	0	0	0	0	0	2	7	22	50	87	119	140	148	124	101	85	74	69	64	61	57	54	50	45	42	40	40	38	37	33	23
1.0	0	0	0	0	0	0	0	0	1	3	11	28	55	114	142	135	113	93	80	69	64	60	56	52	48	44	41	40	39	37	34	24
1.5	0	0	0	0	0	0	0	0	0	0	0	1	2	17	52	97	124	129	115	91	75	65	59	55	52	48	43	41	39	38	35	25
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	19	49	84	111	120	102	79	65	59	55	51	47	43	40	39	36	26
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	20	45	89	113	104	78	65	59	55	51	47	41	39	36	28
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	30	68	108	99	77	65	58	54	50	43	40	37	29
			IA/P = 0.50											* * * TC =0.2 HR * * *															IA/P = 0.50			
0.0	0	0	0	0	0	0	4	15	28	38	43	45	45	48	49	50	52	53	53	53	53	53	53	50	50	50	49	49	49	48	45	32
.10	0	0	0	0	0	0	3	11	22	32	40	43	45	47	48	50	52	53	53	53	53	53	53	50	50	50	49	49	49	48	45	32
.20	0	0	0	0	0	0	2	8	17	27	36	41	43	46	48	49	51	53	53	53	53	53	53	51	50	50	49	49	49	48	45	33
.30	0	0	0	0	0	0	1	6	13	23	31	38	41	45	48	49	51	52	53	53	53	53	53	51	50	50	49	49	49	48	46	33
.40	0	0	0	0	0	0	1	4	10	19	27	34	39	44	47	49	50	52	53	53	53	53	53	51	50	50	49	49	49	48	46	33
.50	0	0	0	0	0	0	1	3	8	15	23	30	36	43	46	48	50	51	53	53	53	53	53	52	50	50	49	49	49	48	46	33
.75	0	0	0	0	0	0	0	0	3	8	14	20	27	37	43	46	48	50	52	53	53	53	53	52	50	50	50	49	49	48	46	34
1.0	0	0	0	0	0	0	0	0	0	0	0	2	4	14	26	36	42	46	48	51	52	53	53	53	52	50	50	49	49	49	47	35
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	13	23	33	40	46	49	52	53	53	53	51	50	50	49	49	48	37
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	16	26	37	44	50	52	53	53	53	51	50	49	49	48	38
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	19	31	43	50	52	53	53	52	51	50	49	48	39
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	11	25	41	49	52	53	53	52	50	49	48	41

RAINFALL TYPE = I * * * TC = 0.2 HR * * * SHEET 2 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

TRVL	HYDROGRAPH TIME (HOURS)																															
TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
			IA/P = 0.10												* * * TC =0.3 HR * * *														IA/P = 0.10			
0.0	25	34	46	97	138	242	349	346	256	182	141	115	97	76	66	60	57	54	52	48	45	42	38	34	30	29	28	28	26	24	21	13
.10	24	32	44	77	118	200	299	330	281	215	166	132	109	82	69	62	58	55	52	49	46	42	38	34	30	29	29	28	26	24	21	14
.20	21	28	38	54	69	102	167	255	305	289	240	190	152	103	79	67	61	57	54	50	47	44	40	35	31	30	29	28	26	25	21	14
.30	20	27	36	51	63	89	141	217	276	295	255	212	172	115	85	71	63	58	55	51	48	44	40	36	32	30	29	28	26	25	21	14
.40	17	23	31	42	48	58	79	120	185	246	272	260	228	156	108	82	69	62	57	53	49	45	41	37	33	30	29	28	27	25	22	14
.50	16	22	30	40	45	54	70	104	158	216	253	258	238	173	120	89	72	63	58	54	50	46	42	37	33	30	29	28	27	25	22	14
.75	13	17	24	32	35	39	45	54	72	104	147	189	219	231	182	135	100	79	67	58	53	48	44	40	35	32	30	29	27	26	22	15
1.0	11	13	17	24	26	29	32	35	40	46	58	79	110	184	221	202	158	118	90	68	58	52	46	42	38	34	31	29	28	26	23	15
1.5	8	10	12	15	17	19	21	23	25	28	31	35	40	62	107	163	199	193	165	114	81	61	52	46	42	37	33	31	28	27	23	16
2.0	5	7	9	10	11	12	13	14	15	17	18	20	22	27	35	50	80	125	165	184	152	99	64	53	47	42	38	34	29	28	24	17
2.5	3	5	6	8	8	9	10	10	11	12	13	14	15	18	22	27	35	50	78	134	173	154	96	64	52	46	42	37	31	28	25	18
3.0	2	3	4	6	6	7	7	8	8	9	9	10	11	12	14	17	21	26	34	61	107	164	145	94	64	52	46	41	33	29	26	19
			IA/P = 0.30												* * * TC =0.3 HR * * *														IA/P = 0.30			
0.0	0	0	0	8	32	98	198	217	192	148	125	108	95	79	72	67	64	63	61	58	56	53	49	45	41	40	40	39	38	36	32	22
.10	0	0	0	1	6	23	73	156	197	194	164	138	118	91	77	70	66	64	62	59	57	54	50	46	41	40	40	39	38	36	32	22
.20	0	0	0	1	4	17	54	122	172	187	171	149	128	98	81	72	67	64	63	60	57	54	51	46	42	40	40	39	38	36	32	22
.30	0	0	0	0	0	3	12	40	95	146	173	172	157	120	94	79	71	67	64	61	58	55	52	48	43	40	40	39	38	37	33	23
.40	0	0	0	0	0	2	9	30	73	122	156	167	160	128	100	83	73	68	65	62	59	56	52	48	44	41	40	39	38	37	33	23
.50	0	0	0	0	0	1	6	22	56	100	137	157	159	135	107	87	76	69	65	62	59	56	53	49	44	41	40	40	38	37	33	23
.75	0	0	0	0	0	0	1	3	9	26	53	86	115	143	134	113	93	80	72	65	62	58	54	51	46	42	40	40	39	37	33	23
1.0	0	0	0	0	0	0	0	0	1	5	14	32	57	111	138	132	113	94	81	69	64	60	56	52	48	44	41	40	39	37	34	24
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	8	34	74	111	126	121	99	80	67	61	56	53	49	44	41	39	38	35	26
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	33	66	97	118	108	84	67	60	56	52	48	44	40	39	36	27
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	12	32	74	106	112	83	67	60	56	52	48	41	39	37	28
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	21	54	98	107	81	67	60	55	51	43	40	37	29
			IA/P = 0.50												* * * TC =0.3 HR * * *														IA/P = 0.50			
0.0	0	0	0	0	0	0	1	6	16	27	36	41	44	46	48	49	51	52	52	52	52	52	52	51	50	50	49	49	49	48	46	33
.10	0	0	0	0	0	0	1	4	12	22	31	38	42	45	48	49	51	52	52	52	52	52	52	51	50	50	49	49	49	48	46	33
.20	0	0	0	0	0	0	0	3	9	18	27	34	39	44	47	49	50	51	52	52	52	52	52	51	50	50	49	49	49	48	46	33
.30	0	0	0	0	0	0	0	2	7	14	23	30	36	43	46	48	50	51	52	52	52	52	52	51	50	50	49	49	49	48	46	33
.40	0	0	0	0	0	0	0	1	5	11	19	26	33	41	46	48	49	51	52	52	52	52	52	52	50	50	49	49	49	48	46	33
.50	0	0	0	0	0	0	0	1	4	9	15	23	30	39	44	47	49	50	51	52	52	52	52	52	50	50	49	49	49	48	46	33
.75	0	0	0	0	0	0	0	0	2	4	8	14	20	31	40	44	47	49	51	52	52	52	52	52	50	50	50	49	49	48	46	34
1.0	0	0	0	0	0	0	0	0	0	0	0	1	2	9	20	31	39	44	47	50	51	52	52	52	52	50	50	50	49	49	47	36
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	9	18	28	36	44	48	51	52	52	52	51	50	50	49	49	48	37
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	12	21	33	42	48	51	52	52	52	51	50	49	49	48	38
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	15	27	40	48	51	52	52	52	51	50	49	48	40
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	11	25	41	48	51	52	52	51	50	49	48	41
			RAINFALL TYPE = I												* * * TC = 0.3 HR * * *														SHEET 3 OF 10			

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

```
TRVL  ------------------------------------------------ HYDROGRAPH TIME (HOURS) ------------------------------------------------
TIME        9.3     9.9    10.1    10.3    10.5    10.7    11.0    11.4    11.8    12.3    13.0    14.0    15.0    16.0    18.0    24.0
(HR)   9.0     9.6    10.0    10.2    10.4    10.6    10.8    11.2    11.6    12.0    12.6    13.5    14.5    15.5    17.0    20.0
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            IA/P = 0.10                                        * * * TC =0.4  HR * * *                                   IA/P = 0.10
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
0.0     23  31  42  66  96 157 250 310 304 244 186 149 122  89  73  64  59  56  53  49  46  43  39  35  31  29  29  28  26  25  21  14
.10     22  29  40  61  84 133 211 277 295 261 211 170 138  98  78  66  60  56  54  50  47  43  39  35  31  29  29  28  26  25  21  14
.20     19  26  34  47  56  75 114 178 244 278 267 230 190 128  93  75  65  59  56  52  48  44  40  36  32  30  29  28  27  25  21  14
.30     18  24  33  45  53  67  98 152 213 257 263 241 207 143 102  80  68  61  57  52  49  45  41  37  32  30  29  28  27  25  21  14

.40     15  21  28  38  43  49  61  86 130 185 233 253 245 188 132  97  77  66  60  55  51  46  42  38  34  30  29  28  27  25  22  14
.50     15  20  27  36  41  46  56  76 112 161 209 238 243 201 146 106  82  69  61  55  51  47  42  38  34  31  29  29  27  25  22  14
.75     12  16  21  29  32  35  39  46  57  77 108 147 184 220 200 157 118  91  74  61  55  50  45  40  36  32  30  29  27  26  22  15
1.0     10  12  16  21  24  26  29  32  36  40  48  61  83 147 202 212 178 138 105  75  62  54  47  43  39  35  31  29  28  26  23  16

1.5      8   9  11  14  16  17  19  21  23  25  28  31  35  50  83 134 179 193 177 131  92  65  53  47  42  38  34  31  29  27  24  16
2.0      5   6   8  10  10  11  12  13  14  15  17  18  20  25  31  42  64 102 144 179 163 111  70  55  48  43  39  35  30  28  25  17
2.5      3   4   6   7   8   8   9   9  10  11  12  13  14  16  20  24  30  42  63 114 160 170 107  70  54  47  43  38  31  29  25  18
3.0      2   3   4   5   6   6   7   7   8   8   9   9  10  11  13  16  19  23  30  51  90 148 161 104  69  54  47  42  34  29  26  19
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            IA/P = 0.30                                        * * * TC =0.4  HR * * *                                   IA/P = 0.30
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
0.0      0   0   0   3  14  48 115 184 192 178 148 127 111  88  77  70  66  64  62  59  56  54  50  46  41  40  40  39  38  36  32  22
.10      0   0   0   0   2  10  35  89 152 179 178 158 137 105  85  75  69  65  63  60  58  55  51  47  42  40  40  39  38  36  32  22
.20      0   0   0   0   2   7  26  68 124 161 172 163 146 113  90  78  70  66  64  61  58  55  52  47  43  40  40  39  38  37  33  22
.30      0   0   0   0   1   5  19  52 100 140 162 162 151 120  96  81  72  67  64  61  59  55  52  48  43  41  40  39  38  37  33  23

.40      0   0   0   0   0   1   4  14  39  80 120 148 158 142 114  92  79  71  67  63  60  57  53  49  45  41  40  40  38  37  33  23
.50      0   0   0   0   0   1   3  10  29  63 101 132 152 145 120  97  82  73  68  63  60  57  53  50  45  41  40  40  38  37  33  23
.75      0   0   0   0   0   0   0   1   4  13  31  58  87 130 138 123 103  87  77  68  63  59  55  51  47  43  41  40  39  37  34  24
1.0      0   0   0   0   0   0   0   0   0   2   7  18  36  86 125 134 122 104  88  73  66  61  57  53  49  45  41  40  39  38  34  24

1.5      0   0   0   0   0   0   0   0   0   0   0   0   1  10  36  75 109 124 120 100  81  68  61  56  53  49  44  41  40  38  35  26
2.0      0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   6  22  50  83 116 116  91  70  61  57  53  49  45  40  39  36  27
2.5      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2   8  22  60  97 111  88  70  61  56  53  48  42  39  37  28
3.0      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2  14  43  89 106  86  69  61  56  52  44  40  37  29
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            IA/P = 0.50                                        * * * TC =0.4  HR * * *                                   IA/P = 0.50
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
0.0      0   0   0   0   0   0   0   2   8  17  27  34  40  44  47  49  50  51  51  51  51  51  51  51  50  50  49  49  49  48  46  33
.10      0   0   0   0   0   0   0   0   2   6  13  22  30  40  45  47  49  50  51  51  51  51  51  51  50  50  50  49  49  48  46  34
.20      0   0   0   0   0   0   0   0   0   1   4  10  18  33  41  45  48  49  51  51  51  51  51  51  50  50  50  49  49  49  46  34
.30      0   0   0   0   0   0   0   0   0   0   1   3   8  22  35  42  46  48  50  51  51  51  51  51  51  50  50  49  49  49  47  35

.40      0   0   0   0   0   0   0   0   0   0   1   2   6  19  32  40  45  47  49  51  51  51  51  51  51  50  50  49  49  49  47  35
.50      0   0   0   0   0   0   0   0   0   0   0   0   2   9  23  34  41  45  48  50  51  51  51  51  51  50  50  49  49  49  47  35
.75      0   0   0   0   0   0   0   0   0   0   0   0   1   5  14  26  35  42  46  49  50  51  51  51  51  50  50  50  49  49  47  36
1.0      0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   5  14  25  35  44  48  50  51  51  51  51  50  50  49  49  48  37

1.5      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2   6  13  27  39  47  50  51  51  51  51  50  49  49  48  39
2.0      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2   9  21  36  47  50  51  51  51  51  50  49  48  40
2.5      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   6  19  37  47  50  51  51  51  50  49  48  42
3.0      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   8  25  40  48  50  51  51  50  50  49  43
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            RAINFALL TYPE =  I                                 * * * TC = 0.4  HR * * *                                  SHEET  4 OF 10
```

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

TRVL														HYDROGRAPH TIME (HOURS)																		
TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
			IA/P = 0.10												* * * TC =0.5 HR * * *														IA/P = 0.10			
0.0	21	28	38	56	73	111	175	247	282	271	229	186	152	108	84	71	63	58	55	51	47	44	40	35	31	30	29	28	26	25	21	14
.10	20	27	36	52	66	96	149	214	259	267	242	204	169	119	90	74	65	59	55	51	48	44	40	36	32	30	29	28	26	25	21	14
.20	17	23	31	42	49	60	84	127	185	234	256	247	219	156	112	86	72	63	58	53	49	45	41	37	33	30	29	28	27	25	22	14
.30	16	22	30	40	46	55	74	110	160	210	241	245	227	171	123	93	76	66	59	54	50	46	42	38	33	30	29	28	27	25	22	14
.40	14	19	26	35	38	43	51	67	95	138	186	222	237	210	157	115	89	73	64	57	52	47	43	39	35	31	29	29	27	25	22	15
.50	14	18	25	33	37	41	48	61	84	120	164	203	229	216	170	126	96	77	66	58	53	48	43	39	35	31	30	29	27	25	22	15
.75	11	14	19	26	29	32	35	40	48	61	83	114	148	202	210	176	137	106	84	66	57	51	46	41	37	33	30	29	28	26	22	15
1.0	10	11	15	19	21	24	26	29	32	36	41	50	65	116	176	203	190	156	122	85	67	56	49	44	40	35	32	30	28	26	23	16
1.5	7	9	11	13	14	16	17	19	21	23	25	28	31	42	67	110	157	187	183	146	104	72	55	48	43	39	35	32	29	27	24	17
2.0	4	6	7	9	10	10	11	12	13	14	15	17	18	22	27	36	53	33	123	175	175	124	77	57	49	44	40	35	30	28	25	18
2.5	3	4	5	7	7	8	8	9	9	10	11	12	13	15	18	22	27	36	53	97	146	166	119	76	57	49	44	39	32	29	25	18
3.0	1	2	3	5	5	6	6	6	7	8	8	9	9	11	12	15	17	21	27	43	76	135	158	114	75	57	48	43	35	30	26	19
			IA/P = 0.30												* * * TC =0.5 HR * * *														IA/P = 0.30			
0.0	0	0	0	1	6	22	64	123	168	174	165	143	126	100	84	74	68	65	63	60	57	54	51	47	42	40	40	39	38	36	32	22
.10	0	0	0	1	5	16	48	98	144	164	165	150	134	106	87	77	70	66	63	60	58	55	51	47	42	40	40	39	38	36	32	22
.20	0	0	0	0	1	3	12	36	77	122	150	160	154	126	101	85	75	69	65	62	59	56	52	48	44	41	40	39	38	37	33	23
.30	0	0	0	0	0	2	9	27	60	101	134	151	153	132	107	89	77	70	66	63	60	56	53	49	44	41	40	40	38	37	33	23
.40	0	0	0	0	0	0	2	6	20	47	83	117	140	148	125	102	86	76	69	64	61	57	54	50	46	42	40	40	39	37	33	23
.50	0	0	0	0	0	0	1	5	15	36	68	101	127	144	130	108	90	78	71	65	62	58	54	50	46	42	40	40	39	37	33	23
.75	0	0	0	0	0	0	0	2	6	17	36	60	87	125	133	121	103	88	78	68	63	59	55	52	47	43	41	40	39	37	34	24
1.0	0	0	0	0	0	0	0	0	0	1	3	9	21	62	106	130	126	112	96	78	69	62	57	54	50	46	42	40	39	38	34	25
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	6	23	56	92	115	120	106	87	71	62	57	53	49	45	42	40	38	35	26
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	14	36	67	104	113	96	74	63	58	54	50	46	40	39	36	27
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	15	47	85	109	93	73	63	57	53	49	42	40	37	28
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	32	77	105	90	72	62	57	53	45	40	38	30
			IA/P = 0.50												* * * TC =0.5 HR * * *														IA/P = 0.50			
0.0	0	0	0	0	0	0	0	1	4	10	18	26	33	41	45	47	49	50	50	50	50	50	50	50	50	50	50	49	49	48	46	33
.10	0	0	0	0	0	0	0	1	3	8	15	22	30	39	44	47	49	50	50	50	50	50	50	50	50	50	50	49	49	48	46	34
.20	0	0	0	0	0	0	0	0	2	6	12	19	26	37	43	46	48	50	50	50	50	50	50	50	50	50	50	49	49	48	46	34
.30	0	0	0	0	0	0	0	0	1	4	9	16	23	34	41	45	48	49	50	50	50	50	50	50	50	50	50	49	49	49	46	34
.40	0	0	0	0	0	0	0	0	1	3	7	13	19	31	39	44	47	49	50	50	50	50	50	50	50	50	50	49	49	49	46	34
.50	0	0	0	0	0	0	0	0	1	2	6	10	16	28	37	43	46	48	50	50	50	50	50	50	50	50	50	49	49	49	46	34
.75	0	0	0	0	0	0	0	0	0	1	3	6	10	20	30	38	43	46	48	50	50	50	50	50	50	50	50	49	49	49	47	35
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	20	30	38	43	47	49	50	50	50	50	50	50	50	49	49	47	36
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	14	23	31	41	46	49	50	50	50	50	50	50	49	49	48	38
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	13	25	36	45	49	50	50	50	50	50	49	49	48	39
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	12	23	37	46	49	50	50	50	50	50	49	48	40
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	21	37	46	49	50	50	50	50	49	48	42

RAINFALL TYPE = I * * * TC = 0.5 HR * * * SHEET 5 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
IA/P = 0.10														* * * TC =0.75 HR * * *														IA/P = 0.10				
C.0	16	22	30	41	47	59	82	119	167	209	229	233	212	161	122	97	80	69	62	56	51	46	42	38	33	31	29	28	27	25	22	14
.10	14	19	26	35	39	44	54	72	104	146	188	215	227	197	150	116	93	77	68	59	53	48	43	39	35	31	30	29	27	25	22	15
.20	13	16	22	30	33	37	42	50	65	91	128	168	200	218	183	142	110	89	75	63	56	49	44	40	36	32	30	29	27	26	22	15
.30	12	16	21	28	31	35	39	46	59	80	112	149	183	214	191	151	118	94	79	65	57	50	45	41	36	32	30	29	27	26	22	15
.40	12	15	20	27	30	33	37	43	54	71	98	132	166	207	197	161	126	100	83	67	58	51	45	41	37	33	30	29	27	26	22	15
.50	11	13	18	24	26	29	32	36	41	49	64	87	117	178	204	186	152	120	96	74	62	53	47	42	38	34	31	29	28	26	23	15
.75	10	12	15	21	23	25	28	31	35	40	49	63	83	136	180	190	171	142	115	85	69	57	49	44	39	35	32	30	28	26	23	16
1.0	8	10	12	16	17	19	21	23	25	28	31	35	42	66	110	158	186	180	157	116	86	65	53	46	42	38	34	31	28	27	23	16
1.5	5	7	8	10	11	12	13	14	15	17	18	20	22	27	35	52	83	124	159	174	147	102	69	54	47	42	38	34	30	28	24	17
2.0	3	5	6	8	8	9	9	10	11	12	13	14	15	18	22	27	36	52	80	131	165	148	99	68	54	47	42	38	31	28	25	18
2.5	2	3	4	5	6	6	7	7	8	9	9	10	11	12	14	17	21	26	35	63	107	157	141	96	67	54	46	42	34	29	26	19
3.0	1	1	2	3	4	4	4	5	5	6	6	7	7	8	10	11	13	15	19	26	42	86	151	141	101	71	55	47	38	31	27	20
IA/P = 0.30														* * * TC =0.75 HR * * *														IA/P = 0.30				
C.0	0	0	0	0	1	4	14	35	69	105	131	143	146	124	104	89	79	72	68	64	60	56	53	49	44	41	40	40	38	37	33	23
.10	0	0	0	0	0	1	3	10	27	55	88	117	134	142	118	100	87	77	71	66	62	58	54	50	46	42	40	40	39	37	33	23
.20	0	0	0	0	0	0	2	7	20	43	73	102	123	137	123	105	90	80	73	66	62	58	54	50	46	42	40	40	39	37	33	23
.30	0	0	0	0	0	0	0	1	5	15	34	60	88	126	134	118	101	88	78	69	64	60	55	52	48	43	41	40	39	37	34	24
.40	0	0	0	0	0	0	0	1	4	12	27	49	75	118	131	121	105	91	80	71	65	60	56	52	48	44	41	40	39	37	34	24
.50	0	0	0	0	0	0	0	0	1	3	9	21	39	87	122	128	116	101	88	75	68	62	57	53	49	45	42	40	39	38	34	24
.75	0	0	0	0	0	0	0	0	0	1	4	10	21	56	95	118	121	110	98	82	72	64	58	54	50	46	42	41	39	38	34	25
1.0	0	0	0	0	0	0	0	0	0	0	0	1	2	12	39	76	106	119	115	98	82	69	61	57	53	49	44	42	40	38	35	26
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	14	37	67	95	112	105	85	69	61	56	52	48	44	40	39	36	27
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	15	35	74	102	107	84	69	61	56	52	48	41	39	37	28
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	23	55	94	103	82	68	60	56	52	44	40	37	29
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	15	50	93	100	81	68	60	55	47	41	38	30
IA/P = 0.50														* * * TC =0.75 HR * * *														IA/P = 0.50				
C.0	0	0	0	0	0	0	0	0	1	2	5	10	17	29	37	42	45	48	49	49	49	49	49	49	49	49	49	49	49	49	47	34
.10	0	0	0	0	0	0	0	0	0	2	4	8	14	26	35	41	45	47	49	49	49	49	49	49	49	49	49	49	49	49	47	35
.20	0	0	0	0	0	0	0	0	0	1	3	7	11	23	33	39	44	47	48	49	49	49	49	49	49	49	49	49	49	49	47	35
.30	0	0	0	0	0	0	0	0	0	1	2	5	9	20	30	38	43	46	48	49	49	49	49	49	49	49	49	49	49	49	47	35
.40	0	0	0	0	0	0	0	0	0	1	2	4	8	17	28	36	41	45	47	49	49	49	49	49	49	49	49	49	49	49	47	35
.50	0	0	0	0	0	0	0	0	0	0	1	3	6	15	25	34	40	44	47	48	49	49	49	49	49	49	49	49	49	49	47	35
.75	0	0	0	0	0	0	0	0	0	0	1	1	3	9	16	27	35	40	44	47	48	49	49	49	49	49	49	49	49	49	47	36
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	18	27	35	40	45	48	49	49	49	49	49	49	49	49	49	48	37
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	13	21	29	38	44	48	49	49	49	49	49	49	49	49	48	38
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	9	15	26	36	44	48	49	49	49	49	49	49	49	48	39
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	21	34	44	48	48	48	48	48	48	48	48	40
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	19	35	44	48	48	48	48	48	48	48	42

RAINFALL TYPE = I

* * * TC = 0.75 HR * * *

SHEET 6 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS) 9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
IA/P = 0.10														* * * TC =1.0 HR * * *															IA/P = 0.10			
0.0	14	19	25	34	38	46	58	79	106	136	165	186	202	185	153	122	101	85	74	63	56	50	44	40	35	32	30	29	27	26	22	15
.10	13	18	24	32	36	42	53	70	94	122	151	174	194	188	160	130	106	89	77	65	57	50	44	40	36	32	30	29	27	26	22	15
.20	12	15	21	28	31	34	40	49	63	83	109	137	162	190	180	152	124	102	86	70	61	53	46	41	37	33	31	29	27	26	22	15
.30	12	15	20	26	29	33	37	45	57	75	98	124	149	187	183	159	131	107	90	73	62	53	47	42	37	33	31	29	28	26	23	15
.40	10	13	17	23	25	28	31	35	42	52	67	88	112	160	183	176	151	125	103	81	67	56	48	43	39	35	31	30	28	26	23	15
.50	10	13	16	22	24	27	30	33	39	48	61	79	101	148	181	181	157	131	108	84	69	58	49	43	39	35	32	30	28	26	23	16
.75	9	11	14	19	21	23	26	29	33	38	47	59	75	115	153	172	167	148	125	96	77	62	51	45	40	36	33	30	28	27	23	16
1.0	8	9	11	15	16	17	19	21	23	26	29	33	40	61	95	134	162	169	157	126	97	72	57	49	43	39	35	32	29	27	24	16
1.5	5	6	8	10	10	11	12	13	14	16	17	19	21	25	33	48	74	107	138	160	148	111	76	59	50	44	39	35	30	28	25	17
2.0	3	4	6	7	8	8	9	9	10	11	12	13	14	17	20	25	33	48	71	115	153	153	108	75	58	49	43	39	32	29	25	18
2.5	2	3	4	5	5	6	6	7	7	8	9	9	10	12	14	16	20	25	33	56	94	139	147	104	74	58	49	43	34	30	26	19
3.0	1	1	2	3	3	4	4	4	5	5	6	6	7	8	9	10	12	14	17	24	38	76	131	143	108	78	60	50	39	32	27	20
IA/P = 0.30														* * * TC =1.0 HR * * *															IA/P = 0.30			
0.0	0	0	0	0	1	2	7	17	34	55	79	99	114	128	114	100	89	80	74	68	63	59	54	51	46	43	41	40	39	37	33	23
.10	0	0	0	0	0	0	2	5	13	27	46	68	89	116	124	110	98	87	79	71	65	60	56	52	48	43	41	40	39	37	34	24
.20	0	0	0	0	0	0	1	4	10	21	37	58	78	109	121	113	101	90	81	72	66	61	56	52	48	44	41	40	39	37	34	24
.30	0	0	0	0	0	0	0	1	3	8	17	31	49	87	113	118	109	98	87	76	69	63	57	53	49	45	42	40	39	38	34	24
.40	0	0	0	0	0	0	0	1	2	6	13	25	41	78	107	117	111	101	90	78	70	63	58	54	50	45	42	41	39	38	34	25
.50	0	0	0	0	0	0	0	0	2	5	10	20	34	69	100	115	113	103	93	80	71	64	58	54	50	46	42	41	39	38	34	25
.75	0	0	0	0	0	0	0	0	0	1	2	5	10	31	61	90	107	110	104	90	79	69	61	56	52	48	44	41	40	38	35	25
1.0	0	0	0	0	0	0	0	0	0	0	0	1	3	12	33	61	89	105	109	99	86	73	64	58	54	50	45	42	40	38	35	26
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	13	31	55	80	104	104	88	73	63	58	53	49	45	41	39	36	27
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	20	51	82	100	90	74	64	58	54	50	42	40	37	28
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	13	37	76	98	88	73	64	58	53	45	41	38	30
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	34	77	95	86	73	63	58	49	42	38	31
IA/P = 0.50														* * * TC =1.0 HR * * *															IA/P = 0.50			
0.0	0	0	0	0	0	0	0	0	0	1	3	5	9	18	28	35	40	44	47	48	48	48	48	48	48	48	48	48	48	48	47	35
.10	0	0	0	0	0	0	0	0	0	1	2	4	7	16	25	33	39	43	46	48	48	48	48	48	48	48	48	48	48	48	47	35
.20	0	0	0	0	0	0	0	0	0	1	2	3	6	14	23	31	38	42	45	47	48	48	48	48	48	48	48	48	48	48	47	36
.30	0	0	0	0	0	0	0	0	0	0	1	3	5	12	21	29	36	41	44	47	48	48	48	48	48	48	48	48	48	48	47	36
.40	0	0	0	0	0	0	0	0	0	0	1	2	4	10	19	27	34	40	44	47	48	48	48	48	48	48	48	48	48	48	47	36
.50	0	0	0	0	0	0	0	0	0	0	1	2	3	8	16	25	33	38	43	46	48	48	48	48	48	48	48	48	48	48	47	36
.75	0	0	0	0	0	0	0	0	0	0	1	2	3	8	15	23	30	36	41	45	47	48	48	48	48	48	48	48	48	48	47	36
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	19	27	33	41	45	47	48	48	48	48	48	48	48	48	48	37
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	11	17	28	37	44	47	48	48	48	48	48	48	48	48	39
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	16	26	38	45	47	48	48	48	48	48	48	48	40
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	12	24	38	45	47	47	47	47	47	47	47	41
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	14	29	40	46	47	47	47	47	47	47	42

RAINFALL TYPE = I

* * * TC = 1.0 HR * * *

SHEET 7 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

TRVL	HYDROGRAPH TIME (HOURS)																															
TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
			IA/P = 0.10											* * * TC =1.25 HR * * *														IA/P = 0.10				
0.0	12	16	22	29	33	38	47	61	80	103	127	149	164	180	163	138	115	98	85	71	62	53	47	41	37	33	31	29	27	26	22	15
.10	11	14	19	25	28	31	36	44	55	72	92	116	138	167	175	156	132	111	95	77	66	56	48	43	38	34	31	30	28	26	23	15
.20	11	14	18	24	27	30	34	40	50	65	83	105	127	160	172	160	138	116	99	80	68	57	49	43	39	34	31	30	28	26	23	15
.30	10	12	16	21	23	25	28	32	38	46	58	75	95	136	164	169	154	132	112	89	74	61	51	45	40	36	32	30	28	26	23	16
.40	9	12	15	20	22	24	27	30	35	42	53	68	86	126	157	167	157	137	117	92	76	62	52	46	40	36	33	30	28	26	23	16
.50	9	11	13	17	19	21	23	26	29	33	39	49	61	97	134	160	165	152	132	104	84	67	55	47	42	37	33	31	28	27	23	16
.75	7	9	11	14	15	17	18	20	22	25	28	32	38	59	90	124	150	159	152	126	101	77	60	51	45	40	35	32	29	27	24	17
1.0	6	8	10	12	13	14	15	17	19	20	23	25	29	40	60	91	123	148	157	144	118	88	66	54	47	41	37	33	29	27	24	17
1.5	4	6	7	9	9	10	11	12	13	14	15	16	18	22	28	40	59	85	114	145	150	121	86	65	54	46	41	37	31	28	25	18
2.0	2	3	5	6	6	7	7	8	9	9	10	11	11	13	16	19	24	33	47	80	119	144	124	90	68	55	47	42	33	29	26	19
2.5	1	2	3	4	4	5	5	6	6	7	7	8	8	10	11	13	16	19	24	38	65	111	140	120	88	67	54	47	37	31	27	20
3.0	1	1	2	2	3	3	3	4	4	5	5	5	6	7	8	9	11	13	15	21	32	62	114	136	116	86	66	54	41	33	27	20
			IA/P = 0.30											* * * TC =1.25 HR * * *														IA/P = 0.30				
0.0	0	0	0	0	0	1	4	10	21	35	53	71	86	106	115	104	94	86	79	72	66	61	56	52	48	44	41	40	39	37	34	24
.10	0	0	0	0	0	0	1	3	8	16	29	45	62	92	107	113	101	92	84	75	69	63	58	53	49	45	42	41	39	38	34	24
.20	0	0	0	0	0	0	1	2	6	13	23	37	54	84	104	110	104	94	86	77	70	64	58	54	49	45	42	41	39	38	34	24
.30	0	0	0	0	0	0	0	0	2	4	10	19	31	62	90	106	109	101	92	81	73	66	60	55	51	46	43	41	39	38	34	25
.40	0	0	0	0	0	0	0	0	1	3	8	15	26	55	83	102	107	103	94	83	74	67	60	56	51	47	43	41	39	38	35	25
.50	0	0	0	0	0	0	0	0	0	1	3	6	12	33	62	88	103	106	100	88	78	69	62	57	53	48	44	42	40	38	35	25
.75	0	0	0	0	0	0	0	0	0	0	0	1	3	12	31	56	80	97	103	97	87	75	65	59	55	50	46	43	40	39	35	26
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	13	32	56	79	95	101	94	80	69	61	56	52	48	44	40	39	36	27
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	13	30	51	81	98	94	79	68	61	56	52	47	42	39	36	28
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	13	37	66	95	95	78	68	61	56	51	44	40	37	29
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	26	61	93	89	77	67	60	55	47	41	38	30
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	24	64	91	87	76	66	60	50	43	39	31
			IA/P = 0.50											* * * TC =1.25 HR * * *														IA/P = 0.50				
0.0	0	0	0	0	0	0	0	0	0	1	2	3	6	13	21	29	35	40	43	47	47	47	47	47	47	47	47	47	47	47	47	36
.10	0	0	0	0	0	0	0	0	0	0	1	3	5	11	19	27	34	39	42	47	47	47	47	47	47	47	47	47	47	47	47	36
.20	0	0	0	0	0	0	0	0	0	0	1	2	4	9	17	25	32	37	41	46	47	47	47	47	47	47	47	47	47	47	47	36
.30	0	0	0	0	0	0	0	0	0	0	1	2	3	8	15	23	30	36	40	45	47	47	47	47	47	47	47	47	47	47	47	36
.40	0	0	0	0	0	0	0	0	0	0	0	1	2	7	13	21	28	35	39	45	47	47	47	47	47	47	47	47	47	47	47	37
.50	0	0	0	0	0	0	0	0	0	0	0	1	2	6	12	19	27	33	38	44	46	47	47	47	47	47	47	47	47	47	47	37
.75	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	14	21	28	34	41	45	47	47	47	47	47	47	47	47	47	47	37
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	11	17	24	34	41	46	47	47	47	47	47	47	47	47	47	38
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	10	19	29	39	45	47	47	47	47	47	47	47	47	40
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	9	18	30	41	46	47	47	47	47	47	47	47	41
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	17	31	41	46	47	47	47	47	47	47	42
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	18	32	42	46	47	47	47	47	47	43
			RAINFALL TYPE = I											* * * TC = 1.25 HR * * *														SHEET 8 OF 10				

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																														
	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
IA/P = 0.10 * * * TC =1.5 HR * * *																															
0.0	11	14	19	25	28	32	39	48	60	76	94	112	129	151	163	147	130	112	97	81	69	59	50	44	39	35	32	30	28	26	23	15
.10	10	12	16	22	24	27	30	36	44	55	69	86	103	135	152	159	143	125	108	88	75	62	52	46	41	36	32	30	28	26	23	16
.20	9	11	14	19	21	23	25	29	34	41	50	63	78	112	140	155	152	138	121	98	81	67	55	48	42	37	33	31	28	27	23	16
.30	9	11	14	18	20	22	24	27	31	38	46	57	71	104	133	151	154	141	125	101	84	68	56	48	43	38	34	31	29	27	23	16
.40	8	10	13	17	19	21	23	26	30	35	42	52	65	96	126	147	152	144	129	105	87	70	57	49	43	38	34	31	29	27	23	16
.50	8	9	12	15	17	18	20	22	25	28	33	39	48	73	104	131	148	151	140	117	95	75	60	51	45	40	35	32	29	27	24	17
.75	7	8	11	13	15	16	18	19	21	24	27	32	38	56	82	110	133	146	144	127	106	83	65	54	47	41	36	33	29	27	24	17
1.0	5	7	9	11	11	12	13	15	16	18	19	22	24	32	47	69	96	122	139	145	127	99	74	60	51	44	39	35	30	28	24	17
1.5	4	5	6	8	8	9	10	10	11	12	13	14	16	19	24	32	46	66	90	124	139	128	97	73	59	50	44	39	32	29	25	18
2.0	2	3	4	5	5	6	6	7	7	8	9	9	10	12	14	17	21	27	38	63	96	135	129	100	76	61	51	44	35	30	26	19
2.5	1	2	2	3	4	4	4	5	5	6	6	7	7	8	10	11	14	16	20	31	51	91	132	124	98	75	60	51	39	32	27	20
3.0	0	1	1	2	2	2	2	3	3	3	4	4	5	6	7	8	9	10	12	16	23	42	86	123	128	101	77	62	45	35	28	21
IA/P = 0.30 * * * TC =1.5 HR * * *																															
0.0	0	0	0	0	0	1	3	7	13	21	33	46	60	83	97	106	97	90	84	76	70	64	59	54	50	45	43	41	39	38	34	25
.10	0	0	0	0	0	0	1	2	5	10	18	28	40	66	86	98	103	95	88	80	73	66	60	55	51	47	43	41	39	38	35	25
.20	0	0	0	0	0	0	0	1	4	8	14	23	34	60	81	95	101	97	90	81	74	67	61	56	52	47	44	41	40	38	35	25
.30	0	0	0	0	0	0	0	0	1	3	6	12	19	41	65	85	98	100	95	85	77	69	62	57	53	48	44	42	40	38	35	25
.40	0	0	0	0	0	0	0	0	1	2	5	9	16	36	59	80	94	99	96	87	79	70	63	58	53	49	45	42	40	38	35	26
.50	0	0	0	0	0	0	0	0	1	2	4	8	13	31	54	75	91	98	97	88	80	71	64	58	54	49	45	42	40	38	35	26
.75	0	0	0	0	0	0	0	0	0	0	1	2	4	13	28	49	69	85	95	95	87	76	67	61	56	51	47	44	40	39	36	26
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	13	29	49	69	84	95	92	81	71	63	58	53	49	45	41	39	36	27
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	9	20	35	63	84	92	83	72	64	58	54	49	43	40	37	28
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	9	25	50	79	90	81	71	63	58	53	45	41	38	29
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	18	46	79	88	80	70	63	57	49	42	38	31
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	17	50	79	87	79	70	62	52	45	39	32
IA/P = 0.50 * * * TC =1.5 HR * * *																															
0.0	0	0	0	0	0	0	0	0	0	0	1	2	3	8	15	22	29	34	39	44	46	46	46	46	46	46	46	46	46	46	46	37
.10	0	0	0	0	0	0	0	0	0	0	0	1	2	5	10	17	24	30	35	41	46	46	46	46	46	46	46	46	46	46	46	37
.20	0	0	0	0	0	0	0	0	0	0	0	1	1	4	9	15	22	28	34	40	45	46	46	46	46	46	46	46	46	46	46	37
.30	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	13	20	27	33	39	44	46	46	46	46	46	46	46	46	46	46	38
.40	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	12	18	25	31	38	44	46	46	46	46	46	46	46	46	46	46	38
.50	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	10	17	23	30	37	43	46	46	46	46	46	46	46	46	46	46	38
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	12	19	25	33	40	45	46	46	46	46	46	46	46	46	46	38
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	10	15	25	33	42	46	46	46	46	46	46	46	46	46	39
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	14	23	34	43	46	46	46	46	46	46	46	46	40
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	11	22	35	43	46	46	46	46	46	46	46	42
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	10	23	36	43	46	46	46	46	46	46	43
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	14	27	38	44	46	46	46	46	46	44

RAINFALL TYPE = I * * * TC = 1.5 HR * * * SHEET 9 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

TRVL TIME	HYDROGRAPH TIME (HOURS)																															
(HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
		IA/P = 0.10												* * * TC =2.0 HR * * *														IA/P = 0.10				
0.0	9	11	14	19	21	24	28	33	40	49	59	70	82	106	123	138	138	125	115	97	83	70	59	50	44	39	35	32	29	27	23	16
.10	8	10	13	17	18	20	23	26	31	37	45	54	65	89	110	125	135	130	123	106	90	75	62	53	46	40	36	33	29	27	24	16
.20	8	10	12	16	17	19	22	25	29	34	41	50	60	83	105	121	132	131	125	109	92	77	63	53	46	41	36	33	29	27	24	17
.30	7	9	11	14	15	17	18	21	23	27	32	38	46	66	89	109	123	131	129	117	100	82	66	56	48	42	38	34	30	28	24	17
.40	7	8	10	13	15	16	18	20	22	25	30	35	43	61	83	104	120	131	131	119	103	84	68	57	49	43	38	34	30	28	24	17
.50	6	8	10	13	14	15	17	19	21	24	28	33	39	56	78	99	116	127	130	121	106	86	69	58	50	44	39	35	30	28	24	17
.75	5	7	8	11	12	13	14	15	16	18	20	23	27	38	53	73	93	111	123	127	118	98	77	63	54	47	41	37	31	28	25	17
1.0	4	5	7	8	9	10	11	12	13	14	15	17	18	24	32	45	63	83	102	122	126	113	89	71	59	51	44	39	32	29	25	18
1.5	3	4	5	6	7	7	8	8	9	10	10	11	12	15	18	23	32	44	60	88	111	123	110	87	70	58	50	44	35	30	26	19
2.0	1	2	3	4	5	5	5	6	6	7	7	8	9	10	12	14	18	23	31	49	74	106	121	107	86	69	58	49	38	32	27	20
2.5	1	1	2	2	3	3	3	4	4	4	5	5	6	7	8	9	11	13	16	22	35	62	101	118	108	88	71	59	44	35	28	21
3.0	0	0	1	1	1	2	2	2	3	3	3	3	4	5	5	6	8	9	10	14	19	34	67	103	116	105	86	70	50	39	29	21
		IA/P = 0.30												* * * TC =2.0 HR * * *														IA/P = 0.30				
0.0	0	0	0	0	0	0	1	3	6	10	16	23	31	49	65	77	84	92	86	80	75	69	63	58	53	49	45	43	40	38	35	26
.10	0	0	0	0	0	0	0	1	2	5	9	13	19	35	53	68	79	85	90	83	77	71	64	59	55	50	46	43	40	39	35	26
.20	0	0	0	0	0	0	0	0	1	2	4	7	11	24	40	57	71	81	89	89	80	73	66	61	56	51	47	44	41	39	35	26
.30	0	0	0	0	0	0	0	0	1	1	3	6	9	20	36	53	68	78	84	88	81	74	67	61	56	52	48	44	41	39	36	26
.40	0	0	0	0	0	0	0	0	0	0	1	2	5	12	24	40	57	70	80	87	84	76	69	63	58	53	49	45	41	39	36	27
.50	0	0	0	0	0	0	0	0	0	0	1	2	4	10	21	36	53	67	77	87	85	77	69	63	58	54	49	46	41	39	36	27
.75	0	0	0	0	0	0	0	0	0	0	0	1	2	6	14	26	41	56	69	82	85	80	72	65	60	55	51	47	42	40	36	27
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	20	34	49	68	81	85	77	69	63	58	53	49	43	40	37	28
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	19	38	58	78	83	76	68	62	57	53	45	41	37	29
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	13	29	55	77	82	75	68	62	57	48	43	38	30
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	22	51	75	81	75	68	62	53	45	39	32
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	25	54	75	80	75	68	57	48	40	33
		IA/P = 0.50												* * * TC =2.0 HR * * *														IA/P = 0.50				
0.0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	8	13	18	24	29	36	41	46	46	46	46	46	46	46	46	46	46	38
.10	0	0	0	0	0	0	0	0	0	0	0	1	1	3	7	12	17	22	28	35	40	45	46	46	46	46	46	46	46	46	46	38
.20	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	8	13	18	24	31	38	44	46	46	46	46	46	46	46	46	46	39
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	7	12	17	22	30	37	43	45	46	46	46	46	46	46	46	46	39
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	11	16	21	29	36	42	45	46	46	46	46	46	46	46	46	39
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	5	9	14	20	28	35	42	45	45	45	45	45	45	45	45	45	39
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	9	13	18	26	33	41	45	45	45	45	45	45	45	45	45	39
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	5	9	16	24	33	42	45	45	45	45	45	45	45	45	40
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	8	15	25	36	43	45	45	45	45	45	45	45	42
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	14	26	37	43	45	45	45	45	45	45	43
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	15	27	37	43	45	45	45	45	45	44
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	19	30	39	44	45	45	45	45	45

RAINFALL TYPE = I

* * * TC = 2.0 HR * * *

SHEET 10 OF 10

Exhibit 5-IA: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																															
	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
IA/P = 0.10														* * * TC =0.1 HR * * *															IA/P = 0.10			
0.0	28	36	50	143	154	163	140	103	87	76	68	67	65	61	54	49	45	44	44	41	40	39	36	33	32	32	31	30	30	29	26	21
.10	27	32	43	104	130	146	157	145	117	97	83	73	69	65	59	53	48	45	45	42	40	39	37	34	33	32	32	31	30	29	27	22
.20	26	29	37	59	89	116	136	150	147	127	107	91	79	68	63	57	52	47	45	44	41	39	37	35	33	32	32	31	30	29	27	22
.30	25	28	35	53	77	103	125	142	145	133	116	99	86	71	65	59	53	48	46	44	41	39	38	35	33	32	32	31	30	29	27	22
.40	24	26	31	41	49	68	91	114	132	141	136	122	107	82	70	63	57	52	48	45	43	40	38	36	33	32	32	31	30	29	27	22
.50	24	26	30	39	46	60	81	103	123	135	135	127	114	88	73	65	59	53	49	45	43	40	39	36	33	33	32	31	30	29	27	22
.75	20	24	27	32	35	39	47	60	76	94	111	122	125	114	94	79	68	61	55	48	45	42	39	37	35	33	32	32	30	30	27	22
1.0	16	20	24	27	28	30	32	36	41	49	62	77	94	118	122	104	86	74	65	55	49	44	41	39	36	34	33	32	31	30	28	23
1.5	12	15	18	22	23	24	25	27	28	30	32	36	42	61	86	107	112	104	91	73	60	50	44	41	38	36	34	33	31	30	28	23
2.0	7	10	12	15	16	18	19	20	21	22	24	25	26	30	36	50	69	90	106	103	87	67	52	45	41	39	36	34	32	31	29	24
2.5	4	6	8	11	12	13	14	15	16	17	18	19	21	23	26	30	36	49	66	91	101	89	66	51	44	41	38	36	33	31	29	25
3.0	2	3	5	7	8	9	10	11	11	12	13	14	16	18	20	23	25	29	36	55	79	98	86	65	51	44	41	38	34	32	30	25
IA/P = 0.30														* * * TC =0.1 HR * * *															IA/P = 0.30			
0.0	0	0	1	45	65	89	78	64	59	54	54	53	51	50	48	45	44	43	43	43	42	42	41	40	40	40	40	40	39	39	38	33
.10	0	0	0	18	36	55	78	78	69	62	57	55	53	51	50	47	44	44	43	43	42	42	41	40	40	40	40	40	39	39	38	34
.20	0	0	0	13	29	46	67	74	71	65	60	56	54	52	50	48	45	44	43	43	43	42	41	41	40	40	40	40	39	39	38	34
.30	0	0	0	10	22	38	58	69	70	67	62	58	56	52	51	48	46	44	44	43	43	42	41	41	40	40	40	40	39	39	38	34
.40	0	0	0	2	7	17	31	49	62	67	67	64	60	55	52	50	48	45	44	43	43	42	42	41	40	40	40	40	39	39	38	34
.50	0	0	0	1	5	13	25	41	55	63	66	64	61	56	53	51	48	46	44	43	43	42	42	41	40	40	40	40	39	39	38	34
.75	0	0	0	0	0	2	6	13	24	36	47	55	61	61	57	54	51	49	47	44	43	43	42	41	41	40	40	40	40	39	38	34
1.0	0	0	0	0	0	1	3	8	15	25	36	46	53	60	59	55	53	50	48	45	44	43	42	42	41	40	40	40	40	39	38	35
1.5	0	0	0	0	0	0	0	0	1	2	5	9	15	31	47	55	57	56	53	50	46	44	43	42	41	41	40	40	40	39	39	35
2.0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	15	28	42	51	55	54	51	47	44	43	42	41	41	40	40	39	39	36
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	14	26	38	50	54	52	47	44	43	42	41	40	40	40	39	36
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	13	29	43	53	51	47	44	43	42	41	40	40	39	37
IA/P = 0.50														* * * TC =0.1 HR * * *															IA/P = 0.50			
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	12	14	18	21	23	26	30	32	33	37	38	41	42	46	48	53	49
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	9	12	15	19	22	25	29	32	32	35	39	41	42	45	48	53	49
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7	11	14	18	22	24	28	32	32	35	39	41	42	45	48	53	49
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	8	12	15	20	23	27	31	31	34	39	40	41	45	48	53	49
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	9	13	18	22	25	30	31	33	37	39	41	44	47	53	49
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	10	15	20	24	29	31	32	36	39	41	44	47	53	53
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	11	16	21	26	30	31	34	38	40	43	46	53	53
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	11	17	23	28	31	32	35	39	42	45	53	53
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	17	23	28	31	32	35	40	43	49	52
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	17	23	28	31	32	38	42	48	52
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	18	24	28	31	36	40	47	52
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	11	18	24	28	33	39	45	52

RAINFALL TYPE = IA

* * * TC = 0.1 HR * * *

SHEET 1 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

```
TRVL  ------------------------------------------------------------------ HYDROGRAPH TIME (HOURS) ------------------------------------------------------------------
TIME         7.3       7.9       8.1       8.3       8.5       8.7       9.0       9.4       9.8      10.3      11.0      12.0      13.0      14.0      16.0      22.0
(HR)    7.0       7.6       8.0       8.2       8.4       8.6       8.8       9.2       9.6      10.0      10.6      11.5      12.5      13.5      15.0      18.0
------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
           IA/P = 0.10                                             * * * TC =0.2  HR * * *                                                     IA/P = 0.10
------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
0.0      27   34   46  124  143  153  153  127  103   87   76   68   67   63   57   51   47   45   44   42   40   39   36   33   33   32   32   31   30   29   27   21
.10      27   33   44  108  131  146  151  135  113   96   83   73   69   65   59   53   48   45   45   42   40   39   37   33   33   32   32   31   30   29   27   22
.20      26   29   38   67   95  119  137  146  139  122  105   90   79   69   63   57   52   47   45   44   41   39   37   34   33   32   32   31   30   29   27   22
.30      25   27   33   45   60   83  107  127  140  139  128  112   97   76   68   62   56   50   47   45   42   40   38   35   33   33   32   31   30   29   27   22

.40      24   27   32   43   54   73   96  117  132  137  131  118  104   81   70   63   57   52   48   45   43   40   38   36   33   33   32   32   30   29   27   22
.50      23   25   29   37   41   50   65   86  106  124  132  131  123   98   79   69   62   56   51   46   44   41   39   37   34   33   32   32   30   29   27   22
.75      20   24   27   33   36   41   50   63   80   97  112  121  123  111   93   78   68   61   55   48   45   42   39   37   34   33   32   32   30   30   27   22
1.0      16   20   24   27   29   31   33   37   43   52   65   81   96  120  120  102   85   73   64   55   49   44   41   39   36   34   33   32   31   30   28   23

1.5      12   15   19   22   23   24   26   27   28   30   33   37   44   63   88  107  111  102   89   72   60   50   44   41   38   36   34   33   32   30   28   23
2.0       7   10   12   16   17   18   19   20   22   23   24   25   27   30   38   52   71   91  105  101   86   66   52   45   41   39   36   34   32   31   29   24
2.5       4    6    9   11   12   13   14   15   16   17   19   20   21   23   26   30   38   50   68   92  101   88   65   51   44   41   38   36   33   31   29   25
3.0       2    3    5    7    7    8    9   10   11   12   13   14   15   17   19   22   24   28   33   49   72   97   89   68   53   45   41   39   34   32   30   25
------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
           IA/P = 0.30                                             * * * TC =0.2  HR * * *                                                     IA/P = 0.30
------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
0.0       0    0    0   26   45   64   76   74   65   59   55   53   52   51   49   46   44   44   43   43   42   42   41   40   40   40   40   40   39   39   38   33
.10       0    0    0   20   37   55   69   72   67   62   57   54   53   52   50   47   44   44   43   43   42   42   41   40   40   40   40   40   39   39   38   34
.20       0    0    0    5   15   30   47   61   68   68   64   59   56   53   52   49   46   44   44   43   43   42   42   41   40   40   40   40   39   39   38   34
.30       0    0    0    4   11   23   39   54   64   66   65   61   58   54   52   50   47   45   44   43   43   42   42   41   40   40   40   40   39   39   38   34

.40       0    0    0    3    8   18   32   47   58   64   64   62   59   55   52   50   48   45   44   43   43   42   42   41   40   40   40   40   40   39   38   34
.50       0    0    0    0    2    6   14   26   40   52   60   63   62   58   54   52   50   47   45   44   43   42   42   41   40   40   40   40   40   39   38   34
.75       0    0    0    0    1    3    7   14   24   35   45   53   57   59   56   54   51   49   47   44   43   43   42   41   41   40   40   40   40   39   38   34
1.0       0    0    0    0    0    0    1    4    8   15   25   35   44   56   58   56   54   51   49   46   44   43   42   42   41   40   40   40   40   39   39   35

1.5       0    0    0    0    0    0    0    0    0    1    2    5    9   23   38   50   55   56   54   51   47   44   43   42   42   41   40   40   40   39   39   35
2.0       0    0    0    0    0    0    0    0    0    0    0    1    1    6   15   27   40   49   54   54   51   47   44   43   42   41   41   40   40   40   39   36
2.5       0    0    0    0    0    0    0    0    0    0    0    0    0    0    2    6   14   25   36   49   53   51   47   44   43   42   41   41   40   40   39   36
3.0       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    2    6   13   28   42   52   51   47   44   43   42   41   40   40   39   37
------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
           IA/P = 0.50                                             * * * TC =0.2  HR * * *                                                     IA/P = 0.50
------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
0.0       0    0    0    0    0    0    0    0    0    0    0    0    0    0    5   10   13   16   19   23   25   29   32   33   36   39   41   42   46   48   50   49
.10       0    0    0    0    0    0    0    0    0    0    0    0    0    0    2    6   10   14   17   21   24   28   31   32   35   40   41   42   45   48   50   49
.20       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    3    7   11   15   19   23   26   31   31   34   39   40   41   45   48   50   49
.30       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    4    8   12   17   21   25   30   31   33   37   39   41   44   47   50   50

.40       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    2    5    9   15   19   23   28   31   32   35   39   41   44   47   50   50
.50       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    3    6   12   17   22   27   31   32   34   39   40   43   46   50   50
.75       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    4    9   14   20   25   30   31   33   37   39   42   46   50   50
1.0       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    4    9   16   22   27   31   32   35   38   42   45   49   50

1.5       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    3    8   17   23   28   31   32   35   40   43   49   50
2.0       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    2    9   17   23   28   31   32   38   42   48   50
2.5       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    2    9   16   22   27   30   35   40   46   50
3.0       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    3    9   17   23   27   33   38   45   50
------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
           RAINFALL TYPE =  IA                                     * * * TC = 0.2  HR * * *                                                    SHEET  2 OF 10
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Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

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TRVL ------------------------------------------------------------ HYDROGRAPH TIME (HOURS) ---------------------------------------------------------------------
TIME       7.3       7.9       8.1       8.3       8.5       8.7       9.0       9.4       9.8      10.3      11.0      12.0      13.0      14.0      16.0      22.0
(HR)  7.0       7.6       8.0       8.2       8.4       8.6       8.8       9.2       9.6      10.0      10.6      11.5      12.5      13.5      15.0      18.0
--------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
          IA/P = 0.10                                         * * * TC =0.3  HR * * *                                                  IA/P = 0.10
--------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
0.0    26   31   41   92  120  138  145  144  125  105   90   78   71   66   60   54   49   46   45   43   40   39   37   34   33   32   32   31   30   29   27   22
.10    26   30   39   80  106  128  139  142  131  113   98   85   76   68   62   56   51   47   45   43   41   39   37   34   33   32   32   31   30   29   27   22
.20    25   28   34   51   70   94  117  131  139  133  120  105   92   74   67   60   54   49   46   44   42   40   38   35   33   33   32   31   30   29   27   22
.30    24   26   31   40   47   62   84  106  123  133  133  124  112   87   73   65   59   53   49   45   43   40   39   36   33   33   32   32   30   29   27   22

.40    23   26   30   38   44   56   75   95  114  127  131  127  117   93   76   67   60   55   50   46   43   40   39   36   34   33   32   32   30   29   27   22
.50    21   25   28   34   37   42   51   67   86  104  119  127  127  110   88   74   66   59   53   47   45   41   39   37   34   33   32   32   30   30   27   22
.75    19   23   26   31   33   36   42   51   64   80   96  109  119  116  102   85   73   65   58   50   46   43   40   38   35   33   33   32   31   30   28   23
1.0    15   19   23   26   27   29   31   33   37   44   53   66   80  106  116  109   93   79   69   58   51   45   41   39   37   34   33   32   31   30   28   23

1.5    11   14   17   21   22   23   24   26   27   29   31   34   38   53   75   97  109  106   96   78   64   52   45   41   39   36   34   33   32   30   28   24
2.0     6    9   11   14   16   17   18   19   20   21   23   24   25   28   34   44   61   81   97  103   91   71   54   46   42   39   37   34   32   31   29   24
2.5     4    5    8   10   11   12   13   14   15   16   17   19   20   22   25   28   34   44   58   84   99   92   70   54   46   41   39   36   33   32   29   25
3.0     2    3    5    7    7    8    9   10   11   12   13   14   15   17   19   22   24   28   33   49   71   96   89   68   53   45   41   39   34   32   30   25
--------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
          IA/P = 0.30                                         * * * TC =0.3  HR * * *                                                  IA/P = 0.30
--------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
0.0     0    0    0   13   28   45   63   69   69   65   60   55   53   53   51   48   45   44   43   43   42   42   42   40   40   40   40   40   39   39   38   34
.10     0    0    0    9   21   37   54   64   67   65   62   57   54   53   51   49   46   44   43   43   42   42   42   41   40   40   40   40   40   39   38   34
.20     0    0    0    7   17   30   46   58   64   65   63   59   56   53   52   49   46   44   44   43   42   42   42   41   40   40   40   40   40   39   38   34
.30     0    0    0    1    5   13   25   39   52   60   63   63   60   55   53   51   49   46   44   43   43   42   42   41   40   40   40   40   40   39   38   34

.40     0    0    0    1    4   10   20   33   45   55   61   62   61   56   54   52   49   46   45   43   43   42   42   41   40   40   40   40   40   39   38   34
.50     0    0    0    1    3    7   15   27   39   50   57   60   61   57   54   52   50   47   45   44   43   42   42   41   40   40   40   40   40   39   38   34
.75     0    0    0    0    1    3    8   15   24   34   43   51   55   58   56   54   52   49   47   44   43   43   42   41   41   40   40   40   40   39   38   34
1.0     0    0    0    0    0    0    0    2    4    9   16   25   34   49   56   57   55   53   50   47   44   43   42   42   41   40   40   40   40   39   39   35

1.5     0    0    0    0    0    0    0    0    0    1    3    5   10   23   37   49   54   55   54   51   47   44   43   42   42   41   40   40   40   39   39   35
2.0     0    0    0    0    0    0    0    0    0    0    0    0    1    3   10   21   33   44   51   54   52   48   44   43   42   41   41   40   40   40   39   36
2.5     0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    4   10   19   30   45   53   53   48   44   43   42   41   41   40   40   39   37
3.0     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    4    9   23   37   50   52   47   44   43   42   41   40   40   39   37
--------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
          IA/P = 0.50                                         * * * TC =0.3  HR * * *                                                  IA/P = 0.50
--------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
0.0     0    0    0    0    0    0    0    0    0    0    0    0    0    0    3    7   11   14   18   22   24   28   32   32   35   40   41   42   45   48   48   48
.10     0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    4    8   12   15   20   23   27   31   31   34   39   40   41   45   48   48   48
.20     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    5    9   13   18   21   25   30   31   33   37   39   41   44   47   48   48
.30     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    4    8   12   17   21   25   30   31   33   37   39   41   44   47   48   48

.40     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    2    5    9   14   19   23   28   31   32   35   39   41   44   47   48   48
.50     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    4   10   15   21   26   30   31   33   38   40   43   46   48   48
.75     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    3    7   13   19   24   29   31   33   36   39   42   46   48   48
1.0     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    4    9   16   22   27   31   32   35   38   42   45   48   48

1.5     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    3    8   16   23   27   31   32   35   40   43   48   48
2.0     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    2    8   16   22   27   30   32   38   42   47   48
2.5     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    2    9   16   22   27   30   35   40   46   48
3.0     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    3    9   17   23   27   33   38   45   48
--------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
          RAINFALL TYPE =  IA                                 * * * TC = 0.3  HR * * *                                                 SHEET  3 OF 10
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Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																														
	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
IA/P = 0.10															* * * TC =0.4 HR * * *														IA/P = 0.10			
0.0	26	29	37	67	93	117	134	137	136	121	105	91	81	70	64	58	52	48	46	44	41	40	37	34	33	33	32	31	30	29	27	22
.10	25	29	36	60	82	105	124	133	135	126	112	98	87	73	66	59	53	49	46	44	41	40	38	34	33	33	32	31	30	29	27	22
.20	24	27	32	43	55	73	94	114	127	132	128	117	104	83	71	64	58	52	48	45	43	40	38	35	33	33	32	32	30	29	27	22
.30	24	26	31	41	50	65	85	104	119	128	128	121	110	88	74	66	59	54	49	46	43	40	39	35	34	33	32	32	30	29	27	22
.40	22	25	28	35	39	46	59	76	95	111	122	126	122	104	85	72	64	58	52	47	44	41	39	37	34	33	32	32	30	29	27	22
.50	20	23	26	31	34	37	43	54	69	86	103	116	123	117	98	82	71	63	56	49	46	42	40	38	34	33	33	32	30	30	27	22
.75	16	20	24	27	29	31	33	37	43	53	65	80	94	116	116	101	86	74	65	56	49	44	41	39	36	34	33	32	31	30	28	23
1.0	14	18	22	25	26	27	29	31	34	38	45	54	67	93	111	113	101	87	75	62	53	47	42	40	37	34	33	33	31	30	28	23
1.5	10	13	16	20	21	22	23	24	26	27	29	31	34	45	64	86	102	107	101	84	69	55	46	42	39	37	34	33	32	30	28	24
2.0	6	8	11	13	14	16	17	18	19	20	21	23	24	27	31	39	52	71	88	102	96	76	57	47	42	40	37	35	33	31	29	24
2.5	3	5	7	9	10	11	12	13	14	15	16	17	18	21	23	26	31	38	51	75	94	98	74	57	47	42	39	37	33	32	30	25
3.0	1	2	4	6	7	7	8	9	10	11	12	13	14	16	18	20	23	26	30	43	64	89	95	72	56	47	42	39	34	33	30	25
IA/P = 0.30															* * * TC =0.4 HR * * *														IA/P = 0.30			
0.0	0	0	0	6	15	29	46	60	65	65	63	59	56	53	52	49	47	44	44	43	42	42	42	41	40	40	40	40	40	39	38	34
.10	0	0	0	4	12	23	38	53	61	63	63	60	57	54	53	50	47	45	44	43	42	42	42	41	40	40	40	40	40	39	38	34
.20	0	0	0	3	9	19	32	46	56	61	62	61	59	55	53	51	48	45	44	43	43	42	42	41	40	40	40	40	40	39	38	34
.30	0	0	0	2	7	15	26	39	50	57	61	61	59	56	53	51	49	46	44	44	43	42	42	41	40	40	40	40	40	39	38	34
.40	0	0	0	0	2	5	11	21	33	44	53	58	60	58	55	53	51	48	45	44	43	42	42	41	40	40	40	40	40	39	38	34
.50	0	0	0	0	1	4	9	17	28	39	48	55	59	59	56	53	51	49	46	44	43	42	42	41	40	40	40	40	40	39	38	34
.75	0	0	0	0	0	2	4	9	16	25	34	43	49	57	57	55	53	50	48	45	44	43	42	41	41	40	40	40	40	39	39	35
1.0	0	0	0	0	0	0	1	2	5	10	17	25	34	48	55	56	55	53	50	47	45	43	42	42	41	40	40	40	40	39	39	35
1.5	0	0	0	0	0	0	0	0	0	0	1	3	6	16	30	43	51	55	55	52	49	45	43	42	42	41	40	40	40	40	39	36
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	15	27	39	47	53	53	49	45	43	42	42	41	40	40	40	39	36
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	7	14	25	40	50	52	49	45	43	42	41	41	40	40	39	37
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	18	32	47	52	48	45	43	42	41	40	40	39	37
IA/P = 0.50															* * * TC =0.4 HR * * *														IA/P = 0.50			
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	9	13	16	20	23	27	31	32	34	39	40	42	45	47	47	47
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	10	13	18	22	26	30	31	33	38	39	41	45	47	47	47
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	11	16	20	24	29	31	33	36	39	41	44	47	47	47
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	8	13	18	23	28	31	32	35	39	41	43	47	47	47
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	16	21	26	30	32	34	38	40	43	46	47	47
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	13	19	25	29	31	33	37	39	42	46	47	47
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	11	17	23	28	31	32	35	39	42	45	47	47
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	12	20	25	29	31	33	37	41	44	47	47
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	13	20	26	30	31	34	40	43	47	47
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	14	21	26	30	32	37	41	47	47
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	15	21	26	30	34	40	46	47
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	15	22	27	32	38	45	47

RAINFALL TYPE = IA * * * TC = 0.4 HR * * * SHEET 4 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

HYDROGRAPH TIME (HOURS)

IA/P = 0.10   * * * TC =0.5 HR * * *   IA/P = 0.10

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
0.0	25	28	34	53	72	94	115	129	130	129	117	104	92	76	68	61	55	50	47	44	42	40	38	34	33	33	32	31	30	29	27	22
.10	24	27	33	49	64	84	105	121	127	128	121	109	98	80	70	63	57	51	48	45	42	40	38	34	33	33	32	32	30	29	27	22
.20	23	26	30	39	46	58	75	95	112	122	126	123	114	93	78	69	61	55	50	46	44	41	39	36	34	33	32	32	30	29	27	22
.30	21	24	27	34	37	43	53	68	86	103	116	123	123	108	89	76	67	60	54	48	45	42	39	37	34	33	33	32	30	30	27	22
.40	20	24	27	32	35	40	49	61	78	95	109	118	121	111	93	79	69	62	55	49	45	42	40	37	34	33	33	32	30	30	27	22
.50	18	22	25	29	31	34	38	45	56	70	87	101	113	118	106	89	77	67	60	52	47	43	40	38	35	33	33	32	31	30	28	23
.75	15	19	23	26	27	29	31	34	38	45	54	67	80	104	112	106	93	80	70	59	51	46	41	39	36	34	33	33	31	30	28	23
1.0	13	16	20	24	25	26	27	29	31	34	39	46	56	80	102	110	105	93	81	66	56	48	43	40	38	35	33	33	31	30	28	23
1.5	9	12	15	18	20	21	22	23	24	26	27	29	31	39	55	75	94	104	103	89	74	58	48	43	40	37	35	33	32	31	29	24
2.0	5	7	10	12	13	14	15	17	18	19	20	21	23	25	29	35	45	62	79	100	100	81	61	49	43	40	38	35	33	31	29	25
2.5	3	4	6	8	9	10	11	12	13	14	15	16	17	20	22	25	28	34	45	67	88	96	79	60	49	43	40	37	33	32	30	25
3.0	1	2	3	5	6	7	7	8	9	10	11	12	13	15	17	19	21	24	28	38	56	83	93	77	59	48	43	40	35	33	30	26

IA/P = 0.30   * * * TC =0.5 HR * * *   IA/P = 0.30

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
0.0	0	0	0	2	8	18	31	46	57	61	61	61	58	54	53	51	48	45	44	44	43	42	42	41	40	40	40	40	40	39	38	34
.10	0	0	0	2	6	14	25	39	51	58	60	61	59	55	53	51	49	46	44	44	43	42	42	41	40	40	40	40	40	39	38	34
.20	0	0	0	0	1	4	11	21	33	45	54	58	60	58	55	53	51	48	46	44	43	42	42	41	40	40	40	40	40	39	38	34
.30	0	0	0	0	1	3	8	16	27	39	49	55	59	59	55	53	51	49	46	44	43	42	42	41	40	40	40	40	40	39	39	34
.40	0	0	0	0	1	2	6	13	23	34	44	51	56	58	56	54	52	49	47	44	43	42	42	41	40	40	40	40	40	39	39	34
.50	0	0	0	0	0	0	2	5	10	18	29	39	47	56	57	55	53	51	49	45	44	43	42	41	41	40	40	40	40	39	39	35
.75	0	0	0	0	0	0	1	2	5	10	17	25	34	48	54	56	55	53	50	47	45	43	42	42	41	40	40	40	40	39	39	35
1.0	0	0	0	0	0	0	0	0	0	1	3	6	11	26	41	51	55	55	54	50	47	44	43	42	41	41	40	40	40	40	39	35
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	23	36	47	52	54	52	48	44	43	42	41	40	40	40	40	39	36
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	16	27	38	49	53	51	47	44	42	42	41	40	40	40	39	36
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	15	30	43	52	50	46	44	42	42	41	40	40	39	37
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	10	23	40	51	50	46	44	42	42	40	40	39	37

IA/P = 0.50   * * * TC =0.5 HR * * *   IA/P = 0.50

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	11	14	19	22	26	30	31	34	38	40	41	45	46	46	46
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	8	12	17	21	25	29	31	33	37	39	41	44	46	46	46
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	9	14	19	23	28	31	32	35	39	41	43	46	46	46
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	12	17	22	27	31	32	34	38	40	43	46	46	46
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	16	21	26	30	32	34	38	40	43	46	46	46
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	13	19	25	29	31	33	37	39	42	46	46	46
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	11	17	23	28	31	32	35	39	42	45	46	46
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	18	24	29	31	33	36	41	44	46	46
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	19	24	29	31	33	39	42	46	46
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	12	19	25	29	31	37	41	46	46
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	13	20	25	29	34	39	45	46
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	14	20	26	32	37	44	46

RAINFALL TYPE = IA   * * * TC = 0.5 HR * * *   SHEET 5 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
		IA/P = 0.10												* * * TC =0.75 HR * * *														IA/P = 0.10				
0.0	22	25	29	38	45	56	71	87	103	114	117	117	111	95	81	72	65	58	53	48	45	41	39	36	33	33	33	32	30	29	27	22
.10	21	25	28	36	42	51	64	79	95	108	114	116	113	99	85	74	66	60	54	48	45	42	39	37	34	33	33	32	30	30	27	22
.20	19	23	26	32	35	39	47	58	72	87	101	110	114	109	95	82	72	65	58	51	47	43	40	38	34	33	33	32	31	30	27	23
.30	19	22	26	31	33	37	44	54	66	80	94	104	112	110	98	85	75	67	60	52	47	43	40	38	34	33	33	32	31	30	28	23
.40	17	21	24	28	30	32	36	41	49	61	74	87	99	111	106	94	82	73	65	56	49	45	41	39	35	33	33	33	31	30	28	23
.50	16	20	23	27	29	31	34	39	46	56	68	81	93	109	107	97	85	75	67	57	50	45	41	39	36	33	33	33	31	30	28	23
.75	15	18	22	25	27	28	31	34	38	45	54	64	75	95	104	102	93	83	74	62	54	47	42	40	37	34	33	33	31	30	28	23
1.0	12	15	18	22	23	24	25	27	29	31	34	39	46	65	85	100	103	98	88	74	62	52	45	41	39	35	33	33	32	30	28	23
1.5	7	10	12	15	17	18	19	20	21	22	24	25	26	31	39	53	71	87	99	99	85	68	53	46	41	39	36	34	33	31	29	24
2.0	4	6	8	11	12	13	14	15	16	17	18	19	21	23	26	31	39	51	67	88	95	86	67	53	45	41	38	36	33	32	29	25
2.5	2	3	5	7	8	9	10	11	11	12	13	14	16	18	20	23	26	30	38	56	77	93	84	66	52	45	41	38	34	33	30	25
3.0	0	1	2	4	4	5	6	6	7	8	8	9	10	12	14	16	18	21	24	30	42	67	90	84	68	54	46	42	36	33	30	26
		IA/P = 0.30												* * * TC =0.75 HR * * *														IA/P = 0.30				
0.0	0	0	0	0	2	4	10	19	29	39	48	53	56	56	54	53	51	49	46	44	44	42	42	40	40	40	40	40	40	39	39	34
.10	0	0	0	0	1	3	8	15	24	34	43	50	54	56	54	53	52	49	47	45	44	42	42	41	40	40	40	40	40	39	39	34
.20	0	0	0	0	0	1	2	6	12	20	30	39	46	54	55	54	53	51	49	46	44	43	42	41	40	40	40	40	40	39	39	35
.30	0	0	0	0	0	1	2	5	10	17	25	34	42	52	55	54	53	51	49	46	44	43	42	42	40	40	40	40	40	39	39	35
.40	0	0	0	0	0	0	1	4	8	14	21	30	38	50	55	55	53	52	50	47	45	43	42	42	40	40	40	40	40	39	39	35
.50	0	0	0	0	0	0	1	3	6	11	18	26	34	47	53	54	54	52	50	47	45	43	42	42	40	40	40	40	40	39	39	35
.75	0	0	0	0	0	0	0	1	3	6	10	16	23	37	47	52	53	53	52	49	46	44	42	42	41	40	40	40	40	40	39	35
1.0	0	0	0	0	0	0	0	0	0	1	2	4	7	17	30	42	50	53	53	51	49	45	43	42	41	40	40	40	40	40	39	36
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	21	33	43	49	52	51	48	45	43	42	41	40	40	40	40	39	36
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	20	30	43	50	51	48	45	43	42	41	40	40	40	39	37
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	10	23	36	48	51	47	44	43	42	41	40	40	39	37
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	17	34	48	50	47	44	43	42	40	40	39	38
		IA/P = 0.50												* * * TC =0.75 HR * * *														IA/P = 0.50				
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	10	15	19	23	28	31	32	36	39	41	44	44	44	44
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	7	12	17	22	27	30	32	34	38	40	43	44	44	44
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	10	15	20	25	30	31	33	37	39	43	44	44	44
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	12	18	24	29	31	33	36	39	42	44	44	44
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	10	16	22	27	30	32	35	38	42	44	44	44
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	14	21	26	30	31	34	38	41	44	44	44
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	19	24	29	31	33	36	41	44	44	44
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	16	22	27	30	32	35	40	43	44	44
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	9	16	23	27	30	32	38	42	44	44
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	17	23	28	30	36	40	44	44
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	18	23	28	33	39	44	44
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	17	23	30	36	43	44

RAINFALL TYPE = IA * * * TC = 0.75 HR * * * SHEET 6 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																															
	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
IA/P = 0.10 * * * TC =1.0 HR * * * IA/P = 0.10																																
0.0	19	23	26	33	37	43	52	63	76	88	97	104	108	102	91	81	72	65	59	52	48	43	40	38	34	33	33	32	31	30	28	23
.10	19	22	26	32	35	41	48	58	70	82	92	100	105	103	94	83	75	67	61	53	48	44	40	38	35	33	33	32	31	30	28	23
.20	17	21	24	28	30	34	38	45	54	65	76	87	96	104	100	91	81	73	66	57	51	45	41	39	36	33	33	33	31	30	28	23
.30	16	20	23	27	29	32	36	42	50	60	71	81	91	103	101	93	84	75	67	58	52	46	42	39	36	34	33	33	31	30	28	23
.40	15	18	22	25	27	29	31	35	40	46	55	65	76	94	102	99	91	81	73	63	55	48	43	40	37	34	33	33	31	30	28	23
.50	14	18	21	25	26	28	30	33	37	43	51	61	71	90	101	101	93	84	75	64	56	49	43	40	37	34	33	33	31	30	28	23
.75	13	16	19	23	24	25	27	29	32	37	42	49	58	76	91	98	96	89	81	70	60	51	45	41	38	35	34	33	32	30	28	23
1.0	10	13	16	19	20	22	23	24	26	27	30	33	37	50	67	83	94	97	93	81	70	58	48	43	40	37	34	33	32	31	29	24
1.5	6	8	10	13	14	15	16	18	19	20	21	22	24	27	33	42	56	71	84	93	89	75	59	49	44	40	37	35	33	31	29	24
2.0	3	5	7	9	10	11	12	13	14	15	16	17	18	21	23	27	32	41	53	74	88	91	74	59	49	43	40	37	34	32	30	25
2.5	1	2	4	6	7	7	8	9	10	11	11	12	13	16	18	20	23	26	32	45	64	84	89	72	58	48	43	40	34	33	30	26
3.0	0	1	2	3	3	4	4	5	6	6	7	8	9	10	12	14	16	18	21	26	35	55	81	87	73	59	50	44	37	34	31	26
IA/P = 0.30 * * * TC =1.0 HR * * * IA/P = 0.30																																
0.0	0	0	0	0	1	2	5	10	16	23	31	38	44	51	53	52	52	50	48	46	44	43	42	41	40	40	40	40	40	40	39	35
.10	0	0	0	0	0	1	2	4	8	13	20	27	35	46	51	53	52	51	50	47	45	44	42	42	40	40	40	40	40	40	39	35
.20	0	0	0	0	0	0	1	3	6	11	17	24	31	43	50	52	52	51	50	47	45	44	42	42	40	40	40	40	40	40	39	35
.30	0	0	0	0	0	0	1	2	5	9	14	21	28	40	48	52	52	52	50	48	46	44	43	42	40	40	40	40	40	40	39	35
.40	0	0	0	0	0	0	0	1	2	4	7	12	18	31	42	49	52	52	51	49	47	45	43	42	41	40	40	40	40	40	39	35
.50	0	0	0	0	0	0	0	1	1	3	6	10	15	28	39	47	51	52	51	49	47	45	43	42	41	40	40	40	40	40	39	35
.75	0	0	0	0	0	0	0	0	1	1	3	6	9	19	31	41	47	50	51	50	48	46	43	42	41	40	40	40	40	40	39	36
1.0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	14	25	36	44	49	51	50	47	45	43	42	41	40	40	40	40	39	36
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	13	23	33	44	49	50	47	44	43	42	41	40	40	40	39	37
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	13	25	38	48	50	47	44	43	42	41	40	40	39	37
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	9	19	36	48	49	47	44	43	42	40	40	39	38
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	18	37	47	49	46	44	43	41	40	40	38
IA/P = 0.50 * * * TC =1.0 HR * * * IA/P = 0.50																																
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	7	11	16	21	26	30	32	34	38	40	43	43	43	43
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	9	14	19	25	29	31	33	37	39	42	43	43	43
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	11	17	23	28	30	32	36	39	42	43	43	43
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	9	15	21	27	30	32	35	38	41	43	43	43
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	13	20	25	29	31	34	37	41	43	43	43
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	18	24	28	31	33	36	41	43	43	43
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	16	22	27	30	32	35	40	43	43	43
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	13	20	25	29	31	34	39	42	43	43
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	14	20	25	29	31	37	41	43	43
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	14	20	26	29	34	39	43	43
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	8	15	21	26	32	37	43	43
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	8	14	20	29	34	42	43

RAINFALL TYPE = IA   * * * TC = 1.0 HR * * *   SHEET 7 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																															
	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
IA/P = 0.10																* * * TC =1.25 HR * * *													IA/P = 0.10			
0.0	17	21	24	29	33	37	43	52	61	71	81	89	95	100	94	86	78	71	64	57	51	46	42	39	35	34	33	33	31	30	28	23
.10	16	19	23	27	29	31	35	41	48	57	66	76	85	96	99	92	84	76	69	60	54	47	43	40	36	34	34	33	31	30	28	23
.20	15	19	22	26	28	30	33	38	45	53	62	71	80	93	97	93	86	78	71	62	55	48	43	40	37	34	34	33	31	30	28	23
.30	14	17	20	24	25	27	29	32	36	42	49	58	67	84	95	96	91	84	76	66	58	50	44	41	38	35	34	33	31	30	28	23
.40	13	16	20	23	25	26	28	31	34	39	46	54	62	80	92	96	93	86	78	68	59	51	45	41	38	35	34	33	31	30	28	23
.50	12	15	18	21	23	24	25	27	29	33	37	43	50	67	83	93	95	91	84	73	63	54	46	42	39	36	34	33	32	30	28	23
.75	10	13	16	20	21	22	23	25	27	29	32	36	42	55	71	84	93	93	88	78	68	57	49	43	40	37	34	34	32	31	28	24
1.0	8	10	13	16	17	19	20	21	22	23	25	27	29	37	49	63	78	88	92	88	78	65	53	46	42	39	36	34	33	31	29	24
1.5	5	7	9	12	13	14	15	16	17	18	19	20	22	25	29	36	47	60	73	87	89	79	64	53	46	42	38	36	33	32	29	25
2.0	2	4	6	8	9	10	10	11	12	13	14	15	16	19	21	24	29	36	45	64	80	87	77	63	52	46	41	38	34	32	30	25
2.5	1	2	3	4	5	6	6	7	8	8	9	10	11	13	15	17	19	22	26	35	49	72	85	78	65	53	46	42	36	33	30	26
3.0	0	1	1	2	3	3	4	4	5	5	6	7	7	9	11	12	14	17	19	23	31	47	73	84	76	63	53	46	38	34	31	26
IA/P = 0.30																* * * TC =1.25 HR * * *													IA/P = 0.30			
0.0	0	0	0	0	0	1	3	6	10	15	22	28	34	43	48	51	51	51	49	47	45	44	43	42	40	40	40	40	40	40	39	35
.10	0	0	0	0	0	0	1	2	5	8	13	19	25	36	45	49	51	50	50	48	46	44	43	42	40	40	40	40	40	40	39	35
.20	0	0	0	0	0	0	1	2	4	7	11	16	22	34	43	48	50	50	50	48	46	44	43	42	41	40	40	40	40	40	39	35
.30	0	0	0	0	0	0	1	1	3	5	9	14	19	31	40	46	49	50	50	48	46	45	43	42	41	40	40	40	40	40	39	35
.40	0	0	0	0	0	0	0	1	2	4	8	12	17	28	38	45	49	50	50	49	47	45	43	42	41	40	40	40	40	40	39	35
.50	0	0	0	0	0	0	0	1	2	4	6	10	14	25	36	43	48	50	50	49	47	45	43	42	41	40	40	40	40	40	39	35
.75	0	0	0	0	0	0	0	0	0	1	2	3	6	13	23	33	41	46	49	50	48	46	44	43	42	40	40	40	40	40	39	36
1.0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	14	23	32	40	46	49	49	47	45	43	42	41	40	40	40	40	39	36
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	13	21	30	41	47	49	47	45	43	42	41	40	40	40	39	37
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	12	23	35	45	48	47	45	43	42	41	40	40	40	37
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	18	33	45	48	46	44	43	42	40	40	40	38
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	17	34	45	48	46	44	43	41	40	40	38
IA/P = 0.50																* * * TC =1.25 HR * * *													IA/P = 0.50			
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	5	9	14	19	24	28	31	33	37	39	42	42	42	42
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	11	17	23	27	30	32	36	38	42	42	42	42
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	9	15	21	26	29	32	35	38	41	42	42	42
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	13	19	25	29	31	34	37	41	42	42	42
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	17	23	28	30	33	36	40	42	42	42
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	15	22	26	30	32	35	40	42	42	42
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	7	13	20	25	29	31	34	39	42	42	42
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	17	23	27	30	33	38	42	42	42
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	11	18	23	28	30	36	40	42	42
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	12	18	24	28	33	39	42	42
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	13	19	24	31	37	42	42
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	12	18	28	33	42	42

RAINFALL TYPE = IA

* * * TC = 1.25 HR * * *

SHEET 8 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

TRVL	HYDROGRAPH TIME (HOURS)																														
TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	1C.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
		IA/P = 0.10												* * * TC =1.5 HR * * *															IA/P = 0.10			
0.0	15	19	22	27	29	32	37	42	49	57	65	73	80	89	94	89	83	76	70	62	55	49	44	40	37	35	34	33	31	30	28	23
.10	14	17	20	24	26	28	31	35	40	46	53	61	69	82	90	92	87	81	74	65	58	51	45	41	38	35	34	33	31	30	28	23
.20	13	16	20	23	25	27	29	33	37	43	50	57	65	79	88	91	88	82	76	67	59	52	46	42	38	35	34	33	32	30	28	23
.30	12	15	18	22	23	24	26	28	31	35	41	47	54	69	81	89	90	86	81	71	63	54	47	43	39	36	34	34	32	30	28	24
.40	11	14	18	21	22	24	25	27	30	34	38	44	51	65	78	87	90	87	82	73	64	55	48	43	40	36	34	34	32	30	28	24
.50	10	13	16	19	20	22	23	24	26	29	32	36	41	54	69	81	88	89	86	77	68	58	50	44	41	37	35	34	32	31	29	24
.75	9	11	14	18	19	20	21	22	24	26	28	31	35	46	58	71	82	88	88	81	73	62	52	46	42	38	35	34	32	31	29	24
1.0	7	9	11	14	15	16	18	19	20	21	22	24	26	32	40	52	65	76	84	87	81	70	58	49	44	40	37	35	33	31	29	24
1.5	4	6	8	10	11	12	13	14	15	16	17	18	19	22	26	31	39	50	62	77	85	81	69	57	49	44	40	37	34	32	30	25
2.0	2	3	5	7	7	8	9	10	11	12	12	13	14	17	19	22	25	31	38	53	69	83	80	68	56	48	43	40	35	33	30	25
2.5	1	1	2	3	4	5	5	6	6	7	8	9	9	11	13	15	17	20	23	30	41	61	82	82	69	58	49	44	37	34	31	26
3.0	0	0	1	2	2	2	3	3	4	4	5	5	6	8	9	11	13	15	17	21	27	40	63	80	78	68	57	49	40	35	31	27
		IA/P = 0.30												* * * TC =1.5 HR * * *															IA/P = 0.30			
0.0	0	0	0	0	0	1	2	4	6	10	14	19	24	34	41	46	48	49	48	47	46	44	43	42	41	40	40	40	40	40	39	35
.10	0	0	0	0	0	0	1	1	3	5	8	12	17	27	36	42	46	48	49	48	46	45	43	42	41	40	40	40	40	40	39	36
.20	0	0	0	0	0	0	0	1	2	4	7	10	15	24	33	41	45	48	49	48	47	45	43	43	41	40	40	40	40	40	39	36
.30	0	0	0	0	0	0	0	1	2	3	6	9	13	22	31	39	44	47	48	48	47	45	44	43	41	40	40	40	40	40	39	36
.40	0	0	0	0	0	0	0	0	1	1	3	5	7	15	24	33	40	45	47	48	47	46	44	43	42	40	40	40	40	40	39	36
.50	0	0	0	0	0	0	0	0	0	1	2	4	6	13	22	31	38	44	47	48	48	46	44	43	42	40	40	40	40	40	39	36
.75	0	0	0	0	0	0	0	0	0	1	1	2	4	9	16	24	33	39	44	47	48	47	45	43	42	41	40	40	40	40	39	36
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	12	20	29	36	44	47	48	46	44	43	42	40	40	40	40	40	36
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	12	19	30	39	46	47	46	44	43	42	40	40	40	40	37
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	8	17	28	40	46	47	45	44	42	41	40	40	40	37
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	13	26	40	47	47	45	43	42	40	40	40	38
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	12	28	41	46	46	45	43	41	40	40	38
		IA/P = 0.50												* * * TC =1.5 HR * * *															IA/P = 0.50			
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	7	11	16	22	27	30	32	35	38	42	42	42	42
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4	7	13	19	24	28	31	34	37	41	42	42	42
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	12	19	24	28	31	33	36	41	42	42	42
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	12	18	23	28	30	33	36	40	42	42	42
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	11	17	23	27	30	33	36	40	42	42	42
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	10	17	22	27	30	32	36	40	41	41	41
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	10	16	22	26	29	32	35	40	41	41	41
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	17	23	27	30	33	38	41	41	41
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	12	18	23	27	30	36	40	41	41
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	12	18	24	28	33	39	41	41
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	13	19	24	31	36	41	41
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	13	19	28	34	41	41

RAINFALL TYPE = IA * * * TC = 1.5 HR * * * SHEET 9 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																															
	7.0	7.3/	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
IA/P = 0.10														* * * TC =2.0 HR * * *															IA/P = 0.10			
0.0	12	15	18	22	24	26	28	32	36	41	46	52	58	68	76	80	84	79	76	68	62	55	48	44	40	37	35	34	32	31	28	24
.10	11	13	16	20	21	23	25	27	30	34	38	43	49	60	70	77	83	83	78	72	65	57	50	45	41	38	36	34	32	31	29	24
.20	9	12	15	18	19	21	22	24	26	29	32	36	41	52	63	72	78	82	81	75	68	60	52	46	42	39	36	35	32	31	29	24
.30	9	12	14	18	19	20	21	23	25	28	31	34	39	49	60	70	77	81	81	76	70	61	53	47	43	39	36	35	33	31	29	24
.40	9	11	14	17	18	19	21	22	24	26	29	33	37	47	57	67	75	80	81	77	71	62	53	47	43	39	37	35	33	31	29	24
.50	7	10	12	15	17	18	19	20	21	23	25	28	31	39	49	60	69	76	81	79	74	65	56	49	44	40	37	35	33	31	29	24
.75	6	9	11	14	15	16	17	18	20	21	23	25	27	34	42	52	62	70	76	79	76	68	59	51	46	41	38	36	33	31	29	24
1.0	5	6	9	11	12	13	14	15	16	17	18	20	21	25	30	38	47	57	66	76	79	75	64	55	49	44	40	37	34	32	29	25
1.5	3	4	6	8	8	9	10	11	12	13	14	15	16	18	21	24	30	37	45	59	71	78	73	63	55	48	43	40	35	33	30	25
2.0	1	2	3	4	5	5	6	7	7	8	9	10	10	12	14	16	19	22	26	36	48	65	77	73	64	56	49	44	37	34	31	26
2.5	0	1	1	2	3	3	4	4	5	5	6	6	7	8	10	12	14	16	18	23	31	46	66	76	72	63	55	48	40	35	31	27
3.0	0	0	1	1	1	2	2	2	3	3	3	4	4	5	7	8	10	11	13	17	21	30	49	67	75	71	63	54	43	37	32	27
IA/P = 0.30														* * * TC =2.0 HR * * *															IA/P = 0.30			
0.0	0	0	0	0	0	0	1	2	3	5	7	10	13	20	27	34	39	42	44	47	45	45	44	43	42	40	40	40	40	40	39	36
.10	0	0	0	0	0	0	0	1	1	2	4	6	8	15	22	29	35	40	43	45	46	45	44	43	42	41	40	40	40	40	40	36
.20	0	0	0	0	0	0	0	0	1	1	2	3	5	10	17	24	31	36	41	44	46	45	44	43	42	41	40	40	40	40	40	36
.30	0	0	0	0	0	0	0	0	0	1	2	3	4	9	15	22	29	35	39	44	46	45	44	43	42	41	40	40	40	40	40	36
.40	0	0	0	0	0	0	0	0	0	1	1	2	4	8	14	20	27	33	38	43	46	46	44	43	42	41	40	40	40	40	40	36
.50	0	0	0	0	0	0	0	0	0	0	1	1	2	5	9	15	22	29	35	41	44	45	45	44	43	42	40	40	40	40	40	36
.75	0	0	0	0	0	0	0	0	0	0	0	1	1	3	6	11	17	24	30	38	42	45	45	44	43	42	41	40	40	40	40	37
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	9	14	21	30	38	43	45	44	44	43	41	40	40	40	40	37
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	8	16	25	36	43	45	44	43	42	41	40	40	40	38
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	12	24	36	43	45	44	43	42	40	40	40	38
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	12	25	37	43	45	44	43	41	40	40	38
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	13	26	37	43	44	44	42	40	40	39
IA/P = 0.50														* * * TC =2.0 HR * * *															IA/P = 0.50			
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	7	12	18	23	27	30	33	36	40	40	40	40
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	5	10	16	21	26	29	32	35	40	40	40	40
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	8	14	20	25	28	31	34	39	40	40	40
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	12	18	23	27	30	33	38	40	40	40
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	11	16	22	26	29	32	38	40	40	40
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	9	15	20	25	28	31	37	40	40	40
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	13	19	24	27	30	36	40	40	40
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	14	20	24	28	34	39	40	40
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	10	16	21	25	32	37	40	40
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	16	21	29	35	40	40
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	11	17	26	32	40	40
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	11	21	29	39	40

RAINFALL TYPE = IA * * * TC = 2.0 HR * * * SHEET 10 OF 10

Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																														
	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
			IA/P = 0.10											* * * TC =0.1 HR * * *														IA/P = 0.10				
0.0	24	34	53	334	647	1010	623	217	147	123	104	86	76	66	57	51	46	42	38	34	32	29	26	23	21	20	19	18	15	13	12	0
.10	21	29	43	134	267	520	847	701	378	224	157	122	98	75	64	56	50	45	41	36	33	30	27	24	21	20	19	18	16	13	12	0
.20	18	25	35	61	110	215	418	704	702	486	312	209	151	94	73	62	54	49	44	38	34	31	28	25	22	21	19	18	16	14	12	0
.30	17	23	33	56	92	174	337	582	662	545	359	269	190	109	79	65	56	50	45	39	35	32	29	25	22	21	20	18	16	14	12	0
.40	15	20	28	41	51	78	142	272	478	601	563	447	328	172	104	76	63	55	49	42	37	33	29	26	23	21	20	19	17	14	12	0
.50	14	19	26	39	47	68	117	220	392	531	553	482	380	209	121	84	67	57	51	43	38	33	30	27	23	21	20	19	17	14	12	0
.75	12	15	21	29	33	38	49	73	126	224	343	432	464	385	252	156	103	76	62	50	43	36	31	28	25	22	21	19	17	15	12	0
1.0	9	12	15	21	23	26	29	33	40	55	86	148	238	406	434	317	205	130	89	62	50	41	34	30	27	24	22	20	18	16	12	0
1.5	7	8	10	14	15	16	18	20	22	25	29	34	45	101	220	339	373	320	234	131	80	53	40	34	30	27	24	21	19	17	12	2
2.0	4	6	7	9	9	10	11	12	13	15	16	18	20	25	37	72	150	252	336	312	216	109	58	42	34	30	27	24	20	18	13	8
2.5	3	4	5	6	7	7	8	8	9	10	11	12	13	16	19	25	39	75	142	262	308	229	108	58	41	34	30	27	22	19	14	11
3.0	1	2	3	4	4	5	5	6	6	7	7	8	8	10	12	14	17	22	31	76	169	288	236	122	64	43	35	30	24	20	16	11
			IA/P = 0.30											* * * TC =0.1 HR * * *														IA/P = 0.30				
0.0	0	0	0	154	568	936	524	217	172	149	126	107	97	86	76	69	63	58	53	48	46	42	38	34	31	30	28	27	24	20	19	0
.10	0	0	0	19	109	415	762	603	346	230	176	143	119	96	84	74	68	62	57	50	47	44	40	35	32	30	29	27	24	21	19	0
.20	0	0	0	0	13	77	302	609	605	432	297	217	167	115	94	81	73	66	60	53	48	45	41	37	33	31	29	28	25	21	19	0
.30	0	0	0	0	9	54	219	479	563	476	357	263	199	129	99	85	75	68	62	54	49	45	41	37	33	31	29	28	25	21	19	0
.40	0	0	0	0	0	6	38	159	372	500	484	399	309	183	123	96	82	73	66	58	51	46	42	38	34	31	30	28	25	22	19	0
.50	0	0	0	0	0	4	27	115	287	429	465	421	346	213	138	103	86	76	68	59	52	47	43	39	34	32	30	29	25	22	19	0
.75	0	0	0	0	0	0	1	10	46	132	246	338	381	341	243	165	119	94	80	67	58	50	45	41	37	33	31	29	26	23	19	0
1.0	0	0	0	0	0	0	0	1	4	22	69	149	241	357	331	246	170	122	96	76	64	54	47	42	38	34	32	30	27	24	19	0
1.5	0	0	0	0	0	0	0	0	0	0	0	1	4	41	142	258	310	285	224	142	97	71	55	47	43	39	35	32	29	25	20	4
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	49	130	221	279	255	182	108	70	55	47	42	38	34	30	27	20	11
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	14	52	119	224	256	193	107	70	55	47	42	38	32	28	22	17
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	52	141	240	199	117	74	56	48	43	35	30	24	18
			IA/P = 0.50											* * * TC =0.1 HR * * *														IA/P = 0.50				
0.0	0	0	0	0	70	539	377	196	171	154	134	117	108	99	89	83	77	72	67	61	59	56	51	46	43	42	40	38	34	30	28	0
.10	0	0	0	0	47	375	376	256	199	169	146	126	114	102	92	85	79	73	68	62	59	56	52	47	43	42	40	38	34	30	28	0
.20	0	0	0	0	0	31	260	338	283	227	189	160	138	112	99	90	83	77	72	64	60	57	53	48	44	42	41	39	35	30	28	0
.30	0	0	0	0	0	0	21	180	285	284	246	208	176	131	110	97	88	82	76	68	62	59	54	50	45	43	41	39	36	31	28	0
.40	0	0	0	0	0	0	14	125	232	266	253	223	192	142	115	100	91	83	77	69	63	59	55	50	45	43	41	40	36	31	28	0
.50	0	0	0	0	0	0	9	86	183	239	248	231	205	154	122	104	93	85	79	71	64	59	55	51	46	43	41	40	36	32	28	0
.75	0	0	0	0	0	0	3	31	87	147	190	211	213	184	147	121	103	92	84	75	67	61	57	52	47	44	42	40	37	32	28	0
1.0	0	0	0	0	0	0	0	0	1	13	45	92	141	205	197	165	134	112	98	84	75	65	59	55	50	46	43	41	38	34	28	0
1.5	0	0	0	0	0	0	0	0	0	0	0	2	9	51	118	170	183	167	143	111	92	77	65	59	54	50	45	43	39	35	28	2
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	15	51	103	148	168	156	127	96	76	65	58	54	49	45	41	37	29	12
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	31	69	131	159	140	101	78	66	59	54	50	43	39	31	24
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	46	101	151	134	99	77	65	59	54	45	41	33	26

RAINFALL TYPE = II

* * * TC = 0.1 HR * * *

SHEET 1 OF 10

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

```
TRVL -------------------------------------------------- HYDROGRAPH TIME (HOURS) ---------------------------------------------------
TIME    11.3    11.9    12.1    12.3    12.5    12.7    13.0    13.4    13.8    14.3    15.0    16.0    17.0    18.0    20.0    26.0
(HR)11.0    11.6    12.0    12.2    12.4    12.6    12.8    13.2    13.6    14.0    14.6    15.5    16.5    17.5    19.0    22.0
-------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            IA/P = 0.10                                         * * * TC =0.2  HR * * *                                 IA/P = 0.10
-------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
0.0   23  31  47 209 403 739 800 481 250 166 128 102  86  70  61  54  49  44  40  35  33  30  27  24  21  20  19  18  16  13  12   0
.10   19  26  39  86 168 325 601 733 565 355 229 161 122  83  69  59  53  47  43  37  34  31  28  25  22  21  19  18  16  14  12   0
.20   17  23  32  49  74 136 262 488 652 594 435 298 207 115  81  67  58  51  46  40  35  32  29  26  23  21  20  19  16  14  12   0
.30   16  22  30  46  64 112 212 396 566 585 485 360 258 139  90  71  60  53  48  41  36  32  29  26  23  21  20  19  16  14  12   0

.40   14  19  25  37  43  57  94 173 322 485 551 507 409 227 129  87  68  58  52  44  38  33  30  27  24  21  20  19  17  14  12   0
.50   13  18  24  35  40  52  80 142 262 410 504 506 441 269 153  98  73  61  53  45  39  34  30  27  24  22  20  19  17  15  12   0
.75   10  13  17  23  26  30  34  40  55  86 150 247 349 438 360 240 151 101  75  57  47  39  33  29  26  23  21  20  18  15  12   0
1.0    9  11  14  19  21  24  26  30  35  44  62 101 167 337 413 353 245 157 104  68  53  42  35  31  28  24  22  20  18  16  12   0

1.5    6   8  10  13  14  15  17  19  21  23  26  30  37  73 166 288 356 337 264 154  91  57  42  35  30  27  24  22  19  17  13   3
2.0    4   5   7   8   9  10  10  11  12  14  15  16  18  23  31  55 114 206 291 324 239 125  63  44  35  31  28  24  20  18  14   9
2.5    3   4   5   6   6   7   7   8   9   9  10  11  12  15  18  22  32  58 111 227 298 246 122  63  43  35  31  27  22  19  15  11
3.0    1   2   3   4   4   4   5   5   6   6   7   7   8   9  11  13  16  19  27  59 138 280 248 137  70  46  36  31  25  21  16  11
-------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            IA/P = 0.30                                         * * * TC =0.2  HR * * *                                 IA/P = 0.30
-------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
0.0    0   0   0  39 180 545 697 497 276 198 158 130 110  93  81  73  67  61  56  49  46  43  39  35  32  30  29  27  24  21  19   0
.10    0   0   0   2  27 129 407 600 532 361 252 190 150 108  90  79  71  65  59  52  48  44  41  36  32  31  29  28  25  21  19   0
.20    0   0   0   2  19  92 302 501 521 415 306 228 176 119  95  82  73  67  61  53  48  45  41  37  33  31  29  28  25  21  19   0
.30    0   0   0   0   1  13  66 223 408 484 438 350 269 163 114  93  80  72  65  57  51  46  42  38  34  31  30  28  25  22  19   0

.40    0   0   0   0   1   9  47 164 327 431 436 379 306 189 127  98  83  74  67  58  52  47  43  38  34  31  30  28  25  22  19   0
.50    0   0   0   0   0   0   6  33 120 258 374 415 391 271 173 121  95  81  72  62  55  48  44  40  35  32  30  29  26  22  19   0
.75    0   0   0   0   0   0   2  13  50 126 221 302 348 323 240 167 121  96  81  68  59  50  45  41  37  33  31  29  26  23  19   0
1.0    0   0   0   0   0   0   0   0   1   6  24  69 139 285 331 280 204 145 109  82  68  56  48  43  39  35  32  30  27  24  19   0

1.5    0   0   0   0   0   0   0   0   0   0   0   0   1  16  79 186 271 288 247 165 110  76  58  49  44  40  35  32  29  26  20   5
2.0    0   0   0   0   0   0   0   0   0   0   0   0   0   0   3  24  80 163 235 262 202 123  76  58  49  43  39  35  30  27  21  13
2.5    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   6  28  77 179 242 207 120  75  57  48  43  39  32  29  22  17
3.0    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   4  30 101 207 227 130  80  59  49  44  35  30  24  18
-------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            IA/P = 0.50                                         * * * TC =0.2  HR * * *                                 IA/P = 0.50
-------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
0.0    0   0   0   0   7  98 371 322 221 182 158 137 120 104  94  86  80  74  69  62  60  57  52  47  44  42  40  39  35  30  28   0
.10    0   0   0   0   4  67 270 305 249 204 174 149 130 108  97  88  82  76  71  64  60  57  53  48  44  42  41  39  35  30  28   0
.20    0   0   0   0   0   3  45 195 268 255 221 189 163 125 106  95  87  80  75  67  62  58  54  49  45  43  41  39  35  31  28   0
.30    0   0   0   0   0   2  31 140 226 245 229 203 176 134 111  98  89  82  76  68  62  59  55  50  45  43  41  39  36  31  28   0

.40    0   0   0   0   0   1  21 101 184 225 228 211 188 144 117 101  91  84  78  69  63  59  55  50  45  43  41  40  36  31  28   0
.50    0   0   0   0   0   0   1  14  72 146 199 218 213 175 137 113  99  89  82  73  66  60  56  52  47  43  42  40  36  32  28   0
.75    0   0   0   0   0   0   0   5  28  71 121 162 186 193 161 133 112  98  88  78  70  62  57  53  48  44  42  41  37  33  28   0
1.0    0   0   0   0   0   0   0   0   0   2  13  38  77 154 186 174 147 122 105  89  78  68  60  56  51  46  43  42  38  34  28   0

1.5    0   0   0   0   0   0   0   0   0   0   0   0   2  22  71 129 163 168 150 120  98  80  67  60  55  51  46  43  40  36  28   4
2.0    0   0   0   0   0   0   0   0   0   0   0   0   0   0   5  25  65 112 146 157 134 103  79  67  60  55  50  46  41  38  29  14
2.5    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   8  26  60 117 148 136 101  79  66  59  54  50  43  39  31  24
3.0    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2   9  40  90 142 130  99  78  66  59  54  45  41  33  26
-------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            RAINFALL TYPE = II                                  * * * TC = 0.2  HR * * *                                SHEET  2 OF 10
```

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
			IA/P = 0.10												* * * TC =0.3 HR * * *														IA/P = 0.10			
0.0	20	28	41	118	235	447	676	676	459	283	196	146	114	80	66	57	51	46	42	37	33	31	28	24	22	20	19	18	16	13	12	0
.10	19	26	39	99	189	361	571	641	520	362	251	181	136	89	70	60	53	48	43	37	34	31	28	25	22	21	19	18	16	14	12	0
.20	17	23	32	53	83	154	292	478	587	542	422	308	223	127	86	68	58	52	46	40	35	32	29	26	23	21	20	19	16	14	12	0
.30	16	22	30	49	72	127	237	398	524	536	460	359	268	151	97	73	61	53	48	41	36	32	29	26	23	21	20	19	16	14	12	0
.40	14	19	25	37	45	63	105	193	330	459	510	477	398	237	139	92	70	59	52	44	38	34	30	27	24	21	20	19	17	14	12	0
.50	13	18	24	35	42	56	89	158	272	397	472	475	424	274	163	104	76	62	54	46	39	34	30	27	24	22	20	19	17	15	12	0
.75	11	14	19	26	30	34	42	59	95	160	250	339	417	398	299	196	128	89	69	54	45	37	32	29	26	23	21	20	17	15	12	0
1.0	9	11	14	19	21	24	27	30	36	46	68	109	174	328	396	346	248	163	109	70	54	43	35	31	28	24	22	20	18	16	12	0
1.5	6	8	10	13	14	15	17	19	21	23	26	31	38	77	169	282	347	330	264	158	94	58	42	35	31	27	24	22	19	17	13	3
2.0	4	5	7	8	9	10	10	11	12	14	15	16	18	23	32	57	116	205	285	317	239	128	64	44	36	31	28	25	20	18	14	9
2.5	2	4	5	6	6	7	7	8	9	9	10	11	12	15	18	23	33	60	113	223	293	245	125	65	44	35	31	27	22	19	15	11
3.0	1	2	3	4	4	4	5	5	6	6	7	7	8	9	11	13	16	20	27	61	138	275	246	139	72	46	36	31	25	21	16	11
			IA/P = 0.30												* * * TC =0.3 HR * * *														IA/P = 0.30			
0.0	0	0	0	11	64	251	525	574	454	303	221	173	140	104	88	77	70	64	58	51	47	44	40	36	32	31	29	28	24	21	19	0
.10	0	0	0	0	7	45	183	411	520	476	360	268	205	133	101	85	76	69	62	55	49	45	41	37	33	31	30	28	25	21	19	0
.20	0	0	0	0	5	32	132	318	452	468	396	310	240	151	109	90	78	70	64	56	50	46	42	38	33	31	30	28	25	22	19	0
.30	0	0	0	0	0	3	22	96	244	383	440	411	344	217	142	105	87	76	69	60	53	47	43	39	35	32	30	29	26	22	19	0
.40	0	0	0	0	0	2	16	69	186	317	399	407	365	246	160	115	92	79	71	61	54	48	43	39	35	32	30	29	26	22	19	0
.50	0	0	0	0	0	0	2	11	50	140	258	352	389	327	223	149	110	89	77	66	57	50	45	41	36	33	31	29	26	23	19	0
.75	0	0	0	0	0	0	1	4	20	63	135	219	290	335	281	205	146	110	89	72	62	52	46	42	38	34	31	30	27	23	19	0
1.0	0	0	0	0	0	0	0	0	0	2	9	32	78	216	320	306	243	176	128	90	72	59	49	44	40	36	33	31	28	24	19	1
1.5	0	0	0	0	0	0	0	0	0	0	0	0	2	20	84	185	264	281	246	168	112	77	58	49	44	40	36	32	29	26	20	5
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	12	50	121	200	257	224	141	83	61	50	44	40	36	31	28	21	14
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	16	51	145	239	223	137	82	60	50	44	40	33	29	22	17
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	19	74	184	224	146	89	63	51	45	36	31	24	18
			IA/P = 0.50												* * * TC =0.3 HR * * *														IA/P = 0.50			
0.0	0	0	0	0	1	25	151	299	277	219	187	162	141	113	100	90	84	78	72	65	61	58	53	48	44	42	41	39	35	31	28	0
.10	0	0	0	0	1	17	106	235	263	234	202	175	152	120	104	93	85	79	73	66	61	58	54	49	44	42	41	39	35	31	28	0
.20	0	0	0	0	0	0	12	75	182	236	234	213	188	144	116	101	91	84	78	70	63	59	55	50	45	43	41	40	36	31	28	0
.30	0	0	0	0	0	0	8	52	138	203	224	217	197	154	123	105	94	86	79	71	64	59	55	51	46	43	42	40	36	32	28	0
.40	0	0	0	0	0	0	5	37	105	170	206	213	203	164	131	110	97	88	81	72	65	60	56	51	46	43	42	40	36	32	28	0
.50	0	0	0	0	0	0	0	4	26	78	140	184	203	191	155	126	107	95	86	76	69	62	57	53	48	44	42	41	37	33	28	0
.75	0	0	0	0	0	0	0	1	10	34	73	117	153	184	173	146	122	105	94	82	73	64	58	54	49	45	43	41	37	33	28	0
1.0	0	0	0	0	0	0	0	0	0	0	4	17	42	114	168	178	159	134	114	94	82	70	61	57	52	47	44	42	39	35	28	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	10	44	98	144	163	157	130	105	84	69	61	56	52	47	44	40	36	29	6
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	14	44	87	127	153	141	110	83	69	61	56	51	47	42	38	30	17
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	16	42	97	138	145	107	82	68	60	55	51	43	40	32	25
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	27	71	127	139	105	81	68	60	55	46	41	33	27

RAINFALL TYPE = II   * * * TC = 0.3 HR * * *   SHEET 3 OF 10

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

```
TRVL ---------------------------------------------------- HYDROGRAPH TIME (HOURS) -----------------------------------------------------
TIME    11.3    11.9    12.1    12.3    12.5    12.7    13.0    13.4    13.8    14.3    15.0    16.0    17.0    18.0    20.0    26.0
(HR)11.0    11.6    12.0    12.2    12.4    12.6    12.8    13.2    13.6    14.0    14.6    15.5    16.5    17.5    19.0    22.0
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            IA/P = 0.10                                   * * * TC =0.4  HR * * *                                    IA/P = 0.10
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
0.0   18  25  36  77 141 271 468 592 574 431 298 216 163 104  77  63  55  49  44  38  34  31  28  25  22  21  20  18  16  14  12   0
.10   18  24  34  67 116 219 385 523 557 473 357 263 196 119  84  67  57  51  46  39  35  32  29  25  22  21  20  19  16  14  12   0
.20   15  20  28  44  59  97 179 316 454 523 489 401 309 178 112  81  65  56  49  42  37  33  30  26  23  21  20  19  17  14  12   0
.30   15  20  27  41  53  82 147 260 389 478 486 429 349 210 129  89  69  58  51  43  38  33  30  27  24  21  20  19  17  14  12   0

.40   13  17  23  33  38  48  71 121 214 331 429 467 442 308 189 120  85  66  56  47  41  35  31  28  24  22  20  19  17  15  12   0
.50   12  16  22  31  36  44  62 102 176 279 379 438 440 339 218 137  94  71  59  49  42  35  31  28  25  22  21  19  17  15  12   0
.75   10  13  17  24  26  30  35  45  65 106 170 251 326 393 341 245 164 112  81  59  48  39  33  30  26  23  21  20  18  15  12   0
1.0    8  10  13  17  19  21  24  27  31  37  50  75 118 251 360 376 292 205 138  83  60  45  36  32  28  25  22  21  18  16  12   1

1.5    6   7   9  12  13  14  15  17  19  21  23  26  31  56 121 224 311 333 293 192 115  66  45  36  31  28  25  22  19  17  13   4
2.0    4   5   6   8   8   9  10  10  11  12  14  15  16  20  27  43  85 159 243 306 264 154  74  47  37  32  28  25  21  18  14   9
2.5    2   3   4   5   6   6   7   7   8   9   9  10  11  13  16  20  27  46  85 184 285 262 147  74  47  37  32  28  22  19  15  11
3.0    1   2   2   3   4   4   4   5   5   6   6   7   7   8  10  12  14  17  23  47 109 227 268 160  83  50  38  32  25  21  16  11
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            IA/P = 0.30                                   * * * TC =0.4  HR * * *                                    IA/P = 0.30
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
0.0    0   0   0   4  26 113 296 480 495 413 306 234 186 127 1C0  84  74  67  61  54  49  45  41  37  33  31  29  28  25  21  19   0
.10    0   0   0   0   2  18  81 224 395 462 430 347 272 172 121  96  82  73  66  57  51  46  42  38  34  31  30  28  25  22  19   0
.20    0   0   0   0   2  13  59 169 320 414 424 373 3C5 196 134 103  85  75  67  59  52  47  43  39  34  32  30  29  25  22  19   0
.30    0   0   0   0   0   1   9  42 127 255 361 403 383 274 181 127  99  83  73  63  55  48  44  40  36  32  30  29  26  23  19   0

.40    0   0   0   0   0   1   6  30  94 202 308 372 379 298 203 141 106  87  76  65  56  49  44  40  36  32  31  29  26  23  19   0
.50    0   0   0   0   0   0   0   4  21  70 158 258 334 364 270 187 133 102  85  70  60  51  46  41  37  33  31  30  26  23  19   0
.75    0   0   0   0   0   0   0   2   8  30  76 145 219 321 305 241 177 130 102  78  65  55  47  43  38  34  32  30  27  24  19   0
1.0    0   0   0   0   0   0   0   0   0   1   4  15  42 150 267 308 272 209 154 103  79  62  51  45  41  37  33  31  28  25  19   1

1.5    0   0   0   0   0   0   0   0   0   0   0   0   1  10  51 136 226 274 263 195 131  85  62  51  45  41  36  33  29  26  20   6
2.0    0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   6  31  86 162 252 239 162  93  64  52  45  41  37  31  28  21  15
2.5    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   9  33 112 2C2 235 155  92  64  52  45  41  33  29  23  18
3.0    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2  21  76 182 221 148  90  63  51  45  36  31  24  18
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            IA/P = 0.50                                   * * * TC =0.4  HR * * *                                    IA/P = 0.50
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
C.0    0   0   0   0   0   7  59 168 245 257 213 186 163 128 109  96  88  81  75  67  62  58  54  50  45  43  41  39  35  31  28   0
.10    0   0   0   0   0   0   5  41 125 205 240 222 198 154 123 106  94  86  79  71  64  60  56  51  46  43  42  40  36  32  28   0
.20    0   0   0   0   0   0   3  28  93 168 216 220 205 164 131 110  97  88  81  72  65  60  56  51  46  43  42  40  36  32  28   0
.30    0   0   0   0   0   0   0   2  20  69 135 189 209 192 155 126 107  95  86  77  69  62  57  53  48  44  42  41  37  33  28   0

.40    0   0   0   0   0   0   0   1  14  50 106 161 193 202 163 133 112  98  89  78  70  62  58  53  48  44  42  41  37  33  28   0
.50    0   0   0   0   0   0   0   1   9  37  83 135 174 194 171 140 117 102  91  80  71  63  58  54  49  45  43  41  37  33  28   0
.75    0   0   0   0   0   0   0   0   0   3  15  40  76 147 177 169 146 124 107  90  79  68  60  56  51  47  43  42  38  34  28   0
1.0    0   0   0   0   0   0   0   0   0   0   1   7  21  78 141 173 167 146 125 101  86  73  63  58  53  48  45  42  39  35  28   1

1.5    0   0   0   0   0   0   0   0   0   0   0   0   0   5  26  71 121 153 159 139 113  89  72  63  57  53  48  44  40  37  29   7
2.0    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   3  16  45  86 138 150 125  93  74  64  58  53  48  42  39  31  20
2.5    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   4  17  59 112 143 121  91  73  63  57  53  45  40  32  26
3.0    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1  11  40 101 138 117  90  73  63  57  48  42  34  27
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            RAINFALL TYPE = II                            * * * TC = 0.4  HR * * *                                   SHEET  4 OF 10
```

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

TRVL	HYDROGRAPH TIME (HOURS)																														
TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10 * * * TC =0.5 HR * * *																															
0.0	17	23	32	57	94	170	308	467	529	507	402	297	226	140	96	74	61	53	47	41	36	32	29	26	23	21	20	19	16	14	12	0
.10	16	22	30	51	80	140	252	395	484	499	434	343	265	162	108	80	65	55	49	42	36	33	29	26	23	21	20	19	16	14	12	0
.20	14	19	25	38	47	69	116	207	332	434	477	449	378	238	149	101	77	62	53	45	39	34	30	27	24	22	20	19	17	14	12	0
.30	13	18	24	35	43	60	97	170	278	382	446	448	401	270	171	114	83	66	56	46	40	34	31	27	24	22	20	19	17	15	12	0
.40	12	15	21	29	33	40	53	83	141	233	332	408	434	361	243	157	107	79	64	51	43	36	32	28	25	22	21	20	17	15	12	0
.50	11	15	20	28	31	37	48	71	118	194	286	367	412	378	271	178	119	86	68	53	44	37	32	29	25	23	21	20	17	15	12	0
.75	9	11	14	19	21	24	27	31	37	49	74	118	182	319	374	328	244	169	117	76	56	43	35	31	28	25	22	21	18	16	12	1
1.0	7	9	12	16	17	19	21	24	27	32	40	55	83	188	309	359	322	245	172	102	68	49	38	32	29	26	23	21	19	16	12	1
1.5	5	7	8	11	12	13	14	15	17	19	21	23	27	43	89	175	269	322	309	225	140	77	49	38	32	29	25	23	20	17	13	5
2.0	3	4	6	7	8	8	9	10	10	11	12	14	15	18	23	35	65	123	202	297	280	181	88	52	39	33	29	26	21	19	14	10
2.5	2	3	4	5	5	6	6	7	7	8	9	9	10	12	15	18	24	36	66	150	244	278	171	87	52	39	33	29	23	20	15	11
3.0	1	1	2	3	3	4	4	4	5	5	6	6	7	8	9	11	13	16	20	37	86	198	263	182	96	56	40	33	26	21	16	11
IA/P = 0.30 * * * TC =0.5 HR * * *																															
0.0	0	0	0	1	9	53	157	314	433	439	379	299	237	159	118	95	81	71	65	56	50	46	42	38	34	31	30	28	25	22	19	0
.10	0	0	0	0	1	6	37	117	248	372	416	391	330	218	150	113	92	79	70	60	53	47	43	39	35	32	30	29	26	22	19	0
.20	0	0	0	0	1	4	26	87	194	313	382	388	349	244	167	122	97	82	72	62	54	48	43	39	35	32	30	29	26	22	19	0
.30	0	0	0	0	0	0	3	19	64	151	259	341	372	316	223	156	117	94	80	67	58	50	45	41	36	33	31	29	26	23	19	0
.40	0	0	0	0	0	0	2	13	47	116	211	298	354	328	245	172	127	100	83	69	59	51	45	41	37	33	31	29	26	23	19	0
.50	0	0	0	0	0	0	0	1	9	34	89	170	255	341	303	225	161	120	96	76	64	54	47	42	38	34	31	30	27	24	19	0
.75	0	0	0	0	0	0	0	1	4	14	41	89	152	270	305	268	207	155	118	87	70	57	48	44	39	35	32	30	27	24	19	0
1.0	0	0	0	0	0	0	0	0	0	0	2	7	22	98	212	295	285	237	181	120	88	67	53	46	42	38	34	31	28	25	19	2
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	30	95	183	249	265	217	152	96	66	53	46	41	37	34	30	26	20	8
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	18	59	125	221	245	182	105	69	54	47	42	38	32	28	22	16
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	21	84	174	230	172	103	69	54	46	42	34	30	23	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13	56	157	217	163	101	68	53	46	37	31	25	18
IA/P = 0.50 * * * TC =0.5 HR * * *																															
0.0	0	0	0	0	0	2	26	89	170	217	229	200	179	144	119	104	93	85	78	70	64	59	55	51	46	43	41	40	36	32	28	0
.10	0	0	0	0	0	0	1	18	65	135	190	216	205	170	137	115	101	91	83	74	67	61	56	52	47	44	42	40	36	32	28	0
.20	0	0	0	0	0	0	1	12	47	106	162	198	203	178	145	121	105	94	85	76	68	61	57	52	48	44	42	40	37	32	28	0
.30	0	0	0	0	0	0	0	1	8	34	82	135	177	194	168	139	117	102	92	80	71	63	58	54	49	45	43	41	37	33	28	0
.40	0	0	0	0	0	0	0	0	6	25	63	111	155	189	174	146	122	106	94	82	73	64	58	54	50	45	43	41	37	33	28	0
.50	0	0	0	0	0	0	0	0	4	18	48	90	133	184	177	152	128	110	97	84	74	65	59	55	50	45	43	41	38	33	28	0
.75	0	0	0	0	0	0	0	0	1	7	22	47	80	142	169	164	144	124	108	91	79	68	61	56	51	47	44	42	38	34	28	0
1.0	0	0	0	0	0	0	0	0	0	0	1	3	11	51	112	155	166	154	134	109	91	76	65	59	54	49	45	43	39	35	28	2
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	2	16	50	97	136	154	145	121	95	75	64	58	54	49	45	41	37	29	10
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	18	47	86	134	146	125	94	75	64	58	53	49	42	39	31	21
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	11	44	95	140	127	97	77	65	58	54	45	41	33	26
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	29	86	135	122	95	76	65	58	49	43	35	27

RAINFALL TYPE = II * * * TC = 0.5 HR * * * SHEET 5 OF 10

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

TRVL	HYDROGRAPH TIME (HOURS)																														
TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10 * * * TC =0.75 HR * * *																															
0.0	13	18	24	36	46	68	115	194	294	380	424	410	369	252	172	123	93	74	61	49	41	35	31	27	24	22	20	19	17	15	12	0
.10	13	17	23	34	42	59	97	162	250	337	395	405	381	279	191	135	100	79	65	51	42	36	31	28	25	22	21	19	17	15	12	0
.20	11	15	20	28	32	39	52	82	135	211	295	362	391	351	255	178	127	95	75	57	46	38	32	29	26	23	21	20	17	15	12	0
.30	11	14	19	26	30	36	47	70	113	179	256	326	379	360	277	196	140	103	80	60	48	38	33	29	26	23	21	20	18	15	12	0
.40	10	12	16	22	25	28	33	42	61	96	151	221	291	367	336	255	182	131	98	69	54	42	34	30	27	24	22	20	18	16	12	0
.50	9	12	16	21	24	27	31	39	53	82	128	190	258	358	343	274	200	144	106	74	56	43	35	30	27	24	22	20	18	16	12	0
.75	8	10	13	17	18	21	23	26	31	39	55	82	122	230	314	329	281	217	161	104	72	51	38	33	29	26	23	21	19	16	12	1
1.0	6	8	10	13	14	15	17	19	21	23	27	32	42	89	177	272	319	303	249	163	105	66	45	36	31	27	24	22	19	17	13	3
1.5	4	6	7	9	10	10	11	12	14	15	16	18	20	27	46	90	163	241	295	275	204	119	66	45	35	31	27	24	20	18	13	7
2.0	3	4	5	6	7	7	8	9	9	10	11	12	13	16	20	28	48	89	151	245	274	213	115	65	44	35	30	27	22	19	14	10
2.5	1	2	3	4	4	5	5	6	6	7	7	8	8	10	12	14	17	24	37	86	170	260	219	127	71	47	36	31	24	20	16	11
3.0	1	1	2	3	3	3	4	4	4	5	5	5	6	7	8	10	11	14	17	30	64	157	247	205	122	70	46	36	27	22	17	12
IA/P = 0.30 * * * TC =0.75 HR * * *																															
0.0	0	0	0	0	1	6	30	86	174	266	326	348	328	246	181	138	110	92	79	66	57	49	44	40	36	32	31	29	26	23	19	0
.10	0	0	0	0	0	1	4	22	65	137	223	292	329	303	228	170	131	106	89	73	61	52	46	41	37	33	31	29	26	23	19	0
.20	0	0	0	0	0	0	3	15	48	108	185	256	305	321	245	184	141	112	93	75	63	53	46	42	37	34	31	30	27	23	19	0
.30	0	0	0	0	0	0	2	11	36	84	151	221	277	308	260	199	152	120	98	78	65	54	47	42	38	34	31	30	27	23	19	0
.40	0	0	0	0	0	0	0	1	8	27	65	122	188	286	301	243	187	144	114	87	71	57	48	43	39	35	32	30	27	24	19	1
.50	0	0	0	0	0	0	0	1	6	20	50	98	158	263	292	254	200	155	122	91	74	59	49	44	40	35	32	30	27	24	19	1
.75	0	0	0	0	0	0	0	0	0	2	8	23	51	140	231	269	253	211	167	119	90	68	53	46	42	37	34	31	28	25	19	2
1.0	0	0	0	0	0	0	0	0	0	0	0	1	4	29	96	186	249	261	231	169	120	84	61	50	44	40	36	33	29	26	20	5
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	34	91	163	220	241	197	131	83	61	50	44	40	35	31	27	21	12
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	36	85	174	226	200	127	82	60	49	44	39	32	29	22	17
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	37	105	196	214	135	87	62	51	44	36	31	24	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	24	96	205	189	130	85	62	50	39	32	26	18
IA/P = 0.50 * * * TC =0.75 HR * * *																															
0.0	0	0	0	0	0	0	2	16	45	92	137	166	185	170	146	125	110	98	89	79	70	63	58	53	48	44	42	41	37	33	28	0
.10	0	0	0	0	0	0	0	1	11	34	73	115	149	180	163	141	122	107	96	84	74	65	59	54	50	45	43	41	38	33	28	0
.20	0	0	0	0	0	0	0	1	8	25	57	96	131	173	166	146	126	111	99	86	76	66	59	55	50	46	43	41	38	34	28	0
.30	0	0	0	0	0	0	0	0	1	5	18	44	79	143	170	160	141	122	108	92	81	69	61	56	52	47	44	42	38	34	28	1
.40	0	0	0	0	0	0	0	0	0	4	14	34	64	127	166	162	145	127	111	95	82	70	62	57	52	47	44	42	38	34	28	1
.50	0	0	0	0	0	0	0	0	0	0	2	10	26	82	138	162	157	140	123	103	88	75	64	58	53	49	45	43	39	35	28	2
.75	0	0	0	0	0	0	0	0	0	0	1	4	12	47	98	139	154	148	135	113	96	80	67	60	55	50	46	43	39	36	29	3
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	30	73	119	146	151	134	113	91	74	63	58	53	48	45	41	37	29	7
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	30	66	105	143	143	117	90	73	63	57	52	48	42	39	30	18
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	30	77	121	137	114	88	72	63	57	52	44	40	32	25
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	19	55	111	132	111	87	71	62	56	47	42	34	27
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	12	51	112	128	108	86	71	62	51	44	36	27

RAINFALL TYPE = II   * * * TC = 0.75 HR * * *   SHEET 6 OF 10

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

```
TRVL ------------------------------------------------ HYDROGRAPH TIME (HOURS) ------------------------------------------------
TIME    11.3    11.9    12.1    12.3    12.5    12.7    13.0    13.4    13.8    14.3    15.0    16.0    17.0    18.0    20.0    26.0
(HR)11.0    11.6    12.0    12.2    12.4    12.6    12.8    13.2    13.6    14.0    14.6    15.5    16.5    17.5    19.0    22.0
----+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
          IA/P = 0.10                              * * * TC =1.0  HR * * *                                         IA/P = 0.10
----+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
0.0   11  15  20  29  35  47  72 112 168 231 289 329 357 313 239 175 133 103  83  63  50  40  33  29  26  23  21  20  17  15  12   0
.10   10  13  17  24  27  33  42  62  95 144 202 260 306 340 293 222 165 126  98  72  56  43  35  30  27  24  22  20  18  15  12   0
.20   10  13  17  23  26  30  38  54  82 123 176 232 281 332 303 238 179 136 105  76  59  45  35  30  27  24  22  20  18  16  12   1
.30    9  12  16  22  24  28  35  48  70 105 152 205 256 323 310 254 193 146 113  81  61  46  36  31  27  24  22  20  18  16  12   1

.40    8  11  14  19  21  23  27  32  42  61  91 132 181 276 318 294 237 181 138  95  70  51  39  32  28  25  23  21  18  16  12   1
.50    8  10  13  18  20  22  25  30  38  53  78 114 159 253 311 300 251 195 149 102  74  53  40  33  29  25  23  21  18  16  12   1
.75    7   8  11  14  16  17  19  21  25  30  38  53  76 146 228 284 293 256 208 143  99  66  46  36  31  27  24  22  19  17  13   2
1.0    5   7   8  11  12  13  14  16  17  19  22  25  31  57 111 188 256 286 272 208 144  90  56  41  33  29  26  23  20  17  13   4

1.5    4   5   6   8   8   9  10  11  12  13  14  15  17  22  33  59 107 171 231 268 235 157  88  56  41  33  29  25  21  18  14   8
2.0    2   3   4   5   5   6   6   7   7   8   9   9  10  12  15  19  27  44  78 157 231 252 167  96  59  42  34  29  23  20  15  11
2.5    1   2   2   3   4   4   4   5   5   6   6   7   7   8  10  12  15  19  27  58 120 214 241 159  94  59  42  34  26  21  16  11
3.0    0   1   1   2   2   3   3   3   4   4   4   5   5   6   7   8  10  12  14  22  44 113 214 231 152  91  58  42  29  23  17  12
----+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
          IA/P = 0.30                              * * * TC =1.0  HR * * *                                         IA/P = 0.30
----+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
0.0    0   0   0   0   1   4  16  42  83 137 195 243 271 292 227 178 143 117  98  79  66  55  47  42  38  34  31  30  27  23  19   0
.10    0   0   0   0   0   0   3  12  32  66 113 168 218 279 260 213 169 136 113  88  72  59  49  43  39  35  32  30  27  24  19   1
.20    0   0   0   0   0   0   2   9  24  52  93 143 193 271 271 225 180 145 119  92  75  60  50  44  39  35  32  30  27  24  19   1
.30    0   0   0   0   0   0   1   6  18  41  75 120 169 246 264 234 191 153 125  96  78  62  51  44  40  36  33  31  27  24  19   1

.40    0   0   0   0   0   0   0   1   4  14  32  61 100 190 251 259 222 181 146 109  86  67  53  46  41  37  33  31  28  25  19   2
.50    0   0   0   0   0   0   0   1   3  10  24  49  83 168 237 254 230 191 155 115  90  69  54  47  42  37  34  31  28  25  19   2
.75    0   0   0   0   0   0   0   0   0   1   4  12  25  76 150 213 239 228 198 149 112  82  61  50  44  39  35  32  29  26  20   4
1.0    0   0   0   0   0   0   0   0   0   0   0   1   2  15  51 113 182 226 234 197 150 104  72  56  47  42  38  34  30  27  20   7

1.5    0   0   0   0   0   0   0   0   0   0   0   0   0   0   4  18  51 104 162 220 210 158 102  71  56  47  42  37  31  28  22  13
2.0    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   5  20  49 121 187 209 152 100  70  55  47  41  34  29  23  17
2.5    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2   7  32  87 171 199 146  98  69  54  46  37  31  24  18
3.0    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2  13  62 158 192 151 103  73  56  41  34  26  18
----+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
          IA/P = 0.50                              * * * TC =1.0  HR * * *                                         IA/P = 0.50
----+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
0.0    0   0   0   0   0   0   1   7  21  42  71 101 126 160 154 138 123 110 100  87  77  67  60  55  50  46  43  41  38  34  28   1
.10    0   0   0   0   0   0   0   1   5  15  33  58  87 134 156 149 134 120 108  93  82  71  62  57  52  47  44  42  38  34  28   1
.20    0   0   0   0   0   0   0   1   4  12  26  48  74 123 153 153 137 123 111  95  84  72  63  57  52  47  44  42  38  34  28   1
.30    0   0   0   0   0   0   0   0   3   9  20  38  62 111 143 150 140 127 114  98  86  73  63  58  53  48  45  42  39  35  28   1

.40    0   0   0   0   0   0   0   0   0   2   6  16  31  75 120 145 148 137 123 106  91  77  66  59  54  49  45  43  39  35  29   2
.50    0   0   0   0   0   0   0   0   0   1   5  12  25  64 109 139 146 139 127 108  94  79  67  60  55  50  46  43  39  36  29   3
.75    0   0   0   0   0   0   0   0   0   0   2   5  12  39  78 115 136 140 134 117 101  84  70  62  56  51  47  44  40  36  29   4
1.0    0   0   0   0   0   0   0   0   0   0   0   0   1   7  26  59  96 125 139 133 117  97  78  66  59  54  49  46  41  37  29   8

1.5    0   0   0   0   0   0   0   0   0   0   0   0   0   0   2   9  26  54  86 123 133 119  95  77  66  59  54  49  43  39  31  17
2.0    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   3  10  25  64 104 129 116  93  76  65  58  53  45  41  33  24
2.5    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2  10  34  84 125 117  96  78  66  59  49  43  35  27
3.0    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   6  32  89 122 114  94  77  66  53  45  37  27
----+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
          RAINFALL TYPE = II                       * * * TC = 1.0  HR * * *                                        SHEET  7 OF 10
```

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

TRVL	HYDROGRAPH TIME (HOURS)																														
TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC =1.25 HR * * *														IA/P = 0.10				
0.0	10	13	18	25	29	38	54	81	118	163	213	256	284	311	266	212	163	129	104	78	61	47	37	31	27	24	22	20	18	16	12	1
.10	10	13	17	23	27	34	47	69	102	143	189	234	267	297	274	226	175	138	111	82	64	48	38	31	27	24	22	20	18	16	12	1
.20	9	11	15	20	22	26	31	42	60	88	124	168	212	280	292	261	212	166	131	95	72	53	40	33	28	25	23	21	18	16	12	1
.30	8	11	14	19	21	24	29	38	53	76	108	148	190	263	288	268	224	177	140	101	76	55	41	34	29	25	23	21	18	16	12	2
.40	8	10	13	18	20	23	27	34	46	66	94	130	170	245	282	273	235	188	149	107	80	58	42	34	29	26	23	21	19	16	12	2
.50	7	9	12	16	17	19	22	25	31	41	58	82	114	190	256	279	262	222	178	127	93	65	46	36	31	27	24	22	19	17	13	2
.75	6	8	10	14	15	17	19	21	25	31	41	56	78	139	207	254	265	245	208	152	110	75	51	39	32	28	25	22	19	17	13	3
1.0	5	6	8	10	11	13	14	15	17	19	22	26	33	60	109	173	230	261	255	208	153	100	64	46	36	30	26	24	20	18	13	5
1.5	3	4	5	7	7	8	9	9	10	11	12	13	15	19	27	45	79	130	186	247	239	180	108	68	48	37	31	27	22	19	14	10
2.0	2	3	4	5	6	6	7	7	8	8	9	10	11	13	16	22	35	59	98	171	236	236	156	95	62	44	35	30	23	20	15	11
2.5	1	2	2	3	4	4	4	5	5	5	6	6	7	8	10	12	14	19	28	58	114	197	226	163	102	65	46	36	26	21	16	11
3.0	0	1	1	2	2	2	2	3	3	3	4	4	4	5	6	7	9	10	13	19	35	88	184	218	169	109	70	49	31	24	18	12
IA/P = 0.30														* * * TC =1.25 HR * * *														IA/P = 0,30				
0.0	0	0	0	0	0	2	9	25	50	86	130	174	208	253	235	201	164	136	115	92	76	61	51	44	39	35	32	30	27	24	19	1
.10	0	0	0	0	0	0	1	6	19	40	71	110	153	217	247	227	191	157	131	103	84	66	53	46	41	36	33	31	28	24	19	2
.20	0	0	0	0	0	0	1	4	14	31	58	93	133	202	239	231	199	165	138	108	87	68	55	47	41	37	33	31	28	25	19	2
.30	0	0	0	0	0	0	0	1	3	10	24	46	77	152	210	236	222	190	158	122	97	74	58	49	43	38	34	32	28	25	20	3
.40	0	0	0	0	0	0	0	0	2	8	19	37	64	134	196	232	225	198	166	127	101	77	59	50	43	38	35	32	28	25	20	3
.50	0	0	0	0	0	0	0	0	0	2	6	14	30	82	151	206	228	217	189	146	113	85	64	52	45	40	36	33	29	26	20	5
.75	0	0	0	0	0	0	0	0	0	1	2	7	15	49	105	164	205	218	205	166	129	95	69	55	47	41	37	33	29	26	20	6
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	32	77	134	185	214	203	166	120	83	63	52	45	39	35	30	27	21	10
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	33	72	121	184	203	171	117	82	62	51	44	39	32	29	22	15
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	21	67	132	194	174	123	86	64	52	45	35	31	24	18
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	13	46	121	187	166	119	84	63	52	39	32	25	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	44	129	180	160	116	83	63	44	35	27	18
IA/P = 0.50														* * * TC =1.25 HR * * *														IA/P = 0.50				
0.0	0	0	0	0	0	0	1	5	13	26	44	68	91	125	142	142	128	117	107	94	83	72	63	57	52	47	44	42	38	34	28	2
.10	0	0	0	0	0	0	0	0	3	10	20	36	57	100	129	140	136	125	114	100	88	76	65	59	54	49	45	43	39	35	29	3
.20	0	0	0	0	0	0	0	0	2	7	16	30	48	90	122	139	139	127	117	102	90	77	66	60	54	49	45	43	39	35	29	3
.30	0	0	0	0	0	0	0	0	0	2	5	12	24	59	98	126	137	134	125	109	96	82	69	61	56	51	46	44	40	36	29	4
.40	0	0	0	0	0	0	0	0	0	1	4	10	19	51	89	119	134	136	127	112	98	83	70	62	56	51	47	44	40	36	29	5
.50	0	0	0	0	0	0	0	0	0	1	3	7	15	43	79	112	131	135	129	114	100	85	71	63	57	52	47	44	40	36	29	6
.75	0	0	0	0	0	0	0	0	0	0	0	1	3	15	39	71	102	123	130	125	112	94	78	67	60	54	49	46	41	37	29	9
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	17	40	71	101	121	129	121	103	84	71	62	56	51	47	42	38	30	13
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	26	51	92	119	125	105	86	72	63	57	52	44	40	32	23
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	11	35	72	112	122	103	85	71	63	56	47	42	34	26
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	24	66	111	119	101	83	71	62	51	44	36	27
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	23	71	110	116	99	82	70	55	46	37	27

RAINFALL TYPE = II

* * * TC = 1.25 HR * * *

SHEET 8 OF 10

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

```
TRVL ---------------------------------------------- HYDROGRAPH TIME (HOURS) --------------------------------------------------------
TIME      11.3    11.9    12.1    12.3    12.5    12.7    13.0    13.4    13.8    14.3    15.0    16.0    17.0    18.0    20.0    26.0
(HR)  11.0    11.6    12.0    12.2    12.4    12.6    12.8    13.2    13.6    14.0    14.6    15.5    16.5    17.5    19.0    22.0
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---
            IA/P = 0.10                                  * * * TC =1.5  HR * * *                                    IA/P = 0.10
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---
0.0      9  11  15  21  25  31  41  58  82 112 147 184 216 255 275 236 198 159 129  98  76  57  43  35  30  25  23  21  18  16  12   1
.10      8  10  13  18  20  23  28  37  51  72  98 131 166 226 265 254 226 187 151 113  86  63  46  37  31  26  23  21  19  16  13   2
.20      8  10  13  17  19  22  26  33  45  63  87 116 149 212 259 259 233 197 160 119  90  66  48  38  32  27  24  22  19  16  13   2
.30      7   9  12  16  18  21  24  30  40  55  76 103 134 197 244 255 238 206 169 125  95  68  49  38  32  27  24  22  19  17  13   2

.40      7   8  11  14  15  17  19  23  28  36  49  67  91 151 208 247 252 230 196 146 109  77  54  41  34  29  25  22  19  17  13   3
.50      6   8  10  13  15  16  18  21  26  33  43  59  80 136 194 238 249 235 204 154 115  81  56  42  34  29  25  23  20  17  13   3
.75      5   7   8  11  12  13  14  16  18  21  25  32  42  76 125 179 222 240 233 193 148 102  67  48  38  32  27  24  20  18  13   5
1.0      4   5   7   8   9  10  11  12  13  14  16  18  22  34  59 101 152 201 236 230 193 135  86  59  44  35  30  26  21  18  14   7

1.5      3   4   5   6   6   7   8   8   9  10  11  12  13  16  22  34  58  95 141 203 226 197 131  84  58  43  35  29  23  20  15  10
2.0      1   2   3   4   4   5   5   6   6   7   7   8   9  10  12  16  22  34  56 110 172 218 187 126  82  57  43  34  25  21  16  11
2.5      1   1   2   2   3   3   3   4   4   4   5   5   6   7   8   9  11  14  18  34  69 141 210 190 133  87  60  44  30  23  17  12
3.0      0   0   1   1   2   2   2   2   3   3   3   3   4   5   5   6   8   9  11  16  27  66 149 204 181 128  85  58  35  25  18  12
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---
            IA/P = 0.30                                  * * * TC =1.5  HR * * *                                    IA/P = 0.30
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---
0.0      0   0   0   0   0   1   6  15  31  53  80 112 144 193 225 208 186 157 134 108  89  70  56  48  42  37  34  31  28  25  20   2
.10      0   0   0   0   0   0   1   4  12  25  43  68  97 157 198 219 203 178 151 120  98  77  60  50  44  38  35  32  28  25  20   3
.20      0   0   0   0   0   0   0   1   3   9  19  35  57 114 168 201 213 196 171 135 108  84  64  53  46  40  36  33  29  26  20   4
.30      0   0   0   0   0   0   0   1   2   7  15  29  48 100 155 193 210 200 177 140 113  87  66  54  46  41  36  33  29  26  20   5

.40      0   0   0   0   0   0   0   0   2   5  12  23  39  87 141 184 207 202 182 146 117  89  68  55  47  41  36  33  29  26  20   5
.50      0   0   0   0   0   0   0   0   0   1   4   9  18  51 101 153 190 205 197 164 131  99  73  58  49  43  38  34  30  26  20   7
.75      0   0   0   0   0   0   0   0   0   0   2   4   9  30  68 116 160 189 197 179 147 110  80  62  52  45  39  35  30  27  21   8
1.0      0   0   0   0   0   0   0   0   0   0   0   0   1   5  20  49  92 138 175 195 178 137  97  72  57  48  42  37  31  28  21  12

1.5      0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   7  21  47  85 145 187 178 133  95  71  57  48  42  34  29  23  16
2.0      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   4  13  45  97 162 180 138  99  74  58  49  38  32  25  18
2.5      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   8  31  89 161 174 133  97  72  58  42  34  26  18
3.0      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   5  29  98 160 169 129  95  71  48  37  28  19
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---
            IA/P = 0.50                                  * * * TC =1.5  HR * * *                                    IA/P = 0.50
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---
0.0      0   0   0   0   0   0   0   3   8  16  27  42  59  92 116 128 130 121 112 100  90  78  67  60  55  50  46  43  39  35  29   4
.10      0   0   0   0   0   0   0   2   6  12  22  35  51  84 110 125 128 123 114 102  91  79  68  61  55  50  46  43  39  35  29   4
.20      0   0   0   0   0   0   0   0   1   4  10  18  29  60  91 114 126 128 120 108  97  83  71  63  57  52  47  44  40  36  29   5
.30      0   0   0   0   0   0   0   0   1   3   8  14  24  52  83 108 123 126 122 110  98  85  72  63  57  52  48  44  40  36  29   6

.40      0   0   0   0   0   0   0   0   0   1   2   6  12  31  60  90 112 124 126 116 104  90  75  66  59  54  49  45  41  37  29   8
.50      0   0   0   0   0   0   0   0   0   0   2   4   9  26  53  83 106 121 125 118 106  91  77  67  60  54  49  46  41  37  29   8
.75      0   0   0   0   0   0   0   0   0   0   1   2   5  16  36  62  88 108 119 122 112  97  81  69  62  56  51  47  42  38  30  11
1.0      0   0   0   0   0   0   0   0   0   0   0   0   0   3  10  26  49  75  98 118 121 108  90  76  66  59  54  49  43  39  31  16

1.5      0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   3  11  25  45  80 107 118 106  89  75  65  59  53  45  41  32  23
2.0      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   4  11  32  63 100 115 104  87  74  65  58  48  42  34  26
2.5      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   4  16  48  94 113 105  89  76  66  53  45  36  27
3.0      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   3  15  54  96 111 103  88  75  58  48  38  28
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---
            RAINFALL TYPE = II                           * * * TC = 1.5  HR * * *                                   SHEET  9 OF 10
```

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10																* * * TC =2.0 HR * * *													IA/P = 0.10			
0.0	7	9	12	16	18	21	27	36	49	64	82	104	127	171	201	226	208	193	171	132	105	79	58	45	36	30	26	23	20	17	13	3
.10	6	8	10	14	15	17	20	25	33	43	57	74	94	139	179	204	218	205	188	150	118	88	63	48	38	32	27	24	20	17	13	4
.20	6	8	10	13	14	16	19	23	29	39	51	66	84	128	169	198	213	207	192	157	123	91	65	49	39	33	28	24	20	17	13	4
.30	6	7	9	12	14	15	18	21	27	35	45	59	76	117	159	191	211	208	196	163	128	95	68	51	40	33	28	25	20	18	13	4
.40	5	6	8	11	12	13	15	17	20	24	31	41	53	87	128	167	197	209	205	180	145	106	75	55	43	35	30	26	21	18	14	5
.50	5	6	8	10	11	13	14	16	18	22	28	37	48	78	118	158	190	208	208	185	151	111	77	57	44	36	30	26	21	18	14	5
.75	4	6	7	9	10	11	12	13	15	18	22	27	35	58	91	129	164	191	202	194	167	125	87	63	48	38	32	27	22	18	14	6
1.0	3	4	6	7	8	8	9	10	11	12	14	16	18	28	46	74	110	147	178	201	193	156	108	76	56	43	35	30	23	19	14	8
1.5	2	3	3	5	5	5	6	6	7	8	8	9	10	12	16	23	36	57	86	137	178	195	160	113	79	58	45	36	26	21	16	11
2.0	1	2	2	3	3	4	4	4	5	5	6	6	7	8	10	12	16	23	35	67	112	169	190	154	110	78	57	44	30	23	17	11
2.5	0	1	1	2	2	2	3	3	3	4	4	4	5	6	7	8	9	12	16	28	52	105	170	185	149	107	76	56	35	26	18	12
3.0	0	0	1	1	1	1	1	2	2	2	2	3	3	3	4	5	6	7	8	12	18	41	99	161	180	152	112	80	45	30	19	12
IA/P = 0.30																* * * TC =2.0 HR * * *													IA/P = 0.30			
0.0	0	0	0	0	0	1	3	8	15	25	38	54	74	115	148	168	185	170	159	131	110	89	70	57	49	42	38	34	29	26	20	5
.10	0	0	0	0	0	0	0	2	6	12	21	32	47	85	124	153	169	180	168	145	120	96	75	60	51	44	39	35	30	26	20	6
.20	0	0	0	0	0	0	0	2	4	10	17	27	41	75	114	146	165	175	170	149	124	99	76	62	52	45	39	35	30	27	21	6
.30	0	0	0	0	0	0	0	0	1	3	7	14	23	49	86	122	151	170	174	160	136	107	82	66	54	47	41	37	31	27	21	8
.40	0	0	0	0	0	0	0	0	1	2	6	11	19	43	77	113	144	165	173	163	140	111	85	67	55	47	41	37	31	27	21	8
.50	0	0	0	0	0	0	0	0	1	2	4	9	16	37	68	104	136	160	171	165	144	114	87	69	56	48	42	37	31	27	21	9
.75	0	0	0	0	0	0	0	0	0	0	1	2	5	15	34	62	96	127	152	167	160	132	100	77	62	52	45	40	32	28	22	11
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	24	48	79	111	150	166	153	118	90	71	58	49	43	34	29	23	14
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	10	24	45	88	130	161	148	115	88	70	57	48	37	31	24	17
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	32	68	122	157	143	113	87	68	56	42	34	26	18
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	16	51	114	153	144	116	89	70	49	38	27	19
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	15	59	118	150	140	113	88	57	42	29	19
IA/P = 0.50																* * * TC =2.0 HR * * *													IA/P = 0.50			
0.0	0	0	0	0	0	0	0	1	4	8	13	20	28	51	73	92	104	111	112	106	97	86	75	66	60	54	49	46	41	37	30	7
.10	0	0	0	0	0	0	0	1	3	6	11	17	24	45	68	87	101	109	112	107	98	88	76	67	60	55	50	46	41	37	30	8
.20	0	0	0	0	0	0	0	1	2	5	9	14	21	40	62	82	98	107	111	108	100	89	77	68	61	55	50	47	41	37	30	8
.30	0	0	0	0	0	0	0	0	0	2	4	7	12	26	46	67	86	100	108	111	104	93	80	70	63	57	52	48	42	38	30	10
.40	0	0	0	0	0	0	0	0	0	1	3	6	10	22	41	62	81	96	106	110	105	94	81	71	63	57	52	48	42	38	30	11
.50	0	0	0	0	0	0	0	0	0	0	1	2	4	13	27	46	67	85	99	110	108	98	85	74	66	59	54	49	43	39	31	13
.75	0	0	0	0	0	0	0	0	0	0	0	1	2	7	18	33	52	71	88	104	108	102	89	77	68	61	55	50	44	39	31	15
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	13	25	43	62	87	103	108	97	84	73	65	59	53	45	41	32	20
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	12	24	48	74	99	106	95	83	72	64	58	48	43	34	25
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	17	37	69	99	104	94	82	72	64	52	45	36	27
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	27	65	95	102	95	83	73	58	49	38	28
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	32	68	95	101	93	82	64	52	40	28

RAINFALL TYPE = II

* * * TC = 2.0 HR * * *

SHEET 10 OF 10

ODOT Hydraulic Manual Users: Exhibit 5-III, the Type III rainfall distribution, is omitted from this publication. This rainfall distribution does not occur in Oregon.

Chapter 6: Storage volume for detention basins

As rural areas become urbanized, the resulting increases in peak discharges can adversely affect downstream flood plains. Increasingly, planners, developers, and the public want these downstream areas to be protected. Many local governments are adopting ordinances to control the type of development and its allowable impacts on the watershed. One of the most common controls requires that postdevelopment discharges do not exceed present-condition discharges for one or more storm frequencies at specified points along a channel.

This chapter discusses ways to manage peak discharges by delaying runoff. It also presents a procedure for estimating the storage capacity required to maintain the peaks within a specified level.

Efforts to reduce the effects of increased runoff from urban areas have been innovative and diverse. Many methods have been used effectively, such as infiltration trenches, porous pavement, rooftop storage, and cisterns. But these solutions can be expensive or require site conditions that cannot be provided.

The detention basin is the most widely used measure for controlling peak discharge. It is generally the least expensive and most reliable of the measures that have been considered. It can be designed to fit a wide variety of sites and can accommodate multiple-outlet spillways to meet requirements for multifrequency control of outflow. Measures other than a detention basin may be preferred in some locations; their omission here is not intended to discourage their use. Any device selected, however, should be assessed as to its function, maintenance needs, and impact.

Estimating the effect of storage

When a detention basin is installed, hydraulic routing procedures can be used to estimate the effect on hydrographs. Both the TR-20 (SCS 1983) and DAMS2 (SCS 1982) computer programs provide accurate methods of analysis. Programmable calculator and computer programs are available for routing hydrographs through dams.

This chapter contains a manual method for quick estimates of the effects of temporary detention on peak discharges. The method is based on average storage and routing effects for many structures.

Figure 6-1 relates two ratios: peak outflow to peak inflow discharge (q_o/q_i) and storage volume to runoff volume (V_s/V_r) for all four rainfall distributions.

The relationships in figure 6-1 were determined on the basis of single stage outflow devices. Some were controlled by pipe flow, others by weir flow. Verification runs were made using multiple stage outflow devices, and the variance was similar to that in the base data. The method can therefore be used for both single- and multiple-stage outflow devices. The only constraints are that (1) each stage requires a design storm and a computation of the storage required for it and (2) the discharge of the upper stage(s) includes the discharge of the lower stage(s).

The brevity of the procedure allows the planner to examine many combinations of detention basins. When combined with the Tabular Hydrograph method, the procedure's usefulness is increased. Its principal use is to develop preliminary indications of storage adequacy and to allocate control to a group of detention basins. It is also adequate, however, for final design of small detention basins.

Input requirements and procedures

Use figure 6-1 to estimate storage volume (V_s) required or peak outflow discharge (q_o). The most frequent application is to estimate V_s, for which the required inputs are runoff volume (V_r), q_o, and peak inflow discharge (q_i). To estimate q_o, the required inputs are V_r, V_s, and q_i.

Estimating V_s

Use worksheet 6a to estimate V_s, storage volume required, by the following procedure.

1. Determine q_o. Many factors may dictate the selection of peak outflow discharge. The most common is to limit downstream discharges to a desired level, such as predevelopment discharge. Another factor may be that the outflow device has already been selected.
2. Estimate q_i by procedures in chapters 4 or 5. Do not use peak discharges developed by any other procedure. When using the Tabular Hydrograph method to estimate q_i for a subarea, only use

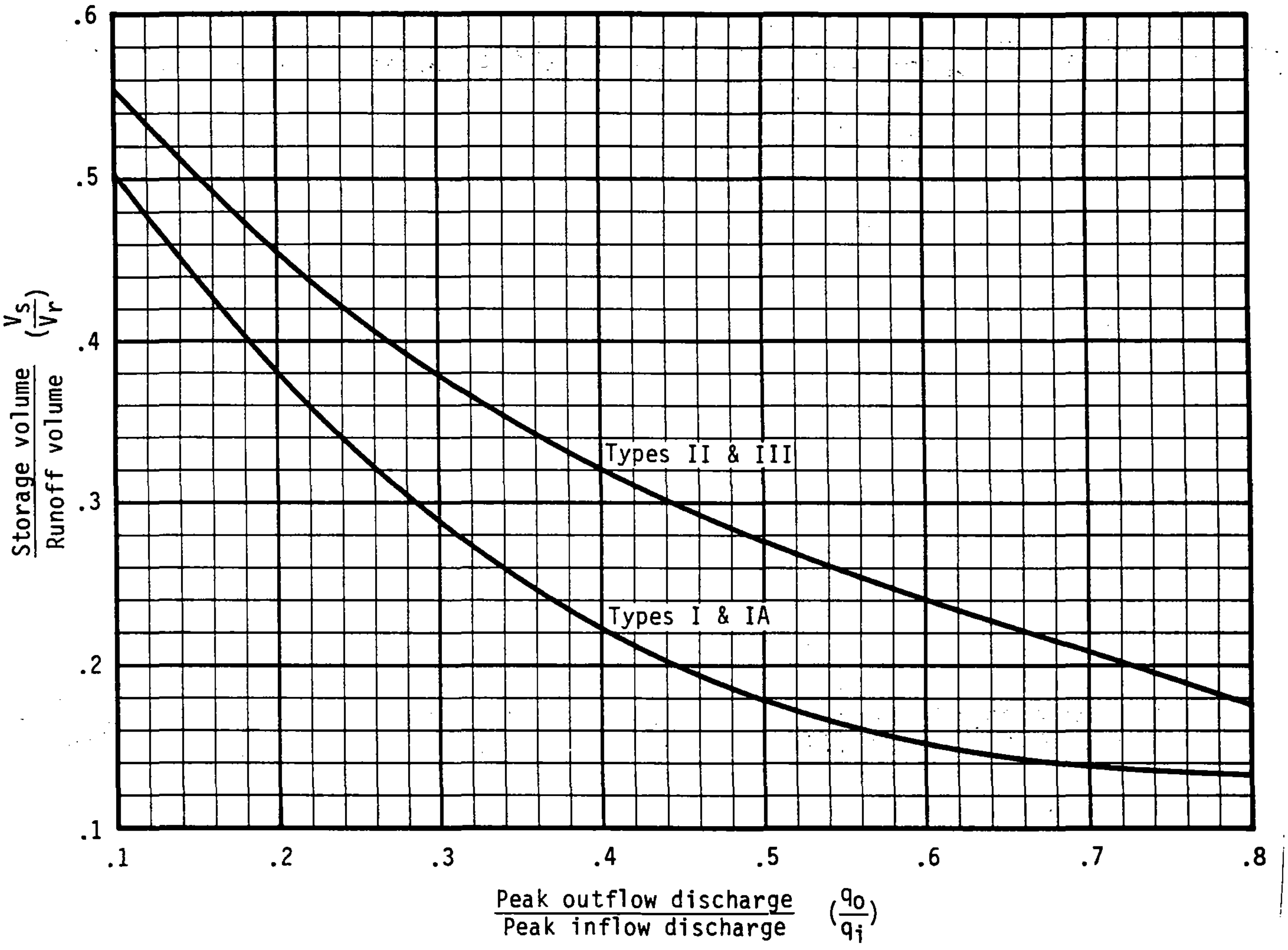


Figure 6-1.—Approximate detention basin routing for rainfall types I, IA, II, and III.

peak discharge associated with $T_t = 0$.

3. Compute q_o/q_i and determine V_s/V_r from figure 6-1.
4. Q (in inches) was determined when computing q_i in step 2, but now it must be converted to the units in which V_s is to be expressed—most likely, acre-feet or cubic feet. The most common conversion of Q to V_r is expressed in acre-feet:

$$V_r = 53.33Q(A_m) \qquad \text{[Eq. 6-1]}$$

where

V_r = runoff volume (acre-ft),
Q = runoff (in),
A_m = drainage area (mi_2), and
53.33 = conversion factor from in-mi^2 to acre-ft.

5. Use the results of steps 3 and 4 to compute V_s:

$$V_s = V_r\left(\frac{V_s}{V_r}\right) \qquad \text{[Eq. 6-2]}$$

where V_s = storage volume required (acre-ft).

6. The stage in the detention basin corresponding to V_s must be equal to the stage used to generate q_o. In most situations a minor modification of the outflow device can be made. If the outflow device has been preselected, repeat the calculations with a modified q_o value.

Estimating q_o

Use worksheet 6b to estimate q_o, required peak outflow discharge, by the following procedure.

1. Determine V_s. If the maximum stage in the detention basin is constrained, set V_s by the maximum permissible stage.
2. Compute Q (in inches) by the procedures in chapter 2, and convert it to the same units as V_s (see step 4 in "Estimating V_s").
3. Compute V_s/V_r and determine q_o/q_i from figure 6-1.
4. Estimate q_i by the procedures in chapters 4 or 5. Do not use peak discharges developed by any other method. When using the Tabular method to estimate q_i for a subarea, use only the peak discharge associated with $T_t = 0$.
5. From steps 3 and 4, compute q_o:

$$q_o = q_i\left(\frac{q_o}{q_i}\right) \qquad \text{[Eq. 6-3]}$$

6. Proportion the outflow device so that the stage at q_o is equal to the stage corresponding to V_s. If q_o cannot be calibrated except in discrete steps (i.e., pipe sizes), repeat the procedure until the stages for q_o and V_s are approximately equal.

Limitations

- This routing method is less accurate as the q_o/q_i ratio approaches the limits shown in figure 6-1. The curves in figure 6-1 depend on the relationship between available storage, outflow device, inflow volume, and shape of the inflow hydrograph. When storage volume (V_s) required is small, the shape of the outflow hydrograph is sensitive to the rate of rise of the inflow hydrograph. Conversely, when V_s is large, the inflow hydrograph shape has little effect on the outflow hydrograph. In such instances, the outflow hydrograph is controlled by the hydraulics of the outflow device and the procedure therefore yields consistent results. When the peak outflow discharge (q_o) approaches the peak inflow discharge (q_i), parameters that affect the rate of rise of a hydrograph, such as rainfall volume, curve number, and time of concentration, become especially significant.

- The procedure should not be used to perform final design if an error in storage of 25 percent cannot be tolerated. Figure 6-1 is biased to prevent undersizing of outflow devices, but it may significantly overestimate the required storage capacity. More detailed hydrograph development and routing will often pay for itself through reduced construction costs.

Examples

Four examples illustrate the use of figure 6-1. Examples 6-1 through 6-4, respectively, show estimation of V_s, use of a two-stage structure, estimation of q_o, and use with the Tabular Hydrograph method.

Example 6-1: Estimating V_s, single-stage structure

A development is being planned in a 75-acre (0.117-mi^2) watershed that outlets into an existing concrete-lined channel designed for present conditions. If the channel capacity is exceeded, damages will be substantial. The watershed is in the type II storm distribution region. The present channel capacity, 180 cfs, was established by computing discharge for the 25-year-frequency storm by the Graphical Peak Discharge method (chapter 4).

The developed-condition peak discharge (q_i) computed by the same method is 360 cfs, and runoff (Q) is 3.4 inches. Since outflow must be held to 180 cfs, a detention basin having that maximum outflow discharge (q_o) will be built at the watershed outlet.

How much storage (V_s) will be required to meet the maximum outflow discharge (q_o) of 180 cfs, and what will be the approximate dimensions of a rectangular weir outflow structure? Figure 6-2 shows how worksheet 6a is used to estimate required storage (V_s = 5.9 acre-ft) and maximum stage (E_{max} = 105.7 ft).

The rectangular weir was chosen for its simplicity; however, several types of outlets can meet the outflow device proportion requirement. Most hydraulic references, along with considerable research data that are available, provide more guidance on variations of outlet devices than can be summarized here.

An outlet device should be proportioned to meet specific objectives. A single-stage device was specified in this example because only one storm was considered. A weir is suitable here because of the low head. The weir crest elevation is 100.0 ft.

Using V_s = 5.9 acre-ft (figure 6-2, step 9) and the elevation-storage curve, the maximum stage (E_{max}) is 105.7 ft.

The rectangular weir equation is

$$q_o = 3.2\ L_w H_w^{1.5} \qquad \text{[Eq. 6-4]}$$

where

q_o = peak outflow discharge (cfs),
L_w = weir crest length (ft), and
H_w = head over weir crest (ft).

H_w and q_o are computed as follows:

$$H_w = E_{max} - \text{weir crest elevation}$$
$$= 105.7 - 100.0 = 5.7 \text{ ft.}$$

Since q_o is known to be 180 cfs, solving equation 6-4 for L_w yields

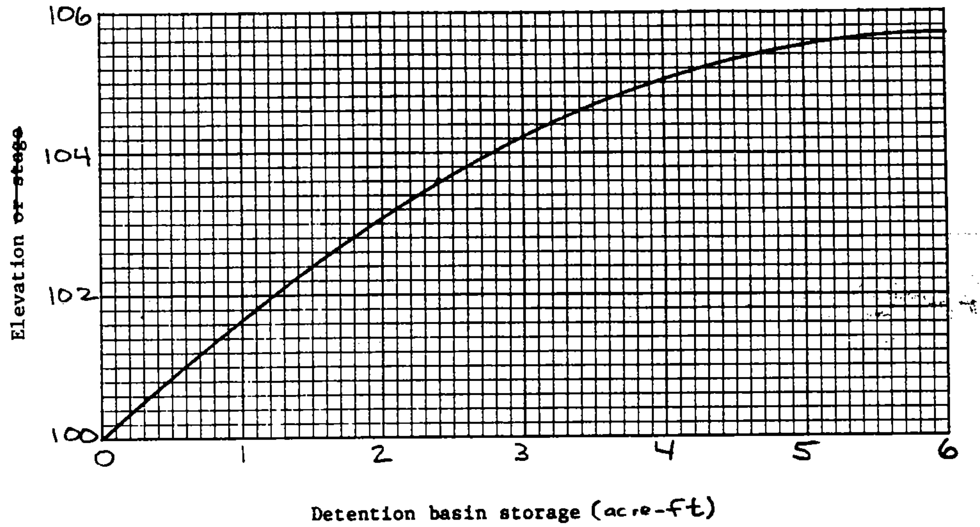
$$L_w = \frac{q_o}{3.2\ H_w^{1.5}} \qquad \text{[Eq. 6-5]}$$

$$= \frac{180}{3.2\ (5.7)^{1.5}} = 4.1 \text{ ft.}$$

In summary, the outlet structure is a rectangular weir with crest length of 4.1 ft, H_w = 5.7 ft, and q_o = 180 cfs corresponding to a V_s = 5.9 acre-ft.

Worksheet 6a: Detention basin storage, peak outflow discharge (q_o) known

Project Robbinsville By SWR Date 11/5/85
Location Dyer County, Tennessee Checked RGC Date 11/8/85
Circle one: Present [✓ Developed] Single-stage-structure



1. Data:
   Drainage area .... A_m = 0.117 mi^2
   Rainfall distribution type (I, IA, II, III) = II

	1st stage	2nd stage
2. Frequency ...... yr	25	
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	360	
4. Peak outflow discharge, q_o .... cfs	180	1/
5. Compute $\frac{q_o}{q_i}$	0.50	
6. $\frac{V_s}{V_r}$ .... (Use $\frac{q_o}{q_i}$ with figure 6-1)	0.28	
7. Runoff, Q ...... in (From worksheet 2)	3.4	
8. Runoff volume, V_r .... ac-ft (V_r = QA_m53.33)	21.2	
9. Storage volume, V_s .... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$)	5.9	
10. Maximum stage, E_{max} (From plot)	105.7	-

1/ 2nd stage q_o includes 1st stage q_o.

Figure 6-2.—Worksheet 6a for example 6-1.

Example 6-2: Estimating V_s, two-stage structure

In addition to the requirements for a 25-year peak outflow discharge of 180 cfs stated in example 6-1, a decision was made to limit the 2-year outflow discharge to 50 cfs because of potential damages to agricultural property below the lined channel. By the method in chapter 4, the estimated 2-year peak discharge for developed conditions will be 91 cfs and runoff (Q) will be 1.5 inches.

Again, a rectangular concrete weir outflow device was selected; the device could have been another type, but it is important to remember that the flows through the first stage are part of the total discharge of the higher stage.

Figure 6-3 shows how worksheet 6a is used to compute the V_s of 2.4 acre-ft and E_{max} of 103.6 for the first stage. E_{max} of 103.6 is the weir crest elevation for the second stage.

Equation 6-5 is again used to compute L_w for the first stage. The weir crest elevation for the first stage is 100.00 ft and $q_o = 50$ cfs. The first-stage computations for H_w and L_w are

$$\begin{aligned} H_w &= E_{max} - \text{weir crest elevation} \\ &= 103.6 - 100.0 = 3.6 \text{ ft;} \end{aligned}$$

and, from equation 6-5,

$$L_w = \frac{50}{3.2(3.6)^{1.5}} = 2.3 \text{ ft.}$$

The second stage is then proportioned to discharge the correct amount at 105.7 ft (figure 6-2, step 10). Compute the discharge through the first stage for elevation 105.7 ft using

$$L_w = 2.3 \text{ ft (first stage)}$$

and

$$H_w = 105.7 - 100.0 = 5.7 \text{ ft.}$$

By substituting these values in equation 6-4, discharge (q_o) through the first stage at 105.7 ft is calculated:

$$q_o = 3.2(2.3)(5.7)^{1.5} = 100 \text{ cfs.}$$

Now compute the required weir crest length (L_w) for the second stage, using equation 6-5. Since the second stage crest elevation is 103.6 ft,

$$H_w = 105.7 - 103.6 = 2.1 \text{ ft;}$$

and, since q_o for the second stage equals the total discharge from example 6-1 minus discharge through the first stage,

$$q_o = 180 - 100 = 80 \text{ cfs.}$$

Finally, substituting these H_w and q_o values in equation 6-5 results in

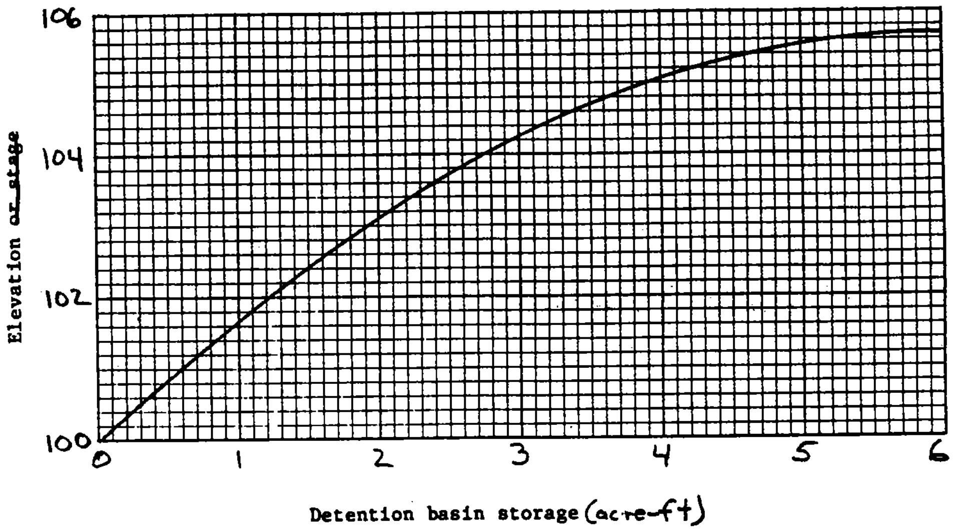
$$L_w = \frac{80}{3.2(2.1)^{1.5}} = 8.2 \text{ ft.}$$

In summary, the outlet structure is a 2-stage rectangular weir with first stage crest length of 2.3 ft at elevation 100.0, and second stage crest length of 8.2 ft at elevation 103.6 ft.

The weir equation used is probably less accurate for the two-stage example than for the single-stage example. The actual second-stage discharge will be slightly more than the one computed, but a discussion of hydraulics of outflow devices is outside the scope of this technical release. Example 6-2 is presented only to illustrate the interrelationship of outflow discharges and storage volume and to show how to develop preliminary estimates of storage requirements for two-stage outlet structures.

Worksheet 6a: Detention basin storage, peak outflow discharge (q_o) known

Project Robbinsville By SWR Date 11/6/85
Location Dyer County, Tennessee Checked RGC Date 11/9/85
Circle one: Present [✓ Developed] 2- stage structure



1. Data:
Drainage area .... A_m = 0.117 mi^2
Rainfall distribution type (I, IA, II, III) = II

	1st stage	2nd stage
2. Frequency ...... yr	2	25
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	91	360
4. Peak outflow discharge, q_o .... cfs [1]	50	180
5. Compute $\frac{q_o}{q_i}$	0.55	0.50
6. $\frac{V_s}{V_r}$ .... (Use $\frac{q_o}{q_i}$ with figure 6-1)	0.26	0.28
7. Runoff, Q ...... in (From worksheet 2)	1.5	3.4
8. Runoff volume, V_r .... ac-ft ($V_r = QA_m 53.33$)	9.4	21.2
9. Storage volume, V_s .... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$)	2.4	5.9
10. Maximum stage, E_{max} (From plot)	103.6	105.7

[1] 2nd stage q_o includes 1st stage q_o.

Figure 6-3.—Worksheet 6a for example 6-2.

Example 6-3: Estimating q_o

A development is being planned for a 10-acre watershed (0.0156 mi^2). A county ordinance requires that the developed-condition outflow from the watershed for a 24-hr, 100-year frequency storm does not exceed the outflow for present conditions. The peak discharge from the watershed for present conditions, 35 cfs, is calculated from procedures in chapter 4. For developed conditions, runoff (Q) is 5.4 inches, peak discharge from the watershed is 42 cfs from procedures in chapter 4, and rainfall distribution is type II.

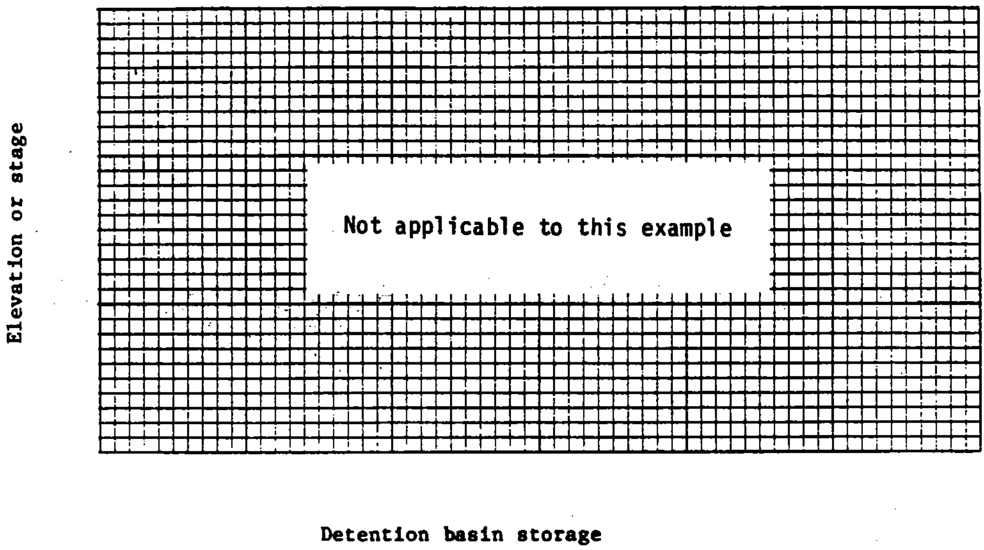
What will be the peak outflow discharge (q_o) from a detention basin that is located at the outlet and has maximum allowable storage volume (V_s) of 35,000 ft^3 and peak inflow discharge (q_i) of 42 cfs? Figure 6-4 shows how worksheet 6b is used to estimate q_o as 33 cfs, which is within the 35-cfs limit. An outflow device will be selected to discharge 33 cfs at a stage corresponding to a V_s of 35,000 ft^3.

Worksheet 6b: Detention basin peak outflow, storage volume (V_s) known

Project Woods Acres By SWR Date 11/8/85

Location Dyer County, Tennessee Checked RGC Date 11/11/85

Circle one: Present [✓ Developed]



1. Data:
Drainage area .... A_m = 0.0156 mi^2
Rainfall distribution type (I, IA, II, III) = II

	1st stage	2nd stage
2. Frequency ...... yr	100	
3. Storage volume, V_s .... ac ft	0.8	
4. Runoff, Q ...... in (From worksheet 2)	5.4	
5. Runoff volume, V_r .... ac-ft (V_r = QA_m53.33)	4.5	
6. Compute $\frac{V_s}{V_r}$	0.18	
7. $\frac{q_o}{q_i}$ .... in (Use $\frac{V_s}{V_r}$ and figure 6-1)	0.78	
8. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	42	
9. Peak outflow discharge, q_o .... cfs ($q_o = q_i(\frac{q_o}{q_i})$)	33	1/
10. Maximum stage, E_{max} (From plot)	N/A	

1/ 2nd stage q_o includes 1st stage q_o.

Figure 6-4.—Worksheet 6b for example 6-3.

Example 6-4: Estimating V_s, Tabular Hydrograph method

This example builds on examples 5-1 and 5-2 (pages 5-4 to 5-8). If peak outflow discharge from subarea 7 must not exceed the discharge for present conditions, what will be the storage volume (V_s) required in a detention basin at the outlet of subarea 6?

First, compute the outflow hydrograph without subarea 6 as shown in the table below, which presents developed-condition discharges for example 5-2. (The information in the table is from figure 5-4.)

	Discharge (cfs) at time (hr)—								
Subarea	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0
	cfs								
1	7	9	11	16	24	40	78	122	155
2	7	9	12	20	33	55	96	132	132
3	14	29	58	89	106	102	74	46	25
4	19	32	63	114	169	207	193	143	83
5	117	167	205	214	202	175	132	99	70
6 omitted	—	—	—	—	—	—	—	—	—
7	244	167	119	90	72	59	48	40	34
Total without subarea 6	408	413	468	543	606	638	621	582	499

After computing the outflow hydrograph, determine the maximum permissible outflow discharge from subarea 6. The present condition peak discharge at the outlet of subarea 7 is 720 cfs at 14.3 hr (figure 5-2), and the developed condition peak discharge at the outlet of subarea 7 minus subarea 6 is 638 cfs (table above). The difference between these two discharges, 82 cfs, is the maximum outflow discharge (q_o) for the detention basin.

Next, determine the peak discharge for subarea 6 for developed conditions by substituting values in equation 5-1:

$$q = q_t A_m Q. \qquad \text{[Eq. 5-1]}$$

From exhibit 5-II, the largest q_t value is 357 csm/in (exhibit 5-II, sheet 7: $T_c = 1.0$ hr, $T_t = 0$, and $I_a/P = 0.10$ at 12.8 hr). From figure 5-4, A_mQ for subarea 6 is 1.31. Therefore,

$$q = (357)(1.31) = 468 \text{ cfs.}$$

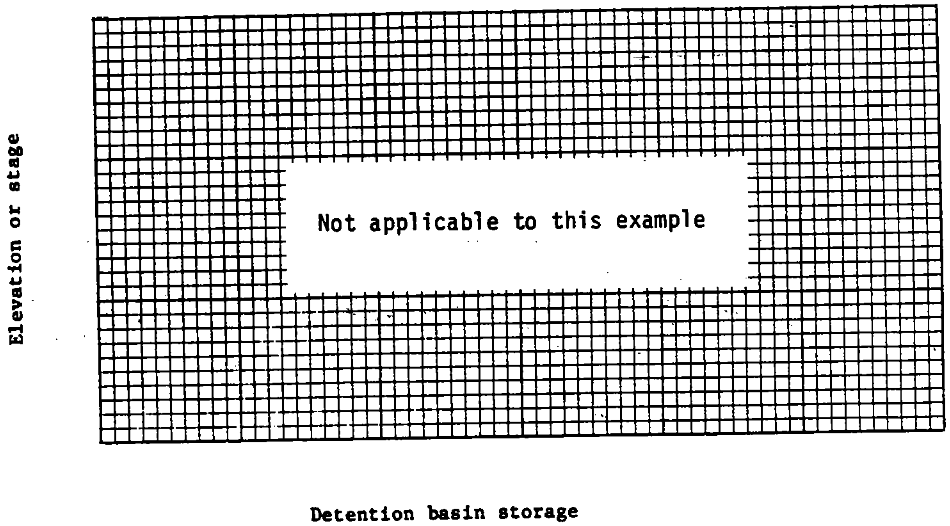
This q value is, of course, the same as the peak inflow discharge (q_i) into the detention basin.

Finally, use worksheet 6a (figure 6-5) to compute V_s as 33.2 acre-ft.

The required storage volume of 33.2 acre-ft is the basis for determining the required stage in the detention basin. This stage is a guide in proportioning a spillway that will discharge 82 cfs or less at that storage. The timing or routing effect is not considered because the outflow hydrograph will discharge at near q_o for a significant period.

Worksheet 6a: Detention basin storage, peak outflow discharge (q_o) known

Project Fallswood By SNR Date 10/8/85
Location Dyer County, Tennessee Checked RGC Date 10/10/85
Circle one: Present Developed



1. Data:
Drainage area .... A_m = 0.40 mi^2
Rainfall distribution type (I, IA, II, III) = II

	1st stage	2nd stage
2. Frequency ...... yr	25	
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	468	
4. Peak outflow discharge, q_o .... cfs	82	[1]
5. Compute $\frac{q_o}{q_i}$	0.175	

6. $\frac{V_s}{V_r}$ .... (Use $\frac{q_o}{q_i}$ with figure 6-1)	0.475	
7. Runoff, Q ...... in (From worksheet 2)	3.28	
8. Runoff volume, V_r .... ac-ft (V_r = QA_m53.33)	69.9	
9. Storage volume, V_s .... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$)	33.2	
10. Maximum stage, E_{max} (From plot)	N/A	

[1] 2nd stage q_o includes 1st stage q_o.

Figure 6-5.—Worksheet 6a for example 6-4.

Appendix A: Hydrologic soil groups

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier; for example, "Abrazo, gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

Disturbed soil profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred (Brakensiek and Rawls 1983):

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay

Drainage and group D soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Ackerman soil is classified as A/D. This indicates that the drained Ackerman soil is in group A and the undrained soil is in group D.

ODOT Hydraulics Manual Users: the Hydrologic Soil Groups for United States Soils listing is omitted from this publication. Use Hydrologic Soil Groups listed in Appendix A to "Oregon Engineering Handbook - Hydrology Guide."

Appendix B: Synthetic rainfall distributions and rainfall data sources

The highest peak discharges from small watersheds in the United States are usually caused by intense, brief rainfalls that may occur as distinct events or as part of a longer storm. These intense rainstorms do not usually extend over a large area and intensities vary greatly. One common practice in rainfall-runoff analysis is to develop a synthetic rainfall distribution to use in lieu of actual storm events. This distribution includes maximum rainfall intensities for the selected design frequency arranged in a sequence that is critical for producing peak runoff.

Synthetic rainfall distributions

The length of the most intense rainfall period contributing to the peak runoff rate is related to the time of concentration (T_c) for the watershed. In a hydrograph created with SCS procedures, the duration of rainfall that directly contributes to the peak is about 170 percent of the T_c. For example, the most intense 8.5-minute rainfall period would contribute to the peak discharge for a watershed with a T_c of 5 minutes; the most intense 8.5-hour period would contribute to the peak for a watershed with a 5-hour T_c.

Different rainfall distributions can be developed for each of these watersheds to emphasize the critical rainfall duration for the peak discharges. However, to avoid the use of a different set of rainfall intensities for each drainage area size, a set of synthetic rainfall distributions having "nested" rainfall intensities was developed. The set "maximizes" the rainfall intensities by incorporating selected short duration intensities within those needed for longer durations at the same probability level.

For the size of the drainage areas for which SCS usually provides assistance, a storm period of 24 hours was chosen for the synthetic rainfall distributions. The 24-hour storm, while longer than that needed to determine peaks for these drainage areas, is appropriate for determining runoff volumes. Therefore, a single storm duration and associated synthetic rainfall distribution can be used to represent not only the peak discharges but also the runoff volumes for a range of drainage area sizes.

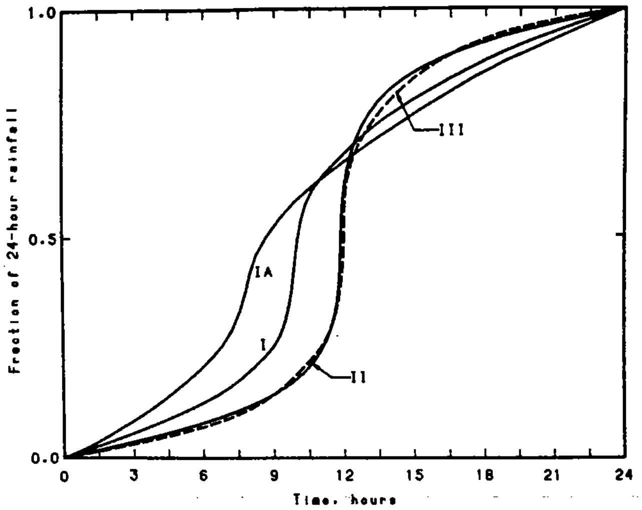
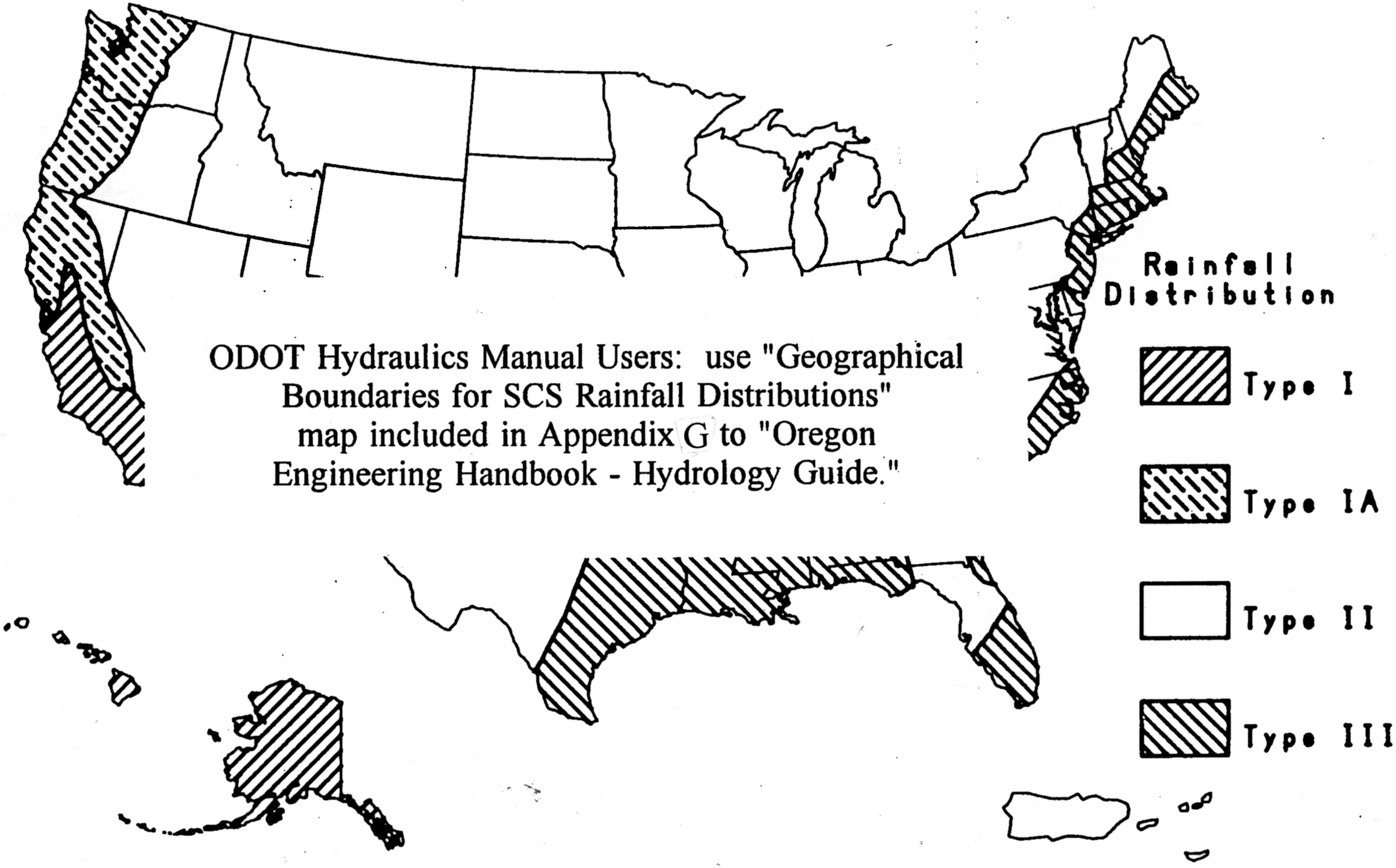


Figure B-1.—SCS 24-hour rainfall distributions.

The intensity of rainfall varies considerably during a storm as well as over geographic regions. To represent various regions of the United States, SCS developed four synthetic 24-hour rainfall distributions (I, IA, II, and III) from available National Weather Service (NWS) duration-frequency data (Hershfield 1961; Frederick et al., 1977) or local storm data. Type IA is the least intense and type II the most intense short duration rainfall. The four distributions are shown in figure B-1, and figure B-2 shows their approximate geographic boundaries.

Types I and IA represent the Pacific maritime climate with wet winters and dry summers. Type III represents Gulf of Mexico and Atlantic coastal areas where tropical storms bring large 24-hour rainfall amounts. Type II represents the rest of the country. For more precise distribution boundaries in a state having more than one type, contact the SCS State Conservation Engineer.



ODOT Hydraulics Manual Users: use "Geographical Boundaries for SCS Rainfall Distributions" map included in Appendix G to "Oregon Engineering Handbook - Hydrology Guide."

Figure B-2.—Approximate geographic boundaries for SCS rainfall distributions.

Rainfall data sources

This section lists the most current 24-hour rainfall data published by the National Weather Service (NWS) for various parts of the country. Because NWS Technical Paper 40 (TP-40) is out of print, the 24-hour rainfall maps for areas east of the 105th meridian are included here as figures B-3 through B-8. For the area generally west of the 105th meridian, TP-40 has been superseded by NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published by the National Oceanic and Atmospheric Administration.

East of 105th meridian

Hershfield, D. M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 115 p.

West of 105th meridian

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-frequency atlas of the Western United States. Vol. I, Montana; Vol. II, Wyoming; Vol. III, Colorado; Vol. IV, New Mexico; Vol. V, Idaho; Vol. VI, Utah; Vol. VII, Nevada; Vol. VIII, Arizona; Vol. IX, Washington; Vol. X, Oregon; Vol. XI, California. U.S. Dep. Commerce, National Weather Service, NOAA Atlas 2. Silver Spring, MD.

Alaska

Miller, John F. 1963. Probable maximum precipitation and rainfall-frequency data for Alaska for areas to 400 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 47. Washington, DC. 69 p.

Hawaii

Weather Bureau. 1962. Rainfall-frequency atlas of the Hawaiian Islands for areas to 200 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 43. Washington, DC. 60 p.

Puerto Rico and Virgin Islands

Weather Bureau. 1961. Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands for areas to 400 square miles, durations to 24 hours, and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 42. Washington, DC. 94 p.

ODOT Hydraulics Manual Users: the 24-hour rainfall maps
For the United States are omitted from this publication.
Use 24-hour precipitation maps in Appendix H to
Chapter 7 in the ODOT Hydraulics Manual

Appendix C: Computer program

The TR-55 procedures have been incorporated in a computer program. The program, written in BASIC, requires less than 256K memory to operate and was developed for an MS-DOS operating system. Users of the program, however, still need to be familiar with the procedures in this TR. Features of the program include the following:

- The full screen (24 lines, 80 columns) is used to enter data. Flexibility of coding allows movement about the screen for quick data modifications.

- Function keys provide menu power to move to different modules (TR-55 chapters) within the program. Some keys are permanently defined while others vary by module.

- "Help" screens provide pertinent information to the user depending on location in the program. Two types of information are included: (1) define system operation and (2) describe input parameters.

- User files provide for optional entry of local data, such as rainfall-frequency, graphic peak discharge equation coefficients, and tabular hydrographs for other rainfall distributions.

Copies of the program can be obtained from—

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Telephone (703) 487-4650

Appendix D: Worksheets

This appendix contains seven worksheets that can be reproduced for use with chapters 2 through 6. There is no worksheet for chapter 1.

Chapter	*Worksheet*
2	2
3	3
4	4
5	5a, 5b
6	6a, 6b

Worksheet 2: Runoff curve number and runoff

Project ______________________ By _____ Date _________

Location _____________________ Checked _____ Date _________

Circle one: Present Developed ______________________

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN [1]			Area ☐ acres ☐ mi^2 ☐ %	Product of CN x area
		Table 2-2	Fig. 2-3	Fig. 2-4		
				Totals =		

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = ______ = ________; Use CN = ☐

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr			
Rainfall, P (24-hour)	in			
Runoff, Q .... (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in			

---

[1] Use only one CN source per line.

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______________________________ By _____ Date ________

Location _____________________________ Checked _____ Date ________

Circle one: Present Developed ____________________

Circle one: T_c T_t 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 T_c only)	Segment ID					
1. Surface description (table 3-1)						
2. Manning's roughness coeff., n (table 3-1) ..						
3. Flow length, L (total L $\leq$ 300 ft)	ft					
4. Two-yr 24-hr rainfall, P_2	in					
5. Land slope, s	ft/ft					
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{\ 0.5}\ s^{0.4}}$ 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 coeff., n						
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s					
18. Flow length, L	ft					
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=	
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr					

Worksheet 4: Graphical Peak Discharge method

Project ______________________ By _____ Date ________

Location ______________________ Checked _____ Date ________

Circle one: Present Developed ______________________

1. Data:

Drainage area .... A_m = __________ mi^2 (acres/640)

Runoff curve number .... CN = __________ (From worksheet 2)

Time of concentration .. T_c = __________ hr (From worksheet 3)

Rainfall distribution type = __________ (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = __________ percent of A_m (____ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr			
3. Rainfall, P (24-hour)	in			
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in			
5. Compute I_a/P				
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-____)	csm/in			
7. Runoff, Q .... (From worksheet 2).	in			
8. Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)				
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs			

Worksheet 5a: Basic watershed data

Project ______________________ Location ______________________ By ______ Date ________

Circle one: Present Developed ______________________ Frequency (yr) ______ Checked ______ Date ________

Subarea name	Drainage area A_m (mi^2)	Time of concentration T_c (hr)	Travel time through subarea T_t (hr)	Downstream subarea names	Travel time summation to outlet ΣT_t (hr)	24-hr Rainfall P (in)	Runoff curve number CN	Runoff Q (in)	A_mQ $(mi^2\text{-}in)$	Initial abstraction I_a (in)	I_a/P

↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑
From worksheet 3

↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑
From worksheet 2

↑ ↑ ↑ ↑
From table 5-1

Worksheet 5b: Tabular hydrograph discharge summary

Project ______________________ Location ______________________ By ________ Date ________

Circle one: Present Developed ______________________ Frequency (yr) ________ Checked ________ Date ________

Subarea name	Basic watershed data used 1/				Select and enter hydrograph times in hours from exhibit 5- 2/											
	Sub-area T_c (hr)	ΣT_t to outlet (hr)	I_a/P	A_mQ (mi^2-in)												
					Discharges at selected hydrograph times 3/ (cfs)											
Composite hydrograph at outlet																

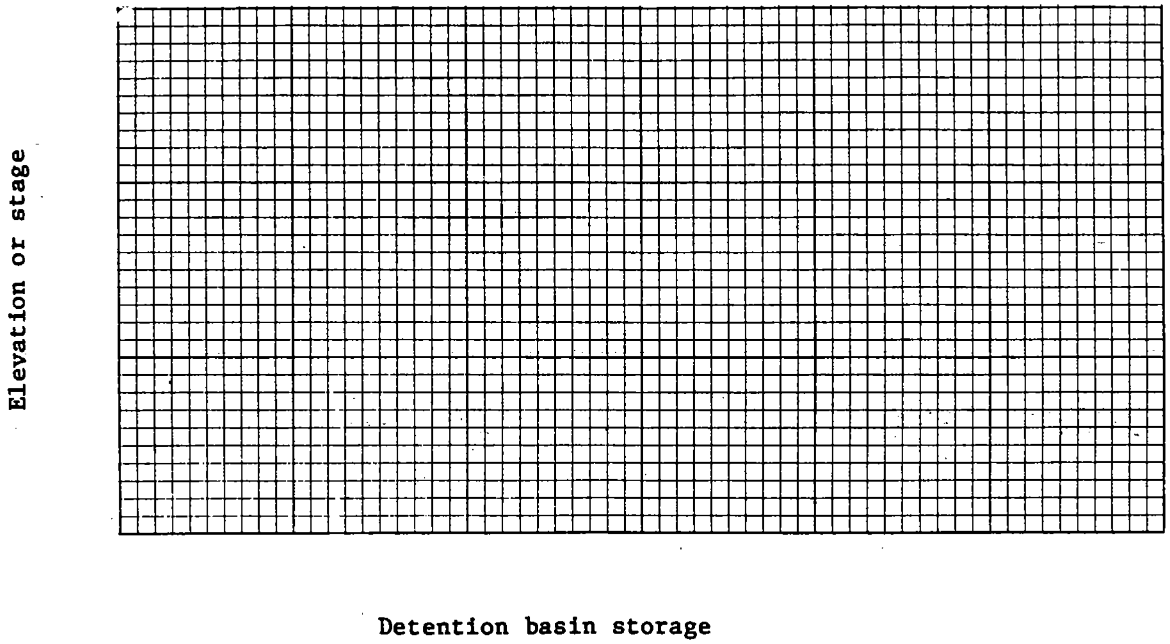
1/ Worksheet 5a. Rounded as needed for use with exhibit 5.
2/ Enter rainfall distribution type used.
3/ Hydrograph discharge for selected times is A_mQ multiplied by tabular discharge from appropriate exhibit 5.

Worksheet 6a: Detention basin storage, peak outflow discharge (q_o) known

Project ______________________________ By _____ Date ________

Location ______________________________ Checked _____ Date ________

Circle one: Present Developed ______________________________



1. Data:
Drainage area .... A_m = ______ mi^2
Rainfall distribution
type (I, IA, II, III) = ______

	1st stage	2nd stage
2. Frequency ...... yr		
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)		
4. Peak outflow discharge, q_o .... cfs		1/
5. Compute $\frac{q_o}{q_i}$		
6. $\frac{V_s}{V_r}$ .... (Use $\frac{q_o}{q_i}$ with figure 6-1)		
7. Runoff, Q ...... in (From worksheet 2)		
8. Runoff volume, V_r .... ac-ft ($V_r = QA_m 53.33$)		
9. Storage volume, V_s .... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$)		
10. Maximum stage, E_{max} (From plot)		

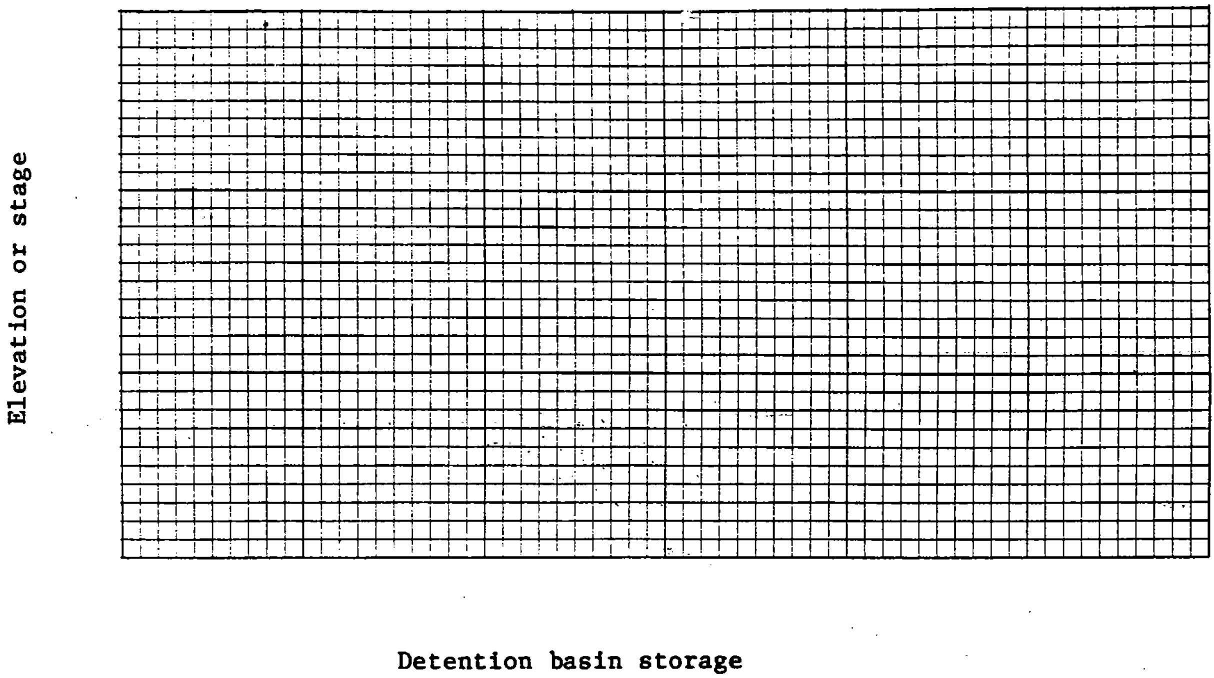
1/ 2nd stage q_o includes 1st stage q_o.

Worksheet 6b: Detention basin peak outflow, storage volume (V_s) known

Project ____________________ By _____ Date ________

Location ____________________ Checked _____ Date ________

Circle one: Present Developed ____________________



1. Data:
Drainage area .... A_m = ______ mi^2
Rainfall distribution type (I, IA, II, III) = ______

	1st stage	2nd stage
2. Frequency ...... yr		
3. Storage volume, V_s .... ac ft		
4. Runoff, Q ...... in (From worksheet 2)		
5. Runoff volume, V_r .... ac-ft ($V_r = QA_m 53.33$)		
6. Compute $\frac{V_s}{V_r}$		
7. $\frac{q_o}{q_i}$ .... in (Use $\frac{V_s}{V_r}$ and figure 6-1)		
8. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)		
9. Peak outflow discharge, q_o .... cfs[1/] ($q_o = q_i(\frac{q_o}{q_i})$)		
10. Maximum stage, E_{max} (From plot)		

[1/] 2nd stage q_o includes 1st stage q_o.

Appendix E: References

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Appendix F: Equations for figures and exhibits

This appendix presents the equations used in procedure applications to generate figures and exhibits in TR-55.

Figure 2-1 (runoff equation):

$$Q = \frac{\left[P - 0.2\left(\frac{1000}{CN} - 10\right)\right]^2}{P + 0.8\left(\frac{1000}{CN} - 10\right)}$$

where

Q = runoff (in),
P = rainfall (in), and
CN = runoff curve number.

Figure 2-3 (composite CN with connected impervious area):

$$CN_c = CN_p + (P_{imp}/100)(98 - CN_p)$$

where

CN_c = composite runoff curve number,
CN_p = pervious runoff curve number, and
P_{imp} = percent imperviousness.

Figure 2-4 (composite CN with unconnected impervious areas and total impervious area less than 30%):

$$CN_c = CN_p + (P_{imp}/100)(98 - CN_p)(1 - 0.5R)$$

where R = ratio of unconnected impervious area to total impervious area.

Figure 3-1 (average velocities for estimating travel time for shallow concentrated flow):

Unpaved $V = 16.1345\,(s)^{0.5}$
Paved $V = 20.3282\,(s)^{0.5}$

where

V = average velocity (ft/s), and
s = slope of hydraulic grade line (watercourse slope, ft/ft).

These two equations are based on the solution of Manning's equation (Eq. 3-4) with different assumptions for n (Manning's roughness coefficient) and r (hydraulic radius, ft). For unpaved areas, n is 0.05 and r is 0.4; for paved areas, n is 0.025 and r is 0.2.

Exhibit 4 (unit peak discharges for SCS type I, IA, II, and III distributions):

$$\log(q_u) = C_0 + C_1 \log(T_c) + C_2 [\log(T_c)]^2$$

where

q_u = unit peak discharge (csm/in),
T_c = time of concentration (hr) (minimum, 0.1; maximum, 10.0), and
C_0, C_1, C_2 = coefficients from table F-1.

Figure 6-1 (approximate detention basin routing through single- and multiple-stage structures for 24-hour rainfalls of the indicated type):

$$V_s/V_r = C_0 + C_1\,(q_o/q_i) + C_2\,(q_o/q_i)^2 + C_3\,(q_o/q_i)^3$$

where

V_s/V_r = ratio of storage volume (V_s) to runoff volume (V_r),
q_o/q_i = ratio of peak outflow discharge (q_o) to peak inflow discharge (q_i), and
C_0, C_1, C_2, C_3 = coefficients from table F-2.

Table F-1.—Coefficients for the equation used to generate exhibits 4-I through 4-III

Rainfall type	I_a/P	C_0	C_1	C_2
I	0.10	2.30550	-0.51429	-0.11750
	0.20	2.23537	-0.50387	-0.08929
	0.25	2.18219	-0.48488	-0.06589
	0.30	2.10624	-0.45695	-0.02835
	0.35	2.00303	-0.40769	0.01983
	0.40	1.87733	-0.32274	0.05754
	0.45	1.76312	-0.15644	0.00453
	0.50	1.67889	-0.06930	0.0
IA	0.10	2.03250	-0.31583	-0.13748
	0.20	1.91978	-0.28215	-0.07020
	0.25	1.83842	-0.25543	-0.02597
	0.30	1.72657	-0.19826	0.02633
	0.50	1.63417	-0.09100	0.0
II	0.10	2.55323	-0.61512	-0.16403
	0.30	2.46532	-0.62257	-0.11657
	0.35	2.41896	-0.61594	-0.08820
	0.40	2.36409	-0.59857	-0.05621
	0.45	2.29238	-0.57005	-0.02281
	0.50	2.20282	-0.51599	-0.01259
III	0.10	2.47317	-0.51848	-0.17083
	0.30	2.39628	-0.51202	-0.13245
	0.35	2.35477	-0.49735	-0.11985
	0.40	2.30726	-0.46541	-0.11094
	0.45	2.24876	-0.41314	-0.11508
	0.50	2.17772	-0.36803	-0.09525

Table F-2.—Coefficients for the equation used to generate figure 6-1

Rainfall distribution (appendix B)	C_0	C_1	C_2	C_3
I, IA	0.660	-1.76	1.96	-0.730
II, III	0.682	-1.43	1.64	-0.804

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