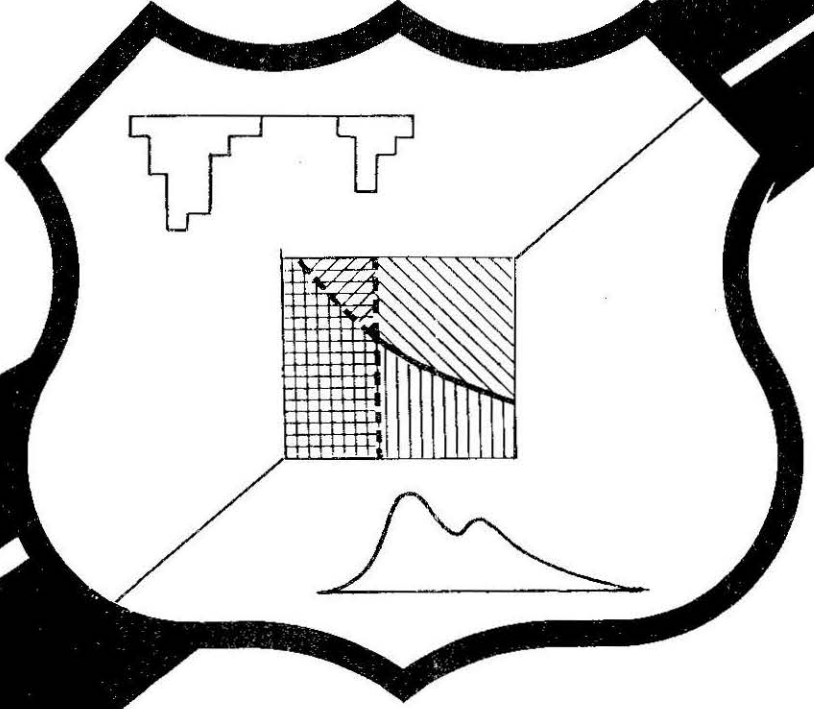
Report No. FHWA/RD-81/061

USER'S MANUAL FOR XSRAIN – A FORTRAN IV PROGRAM FOR CALCULATION OF FLOOD HYDROGRAPHS FOR UNGAGED WATERSHEDS

July 1981
Final Report



Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

DEPARTMENT OF TRANSPORTATION
UNITED STATES OF AMERICA

Prepared for
FEDERAL HIGHWAY ADMINISTRATION
Offices of Research & Development
Environmental Division
Washington, D.C. 20590

FOREWORD

This users manual describes how to use the Fortran IV computer program for calculating flood hydrographs in basins that have a minimum of hydrologic information. The program uses the soil conservation service (SCS) curve numbers which account for soil types and land uses but it uses physically based infiltration equations rather than the empirical SCS equations for computing excess rainfall.

Sufficient copies of this report are being distributed to provide a minimum two copies to each FHWA regional office, one copy to each division office, and one copy to each State highway agency. Direct distribution is being made to division offices.

Charles F. Scheffey
Director, Office of Research
Federal Highway Administration

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof. The contents of this report reflect the views of the contractor, who is responsible for the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policy of the Department of Transportation. This report does not constitute a standard, specification, or regulation.

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein only because they are considered essential to the object of this document.

Technical Report Documentation Page

1. Report No. FHWA/RD-81/061	2. Government Accession No.	3. Recipient's Catalog No. PB82 140435
4. Title and Subtitle USER'S MANUAL for XSRAIN - A FORTRAN IV PROGRAM for CALCULATION of FLOOD HYDROGRAPHS for UNGAGED WATERSHEDS		5. Report Date July 1981 6. Performing Organization Code U356006
7. Author(s) James P. Verdin and Hubert J. Morel-Seytoux		8. Performing Organization Report No.
9. Performing Organization Name and Address Department of Civil Engineering Colorado State University Fort Collins, Colorado 80523		10. Work Unit No. (TRAIS) FCP 35H2-072 11. Contract or Grant No. DOT-FH-PO-9-3-0015
12. Sponsoring Agency Name and Address Offices of Research and Development Federal Highway Administration U. S. Department of Transportation Washington, D.C. 20590		13. Type of Report and Period Covered Final Report, Part 2 14. Sponsoring Agency Code E0561

15. Supplementary Notes

FHWA contract manager: D. C. Woo (HRS-42)

16. Abstract

XSRAIN is a computer program written to calculate flood hydrographs for ungaged watersheds by means of the Soil Conservation Service (SCS) runoff index, the curve number (CN). The curve number (CN) for a watershed is determined by the soil and land use types occuring within it. XSRAIN does *not*, however, use SCS equations for computing excess rainfall. Abstraction from variable intensity rainfall events is accomplished with physically based infiltration equations. The hydraulic soil parameters needed to make use of these equations have been calibrated against CN, and the computer program makes use of this equivalence. Routing of excess rainfall is performed with the SCS dimensionless unit hydrograph (mass curve) to produce a runoff hydrograph. Users may input variable intensity storms or they may simply specify a depth and duration. In the latter case, one of four possible time distributions is imposed at user's option on the rain. Options permit accounting for antecedent moisture conditions. Subroutines are described and variables defined. Examples of the four main options are provided, as well as a hand calculated example. This user's manual is *totally* self-contained and includes all tables and figures needed for the use of XSRAIN.

17. Key Words Runoff Ungaged watersheds Computer program Hydrograph	18. Distribution Statement No restriction. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF EXHIBITS

I. INTRODUCTION

The estimation of rainfall-runoff relations in ungaged watersheds is a common problem in engineering hydrology. Typically, the problem is approached with statistical or empirical tools, the lack of necessary data preventing a physical modeling of the processes involved. The research report which this user's manual accompanies, however, shows how a *correspondence* can be established between the Soil Conservation Service's *curve number*, (a runoff index calibrated against soil-land cover complexes), and the *hydraulic soil parameters* appearing in modern, physically based infiltration equations. Such a correspondence permits the physical modeling of the abstraction of rainfall in basins for which there is a minimum of available hydrologic information. The purpose of the program XSRAIN is to facilitate the application of a curve number-soil parameters correspondence to the prediction of flood hydrographs.

Program XSRAIN can generate a flood hydrograph for a given rainfall event using readily available information on the physical characteristics of the watershed in question. Determination of an SCS curve number from soil and land cover types permits the abstraction of rainfall by means of physical infiltration equations. The routing of the excess rain to yield an outflow hydrograph for the basin outlet is accomplished by means of the SCS dimensionless unit hydrograph (mass curve). This requires the input of additional morphological and time-of-travel characteristics which can be estimated from topographic maps.

The influence of soil moisture variation on runoff volumes due to seasonality and antecedent rainfall may be incorporated if such information is available. However, this is optional--one may simply assume "average" antecedent soil moisture conditions.

For purposes of comparison, there is an option available whereby one may elect to have calculations made using the standard SCS equation for excess precipitation, as well as calculations using the assumption of a uniform rainfall intensity.

In general, an effort was made to keep program XSRAIN flexible in terms of the required assumptions and the form of the input data utilized in its application.

II. IMPLEMENTATION

1. Preliminary Work

1.1 Units Employed in XSRAIN

Program XSRAIN was written to perform all calculations in terms of English units. The metric equivalents of these units are presented here:

1 in. = 25.4 mm
1 ft = 0.3048 m
1 sq mi = 259.00 hectare
35.31 cfs = 1 m^3/sec

1.2 Determination of Curve Number

Regardless of which particular option offered by XSRAIN is ultimately chosen by the user, the first step that must be taken is the determination of a curve number (abbreviated as CN) for the watershed in question. Procedures for accomplishing this are outlined in detail in the SCS National Engineering Handbook, Section 4, Hydrology, Chapters 7-10, in particular (hereafter referred to as NEH-4). Those procedures will be covered briefly here.

The first step is to obtain soil survey information from the SCS state soil scientist for the watershed in question. From this one can determine the names and areal extents of the soils occurring in the watershed. Using Table 7.1 of NEH-4 (reproduced in the appendix of this User's Manual) one can determine the hydrologic group of the soils: A, B, C or D. These hydrologic groups are defined by the SCS by the following descriptions:

"A. (Low runoff potential). Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.

B. Soils having moderate infiltration rates when thoroughly wetted and consisting 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.

C. Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

D. (High runoff potential). Soils having very slow infiltration rates when thoroughly wetted and consisting 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 slow rate of water transmission." (p. 7.1, NEH-4)

Once hydrologic soil groups have been identified, one consults Tables 1 and 2 (taken from NEH-4 and SCS Technical Release No. 55) where curve numbers are tabulated by land use, treatment and hydrologic soil group. Using the characteristics of the watershed in question, the appropriate CN can be identified.

> "A composite curve number (CN) for a watershed having more than one land use, treatment or soil type can be found by weighting each curve number according to its area. If, for example, 80 percent of a watershed has a CN of 75 and the remaining 20 percent is impervious (CN=100), then the weighted CN = 0.80 x 75 + 0.20 x 100 = 80." (Viessman, et al., 1977, p. 618)

Hydrologic condition refers to the relative propensity of a land use to produce runoff and therefore be susceptible to soil erosion. For example, pasture which is heavily grazed by cattle would yield large amounts of runoff and hence be in *poor* hydrologic condition. On the other hand, pasture which is only lightly grazed and has good plant cover would be in *good* hydrologic condition.

Detailed description of the land use and land treatment classes used in Table 1 is provided in Chapter 8 of NEH-4.

Having identified a CN for the watershed of interest, one may next consult the Table of Correspondence (Table A1) in the appendix of this

Table 1. Runoff curve numbers for hydrologic soil-cover complexes (antecedent moisture condition II, and $I_a = 0.2 S$) (from NEH-4), p. 9.2).

	Cover		Hydrologic Soil Group			
Land Use	Treatment or Practice	Hydrologic Condition	A	B	C	D
Fallow	Straight row	----	77	86	91	94
Row crops	Straight row	Poor	72	81	88	91
	Straight row	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	Contoured and terraced	Poor	66	74	80	82
	Contoured and terraced	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
	Straight row	Good	63	75	83	87
	Contoured	Poor	63	74	82	85
	Contoured	Good	61	73	81	84
	Contoured and terraced	Poor	61	72	79	82
	Contoured and terraced	Good	59	70	78	81
Close-seeded legumes 1/ or rotation meadow	Straight row	Poor	66	77	85	89
	Straight row	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	Contoured	Good	55	69	78	83
	Contoured and terraced	Poor	63	73	80	83
	Contoured and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	Contoured	Fair	25	59	75	83
	Contoured	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt) 2/		----	72	82	87	89
(hard surface) 2/		----	74	84	90	92

1/ Close-drilled or broadcast
2/ Including right-of-way

Table 2. Runoff curve numbers for selected agricultural, suburban, and urban land use (antecedent moisture condition II, and $I_a = 0.2$ S) (from SCS Technical Release No. 55, p. 2-5).

Land Use Descriptions		Hydrologic Soil Group			
		A	B	C	D
Cultivated land 1/: without conservation treatment		72	81	88	91
with conservation treatment		62	71	78	81
Pasture or range land: poor condition		68	79	86	89
good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or forest land: thin stand, poor cover, no mulch		45	66	77	83
good cover 2/		25	55	70	77
Open spaces, lawns, parks, golf courses, cemeteries, etc.					
good condition: grass cover on 75% or more of the area		39	61	74	80
fair condition: grass cover on 50% to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious)		81	88	91	93
Residential 3/:					
Average lot size	Average % impervious 4/				
1/8 acre or less	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
Paved parking lots, roofs, driveways, etc. 5/		98	98	98	98
Streets and roads:					
paved with curbs and storm sewers 5/		98	98	98	98
gravel		76	85	89	91
dirt		72	82	87	89

1/ For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Section 4, Hydrology, Chapter 9, Aug. 1972.

2/ Good cover is protected from grazing and litter and brush cover soil.

3/ Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

4/ The remaining pervious areas (lawns) are considered to be in good pasture condition for these curve numbers.

5/ In some warmer climates of the country a curve number of 95 may be used.

User's Manual to determine the equivalent hydraulic soil properties. From that table values for *hydraulic conductivity at natural saturation*, $\tilde{K}$ (in./hr), and for *storage suction factor at field capacity* , $(S_f)_{fc}$ (in.) are obtained. Storage suction factor is defined by the equation:

$$S_f = (\tilde{\theta}-\theta_i)\ H_f \tag{1.1}$$

where H_f is wetting front suction of the soil (effective capillary drive) (in.), $\tilde{\theta}$ is water content of the soil at natural saturation (dimensionless), and θ_i is initial water content.

$(S_f)_{fc}$ is the value of S_f (the storage suction factor) obtained when $\theta_i = \theta_{fc}$, θ_{fc} being the water content at field capacity, a condition comparable to the SCS antecedent moisture content (AMC) type II. Natural saturation refers to saturation under field conditions, where water content, θ, is always somewhat less the the porosity, ϕ, due to the inevitable presence of entrapped air.

Alternatively, it can be left to XSRAIN to compute $\tilde{K}$ and $(S_f)_{fc}$ from the curve number under Suboption 2 (see Section 2.6).

Additional watershed descriptors must be input so that the calculated excess rainfall pattern may be routed to the basin outlet by the SCS dimensionless unit hydrograph. Among these descriptors are the basin area in square miles, the average watershed slope in percent and the length in feet from the basin outlet to the divide. These can be readily determined from a topographic map.

Two options require more information if they are elected. Exact input requirements are described in the Option Summaries.

All options require the specification of a rainfall duration and cumulative depth. This information is provided by the user according to design needs. A time distribution of the rainfall may also be specified, or it may be left to the program to impose a time distribution pattern.

XSRAIN uses the time distributions identified by Huff (1967) in his study of storms occurring in Central Illinois. He classified four types of storms, according to whether peak rainfall occurred in the first, second, third or fourth quartile of the storm duration. For each type he derived curves of cumulative percent of precipitation vs. cumulative percent of storm time. XSRAIN can use the median (50 percent probability) curve for any of the four storm types. As a guide to choosing which quartile to specify for peak rainfall, consult Table 3.

Table 3. Percentage distribution of quartile types. After Huff (1967).

	Percent of Cases for Given Duration (Hours)			Quartile Frequency (%)
Quartile	<12	12-24	>24	
1	45	29	26	32
2	50	33	17	34
3	35	42	23	25
4	22	26	52	9
All Storms	42	33	25	100

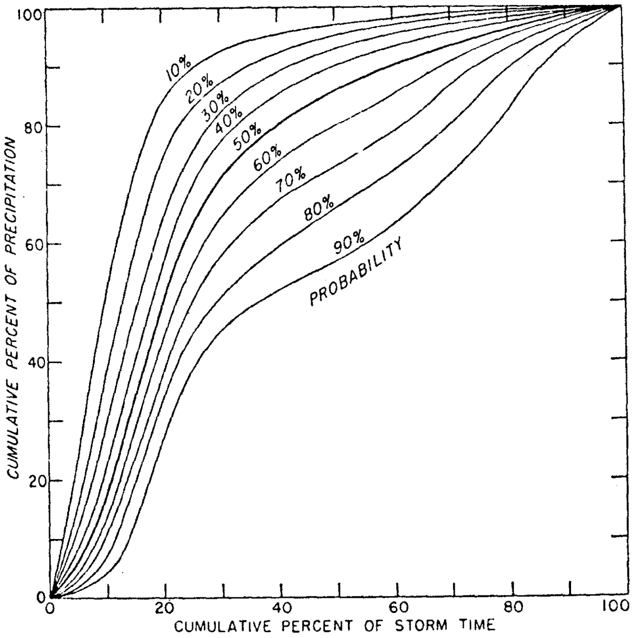


Figure 1. Time distribution of first-quartile storms. After Huff (1967).

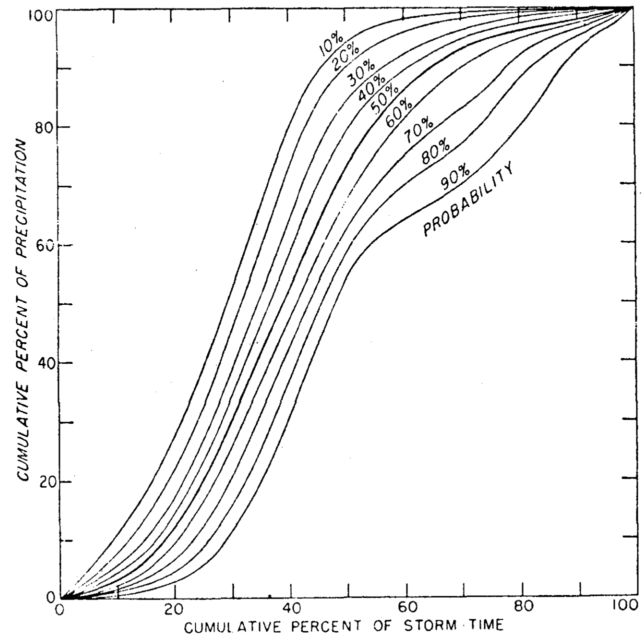


Figure 2. Time distribution of second-quartile storms. After Huff (1967).

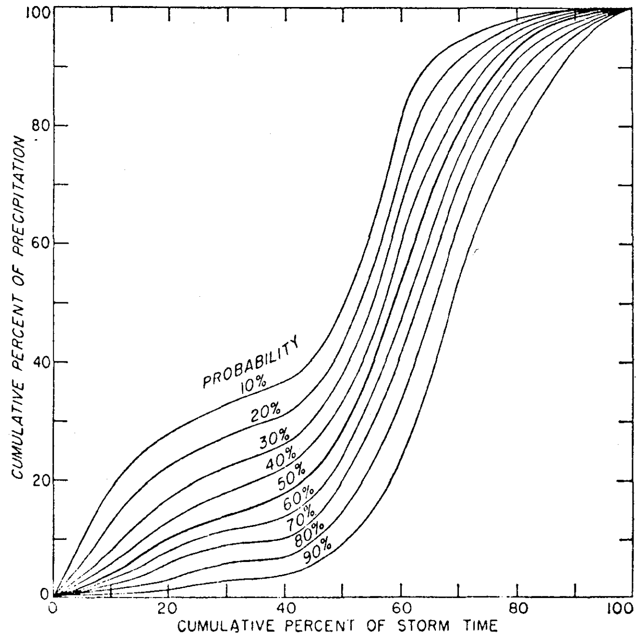


Figure 3. Time distribution of thirs-quartile storms. After Huff (1967).

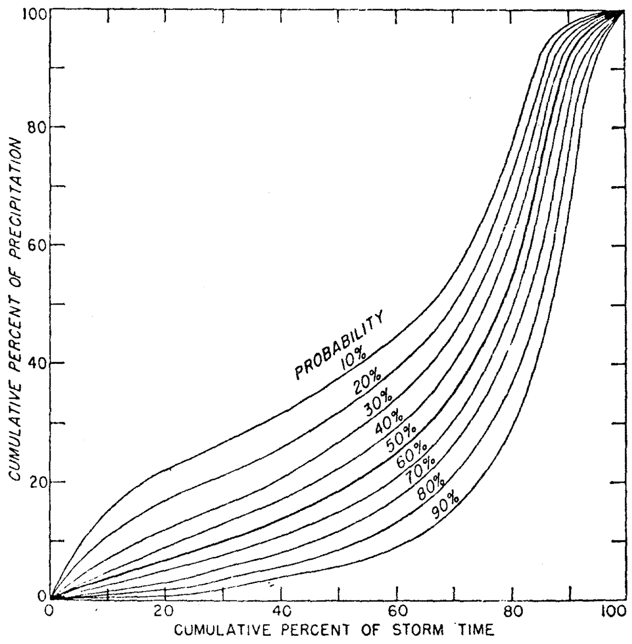


Figure 4. Time distribution of fourth-quartile storms. After Huff (1967).

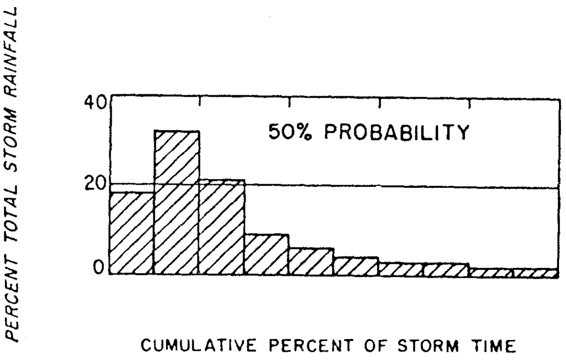


Figure 5. A first-quartile, 50 percent probability time distribution. After Huff (1967).

An example of a first quartile, 50 percent probability histogram is given in Figure 5. First- and second-quartile storms are seen to be the most common, although storm duration is an important factor in determining in which quartile the rainfall peak occurs, as the table shows. In general, Huff identified:

> "A trend for the longer heavier storms to dominate the fourth-quartile grouping, whereas short duration storms account for a major portion of the first- and second-quartile groups."
> (Huff, 1967, p. 1008)

Having identified watershed descriptors and a design storm, the user should consult the following Option Summaries to see which to employ when running XSRAIN.

Table 3 and Figures 1-5 are drawn from, "The Distribution of Rainfall in Heavy Storms," by F. A. Huff, in Water Resources Research Journal, Volume 3, Number 4, p. 1007.

As stated, the user may specify a time distribution of rainfall. This can be read in to be used "as is," or XSRAIN can be called upon to rearrange the input rainfall steps to form a U.S. Army Corps of Engineers "balanced hyetograph." Details are given in the option summaries and the description of subroutine BALANCE.

2. Option Summaries

All main options calculate excess rainfall for a variable rainfall pattern by the infiltration approach. A tabulation is made by time steps of cumulative infiltration, incremental infiltration, mean infiltration rate, mean rainfall rate and mean excess rainfall rate, and a mass balance check is provided. Watershed descriptors are used to derive a unit hydrograph from the SCS dimensionless mass curve, and this in turn is used to route the computed excess rainfall and produce a runoff hydrograph in cfs. Under Suboption 1, it is possible to have these same calculations made by three additional means of computing excess rain, for purposes of comparison. These three cases are: the infiltration approach, with constant rainfall assumed; the SCS method, with variable intensity rainfall; and the SCS method, with constant rainfall assumed.

2.1 Main Option One--Imposed Time Distribution of Rainfall and Average Soil Moisture Conditions

This option will impose a Huff rainfall time distribution according to the quartile and time step specified by the user. Field capacity soil moisture (AMC II) is assumed.

Inputs

The user must provide the following information when employing this option:

CN, curve number

$\tilde{K}$, hydraulic conductivity (in./hr)

$(S_f)_{fc}$, storage suction factor at field capacity (in.)

(The reading in of $\tilde{K}$ and $(S_f)_{fc}$ is optional under Suboption 2)

P, cumulative depth of rainfall (in.)

t_D, duration of storm (hr)

LAGFLAG: if LAGFLAG = 0, watershed lag time (TL, hr) is computed from the following parameters: CN, the watershed curve number; L, the length from basin outlet to the divide (ft); Y, average watershed slope (percent); if LAGFLAG = 1, TL is provided by the user.

Area, in square miles

Q, Huff quartile (1, 2, 3 or 4)

Δt, time step for rainfall distribution (min).

Outputs

The following information is provided by XSRAIN under this option:

Values of cumulative precipitation (in.) at the end of each time step according to the Huff time distribution

Time (hr) at the end of each time step

Mean rainfall intensities for each time step (in./hr)

A unit hydrograph computed from the SCS dimensionless mass curve

The watershed lag time (hr)

The time to peak of the unit hydrograph (hr)

t_p, ponding time for variable intensity rainfall (hr)

r_p, rainfall intensity producing ponding (in./hr)

W_p, cumulative depth of rainfall infiltrated up to ponding (in.)

Last full-time step previous to ponding time

An excess rainfall pattern (in./hr)

A mass balance check

A flood hydrograph, in cfs vs. hr.

If SCS calculations are opted for under Suboption 1 additional outputs are:

S, the maximum watershed storage capacity as defined by SCS (in.)

I_a, the initial abstraction as defined by SCS (in.).

Subroutines

The following subroutines are called by XSRAIN under this option: HUFF, UH, PONTIM, PPINF, ROUTE, CONSTR AND SCS (if comparison hydrographs are generated, that is, Suboption 1 = 4), TABLE (if $\tilde{K}$ and S_f are computed from CN, that is, Suboption 2 = 1).

2.2 Main Option Two--Imposed Time Distribution of Rainfall and Antecedent Soil Moisture Accounting

This option will also impose a Huff rainfall time distribution according to the quartile and time step specified by the user. Storage suction factor is modified for the infiltration equations, and so is the CN for the SCS equations. Modifications are based upon the day of the year and the five day antecedent rainfall depths, additional information which must be provided by the user.

Inputs

The user must provide the following information when employing this option:

CN, curve number

$\tilde{K}$, hydraulic conductivity (in./hr)

$(S_f)_{fc}$, storage suction factor at field capacity (in.)

(The reading in of $\tilde{K}$ and $(S_f)_{fc}$ is optional under Suboption 2)

P, cumulative depth of rainfall (in.)

t_D, duration of storm (hr)

LAGFLAG: if LAGFLAG = 0, watershed lag time (TL, hr) is computed from the following parameters: CN, the watershed curve number; L, the length from basin outlet to the divide (ft); Y, average watershed slope (percent); if LAGFLAG = 1, TL is provided by the user.

Area, in square miles

Q, Huff quartile (1, 2, 3 or 4)

Δt, time step for rainfall distribution (min)

Month and day of the year

Rainfall for previous five days (in.).

Outputs

The following information is provided by XSRAIN under this option:

Values of cumulative precipitation (in.) at the end of each time step according to the Huff time distribution.

Time (hr) at the end of each time step

Mean rainfall intensities for each time step (in./hr)

S, (in.), the maximum watershed storage according to SCS for antecedent moisture condition II

Effective depth of soil profile (in.)

H_f, wetting front suction (in.)

Julian date

S, (in.), seasonally adjusted by sine approximation (see Section 3.2)

$(\tilde{\theta}-\theta_i)$, moisture deficit adjusted for season and antecedent rainfall

S_f, storage suction factor adjusted for season and antecedent rainfall (in.)

A unit hydrograph computed from the SCS dimensionless mass curve

t_p, ponding time for variable intensity rainfall (hr)

r_p, rainfall intensity producing ponding (in./hr)

W_p, cumulative depth of rainfall infiltrated up to ponding (in.)

Last full time step previous to ponding

An excess rainfall pattern (in./hr)

A mass balance check

A flood hydrograph, in cfs vs. hr.

If SCS calculations are opted for under Suboption 1, additional outputs are:

CN, S, I_a, adjusted for time of year and AMC.

Subroutines

The following subroutines are called by XSRAIN under this option:

HUFF, DEFICIT, UH, PONTIM, PPINF, ROUTE, CONSTR AND SCS (if comparison hydrographs are generated, that is, Suboption 1 = 4), TABLE (if $\tilde{K}$ and S_f are computed from CN, that is, Suboption 2 = 1).

2.3 Main Option Three--User Specified Time Distribution of Rainfall and Antecedent Soil Moisture Accounting

With this option, the *user* provides a time distribution of rainfall to be used "as is," or else a set of times and steps of rainfall to be rearranged into a U.S. Army Corps of Engineers "balanced hyetograph." Time steps may be entered in either minutes or hours, and steps of rain may be read in as either incremental depths (in.) or intensities (in./hr).

The user also provides information as to day of the year and five day antecedent rainfall depths for modification of S_f and CN.

Inputs

The user must provide the following information when employing this option:

CN, curve number

$\tilde{K}$, hydraulic conductivity at natural saturation (in./hr)

$(S_f)_{fc}$, storage suction factor at field capacity (in.)

(The reading in of $\tilde{K}$ and $(S_f)_{fc}$ is optional under Suboption 2)

P, cumulative depth of rainfall (in.)

t_D, duration of storm (hr)

LAGFLAG: if LAGFLAG = 0, watershed lag time (TL, hr) is computed from the following parameters: CN, the watershed curve number; L, the length to the divide from basin outlet (ft); Y, the average watershed slope (percent); if LAGFLAG = 1, TL is provided by the program user.

AREA, in square miles

Month and day of the year

Rainfall depth for each of the previous five days (in.)

N, the number of time steps of rainfall

PFLAG: if PFLAG = 0, input rain is in in./hr; if PFLAG = 1, input rain is in inches.

CFLAG: if CFLAG = 0, user time distribution of rain is used "as is;" if CFLAG = 1, a Corps of Engineers "balanced hyetograph" is formed from input steps of rain.

TFLAG: if TFLAG = 0, input times are in minutes; if TFLAG = 1, input times are in hours.

T(I), (I=1,N), the set of times at the end of each step, all of equal length, in either minutes or hours

R(I), (I=1,N), the set of steps of rain, expressed either as increments of depth (in.) or as intensities (in./hr).

Outputs

The following information is provided by XSRAIN under this option:

Values of cumulative precipitation (in.) at the end of each time step.

S, (in.), the maximum watershed storage according to SCS for antecedent moisture condition II

Effective depth of soil profile (in.)

H_f, wetting front suction (in.)

Julian date

S, (in.), seasonally adjusted by sine approximation (see Section 3.2)

$(\tilde{\theta}-\theta_i)$, moisture deficit adjusted for season and antecedent rainfall

A unit hydrograph computed from the SCS dimensionless mass curve

t_p, ponding time for variable intensity rainfall (hr)

r_p, rainfall intensity producing ponding (in./hr)

W_p, quantity infiltrated up to ponding (in.)

Last full time step previous to t_p

An excess rainfall pattern (in./hr)

A mass balance check

A flood hydrograph, in cfs vs. hr.

If SCS calculations are opted for under Suboption 1, additional outputs are:

CN, S, I_a, adjusted for time of year and AMC.

Subroutines

The following subroutines are called by XSRAIN under this option:

DEFICIT, UH, PONTIM, PPINF, ROUTE, CONSTR and SCS (if comparison hydrographs are generated, that is, Suboption 1 = 4), TABLE (if $\tilde{K}$ and S_f are computed from CN, that is, Suboption 2 = 1), BALANCE (if a "balanced hyetograph" is formed, that is, CFLAG = 1).

2.4 Main Option Four--User Specified Time Distribution of Rainfall and Average Soil Moisture Conditions

As in Main Option 3, the *user* provides a time distribution of rainfall to be used "as is," or else a set of times and steps of rainfall to be rearranged into a U.S. Army Corps of Engineers "balanced hyetograph." Time steps may be entered in either minutes or hours, and steps of rain may be read in as either incremental depths (inches) or intensities (in./hr).

This option is simpler than Main Option 3 in that it assumes field capacity soil moisture conditions (AMC II).

Inputs

The user must provide the following information when employing this option:

CN, curve number

$\tilde{K}$, hydraulic conductivity (in./hr)

$(S_f)_{fc}$, storage suction factor at field capacity (in.)

(The reading in of $\tilde{K}$ and $(S_f)_{fc}$ is optional under Suboption 2)

P, cumulative depth of rainfall (in.)

t_D, duration of storm (hr)

LAGFLAG: if LAGFLAG = 0, watershed lag time (TL, hr) is computed from the following parameters: CN, the watershed curve number; L, the length to the divide from basin outlet (ft); Y, the average watershed slope (percent); if LAGFLAG = 1, TL is provided by the program user.

AREA, in square miles

N, the number of time steps of rainfall

PFLAG: if PFLAG = 0, input rain is in in./hr; if PFLAG = 1, input rain is in inches.

CFLAG: if CFLAG = 0, user time distribution of rain is used "as is;" if CFLAG = 1, a Corps of Engineers "balanced hyetograph" is formed from input steps of rain.

TFLAG: if TFLAG = 0, input times are in minutes; if TFLAG = 1, input times are in hours.

T(I), (I=1,N), the set of times at the end of each step, all of equal length, in either minutes or hours

R(I), (I=1,N), the set of steps of rain, expressed either as increments of depth (in.) or as intensities (in./hr).

Outputs

The following information is provided by XSRAIN under this option:

Values of cumulative precipitation (in.) at the end of each time step

A unit hydrograph computed from the SCS dimensionless mass curve

t_p, ponding time for variable intensity rainfall (hr)

r_p, rainfall intensity producing ponding (in./hr)

W_p, cumulative depth of rainfall infiltrated up to ponding (in.)

Last full time step previous to ponding t_p

An excess rainfall pattern (in./hr)

A mass balance check

A flood hydrograph, in cfs vs. hr.

If SCS calculations are opted for under Suboption 1, additional outputs are:

CN, S, I_a for AMC II.

Subroutines

The following subroutines are called by XSRAIN under this option: UH, PONTIM, PPINF, ROUTE, CONSTR AND SCS (if comparison hydrographs are generated, that is, Suboption 1 = 4), TABLE (if $\tilde{K}$ and S_f are computed from CN, that is, Suboption 2 = 1), BALANCE (if a "balanced hyetograph" is formed, that is, CFLAG = 1).

2.5 Suboption 1--Comparison Hydrographs Found with Alternate Means of Computing Excess Rainfall

This suboption permits the production of extra flood hydrographs for comparison of results using other methods of calculating excess rainfall. If these comparisons are not desired, a value of one should be read in (SUBOPT1=1) and excess rain will be calculated by only one approach--by the infiltration method for a variable intensity rainfall event.

If this suboption is set equal to four (SUBOPT1=4), three additional means of computing excess rainfall will be executed: by infiltration method, for constant rainfall; by SCS method for variable rainfall; and by SCS method for constant rainfall. In every case, a flood hydrograph is produced by calling subroutine ROUTE.

2.6 Suboption 2--Specification of Soil Hydraulic Parameters

Under this option there are two possible means of providing the hydraulic soil parameters necessary for computation of infiltration (the hydraulic conductivity, $\tilde{K}$ (in./hr), and the storage suction factor at field capacity, $(S_f)_{fc}$ (in.)). If Suboption 2 is set equal to zero (SUBOPT2=0), then the user must input these values, either after consulting the Table of Correspondence or based on some other means of estimation. This option permits experimentation on the part of the user.

Alternatively, it may be left to XSRAIN to compute $\tilde{K}$ and $(S_f)_{fc}$ from the SCS curve number (SUBOPT2=1). This is done by subroutine TABLE.

3. Description of Subroutines

3.1 Subroutine HUFF: Imposition of a Time Distribution on a Given Depth and Duration of Rainfall

This subroutine first converts the user specified time step, Δt, to units of hours. Subroutine HUFF proceeds to divide the storm duration, t_D, into ten equal steps. These time steps (PT(I)) are used to form a discretized version of a Huff rainfall time distribution (see Figure 6). Then, according to the quartile specified, cumulative depths of precipitation (PP(I)) are calculated which correspond to each of the ten discrete steps. Next, the storm duration is divided by the specified time step, Δt, to get the number of time steps (N) that will appear in the output and upon which all subsequent calculations will be based. In DO loop 10, linear interpolation is performed between the steps of the discretized Huff rainfall time distribution to get cumulative precipitation depths for the user-specified time steps. For example, in Figure 6 we see that the time at the end of user time step t_i has a corresponding depth of cumulative precipitation (by linear interpolation) equal to 68 percent of the total cumulative precipitation. In DO loop 30, these steps of cumulative precipitation are used to compute mean rainfall intensities corresponding to the user-specified time steps.

Variable List

FORTRAN Symbol	Math Symbol	Definition
DELT	Δt	User specified time step. Read-in in minutes. Converted to hours by HUFF.

Variable List (continued)

FORTRAN Symbol	Math Symbol	Definition
PT(I)	$(0.1)(I)(t_D)$	Time (hr) at end of 'Ith' 10 percent step of discretized Huff time distribution imposed on storm duration.
PP(I)		Depth of cumulative precipitation (in.) assigned to time PT(I). Assignment depends on quartile (Q) in which peak rainfall occurs.
TD	t_D	Time elapsed since beginning of storm (storm duration).
P	P	Cumulative depth of rain for entire storm.
CUMP(I)		Cumulative depth of rain (in.) at end of 'Ith' user time step.
Q	Q	Huff quartile (1, 2, 3 or 4).
N	N	Number of time steps of length specified by user occurring in storm. Last step may be of an odd length.
T(I)	t_i	Elapsed time at end of 'Ith' time step of user-specified length.
R(I)	r_i	Mean rainfall intensity during 'Ith' time step of user-specified length.
IFLAG		Flag variable used in interpolation loop 10. Keeps track of number of full 10 percent timesteps (PT(I)) occurring before user time step in question (T(I).

3.2 Subroutine DEFICIT: Revision of Moisture Deficit for Season and Antecedent Rain

This subroutine adjusts the moisture deficit at field capacity, $(\tilde{\theta}-\theta_{fc})$, in response to time of year and five day antecedent rainfall depths. It is a sort of moisture accounting scheme adapted for application on an event basis rather than a continuous one as would be used by a simulation model.

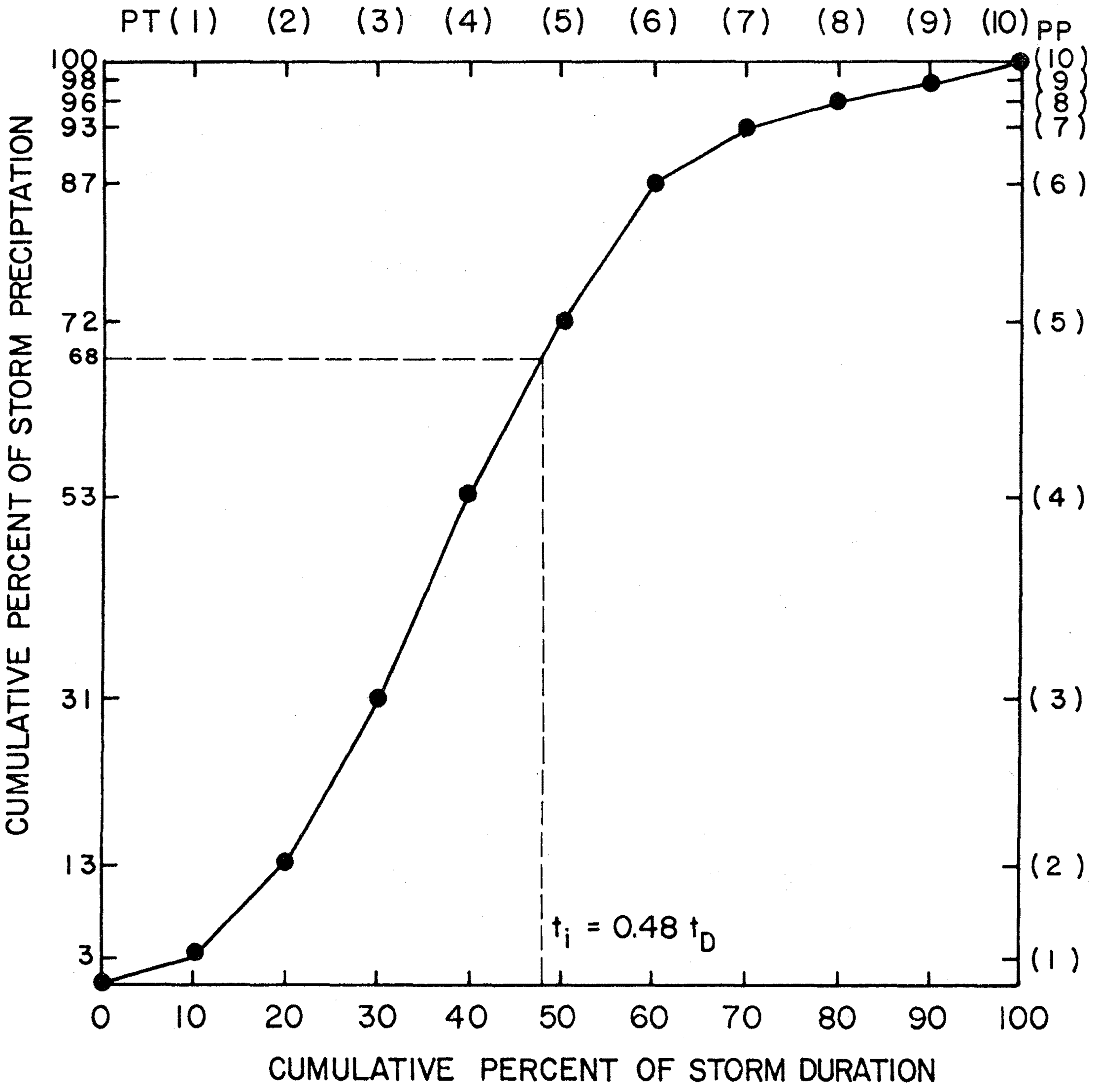


Figure 6. Example of a discretized version of Huff rainfall time distribution for the case of a storm with the peak occurring in the second time quartile.

One of the principal assumptions of this subroutine is that soil moisture variation through the year may be approximated by a sine curve. This assumption is based upon soil moisture lysimeter data presented in USDA Technical Bulletin No. 1367, (1967). Figures in this publication show soil moisture varying in a roughly sinusoidal way through the year, with small, jagged fluctuations about such a path, assumed due to short term wetting and drying. An example is shown here in Figure 7.

The second major assumption employed in this subroutine is that the SCS parameter S (in.), for AMC II, is the volume of soil pore space available to be filled by water when the soil moisture content is at field capacity. Hence, $S = (\tilde{\theta}-\theta_{fc})\ D_e$, where D_e is the effective soil profile depth expressed in inches. D_e is taken to be a constant watershed characteristic.

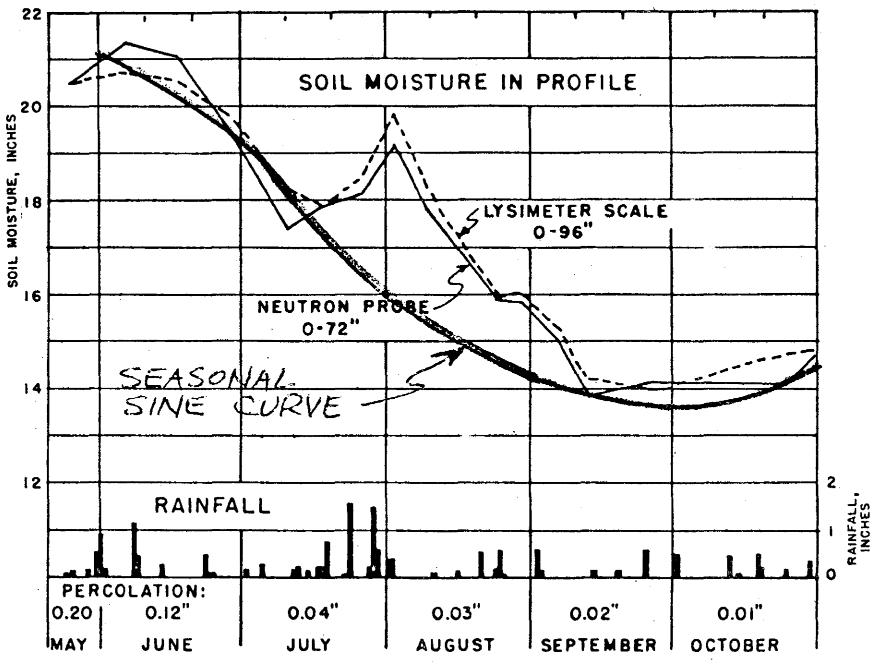


Figure 7. From USDA Technical Bulletin No. 1367 (1967) "Evaluation of Agricultural Hydrology by Monolith Lysimeters, 1956-62." Seasonal sine curve added by authors.

These assumptions are exploited by DEFICIT in the following manner. First, S for AMC II is computed by the SCS formula: $S = 1000/CN - 10$. Then the moisture deficit at field capacity is calculated by the equation $(\tilde{\theta}-\theta_{fc}) = 0.253 - .002\ CN$. (This regression was developed in the establishment of the SCS-infiltration correspondence, see Appendix). Next, the effective soil profile depth is calculated: $D_e = S/(\tilde{\theta}-\theta_{fc})$. Wetting front suction is calculated by $H_f = (S_f)_{fc}/(\tilde{\theta}-\theta_{fc})$. Recall that the definition of storage suction factor at field capacity is $(S_f)_{fc} = H_f(\tilde{\theta}-\theta_{fc})$. Julian date is calculated from the month and day specified by the user with the formula:

$$\text{Julian date} = 30 \times (\text{month}-1) + \text{day}\ . \tag{3.2.1}$$

This date is used in the argument of the sine function used to approximate seasonal variation of S. Seasonal S is computed with the formula:

$$\text{Seasonal } S = 1.3S \left\{\frac{[\sin(\text{Julian date}-5+180°] + 1}{2}\right\} + 0.2S \tag{3.2.2}$$

This formula gives a seasonal S for the date five days before the storm of interest, so that five day antecedent rainfall can be used to arrive at an S value for the day of the storm, hence the -5 term in the argument of the sine. The 180 is the phase shift of the sine curve from the beginning of the year. Work on the establishment of SCS infiltration correspondence showed that the minimum (AMC III) moisture deficit could be approximated by:

$$(\tilde{\theta}-\theta)_{AMC\ III} = 0.2(\tilde{\theta}-\theta_{fc})\ . \tag{3.2.3}$$

If follows analogously that:

$$S_{AMC\ III} = 0.2\ S_{AMC\ II}\ . \tag{3.2.4}$$

This is where the $0.2S$ term in the seasonal S equation came from. Study of figures of lysimeter data from USDA Technical Bulletin No. 1367 suggested a maximum seasonal moisture deficit occurring in late summer which could be approximated by:

$$\text{Late summer } (\tilde{\theta}-\theta_i) = 1.5(\tilde{\theta}-\theta_{fc})\ . \tag{3.2.5}$$

Through the year, S varies between 0.2 $S_{AMC\ II}$ at the end of winter and 1.5 $S_{AMC\ II}$ at the end of summer. This explains the 1.3 S term of the equation. When sine = -1, S = 0.2 $S_{AMC\ II}$; when sine = 1, S = 1.5 $S_{AMC\ II}$.

Once a seasonal S has been established, it is modified by the five day antecedent rainfall to get a value for the day of the storm. The S is treated in much the same way as an antecedent precipitation index (API), the difference being that S is the measure of the <u>dryness</u> of a watershed, and API an indicator of the <u>wetness</u> of a watershed. When using an API, a value for a day without rain is taken as the value from the day before times a factor such as 0.94. The converse of this is done by DEFICIT. S for a day without rain is computed as 1.06 times the value from the day before. For example, if S = 6.00 in. on a given day, and it is followed by a day of drying (no rain), the new S value is calculated to be 1.06 x 6.00 = 6.36 in. If a second day of dryness occurs the new value of S would be 1.06 x 6.36 = 6.74 in. (Study of figures in USDA Technical Bulletin 1367, like Figure 7 of this manual, suggested the factor 1.06.) Rainfall in the five day period will reduce S by the amount infiltrated, W. This is estimated by simply using the SCS equation with $S = S_{AMC\ II}$ and $I_a = 0.2$ S. Thus

$$W = P - \frac{(P-0.2\ S)^2}{P + 0.8\ S} \tag{3.2.6}$$

on a given day of rain depth P. If, referring to the above example, it was found that an amount, W (in.), was infiltrated on that second day, S would have turned out to be (1.06 x 6.36) - W = (6.74-W) in., instead of the 6.74 in. calculated for no rain on the second day. In this manner, the seasonal S calculated by the sine approximation is modified by the rainfall depths reported for the five days previous to the day of the storm in question to give an <u>adjusted S</u>.

The adjusted S is used to calculate an adjusted moisture deficit, $(\tilde{\theta}-\theta_i)$:

$$(\tilde{\theta}-\theta_i) = \frac{\text{adjusted S}}{D_e} . \tag{3.2.7}$$

This, in turn, is used to calculate a storage suction factor:

$$S_f = H_f\ (\tilde{\theta}-\theta_i) \tag{3.2.8}$$

This value of S_f is used in subsequent subroutines for calculations of ponding time and infiltration.

Variable List

FORTRAN Symbol	Math Symbol	Definition
JDATE		Julian date
MO		Month (1-12)
DAY		Day of the month (1-31).
S	S	SCS parameter S, AMC II (in.).
CN	CN	SCS curve number.
DFC	$(\tilde{\theta}-\theta_{fc})$	Moisture deficit at field capacity.
DEPTH	D_e	Effective soil profile depth (in.).
HF	H_f	Wetting front suction (in.).
SFFC	$(S_f)_{fc}$	Storage suction factor at field capacity (in.).
SB		Seasonally adjusted S (in.).
SA		S adjusted for season and antecedent rainfall (in.).
AR(1)		Depth of rain occurring 5 days before storm (in.).
AR(2)		Depth of rain occurring 4 days before storm (in.).
AR(3)		Depth of rain occurring 3 days before storm (in.).
AR(4)		Depth of rain occurring 2 days before storm (in.).
AR(5)		Depth of rain occurring 1 day before storm (in.).
AQ	P_e	Excess precipitation on one of the 5 antecedent days (in.).

Variable List (continued)

FORTRAN Symbol	Math Symbol	Definition
SMAX	S_{max}	$S_{max} = 2\ S_{AMC\ II}$. Corresponds to wilting point moisture deficit, $(\tilde{\theta}-\theta_{wil})$.
SF	S_f	Storage suction factor (in.).
DA	$(\tilde{\theta}-\theta_i)$	Moisture deficit adjusted for season and five day antecedent rainfall.

3.3 Subroutine UH: Determination of a Unit Hydrograph from the SCS Dimensionless Mass Curve

Subroutine UH computes a unit hydrograph for the event and watershed of interest from the SCS dimensionless mass curve. This processs is begun by computing the watershed lag time unless it has been specified by the user. The formula is:

$$t_\ell = \frac{\ell^{0.8}\ (S+1)^{0.7}}{1900\ Y^{0.5}} \tag{3.3.1}$$

where t_ℓ is the lag time (hr), ℓ is the length to the divide from the basin outlet (ft), Y is the average watershed slope (percent), and S = (1000/CN) - 10, the watershed storage (in.). Lag time is defined in NEH-4 as ". . . the time from the center of mass of excessive rainfall to the peak rate of runoff . . ." (p. 15-4).

The lag time is in turn used to estimate the time to peak, T_p, by the formula:

$$T_p = \frac{\Delta t}{2} + t_\ell \tag{3.3.2}$$

where T_p is time to peak (hr), and Δt is the length of a time step in the input rainfall pattern (hr). This time to peak is descriptive only of the hydrograph produced by one inch of rainfall occurring in the period Δt. It is not the time to peak of the event of interest. T_p is calculated because the time scale of the dimensionless mass curve is normalized with respect to this value, and hence it must be known to be able to make use of the mass curve, to derive a unit hydrograph.

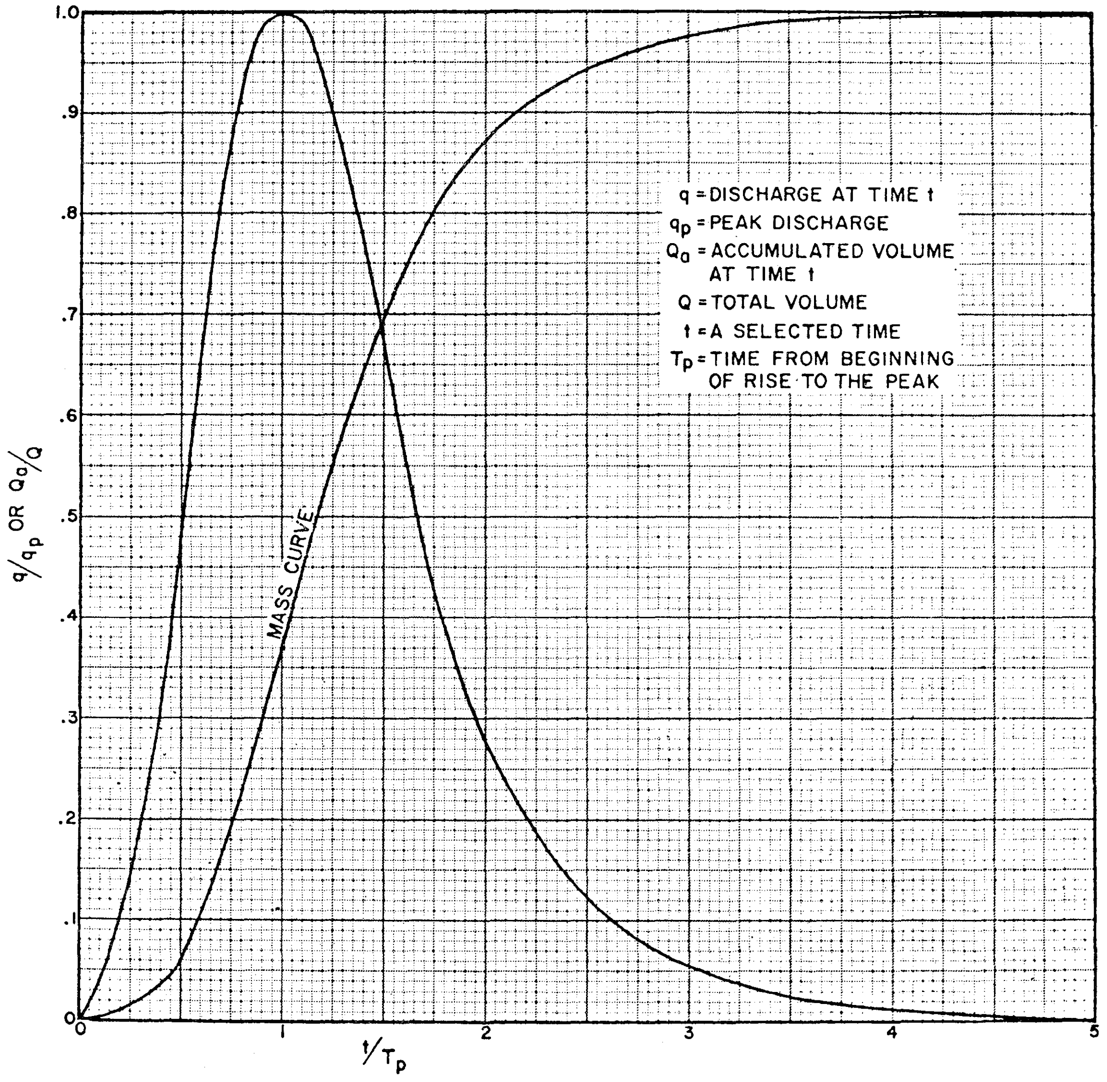


Figure 8. SCS dimensionless unit hydrograph and mass curve from NEH-4).

Chapter 16 of NEH-4 suggests that the length of the time step, Δt, should not exceed $0.25\ T_p$ to ensure a smooth flood hydrograph. Subroutine UH checks Δt against this criterion and prints a message warning of a possibly jagged hydrograph if $\Delta t > 0.25\ T_p$.

After making this check, the subroutine defines the dimensionless mass curve in discrete 5 percent steps of mass along with the corresponding normalized times (see Figure 9). A check is made to determine the number of steps of user-specified length Δt there are in the total time span of the mass curve, which is $5\ T_p$. In DO loop 28 it is ensured that there are this many elements in the time step array T.

In DO loop 12, a linear interpolation scheme is used to find mass curve ordinate values for each time step of user-specified length Δt. Each time step is divided by T_p before the interpolation is performed. Each ordinate value represents the (dimensionless) ratio of (instantaneous) cumulative flow to total cumulative flow (i.e., for the whole storm duration). In DO loop 16, the incremental differences between these ratios are found. These are the dimensionless ordinates of the unit hydrograph for a one inch pulse of rain occurring in a time period of duration Δt. To ensure that these "deltas" add up to one, they are normalized with respect to their sum. The dimensionless deltas are saved, and a set with units of cfs/in. are computed as well. The deltas with units of cfs/in. are those employed in subroutine ROUTE, which computes a flood hydrograph in cfs.

Subroutine UH produces a line printer plot of the unit hydrograph by calling subroutine MAPA. This is a library subroutine on the system at Colorado State University. The DATA statement on line 10 of UH contains the titles used on this plot. Users on other systems should substitute a subroutine of their own, or simply delete the DATA, DIMENSION MT(8), and CALL MAPA statements and forgo plotting the unit hydrograph.

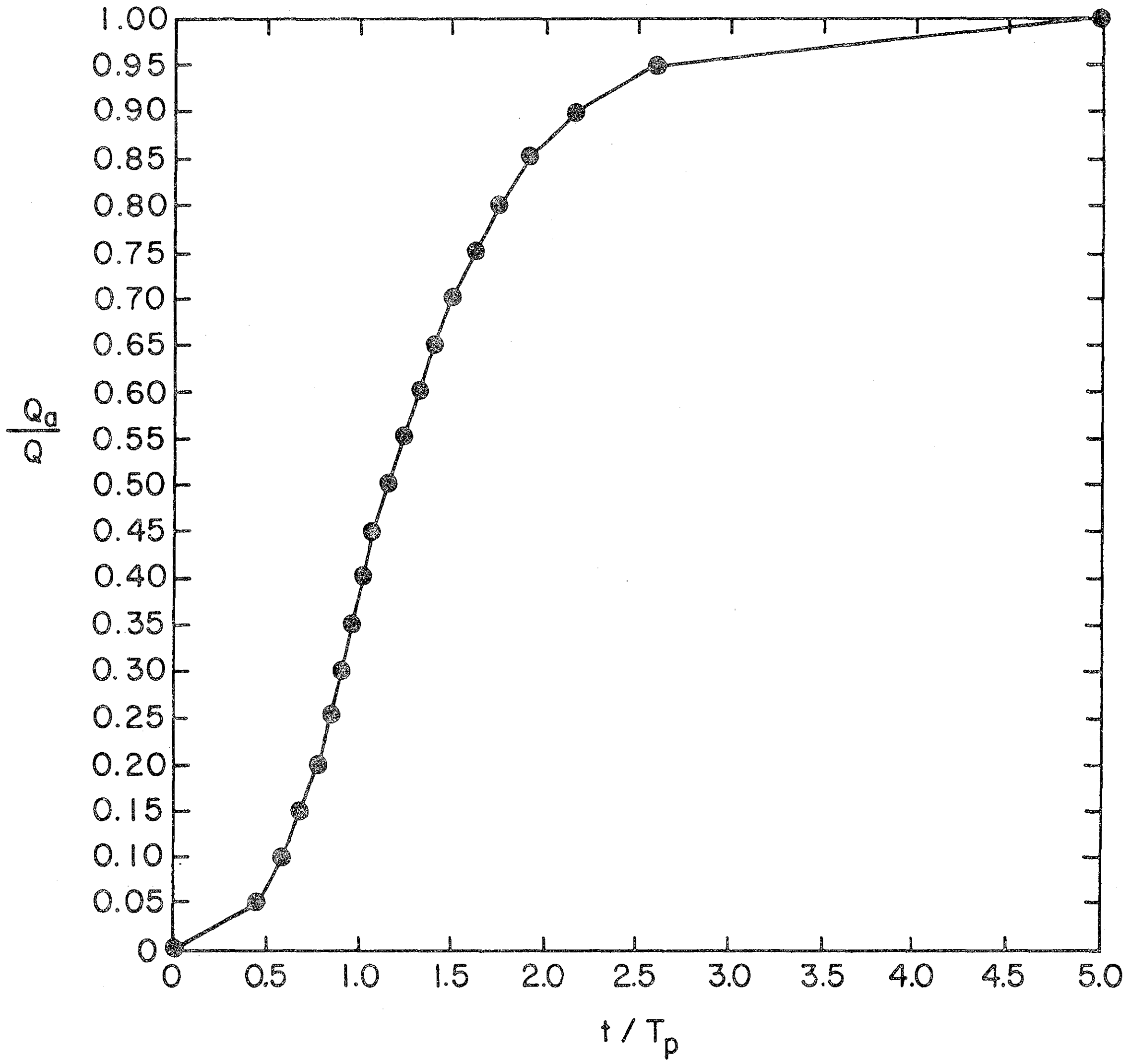


Figure 9. Discretized version of SCS dimensionless mass curve used in subroutine UH.

Variable List

FORTRAN Symbol	Math Symbol	Definition
S	S	Watershed storage (in.).
CN	CN	SCS curve number.
LAGFLAG		Flag variable indicating whether t_ℓ is to be computed. If LAGFLAG = 0, t_ℓ is computed from S, Y, and ℓ. If LAGFLAG = 1, t_ℓ is specified by the user.
TL	T_ℓ	Lag time (hr).
L	ℓ	Length to divide (ft).
Y	Y	Average watershed slope (percent).
TTP	T_p	Time to peak (hr).
D	D	Length of SCS maximum recommended time step, 0.25 T_p (hr).
RATIOQ(I)	Q_a/Q	Ratio of instantaneous cumulative flow to total cumulative flow at 'Ith' 5 percent step of total cumulative flow (see Figure 9).
RATIO(I)	t/T_p	Ratio of time at 'Ith' step to time to peak (T_p).
QQT(I)	Q_a/Q	Ratio value interpolated from RATIOQ for a user specified time step.
DELT	Δt	Length of user-specified time steps.
NN		Integer number of time steps of length Δt in a period equal to 5 T_p.
XNN		Real number of time steps of length Δt in a period of 5 T_p.
N		Number of time steps of length Δt in storm being analyzed.
NPLUS		NPLUS=N+1; the lower index of DO loop 28.

Variable List (continued)

FORTRAN Symbol	Math Symbol	Definition
T(I)		Array of times at the end of each step (hr).
IFLAG		Counter used in loop 12 interpolation scheme.
TTTP	t/T_p	Ratio of time at end of a user time step to time to peak (dimensionless).
DELTA(I)		Unit hydrograph ordinate for 'Ith' time step.
SUMDEL		Sum of unit hydrograph ordinates.
DD(I)		Dimensionless unit hydrograph ordinate for 'Ith' time steps.
AREA		Area of watershed in square miles.
MAPA		Colorado State University subroutine for producing a line printer data plot.

3.4 Subroutine PONTIM: Determination of Ponding Time

This routine calculates ponding time, given a pattern of variable rainfall intensity, according to the formula:

$$t_p = t_{j-1} + \frac{1}{r_j}\left[\frac{S_f}{\frac{r_j}{\tilde{K}} - 1} - \sum_{v=1}^{j-1} r_v\,(t_v - t_{v-1})\right] . \qquad (3.4.1)$$

where t_p is ponding time, t_j is time at the end of 'jth' time step, r_j is mean rainfall intensity for the time step being considered, S_f is storage suction factor, and $\tilde{K}$ is hydraulic conductivity at natural saturation.

The formula is applied to successive time steps until a solution is reached, that is, the calculated t_p is less than t_j.

For example, if $j = 1$, the equation reduces to:

$$t_p = 0 + \frac{1}{r_1}\left[\frac{S_f}{\frac{r_1}{\tilde{K}} - 1} - 0\right] .$$

If $t_p \leq t_1$, ponding time has been identified as falling in the first time step. If $t_p > t_1$ then t_p is recalculated for $j = 2$:

$$t_p = t_1 + \frac{1}{r_2}\left[\frac{S_f}{\frac{r_2}{\tilde{K}} - 1} - r_1 t_1\right]$$

If $t_1 < t_p \leq t_2$, ponding time has been identified as falling in time step two. If $t_p > t_2$, the program proceeds to calculate t_p for $j = 3$. This process is repeated until a solution is reached.

If $r_j \leq \tilde{K}$, ponding cannot possibly take place, and the algorithm proceeds to calculations for the next step.

In some cases it is found that $t_p > t_j$ but in the next calculation, for $j + 1$, it is found that $t_p < t_j < t_{j+1}$. Then ponding time is taken as $t_p = t_j$, but the rainfall producing ponding, r_p, is taken as $r_p = r_{j+1}$. This happens when r_{j+1} is much greater than r_j.

The ponding time calculated by PONTIM is that used in calculations of post-ponding infiltration for variable intensity rainfall, which are carried out in subroutine PPINF.

Variable List

FORTRAN Symbol	Math Symbol	Definition
KT	$\tilde{K}$	Hydraulic conductivity at natural saturation (in./hr).
I		Counter designating time step of consideration.
SUMP	$\sum_{v=1}^{j-1} r_v(t_v - t_{v-1})$	Sum of precipitation depths occurring in time steps previous to that of consideration (in.).

Variable List (continued)

FORTRAN Symbol	Math Symbol	Definition
R(J)	r_j	Mean rainfall intensity during 'jth' time step (in./hr).
T(J)	t_j	Time at the end of the 'jth' time step (hr).
PT(I)		Ponding time calculated for 'ith' time step (hr).
SF	S_f	Storage suction factor (in.).
TP	t_p	Ponding time (hr).
WP	W_p	Cumulative infiltration (also rain fall) up to ponding time (in.).
K		Counter indicating last full time step before ponding time.
RP	r_p	Rainfall rate producing ponding (in./hr).

3.5 Subroutine PPINF: Calculation of Post-Ponding Infiltration

This subroutine picks up where PONTIM leaves off, calculating infiltration quantities by time steps <u>following</u> ponding time, according to the formula:

$$W_j = W_p + S(W_p,\theta_i)\ \{\sqrt{t_j - t_p + B} - \sqrt{B}\ \} + \tilde{K}(t_j - t_p)\ . \qquad (3.5.1)$$

W_j is the cumulative infiltration occurring up to the end of the 'jth' time step. t_j is the time at the end of the 'jth' time step. $S(W_p,\theta_i)$ is the rainfall sorptivity, defined by the equation:

$$S(W_p,\theta_i) = \sqrt{\frac{2\tilde{K}(S_f+W_p)^2}{S_f}} \qquad (3.5.2)$$

B is the quantity determined by the condition that at $t = t_p$, the infiltration capacity is equal to the rainfall rate, r_p. The equation for B is:

$$B = \frac{1}{2} \frac{(S_f + W_p)^2}{\tilde{K} S_f(\frac{r_p}{\tilde{K}} -1)^2} \qquad (3.5.3)$$

Knowing the cumulative infiltration at the end of a time step, it is a simple matter to find the mean infiltration capacity for that time step. The cumulative infiltration for the previous time step is subtracted from that for the just ended time step, yielding the incremental quantity of infiltration occurring in the latest time step. This quantity, a depth of water, is divided by the duration of the latest time step to yield a mean infiltration capacity in inches per hour. To get an excess rainfall rate for the time step, the mean infiltration capacity is subtracted from the mean rainfall rate for that step. If the infiltration capacity is greater than the rainfall rate, then the infiltration rate which actually occurred is simply equal to the rainfall rate, and the excess rainfall rate is zero. The cumulative infiltration occurring up to the end of the time step is revised to reflect the fact that infiltration was occurring at a rate less than capacity. After an excess rainfall pattern is computed for infiltration losses, 0.1 in. is removed from this (immediately after ponding), to account for surface retention losses. Lastly, subroutine ROUTE is called to generate a flood hydrograph from the excess rainfall pattern.

Variable List

FORTRAN Symbol	Math Symbol	Definition
RSORP	$S(W_p,\theta_i)$	Rainfall sorptivity (in./hr$^{1/2}$).
SF	S_f	Storage suction factor (in.).
RP	r_p	Rainfall rate producing ponding (in./hr).
RSTARP	r_p^*	Normalized rainfall rate at ponding ($r_p/\tilde{K}$).
KT	$\tilde{K}$	Hydraulic conductivity at natural saturation.

Variable List (continued)

FORTRAN Symbol	Math Symbol	Definition
WP	W_p	Cumulative infiltration (also rainfall) up to ponding time (in.).
B	B	Term in Equation 3.5.1, used for convenience (hr).
K		Counter passed from PONTIM indicating last full time step before ponding.
M		Index of the first full time step after ponding.
N	N	Number of time steps in event.
W(I)	W_j	Cumulative infiltration occurring up to the end of the 'jth' time step (in.).
DELW(I)		Increment of infiltration occurring during time step I (in.).
IR(I)		Mean infiltration rate occurring during time step I (in./hr).
T(I)		Time at the end of time step I (hr).
TP	t_p	Ponding time (hr).
R(I)	r	Rainfall intensity during time step I (in./hr).
RE(I)		Excess rainfall rate during time step I, before retention is subtracted (in./hr).
RET		Retention depth (in.).
PS		Depth of excess rain in a time step from which retention is being subtracted (in.).
RER(I)		Excess rainfall rate after retention has been subtracted (in./hr).
IFLAG		Counter incremented for each time step after the onset of excess rain.

Variable List (continued)

FORTRAN Symbol	Math Symbol	Definition
DELP	ΔP	Depth of excess rain occurring in a time step (in.).
NF		Number of time steps after the onset of excess rain. The ultimate value of IFLAG.
TM		Array of time steps after the onset of excess rain (hr).
P	P	Total depth of rainfall in the entire event (in.).
PE	P_e	Cumulative excess precipitation depth (in.).

3.6 Subroutine ROUTE: Calculation of a Flood Hydrograph

This subroutine is called by subroutines PPINF, CONSTR AND SCS. It uses the unit hydrograph of subroutine UH to compute a flood hydrograph (in cfs) from excess rain patterns (in inches). This computation is done according to the formula:

$$q(n) = \sum_{j=1}^{n} \Delta P(j)\ \delta(n-j+1) \quad \text{for } n = 1, 2, \ldots, MM \tag{3.6.1}$$

where $q(n)$ is a flood hydrograph ordinate (cfs), $\Delta P(j)$ is an increment of excess rainfall (in.), $\delta(n-j+1)$ is an ordinate of the unit hydrograph produced in UH, (cfs/in.), and MM is the sum of the number of (nonzero) unit hydrograph ordinates (NN) and of the number of steps of excess rain (NF), minus 1, namely: MM = NN + NF -1.

This is the number of time steps for which outflow will appear. The maximum MM that XSRAIN can handle is 150.

The program sets equal to zero the excess rainfall steps for times (NF+1) through MM, and also the deltas for times (NN+1) through MM.

A set of time steps (TM) is defined beginning at the onset of excess rain and running through step MM. Times and computed outflows are printed out. In addition, subroutine MAPA is called to give a line-printer plot of the flood hydrograph. As noted in the summary for subroutine UH, MAPA is a library subroutine on the system at Colorado State University. Users on other systems should substitute a subroutine of their own. If no plot is desired, simply delete the statements DATA, DIMENSION MT(8), and CALL MAPA.

Variable List

FORTRAN Symbol	Math Symbol	Definition
MM		Total number of time steps for which there will be flow.
NN		Number of unit hydrograph ordinates.
NF		Number of steps of excess rain.
TM(I)		Set of times (hr) beginning with onset of runoff. The value of TM(1) gives the time elapsed between the onset of rain and the end of the first time step of runoff.
NPLUS		Counter used in assigning zero values to portions of DELP and DELTA arrays.
DELP	ΔP	Steps of excess rainfall (in.).
DELTA	δ	Ordinate of unit hydrograph in (cfs/in.).
QA	q	Flood hydrograph ordinates (cfs).
MAPA		CSU library subroutine to give a line-printer data plot.

3.7 Subroutine CONSTR: Post-Ponding Infiltration with Assumed Constant Rainfall

This subroutine treats the event specified by the user as one of uniform rainfall intensity. It calculates ponding time, post-ponding infiltration and a pattern of excess rainfall. The purpose of the subroutine is to demonstrate the very different pattern of excess rainfall one obtains with constant rainfall assumed as compared to that arrived at with a variable rainfall event. This can make a big difference when the results are used to compute a flood hydrograph for a watershed.

The constant rainfall rate is first calculated:

$$r = \frac{P}{t_D} \tag{3.7.1}$$

Sorptivity for a constant rainfall event is slightly different from that for a variable rainfall event:

$$S(\theta_i) = \sqrt{2\tilde{K}S_f} \quad . \tag{3.7.2}$$

The normalized rainfall rate, r^*, is computed:

$$r^* = \frac{r}{\tilde{K}} \quad . \tag{3.7.3}$$

Ponding time is computed by the Mein and Larson formula:

$$t_p = \frac{S_f}{r(r^*-1)} \quad . \tag{3.7.4}$$

No successive solution for ponding time is required since the rainfall intensity is the same for every time step. The quantity infiltrated up to ponding is then simply:

$$W_p = rt_p \quad . \tag{3.7.5}$$

Post-ponding infiltration is computed by the formula

$$W_j = W_p + S(\theta_i) \left(\frac{r^*}{r^*-1}\right) \{\sqrt{t_j-t_p+B} - \sqrt{B}\} + \tilde{K}(t_j-t_p) \quad . \tag{3.7.6}$$

W_j is the cumulative infiltration at the end of time step j. B is the quantity, for a constant rainfall event, determined by the condition that at $t = t_p$, the rainfall rate equals the infiltration capacity, namely:

$$B = \frac{t_p}{2} \left(\frac{r^*}{r^*-1}\right)^3 \tag{3.7.7}$$

Incremental values of infiltration are computed for each time step from the cumulative values, and these increments of infiltration are divided by the length of the time steps to get mean infiltration capacities for each time step. As in PPINF, excess rainfall rates are found for each step by subtracting the mean infiltration capacity from the mean rainfall rate. If the infiltration capacity exceeds the rainfall rate, the actual infiltration rate occurring is simply taken as the rainfall rate itself, and the cumulative infiltration is adjusted to reflect this. After an excess rainfall pattern is computed for infiltration losses, 0.1 in. is removed from this (immediately after ponding), to account for surface retention losses. An array of increments of excess rainfall depths (DELP) is computed for use by the subroutine ROUTE, which produces a runoff hydrograph. Finally, a mass balance check is made and ROUTE is called.

Variable List

FORTRAN Symbol	Math Symbol	Definition
CR	r	Constant rainfall rate (in./hr).
P	P	Cumulative precipitation for entire event (in.).
TD	t_D	Duration of rain (hr).
SORP	$S(\theta_i)$	Sorptivity (in./hr$^{1/2}$).
KT	$\tilde{K}$	Hydraulic conductivity at natural saturation (in./hr).
SF	S_f	Storage suction factor (in.)
RSTAR	r^*	Normalized rainfall rate.
TP	t_p	Ponding time (hr).
KK		Counter indicating last full time step before ponding.
RATIO	$(\frac{r^*}{r^*-1})$	Self explanatory; a convenience term.
WP	W_p	Cumulative infiltration (and rainfall) up to ponding (in.).
W(I)	W_j	Cumulative infiltration at end of time step I (in.).

Variable List (continued)

FORTRAN Symbol	Math Symbol	Definition
T(I)	t_j	Time at end of time step I (hr).
B	B	Term in Eq. (3.7.6) (hr).
DELW(I)		Increment of infiltration (in.).
IR(I)		Mean infiltration rate in time step I (in./hr).
RE(I)		Mean excess rainfall rate in time step I (in./hr).
PECONS		Cumulative excess precipitation for a constant rainfall event (in.).
RET		Surface retention depth (in.).
RER(I)		Excess rainfall rate after retention has been subtracted (in./hr).
DELP		Array of increments of excess precipitation; used by ROUTE (in.).
DELT	Δt	Length of a time step (hr).
IFLAG		Counter used to add up the number of steps of excess rainfall.
M		The index of the first full time step after ponding.
N		The total number of time steps in the rainfall event.
NF		The number of steps of excess rainfall.
PS		Increment of excess rainfall from which retention is subtracted.
TM		Array of time steps beginning with onset of excess rainfall after retention is subtracted. This is the time set used to compute a flood hydrograph (hr).

3.8 Subroutine SCS: Excess Rainfall by the SCS Method

This subroutine uses the SCS approach for finding excess rainfall for both variable and constant rainfall events. If main options 2 or 3 are elected, the curve number is modified according to season and five day antecedent rainfall. May through September is taken as the growing season. Criteria for AMC types I and III are those presented in Table 4.2 of NEH-4, presented here in Table 4. Curve numbers are computed for AMC I and III, if criteria dictate, by the Sobhani (1976) equations:

$$CN_{I} = \frac{CN_{II}}{2.334 - 0.01334\ CN_{II}} \tag{3.8.1}$$

$$CN_{III} = \frac{CN_{II}}{0.4036 + 0.0059\ CN_{II}} \tag{3.8.1}$$

These equations match the values of NEH-4, Table 10.1, within ± 1 CN. Table 10.1 is reproduced in the Appendix as Table A2.

Table 4. Seasonal rainfall limits for AMC (after NEH-4).

AMC Group	Total 5-day Antecedent Rainfall	
	Dormant Season	Growing Season
	Inches	Inches
I	Less than 0.5	Less than 1.4
II	0.5 to 1.1	1.4 to 2.1
III	Over 1.1	Over 2.1

The variable rainfall case is addressed first. Starting with the first step, cumulative depth of rain up to that time is compared with the initial abstraction ($I_a = 0.2\ S$) and if it is less than I_a, the program records all rain as having infiltrated, and skips to the next time step. If cumulative rainfall exceeds I_a, cumulative infiltration is computed by the equation

$$W_j = P_j - \frac{(P_j - I_a)^2}{P_j - 0.8\ S} \qquad (3.8.3)$$

where W_j is the cumulative infiltration through time step 'j', and P_j is the cumulative precipitation through time step 'j'.

As in PPINF and CONSTR, increments of infiltration are computed from the cumulative values, and these in turn are divided by the length of their respective time steps to get mean infiltration capacities. Mean excess rainfall rates are equal to the mean rainfall rates minus their respective mean infiltration capacities. If mean infiltration capacity should exceed the rainfall rate for a time step, the infiltration rate for the step is taken as equal to the rainfall rate for that step. In such a case, cumulative infiltration is revised down to maintain mass balance. Finally, steps of incremental excess rainfall depth are computed and subroutine ROUTE is called to compute a flood hydrograph.

The program next turns to the case of the constant rainfall rate storm, and redefines the steps of cumulative precipitation accordingly. It then passes through the same algorithm as for the variable rainfall case to produce a pattern of excess rainfall and a flood hydrograph.

Variable List

FORTRAN Symbol	Math Symbol	Definition
AMC	AMC	Antecedent moisture condition, for SCS, the sum of rainfall depths for the five previous days (in.).
AR(1)		Depth of rain falling on 5th day previous (in.).
AR(2)		Depth of rain falling on 4th day previous (in.).
AR(3)		Depth of rain falling on 3rd day previous (in.).
AR(4)		Depth of rain falling on 2nd day previous (in.).
AR(5)		Depth of rain falling on 1st day previous (in.).

Variable List (continued)

FORTRAN Symbol	Math Symbol	Definition
MO		Month (1-12).
CN	CN	Curve number.
IFLAG		Flag variable distinguishing between constant and variable rain computations.
S	S	SCS watershed storage parameter (in.).
IA	I_a	Initial abstraction (in.).
CUMP(I)		Cumulative rainfall through step I (in.).
W(I)	W	Cumulative infiltration through step I (in.).
DELW(I)		Incremental infiltration in step I (in.).
T(I)		Time at end of step I (hr).
IR(I)		Mean infiltration rate in step I (in./hr).
R(I)		Mean rainfall rate in step I (in./hr).
RE(I)		Mean excess rainfall rate in step I (in./hr).
P	P	Cumulative rainfall depth for entire event (in.).
TD	t_D	Duration of rain (hr).
PESCS		Depth of cumulative excess precipitation for entire event by the SCS method (in.).
CR	R	Constant rainfall rate, $r = P/t_d$ (in./hr).
DELP		Array of increments of excess rain; used by ROUTE (in.).

Variable List (continued)

FORTRAN Symbol	Math Symbol	Definition
DELT	Δt	Length of a time step (hr).
ICOUNT		Index used to count the number of steps of excess rain (DELP).
N		The total number of time steps in the rainfall event.
NF		The number of time steps with excess rain occurring.
TM		Set of time steps beginning with onset of excess rainfall used in ROUTE (hr).

3.9 Subroutine TABLE: Computation of Hydraulic Soil Parameters from Curve Number

This subroutine computes hydraulic conductivity, $\tilde{K}$ (in./hr), and storage suction factor at field capacity, $(S_f)_{fc}$ (in.), given a curve number (CN). Hydraulic conductivity is computed directly from a regression equation which has CN as its only unknown. The storage suction factor is found in two steps. First, the sorptivity at field capacity, $S(\theta_{fc})$, is found directly from a regression equation in CN. Then, $(S_f)_{fc}$ is found by the following equation:

$$(S_f)_{fc} = \frac{[S(\theta_{fc})]^2}{2\tilde{K}} \tag{3.9.1}$$

This is simply a rearrangement of the equation defining sorptivity:

$$S(\theta_i) = \sqrt{2\tilde{K}S_f} \tag{3.9.2}$$

The particular regression equations used to find $\tilde{K}$ depend upon the CN. These equations are:

$$\tilde{K} = \frac{(100-\text{CN})}{315.43}, \qquad \text{CN} > 75 \tag{3.9.3}$$

$$\tilde{K} = 1.236 - 0.0154\ \text{CN}, \qquad 36 < \text{CN} \leq 75 \tag{3.9.4}$$

$$\tilde{K} = 1.853 - 0.0324\ \text{CN}, \qquad \text{CN} \leq 36 \tag{3.9.5}$$

The equations for sorptivity are:

$$S(\theta_{fc}) = \frac{(100-CN)}{42.252}, \qquad CN > 65 \tag{3.9.6}$$

$$S(\theta_{fc}) = 1.191 - 0.00575\ CN, \qquad CN \leq 65 \tag{3.9.7}$$

There is no bias in Equations (3.9.3) through (3.9.7) due to assumed constant rainfall rate in establishing the CN - ($\tilde{K}$, S_f) correspondence. Earlier versions of these equations contained such a bias, but they have since then been corrected.

Variable List

FORTRAN Symbol	Math Symbol	Definition
CN	CN	SCS watershed curve number.
KT	$\tilde{K}$	Hydraulic conductivity (in./hr).
SORP	$S(\theta_{fc})$	Sorptivity at field capacity (in./hr$^{1/2}$).
SFFC	$(S_f)_{fc}$	Storage suction factor at field capacity soil moisture content (in.).

3.10 Subroutine BALANCE: Formation of Corps of Engineers "Balanced Hyetograph"

This subroutine takes a set of input steps of rainfall (either in in. or in./hr) and rearranges them into a "balanced hyetograph" as used in U.S. Army Corps of Engineers practice (see reference number 3, page 3-02).

The algorithm begins in DO loop 40 by arranging the rainfall array so the pulse of greatest magnitude is the first element, that of second greatest magnitude is the second element, etc. Next, in DO loop 90, the steps of rainfall are rearranged to that the greatest is the central element, the second greatest occurs just before it, the third greatest occurs just after it, the fourth greatest occurs just before the second greatest, and so on. This is the form of the "balanced hyetograph."

Variable List

FORTRAN Symbol	Math Symbol	Definition
N		Number of steps of rainfall.
R	r	Array of rainfall steps, either in in. or in./hr.
CHECK		Comparison variable.
ICHECK		Index of the 'Ith' largest step of rainfall.
BR		Intermediate array of rain steps where BR(1) is greatest, BR(2) is next greatest, etc. (in. or in./hr)
CTR		Index of center element of R array which is of greatest magnitude in a "balanced hyetograph."

4. Illustrative Examples

4.1 Main Option One

Suppose a small watershed in central Oklahoma is under investigation. Study of soil maps show 36 percent of the area characterized by soils of hydrologic group D and the remaining 64 percent by group B. The land use is pasture. The watershed has a past history of overgrazing and has suffered from erosion due to this practice, suggesting a classification of poor hydrologic condition. Consulting Table 1 (NEH-4, Table 9.1) shows a curve number of 89 for areas of soil group D and 79 for soil group B. The composite CN is found by weighting by area:

$$CN = 0.36(89) = 0.64(79) = 82.6$$

Next the table of correspondence (Table A1) is consulted to determine infiltration parameters. Interpolating values it is found that $\tilde{K} = 0.055$ in./hr and $(S_f)_{fc} = 1.537$ in.

Maps and air photos are studied to determine the watershed characteristics required as inputs for the SCS dimensionless unit hydrograph procedures. The area is 14 acres, or 0.03 square miles. The lag time will be estimated by Equation (3.3.1), within subroutine UH. The length to the divide from the basin outlet is 1,100 ft. The average watershed slope is estimated from contours to be 8 percent.

During the event of interest, 3.0 in. of rain fell on the watershed in 8.0 hr. The time distribution is unknown, so a Huff distribution will be imposed. Table 3 suggests a storm of 8.0 hr duration would likely fall in the second-quartile category. A time step of 20 min is elected.

All the necessary inputs are now available for running XSRAIN with option one. Data cards are prepared in the following manner:

Input Description for XSRAIN, Main Option One

Card	Field	Columns	Math Symbol	FORTRAN Symbol	Format	Description
1	1	1		OPTION	I1	Main Option of XSRAIN elected
2	1	1,2		SUBOPT1	I2	Suboption 1 (see Sec. 2.5)
	2	3,4			2X	
	3	5,6		SUBOPT2	I2	Suboption 2 (see Sec. 2.6)
3	1	1-10	$\tilde{K}$	KT	F10.3	Hydraulic conductivity at natural saturation in./hr)
	2	11-20	$(S_f)_{fc}$	SFFC	F10.3	Storage suction factor at field capacity (in.)
	3	21-30	P	P	F10.3	Cumulative depth of precipitation (in.)
	4	30-41	t_D	TD	F10.3	Duration of storm (hr)
	5	41-50	CN	CN	F10.3	SCS curve number
4	1	1		LAGFLAG	I1	If LAGFLAG = 0, t_ℓ (hr) is computed by Eq. (3.3.1) If LAGFLAG = 1, t_ℓ is specified by user.

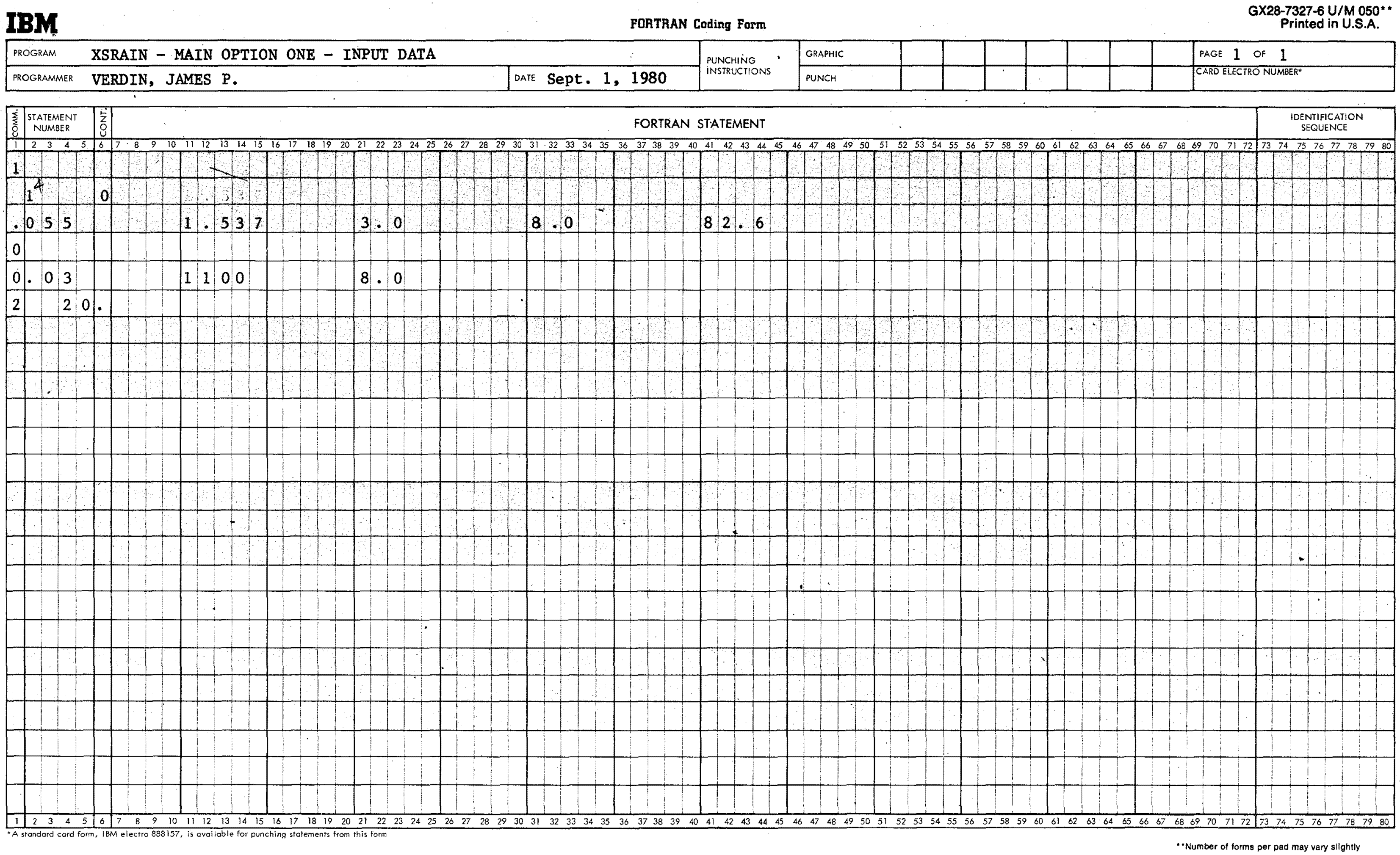
Input Description for XSRAIN, Main Option One (continued)

Card	Field	Columns	Math Symbol	FORTRAN Symbol	Format	Description
If LAGFLAG = 0, Card 5 has the following format:						
5	1	1-10		AREA	F10.2	Watershed area (square) miles
	2	11-20	ℓ	L	F10.2	Length to divide (ft)
	3	21-30	Y	Y	F10.2	Average watershed slope (percent)
If LAGFLAG = 1, Card 5 has the following format:						
5	1	1-10		AREA	F10.2	Watershed area (sq. mi.)
	2	11-20	t_ℓ	TL	F10.2	Lag time (hr)
6	1	1	Q	Q	I1	Huff quartile chosen (1, 2, 3 or 4)
	2	2,3			2X	Two blank columns
	3	4-13	Δt	DELT	F10.1	Time step chosen (min)

The coding sheet for these data is shown as Figure 10.

A copy of the results printed out by XSRAIN for the example is presented in Exhibit 1. It should be noted that in the tabulated output of subroutine PPINF, the first time listed is ponding time, and the values in the W and DELW columns are the cumulative infiltration at ponding, W_p. It is understood that IR = R = RP (the ponding rainfall) and that the excess rainfall rate, RE, is equal to zero.

Note that in the output of subroutine UH there is a warning given that the user-specified time step is greater than 0.25 T_p (T_p is the time to peak). This condition may yield a jagged, discontinuous hydrograph. In this example, however, the flood hydrograph is seen to be smooth in spite of this.



IBM FORTRAN Coding Form GX28-7327-6 U/M 050** Printed in U.S.A.

PROGRAM	XSRAIN - MAIN OPTION ONE - INPUT DATA
PROGRAMMER	VERDIN, JAMES P.
DATE	Sept. 1, 1980
PAGE	1 OF 1

```
1
 14  0
.055      1.537     3.0       8.0       82.6
0
0.03      1100      8.0
2  20.
```

*A standard card form, IBM electro 888157, is available for punching statements from this form

**Number of forms per pad may vary slightly

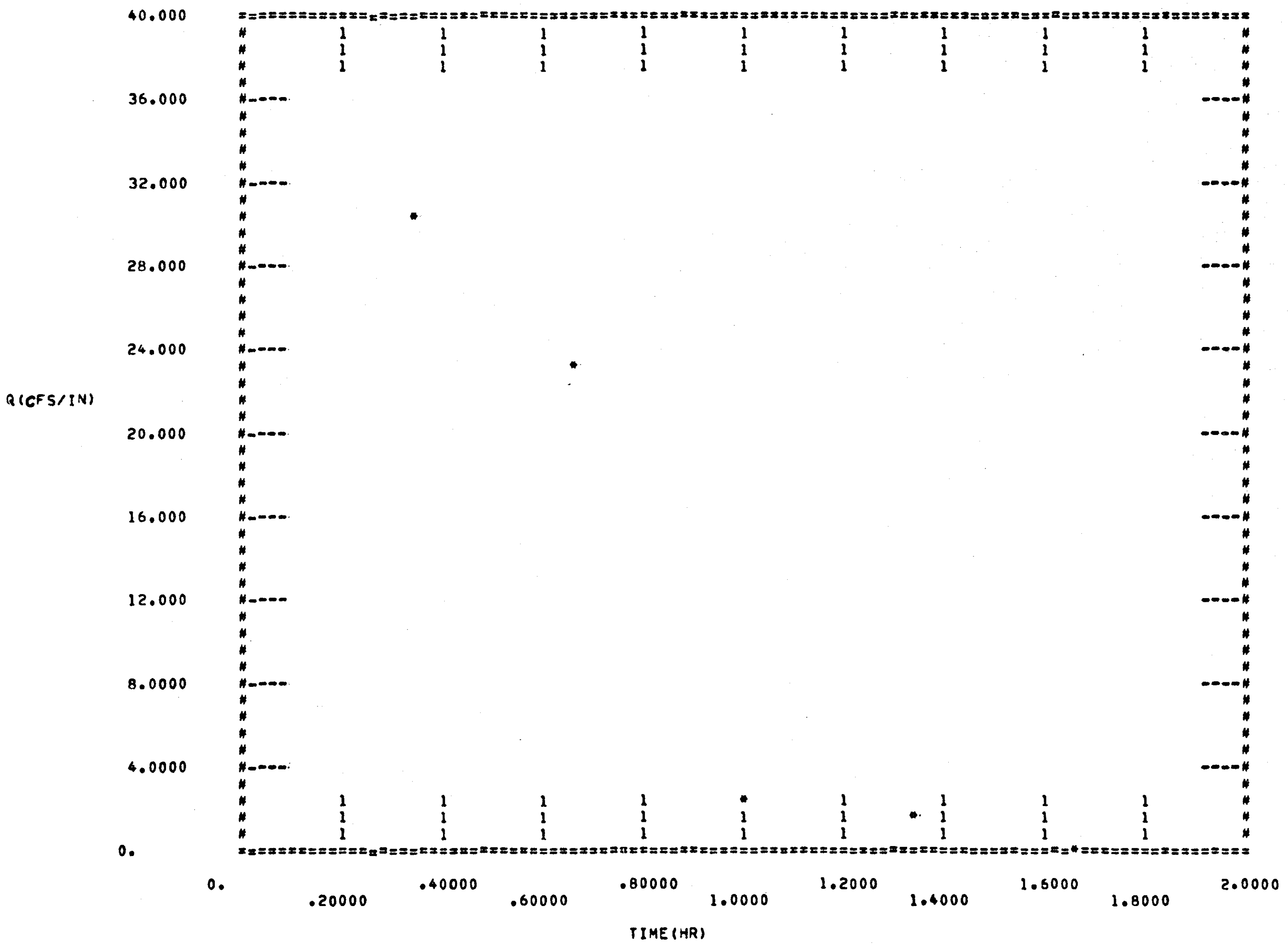
Figure 10. Coding sheet showing input data for example of Main Option One.

Exhibit 1. Output of XSRAIN for example of Main Option One.

```
MAIN OPTION CHOSEN IS   1


IF SUBOPT1 = 1, ONLY INFILTRATION APPROACH IS USED WITH VARIABLE RAINFALL RATES
IF SUBOPT1 = 4, HYDROGRAPHS ARE DERIVED WITH FOUR DIFFERENT MEANS OF CALCULATING EXCESS RAIN

IF SUBOPT2 = 0, USER INPUTS KT AND SFFC
IF SUBOPT2 = 1, KT AND SFFC ARE COMPUTED FROM CN



SUB OPTION 1 =  1           SUB OPTION 2 =  0


HYDRAULIC CONDUCTIVITY, KT =     .055 IN/HR
STORAGE SUCTION FACTOR AT FIELD CAPACITY, SFFC =   1.537 IN
TOTAL PRECIP, P=    3.000 IN
DURATION TIME, TD =    8.000 HR
CURVE NUMBER, CN =     82.6


IF LAGFLAG = 0, LAG TIME IS COMPUTED IN SUBROUTINE UH
IF LAGFLAG = 1, LAG TIME IS PROVIDED BY THE USER

LAGFLAG =  0

AREA=        .03  SQ MI
   LENGTH TO DIVIDE=   1100.00  FT      AVG WATERSHED SLOPE =        8.00  PERCENT
HUFF QUARTILE=   2      TIME STEP=       20.0MIN
*******************************************************************************************


        OUTPUT OF SUBROUTINE HUFF

        HUFF HYETOGRAPH
        ===============

TIME (HR)      CUMULATIVE PRECIP (IN)      RAINFALL INTENSITY (IN/HR)

     .333                  .038                         .113
     .667                  .075                         .113
    1.000                  .165                         .270
    1.333                  .290                         .375
    1.667                  .435                         .435
    2.000                  .660                         .675
    2.333                  .885                         .675
    2.667                 1.150                         .795
    3.000                 1.425                         .825
    3.333                 1.685                         .780
    3.667                 1.923                         .713
    4.000                 2.160                         .712
    4.333                 2.348                         .563
    4.667                 2.535                         .562
    5.000                 2.655                         .360
    5.333                 2.730                         .225
    5.667                 2.798                         .203
    6.000                 2.835                         .113
    6.333                 2.873                         .112
    6.667                 2.900                         .083
    7.000                 2.925                         .075
    7.333                 2.950                         .075
    7.667                 2.975                         .075
    8.000                 3.000                         .075
*******************************************************************************************


OUTPUT OF SUBROUTINE UH

USER TIME STEP OF    .333 HR IS GREATER THAN 0.25 TIME TO PEAK WHICH IS    .070 HR
RESULTING HYDROGRAPH MAY BE JAGGED

WATERSHED LAG TIME =     .112HR
TIME TO PEAK=     .278HR

        UNIT HYDROGRAPH
 TIME(HR)           ORDINATES IN (CFS/IN)          DIMENSIONLESS ORDINATES

     .333                     30.42                              .524
     .667                     23.43                              .404
    1.000                      2.52                              .043
    1.333                      1.45                              .025
    1.667                       .25                              .004
```

Exhibit 1. (continued).

GRAPH 1



UNIT HYDROGRAPH

Exhibit 1. (continued).

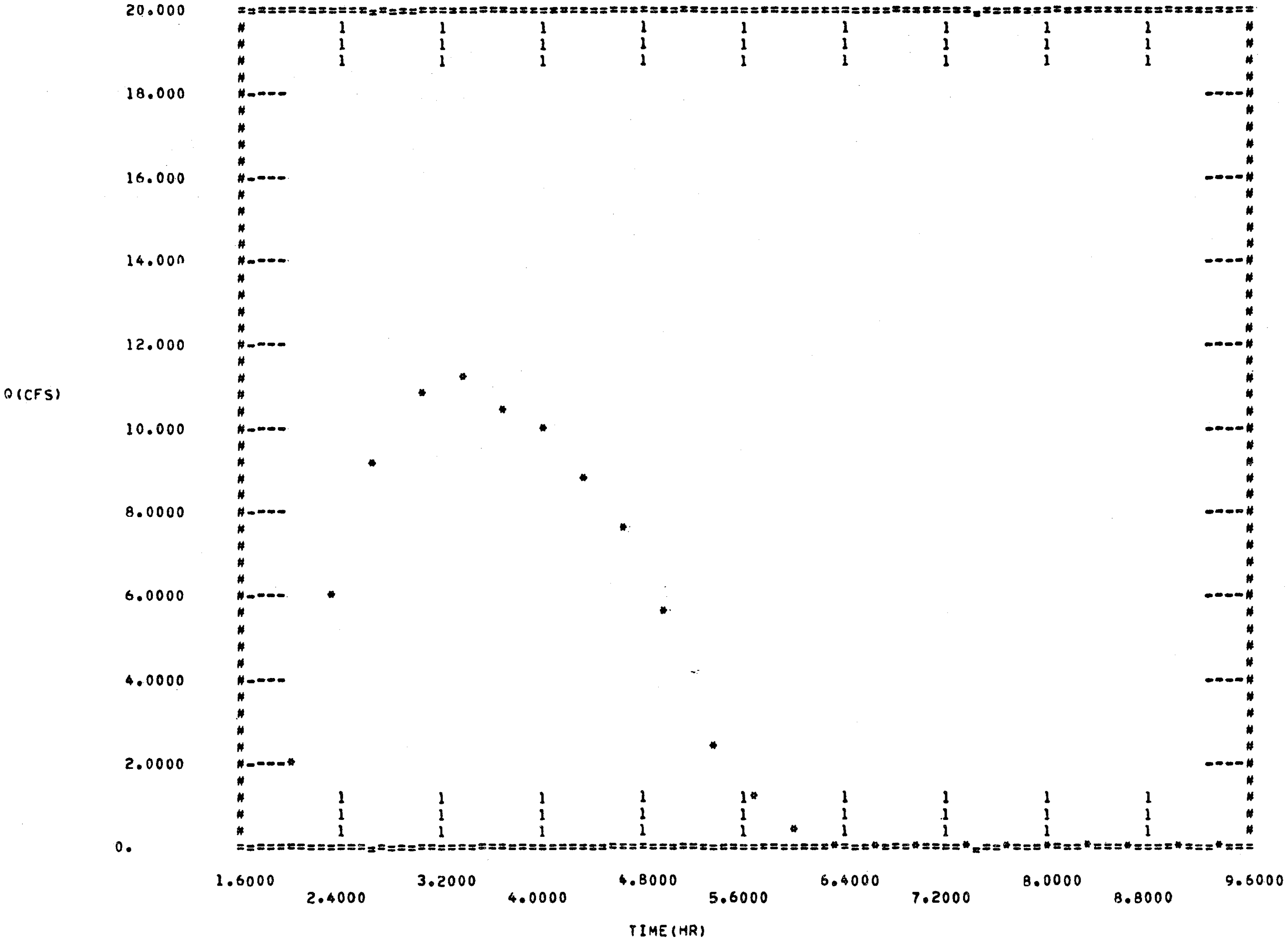
```
**************************************************************************************************

         OUTPUT OF SUBROUTINE PONTIM

PONDING TIME=   1.264 HR     PONDING RAINFALL=    .375 IN/HR     DEPTH OF RAIN INFILTRATED PREVIOUS TO PONDING=    .264 IN
LAST FULL TIME STEP T( 3)=   1.000

**************************************************************************************************

        .OUTPUT OF SUBROUTINE PPINF, VARIABLE RAINFALL, INFILTRATION APPROACH

   T(HR) = TIME IN HOURS
   W(IN) = CUMULATIVE INFILTRATION IN INCHES
   DELW(IN) = INCREMENTAL INFILTRATION IN INCHES
   IR(IN/HR) = INFILTRATION RATE IN INCHES PER HOUR
   R(IN/HR) = RAINFALL RATE IN INCHES PER HOUR
   RE(IN/HR) = RAINFALL RATE AFTER INFILTRATION SUBTRACTED
   RER(IN/HR) = NET EXCESS RAINFALL RATE AFTER RETENTION SUBTRACTED

   T(HR)      W(IN)    DELW(IN) IR(IN/HR)  R(IN/HR)  RE(IN/HR)  RER(IN/HR)

    1.264      .264      .264
    1.333      .289      .025      .366      .375      .009      0.000
    1.667      .398      .108      .325      .435      .110      0.000
    2.000      .492      .094      .282      .675      .393       .205
    2.333      .576      .085      .254      .675      .421       .421
    2.667      .655      .078      .235      .795      .560       .560
    3.000      .728      .073      .220      .825      .605       .605
    3.333      .797      .069      .208      .780      .572       .572
    3.667      .864      .066      .199      .713      .514       .514
    4.000      .927      .064      .191      .712      .521       .521
    4.333      .989      .061      .184      .563      .378       .378
    4.667     1.048      .060      .179      .562      .384       .384
    5.000     1.106      .058      .173      .360      .187       .187
    5.333     1.163      .056      .169      .225      .056       .056
    5.667     1.218      .055      .165      .203      .038       .038
    6.000     1.255      .038      .113      .113     0.000      0.000
    6.333     1.293      .037      .112      .112     0.000      0.000
    6.667     1.320      .028      .083      .083     0.000      0.000
    7.000     1.345      .025      .075      .075     0.000      0.000
    7.333     1.370      .025      .075      .075     0.000      0.000
    7.667     1.395      .025      .075      .075     0.000      0.000
    8.000     1.420      .025      .075      .075     0.000      0.000

MASS BALANCE CHECK

EXCESS PRECIP=   1.480  IN
CUMULATIVE INFILTRATION=   1.420  IN
RETENTION=    .100  IN
TOTAL PRECIP=   3.000  IN
```

Exhibit 1. (continued).

```
DATA USED TO COMPUTE FLOOD HYDROGRAPH:

 T(HR) = TIME IN HOURS
 DELP(IN) = INCREMENTAL DEPTH OF EXCESS RAINFALL
 DELTA(CFS/IN) = UNIT HYDROGRAPH ORDINATE

 T(HR)          DELP(IN)       DELTA(CFS/IN)

   2.000          .068              30.424
   2.333          .140              23.435
   2.667          .187               2.517
   3.000          .202               1.450
   3.333          .191                .251
   3.667          .171               0.000
   4.000          .174               0.000
   4.333          .126               0.000
   4.667          .128               0.000
   5.000          .062               0.000
   5.333          .019               0.000
   5.667          .013               0.000
   6.000         0.000               0.000
   6.333         0.000               0.000
   6.667         0.000               0.000
   7.000         0.000               0.000
   7.333         0.000               0.000
   7.667         0.000               0.000
   8.000         0.000               0.000
   8.333         0.000               0.000
   8.667         0.000               0.000
   9.000         0.000               0.000
   9.333         0.000               0.000

 FLOOD HYDROGRAPH

    TIME(HR)                    Q(CFS)

       2.000                      2.08
       2.333                      5.87
       2.667                      9.14
       3.000                     10.97
       3.333                     11.21
       3.667                     10.49
       4.000                     10.12
       4.333                      8.67
       4.667                      7.58
       5.000                      5.50
       5.333                      2.57
       5.667                      1.19
       6.000                       .46
       6.333                       .07
       6.667                       .02
       7.000                       .00
       7.333                      0.00
       7.667                      0.00
       8.000                      0.00
       8.333                      0.00
       8.667                      0.00
       9.000                      0.00
       9.333                      0.00
```

Exhibit 1. (continued).

GRAPH 2



FLOOD HYDROGRAPH

4.2 Main Option Two

In this example, the same problem as posed in Section 4.1 will be solved, with the difference that this time the influences of season and five day antecedent rainfall will be taken into account. The rainfall event occurred on September 29 and was preceded by 0.25 in. of rain 4 days earlier. This means that:

MO = 9

DAY = 29

AR(1) = 0.0, AR(2) = 0.25, AR(3) = 0.0, AR(4) = 0.0, AR(5) = 0.0

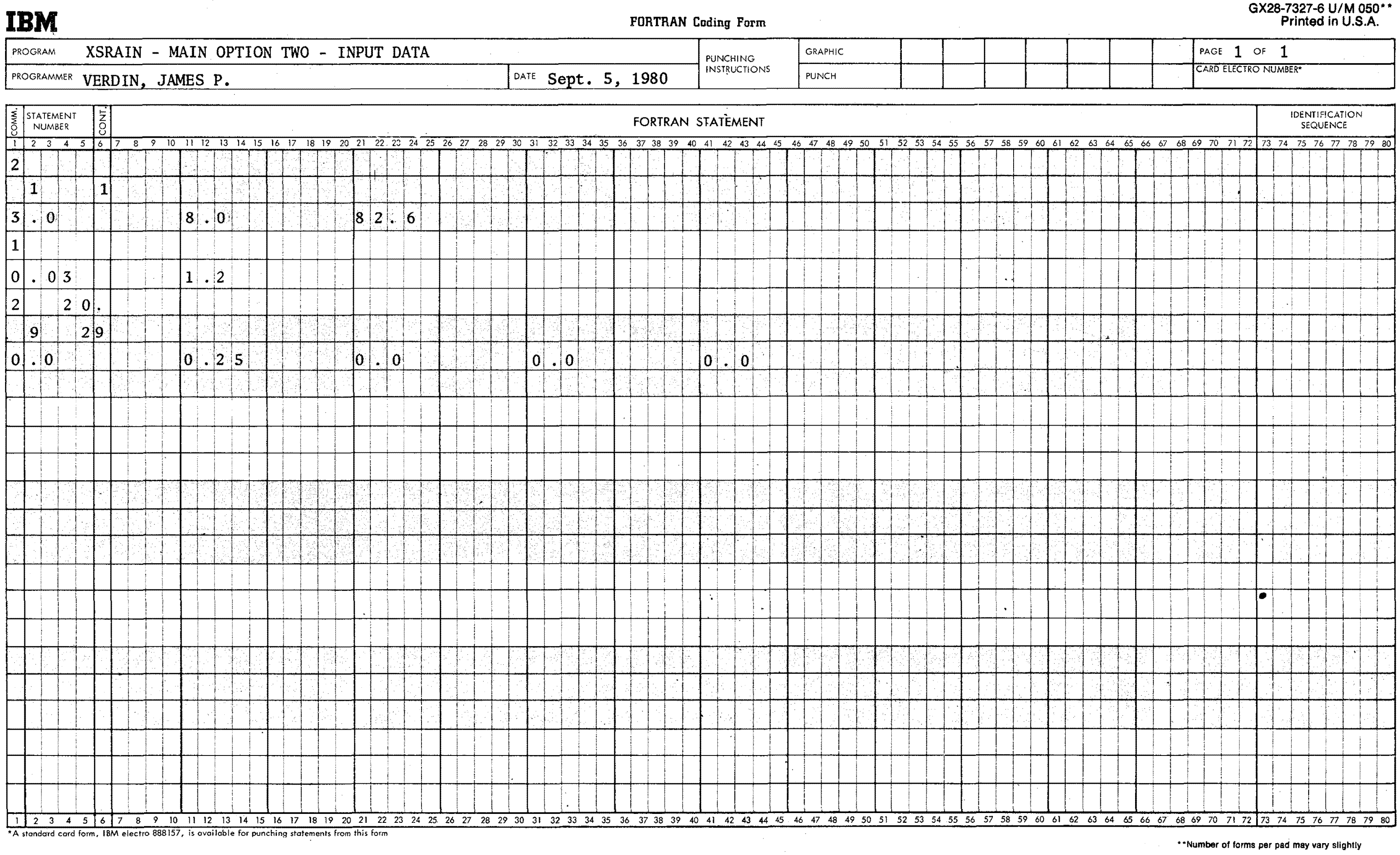
It will be left to XSRAIN to determine the hydraulic conductivity, $\tilde{K}$, and storage suction factor, $(S_f)_{fc}$, from the curve number. Hence, SUBOPT2 = 1. In addition, a lag time will be specified from a study of the basin's geomorphology and channel characteristics. That estimate of lag time is 1.2 hr. It follows then that LAGFLAG is set equal to 1. Data cards should be of the following format.

Input Description for XSRAIN, Main Option Two

Card	Field	Columns	Math Symbol	FORTRAN Symbol	Format	Description
1	1	1		OPTION	I1	Main Option of XSRAIN elected
2	1	1,2		SUBOPT1	I2	Suboption 1 (see Sec. 2.5)
	2	3,4			2X	
	3	5,6		SUBOPT2	I2	Suboption 2 (see Sec. 2.6)
3	1	1-10	P	P	F10.3	Cumulative depth of precipitation (in.)
	2	11-20	t_D	TD	F10.3	Duration of storm (hr)
	3	21-30	CN	CN	F10.3	SCS curve number
4	1	1		LAGFLAG	I1	If LAGFLAG = 0, t_ℓ (hr) is computed by Eq. (3.3.1) If LAGFLAG = 1, t_ℓ is specified by user.

Input Description for XSRAIN, Main Option Two (continued)

Card	Field	Columns	Math Symbol	FORTRAN Symbol	Format	Description
If LAGFLAG = 0, Card 5 has the following format:						
5	1	1-10		AREA	F10.2	Watershed area (square) miles
	2	11-20	ℓ	L	F10.2	Length to divide (ft)
	3	21-30	Y	Y	F10.2	Average watershed slope (percent)
If LAGFLAG = 1, Card 5 has the following format:						
5	1	1-10		AREA	F10.2	Watershed area (square mile)
	2	11-20	t_ℓ	TL	F10.2	Lag time (hr)
6	1	1	Q	Q	I1	Huff quartile chosen (1, 2, 3 or 4)
	2	2,3			2X	Two blank columns
	3	4-13	Δt	DELT	F10.1	Time step chosen (min)
7	1	1,2		MO	I2	Month in which storm occurs (1-12)
	2	2,3			2X	Two blank columns
	3	5,6		DAY	I2	Day of the month on which storm occurs (1-31)
8	1	1-10		AR(1)	F10.3	Depth of rain fallen 5 days previous (in.)
	2	11-20		AR(2)	F10.3	Depth of rain fallen 4 days previous (in.)
	3	21-30		AR(3)	F10.3	Depth of rain fallen 3 days previous (in.)
	4	31-40		AR(4)	F10.3	Depth of rain fallen 2 days previous (in.)
	5	41-50		AR(5)	F10.3	Depth of rain fallen 1 day previous (in.)



IBM FORTRAN Coding Form GX28-7327-6 U/M 050** Printed in U.S.A.

PROGRAM XSRAIN - MAIN OPTION TWO - INPUT DATA

PROGRAMMER VERDIN, JAMES P.

DATE Sept. 5, 1980

PUNCHING INSTRUCTIONS GRAPHIC PUNCH

PAGE 1 OF 1

CARD ELECTRO NUMBER*

```
2
 1   1
3.0       8.0       82.6
1
0.03      1.2
2  20.
 9  29
0.0       0.25      0.0       0.0       0.0
```

*A standard card form, IBM electro 888157, is available for punching statements from this form

**Number of forms per pad may vary slightly

Figure 11. Coding sheet showing input data for example of Main Option Two.

Exhibit 2. Output of XSRAIN for example of Main Option Two.

```
MAIN OPTION CHOSEN IS   2


IF SUBOPT1 = 1, ONLY INFILTRATION APPROACH IS USED WITH VARIABLE RAINFALL RATES
IF SUBOPT1 = 4, HYDROGRAPHS ARE DERIVED WITH FOUR DIFFERENT MEANS OF CALCULATING EXCESS RAIN

IF SUBOPT2 = 0, USER INPUTS KT AND SFFC
IF SUBOPT2 = 1, KT AND SFFC ARE COMPUTED FROM CN


SUB OPTION 1 =  1           SUB OPTION 2 =  1

STORM DEPTH P =      3.000  IN      STORM DURATION TD =      8.000  HR      CURVE NUMBER CN =    82.600

****************************************************************************************************


        OUTPUT OF SUBROUTINE TABLE


HYDRAULIC CONDUCTIVITY, KT =       .055  IN/HR
STORAGE SUCTION FACTOR AT FIELD CAPACITY, SFFC =     1.537 IN


****************************************************************************************************


IF LAGFLAG = 0, LAG TIME IS COMPUTED IN SUBROUTINE UH
IF LAGFLAG = 1, LAG TIME IS PROVIDED BY THE USER

LAGFLAG =  1

AREA=       .03  SQ MI
   USER PROVIDED LAG TIME =   1.200HR

HUFF QUARTILE=   2     TIME STEP=      20.0MIN
MONTH=   9     DAY=  29

ARRAY OF ANTECEDENT RAINFALL DEPTHS

AR( 1)=     0.000
AR( 2)=      .250
AR( 3)=     0.000
AR( 4)=     0.000
AR( 5)=     0.000
```

Exhibit 2. (continued).

```
          OUTPUT OF SUBROUTINE HUFF

          HUFF HYETOGRAPH -
          ===============

  TIME (HR)      CUMULATIVE PRECIP (IN)      RAINFALL INTENSITY (IN/HR)

       .333                 .038                          .113
       .667                 .075                          .113
      1.000                 .165                          .270
      1.333                 .290                          .375
      1.667                 .435                          .435
      2.000                 .660                          .675
      2.333                 .885                          .675
      2.667                1.150                          .795
      3.000                1.425                          .825
      3.333                1.685                          .780
      3.667                1.923                          .713
      4.000                2.160                          .712
      4.333                2.348                          .563
      4.667                2.535                          .562
      5.000                2.655                          .360
      5.333                2.730                          .225
      5.667                2.798                          .203
      6.000                2.835                          .113
      6.333                2.873                          .112
      6.667                2.900                          .083
      7.000                2.925                          .075
      7.333                2.950                          .075
      7.667                2.975                          .075
      8.000                3.000                          .075
****************************************************************************************

          OUTPUT OF SUBROUTINE DEFICIT

S=     2.107  IN
EFFECTIVE DEPTH=     23.99  IN   WETTING FRONT SUCTION,HF,=    17.508  IN   JULIAN DATE = 269.   SEASONAL S =     3.152  IN
ADJUSTED DEFICIT=     .163     STORAGE SUCTION FACTOR     ,SF,=     2.861  IN

****************************************************************************************
```

Exhibit 2. (continued).

```
OUTPUT OF SUBROUTINE UH

WATERSHED LAG TIME =   1.200HR
TIME TO PEAK=   1.367HR

        UNIT HYDROGRAPH
 TIME(HR)           ORDINATES IN (CFS/IN)           DIMENSIONLESS ORDINATES

     .333                    1.51                                   .026
     .667                    1.79                                   .031
    1.000                    6.76                                   .116
    1.333                   10.60                                   .182
    1.667                   10.55                                   .182
    2.000                    8.10                                   .140
    2.333                    6.21                                   .107
    2.667                    4.36                                   .075
    3.000                    2.70                                   .046
    3.333                    1.57                                   .027
    3.667                    1.14                                   .020
    4.000                     .30                                   .005
    4.333                     .30                                   .005
    4.667                     .30                                   .005
    5.000                     .30                                   .005
    5.333                     .30                                   .005
    5.667                     .30                                   .005
    6.000                     .30                                   .005
    6.333                     .30                                   .005
    6.667                     .30                                   .005
    7.000                     .15                                   .003
```

Exhibit 2. (continued).

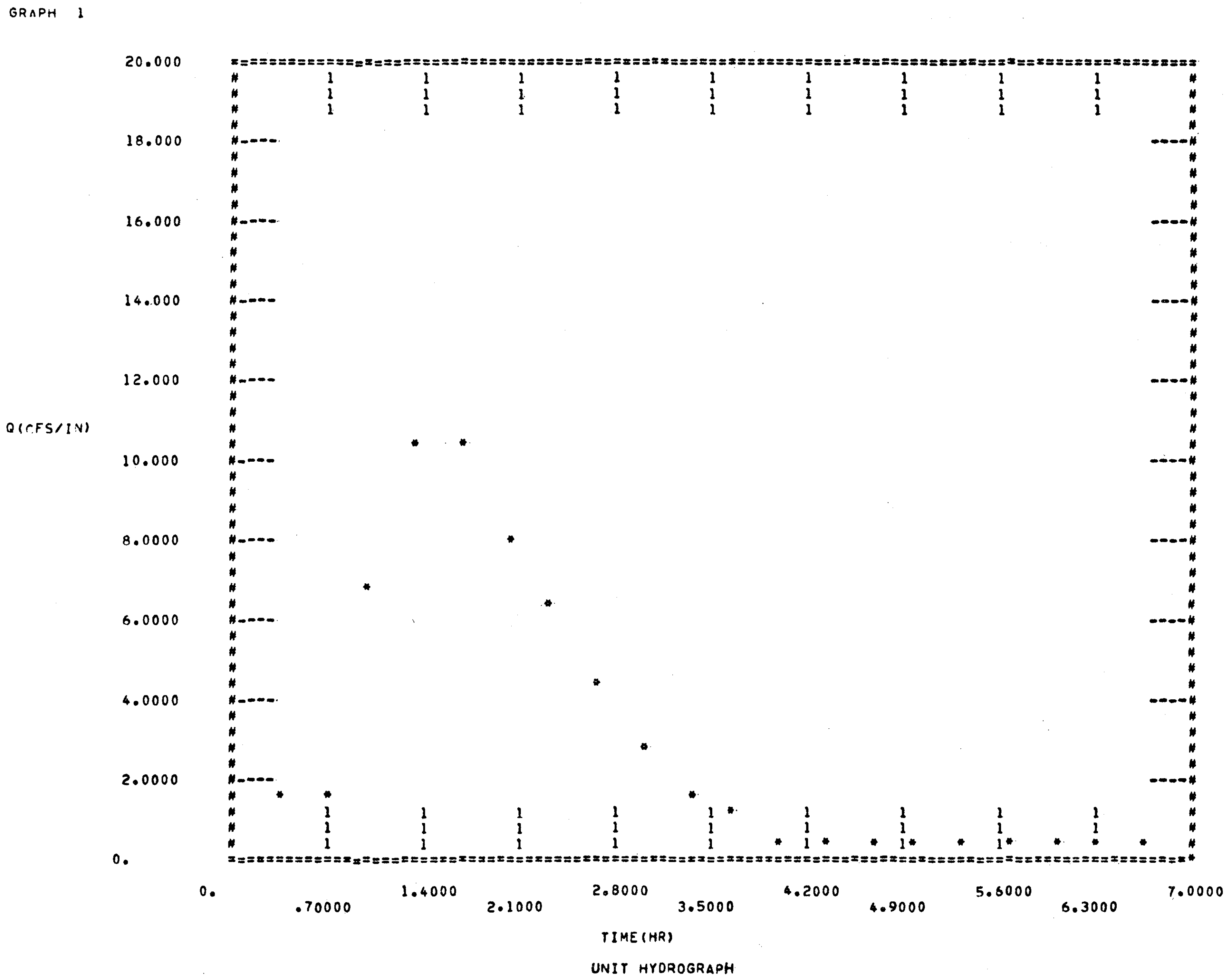


Exhibit 2. (continued).

```
**************************************************************************************************************

         OUTPUT OF SUBROUTINE PONTIM

PONDING TIME=   1.622 HR      PONDING RAINFALL=    .435 IN/HR      DEPTH OF RAIN INFILTRATED PREVIOUS TO PONDING=    .416 IN
LAST FULL TIME STEP T( 4)=    1.333

**************************************************************************************************************

         OUTPUT OF SUBROUTINE PPINF, VARIABLE RAINFALL, INFILTRATION APPROACH

   T(HR) = TIME IN HOURS
   W(IN) = CUMULATIVE INFILTRATION IN INCHES
   DELW(IN) = INCREMENTAL INFILTRATION IN INCHES
   IR(IN/HR) = INFILTRATION RATE IN INCHES PER HOUR
   R(IN/HR) = RAINFALL RATE IN INCHES PER HOUR
   RE(IN/HR) = RAINFALL RATE AFTER INFILTRATION SUBTRACTED
   RER(IN/HR) = NET EXCESS RAINFALL RATE AFTER RETENTION SUBTRACTED

   T(HR)       W(IN)    DELW(IN) IR(IN/HR)  R(IN/HR)  RE(IN/HR)  RER(IN/HR)

    1.622       .416       .416
    1.667       .435       .019       .429       .435       .006      0.000
    2.000       .565       .130       .390       .675       .285      0.000
    2.333       .679       .114       .342       .675       .333       .318
    2.667       .782       .103       .310       .795       .485       .485
    3.000       .878       .096       .287       .825       .538       .538
    3.333       .968       .090       .269       .780       .511       .511
    3.667      1.053       .085       .255       .713       .458       .458
    4.000      1.134       .081       .243       .712       .469       .469
    4.333      1.212       .078       .233       .563       .329       .329
    4.667      1.287       .075       .225       .562       .338       .338
    5.000      1.359       .073       .218       .360       .142       .142
    5.333      1.429       .070       .211       .225       .014       .014
    5.667      1.497       .068       .203       .203      0.000      0.000
    6.000      1.534       .038       .113       .113      0.000      0.000
    6.333      1.572       .037       .112       .112      0.000      0.000
    6.667      1.599       .028       .083       .083      0.000      0.000
    7.000      1.624       .025       .075       .075      0.000      0.000
    7.333      1.649       .025       .075       .075      0.000      0.000
    7.667      1.674       .025       .075       .075      0.000      0.000
    8.000      1.699       .025       .075       .075      0.000      0.000

MASS BALANCE CHECK

EXCESS PRECIP=   1.201  IN
CUMULATIVE INFILTRATION=   1.699  IN
RETENTION=    .100  IN
TOTAL PRECIP=   3.000  IN
```

Exhibit 2. (continued).

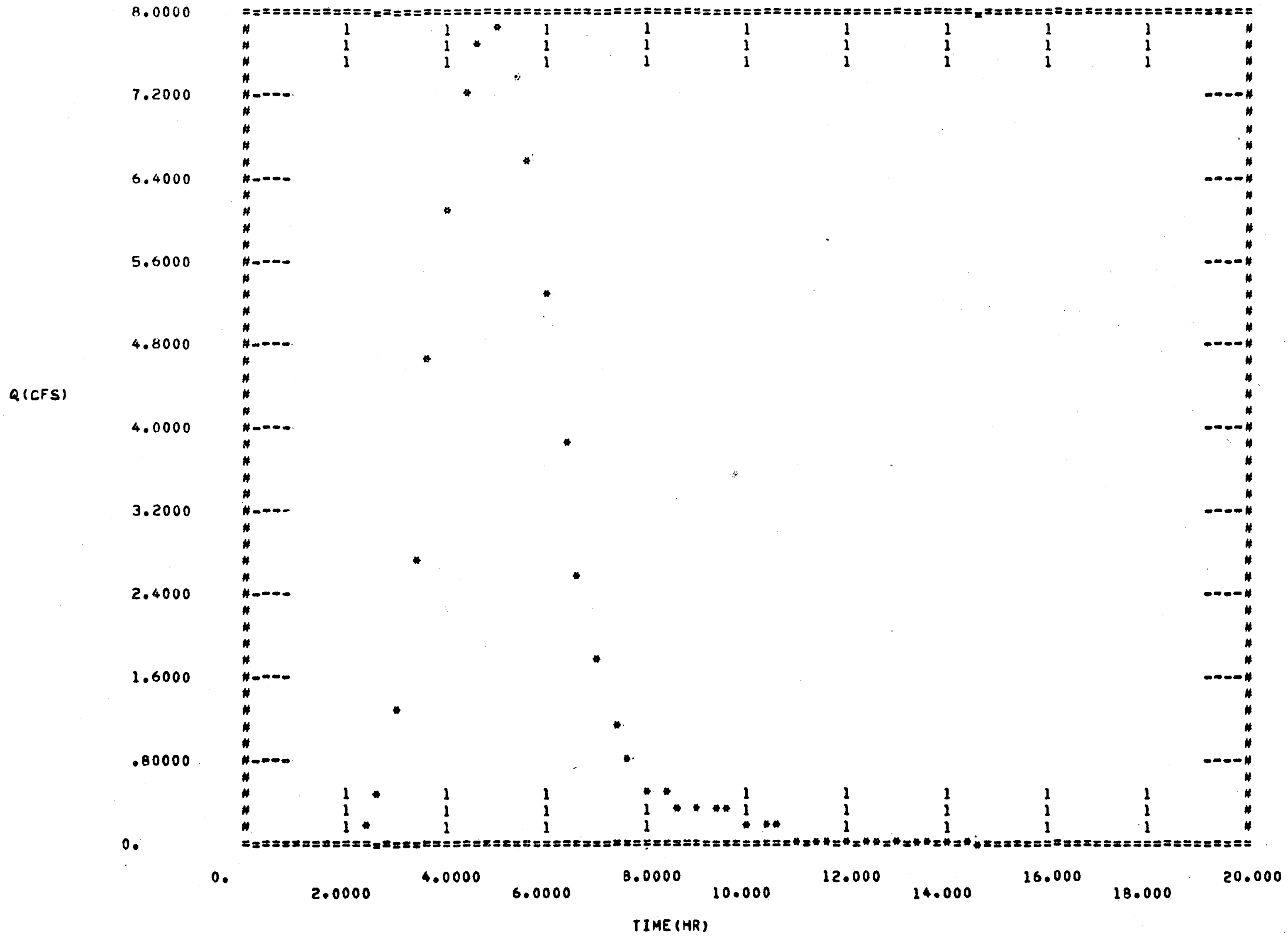
```
DATA USED TO COMPUTE FLOOD HYDROGRAPH:

  T(HR) = TIME IN HOURS
  DELP(IN) = INCREMENTAL DEPTH OF EXCESS RAINFALL
  DELTA(CFS/IN) = UNIT HYDROGRAPH ORDINATE

  T(HR)         DELP(IN)      DELTA(CFS/IN)

    2.333         .106               1.507
    2.667         .162               1.795
    3.000         .179               6.756
    3.333         .170              10.596
    3.667         .153              10.546
    4.000         .156               8.102
    4.333         .110               6.207
    4.667         .113               4.356
    5.000         .047               2.696
    5.333         .005               1.574
    5.667        0.000               1.139
    6.000        0.000                .295
    6.333        0.000                .295
    6.667        0.000                .295
    7.000        0.000                .295
    7.333        0.000                .295
    7.667        0.000                .295
    8.000        0.000                .295
    8.333        0.000                .295
    8.667        0.000                .295
    9.000        0.000                .148
    9.333        0.000               0.000
    9.667        0.000               0.000
   10.000        0.000               0.000
   10.333        0.000               0.000
   10.667        0.000               0.000
   11.000        0.000               0.000
   11.333        0.000               0.000
   11.667        0.000               0.000
   12.000        0.000               0.000
   12.333        0.000               0.000
   12.667        0.000               0.000
   13.000        0.000               0.000
   13.333        0.000               0.000
   13.667        0.000               0.000
   14.000        0.000               0.000
   14.333        0.000               0.000
   14.667        0.000               0.000
```

Exhibit 2. (continued).

```
FLOOD HYDROGRAPH

   TIME(HR)              Q(CFS)

     2.333                 .16
     2.667                 .43
     3.000                1.28
     3.333                2.79
     3.667                4.58
     4.000                6.12
     4.333                7.14
     4.667                7.75
     5.000                7.76
     5.333                7.34
     5.667                6.49
     6.000                5.20
     6.333                3.79
     6.667                2.60
     7.000                1.72
     7.333                1.12
     7.667                 .72
     8.000                 .52
     8.333                 .40
     8.667                 .36
     9.000                 .34
     9.333                 .30
     9.667                 .25
    10.000                 .20
    10.333                 .15
    10.667                 .10
    11.000                 .06
    11.333                 .03
    11.667                 .01
    12.000                 .00
    12.333                0.00
    12.667                0.00
    13.000                0.00
    13.333                0.00
    13.667                0.00
    14.000                0.00
    14.333                0.00
    14.667                0.00
```

Exhibit 2. (continued).

GRAPH 2



FLOOD HYDROGRAPH

4.3 Main Option Three

In this example, the same problem introduced in the example for Main Option One will be treated. The seasonal and antecedent rainfall data and the lag time estimate of Main Option Two will be used as well. The fact that a Huff time distribution of rainfall is replaced with a user-specified set of rainfall increments is what makes this example different from the example of Main Option Two. For this specific case, the rainfall steps will be rearranged into a "balanced hyetograph," but this is not a requirement under Main Option Three. It is possible to have the user-specified rainfall used "as is."

It should be noted that any set of rainfall steps specified under Main Option Three (or Four) must correspond to a set of equal length time steps. This is required for compatibility with the unit hydrograph used for routing of excess rainfall.

XSRAIN is set up to handle a user-specified rainfall pattern of up to 100 steps. If it is desired to use the program with more steps, changes in the coding have to be made. See Section 4.5.

The rainfall pattern for this example is tabulated below. In this case N = 32.

I	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
T(I) hr	.25	.50	.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75	6.00	6.25	6.50	6.75	7.00	7.25	7.50	7.75	8.00
R(I) in.	.01	.01	.01	.01	.01	.02	.03	.03	.03	.04	.05	.05	.20	.25	.25	.50	.40	.35	.25	.08	.08	.07	.07	.03	.03	.03	.02	.02	.02	.02	.02	.01

Since a "balanced hyetograph" will be formed from the R(I) values, they could have been entered in any order. There is nothing special about the order that is presented. Although in this case the R(I) values are input as depths (in.) and the times are input in hours, they could have been read in as rates (in./hr) and minutes if it had been so desired. The program distinguishes between the various units by means of flag variables. They are PFLAG and TFLAG.

If PFLAG = 0, input rain is in inches/hour.

If PFLAG = 1, input rain is in inches.

If TFLAG = 0, time is input in minutes.

If TFLAG = 1, time is input in hours.

In addition, the flag variable CFLAG is used to determine whether a "balanced hyetograph" is to be formed or if the user rainfall steps are to be used "as is."

If CFLAG = 0, user time distribution is used "as is."

If CFLAG = 1, a "balanced hyteograph" is formed.

Input Description for XSRAIN, Main Option Three

Card	Field	Columns	Math Symbol	FORTRAN Symbol	Format	Description
1	1	1		OPTION	II	Main Option XSRAIN elected
2	1	1,2		SUBOPT1	I2	Suboption 1 (see Sec. 2.5)
	2	3,4			2X	
	3	5,6		SUBOPT2	I2	Suboption 2 (see Sec. 2.6)
3	1	1-10	P	P	F10.3	Cumulative depth of precipitation (in.)
	2	11-20	t_D	TD	F10.3	Duration of storm (hr)
	3	21-30	CN	CN	F10.3	SCS curve number
4	1	1		LAGFLAG	I1	If LAGFLAG = 0, t_ℓ (hr) is computed by Eq. (3.3.1) If LAGFLAG = 1, t_ℓ is specified by user.

If LAGFLAG = 0, Card 5 has the following format:

5	1	1-10		AREA	F10.2	Watershed area (square) miles
	2	11-20	ℓ	L	F10.2	Length to divide (ft)
	3	21-30	Y	Y	F10.2	Average watershed slope (percent)

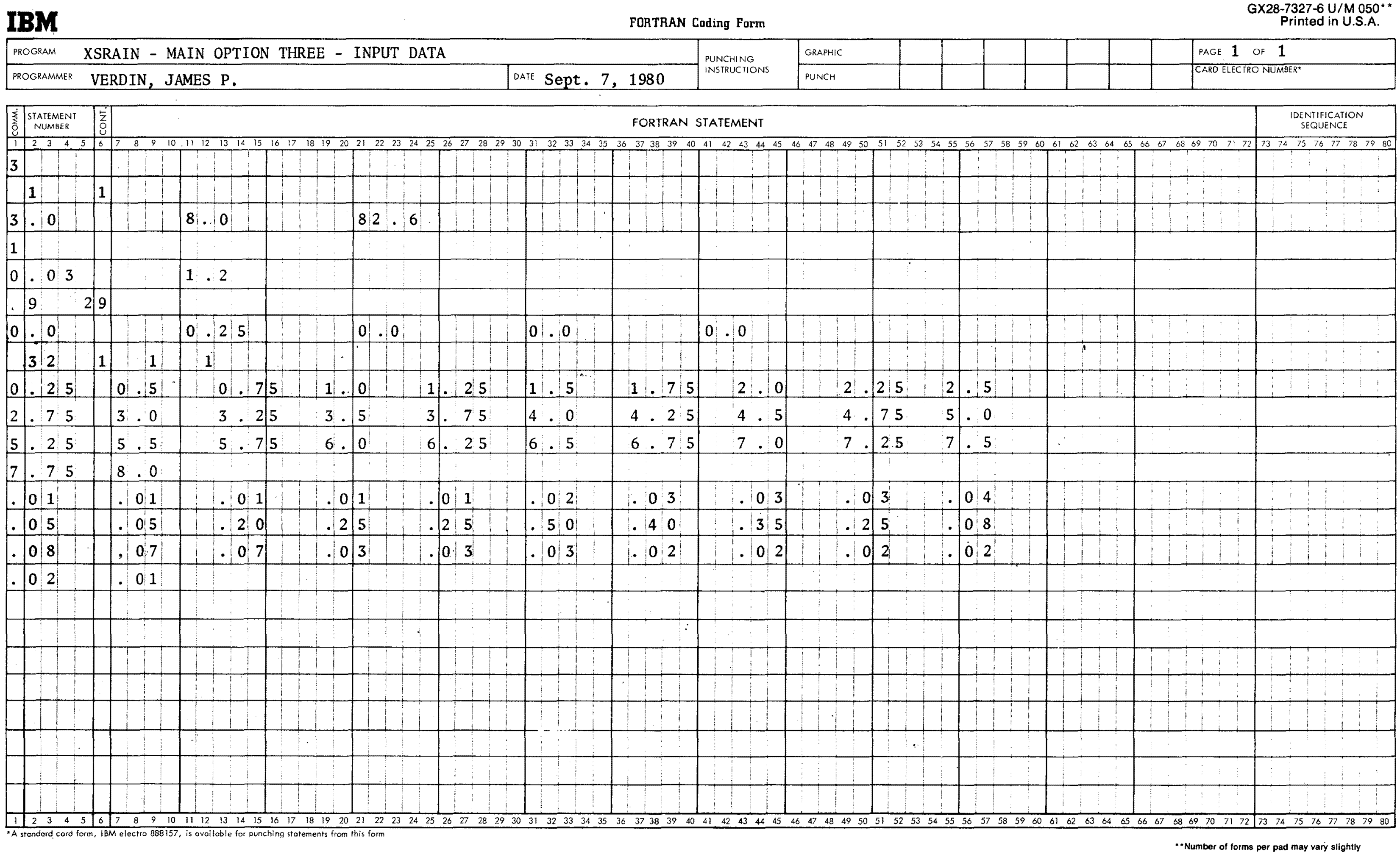
Input Description for XSRAIN, Main Option Three (continued)

Card	Field	Columns	Math Symbol	FORTRAN Symbol	Format	Description
If LAGFLAG = 1, Card 5 has the following format:						
5	1	1-10		AREA	F10.2	Watershed area (square mile)
	2	11-20	t_ℓ	TL	F10.2	Lag time (hr)
6	1	1,2		MO	I2	Month in which storm occurs (1-12)
	2	3,4			2X	Two blank columns
	3	5,6		DAY	I2	Day of month on which storm occurs (1-31)
7	1	1-10		AR(1)	F10.3	Depth of rain fallen 5 days previous (in.)
	2	11-20		AR(2)	F10.3	Depth of rain fallen 4 days previous (in.)
	3	21-30		AR(3)	F10.3	Depth of rain fallen 3 days previous (in.)
	4	31-40		AR(4)	F10.3	Depth of rain fallen 2 days previous (in.)
	5	41-50		AR(5)	F10.3	Depth of rain fallen 1 day previous (in.)
8	1	1-3	N	N	I3	Number of time steps specified by user
	2	4,5			2X	Two blank columns
	3	6		PFLAG	I1	Flag indicating units of user input rainfall steps
	4	7,8			2X	Two blank columns
	5	9		CFLAG	I1	Flag determining whether a "balanced hyetograph" should be formed
	6	10,11			2X	Two blank columns
	7	12		TFLAG	I1	Flag indicating units of user input time steps

Input Description for XSRAIN, Main Option Three (continued)

Card	Field	Columns	Math Symbol	FORTRAN Symbol	Format	Description
9-18*	1	1-10	t_1	T(1)	F6.3	Time (min or hr) at end of 1st time step
	.	.	.	.	.	. . . .
	.	.	.	.	.	. . . .
	.	.	.	.	.	. . . .
	10	91-100	t_{10}	T(10)	F6.3	Time (min or hr) at end of 10th time step
19-28*	1	1-10	r_1	R(1)	F6.3	Rainfall rate (in./hr or in.) in 1st time step
	.	.	.	.	.	. . . . .
	.	.	.	.	.	. . . . .
	.	.	.	.	.	. . . . .
	10	91-100	r_{10}	R(10)	F6.3	Rainfall rate (in./hr or in.) in 10th time step

*Number of cards depends on number of time steps of rainfall specified by user. Program is set up to take as many as 100 time steps.



IBM

FORTRAN Coding Form

GX28-7327-6 U/M 050**
Printed in U.S.A.

PROGRAM XSRAIN - MAIN OPTION THREE - INPUT DATA

PROGRAMMER VERDIN, JAMES P.

DATE Sept. 7, 1980

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

PAGE 1 OF 1

CARD ELECTRO NUMBER*

COMM. | STATEMENT NUMBER | CONT. | FORTRAN STATEMENT | IDENTIFICATION SEQUENCE

```
3
 1   1
3.0       8.0       82.6
1
0.03      1.2
 9  29
0.0       0.25      0.0       0.0       0.0
 32  1  1  1
0.25  0.5   0.75  1.0   1.25  1.5   1.75  2.0   2.25  2.5
2.75  3.0   3.25  3.5   3.75  4.0   4.25  4.5   4.75  5.0
5.25  5.5   5.75  6.0   6.25  6.5   6.75  7.0   7.25  7.5
7.75  8.0
.01   .01   .01   .01   .01   .02   .03   .03   .03   .04
.05   .05   .20   .25   .25   .50   .40   .35   .25   .08
.08   ,07   .07   .03   .03   .03   .02   .02   .02   .02
.02   .01
```

*A standard card form, IBM electro 888157, is available for punching statements from this form

**Number of forms per pad may vary slightly

Figure 12. Coding sheet showing input data for example of Main Option Three.

Exhibit 3. Output of XSRAIN for example of Main Option Three.

```
MAIN OPTION CHOSEN IS   3


IF SUBOPT1 = 1, ONLY INFILTRATION APPROACH IS USED WITH VARIABLE RAINFALL RATES
IF SUBOPT1 = 4, HYDROGRAPHS ARE DERIVED WITH FOUR DIFFERENT MEANS OF CALCULATING EXCESS RAIN

IF SUBOPT2 = 0, USER INPUTS KT AND SFFC
IF SUBOPT2 = 1, KT AND SFFC ARE COMPUTED FROM CN



SUB OPTION 1 =  1           SUB OPTION 2 =  1

STORM DEPTH P =      3.000  IN      STORM DURATION TD =      8.000  HR      CURVE NUMBER CN =    82.600

****************************************************************************************************


        OUTPUT OF SUBROUTINE TABLE


HYDRAULIC CONDUCTIVITY, KT =      .055  IN/HR
STORAGE SUCTION FACTOR AT FIELD CAPACITY, SFFC =     1.537 IN


****************************************************************************************************


IF LAGFLAG = 0, LAG TIME IS COMPUTED IN SUBROUTINE UH
IF LAGFLAG = 1, LAG TIME IS PROVIDED BY THE USER

LAGFLAG =  1

AREA=       .03  SQ MI
   USER PROVIDED LAG TIME =   1.200HR

MONTH=   9     DAY=  29

ARRAY OF ANTECEDENT RAINFALL DEPTHS

AR( 1)=     0.000
AR( 2)=      .250
AR( 3)=     0.000
AR( 4)=     0.000
AR( 5)=     0.000

N= 32     PFLAG =  1     CFLAG =  1     TFLAG=  1

N IS THE NUMBER OF TIME STEPS IN THE USER SUPPLIED STORM
IF PFLAG=0, INPUT RAIN IS IN IN/HR
IF PFLAG=1, INPUT RAIN IS IN INCHES

IF CFLAG=0, USER TIME DISTRIBUTION IS UTILIZED AS IS
IF CFLAG=1, CORPS OF ENGINEERS BALANCED HYETOGRAPH IS FORMED FROM INPUT RAINFALL

IF TFLAG = 0, INPUT TIME IS IN MINUTES
IF TFLAG = 1, INPUT TIME IS IN HOURS
```

Exhibit 3. (continued).

```
TIME STEPS, HOURS
 .250  .500  .750 1.000 1.250 1.500 1.750 2.000 2.250 2.500 2.750 3.000 3.250 3.500 3.750 4.000 4.250 4.500 4.750 5.000
5.250 5.500 5.750 6.000 6.250 6.500 6.750 7.000 7.250 7.500 7.750 8.000
RAINFALL DEPTH INCREMENTS
 .010  .010  .010  .020  .020  .020  .030  .030  .030  .040  .050  .070  .080  .250  .250  .400  .500  .350  .250  .200
 .080  .070  .050  .030  .030  .030  .020  .020  .020  .010  .010  .010
RAINFALL INTENSITIES, IN/HR
 .040  .040  .040  .080  .080  .080  .120  .120  .120  .160  .200  .280  .320 1.000 1.000 1.600 2.000 1.400 1.000  .800
 .320  .280  .200  .120  .120  .120  .080  .080  .080  .040  .040  .040
STEPS OF CUMULATIVE PRECIP
 .010  .020  .030  .050  .070  .090  .120  .150  .180  .220  .270  .340  .420  .670  .920 1.320 1.820 2.170 2.420 2.620
2.700 2.770 2.820 2.850 2.880 2.910 2.930 2.950 2.970 2.980 2.990 3.000

****************************************************************************************************


        OUTPUT OF SUBROUTINE DEFICIT

S=      2.107  IN
EFFECTIVE DEPTH=      23.99  IN   WETTING FRONT SUCTION,HF,=     17.508  IN   JULIAN DATE = 269.   SEASONAL S =      3.152  IN
ADJUSTED DEFICIT=      .163     STORAGE SUCTION FACTOR    ,SF,=     2.861  IN

****************************************************************************************************


OUTPUT OF SUBROUTINE UH

WATERSHED LAG TIME =   1.200HR
TIME TO PEAK=   1.325HR

        UNIT HYDROGRAPH
 TIME(HR)          ORDINATES IN (CFS/IN)          DIMENSIONLESS ORDINATES

     .250                    1.55                           .020
     .500                    1.55                           .020
     .750                    3.62                           .047
    1.000                    7.67                           .099
    1.250                   10.64                           .137
    1.500                   12.32                           .159
    1.750                    9.13                           .118
    2.000                    7.69                           .099
    2.250                    6.22                           .080
    2.500                    4.86                           .063
    2.750                    3.23                           .042
    3.000                    2.18                           .028
    3.250                    1.62                           .021
    3.500                    1.33                           .017
    3.750                     .30                           .004
    4.000                     .30                           .004
    4.250                     .30                           .004
    4.500                     .30                           .004
    4.750                     .30                           .004
    5.000                     .30                           .004
    5.250                     .30                           .004
    5.500                     .30                           .004
    5.750                     .30                           .004
    6.000                     .30                           .004
    6.250                     .30                           .004
    6.500                     .30                           .004
    6.750                     .15                           .002
```

Exhibit 3. (continued).

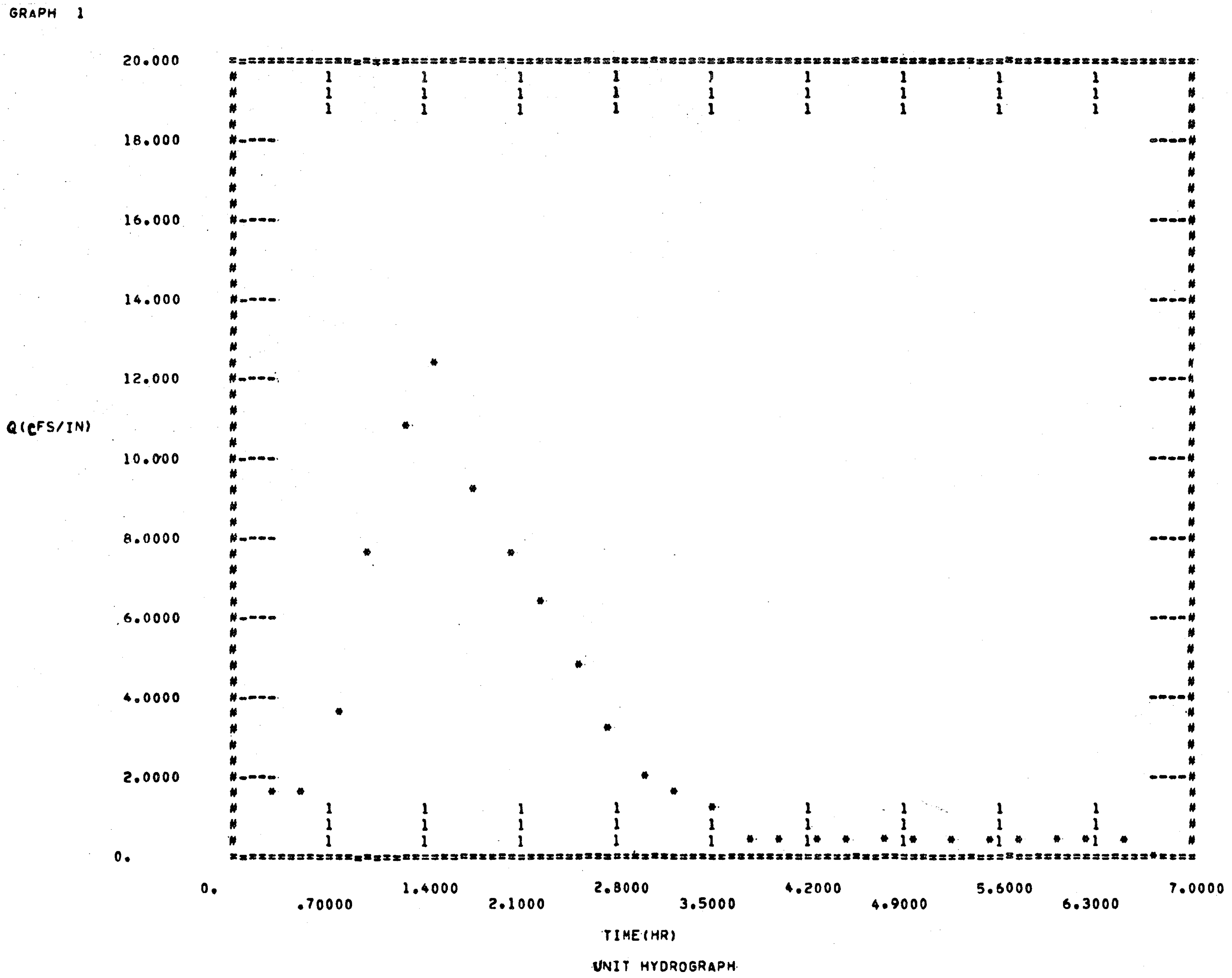


Exhibit 3. (continued).

```
        OUTPUT OF SUBROUTINE PONTIM

PONDING TIME=   3.250 HR     PONDING RAINFALL=   1.000 IN/HR     DEPTH OF RAIN INFILTRATED PREVIOUS TO PONDING=    .420 IN
LAST FULL TIME STEP T(13)=   3.250

***************************************************************************************************************

        OUTPUT OF SUBROUTINE PPINF, VARIABLE RAINFALL, INFILTRATION APPROACH

   T(HR) = TIME IN HOURS
   W(IN) = CUMULATIVE INFILTRATION IN INCHES
   DELW(IN) = INCREMENTAL INFILTRATION IN INCHES
   IR(IN/HR) = INFILTRATION RATE IN INCHES PER HOUR
   R(IN/HR) = RAINFALL RATE IN INCHES PER HOUR
   RE(IN/HR) = RAINFALL RATE AFTER INFILTRATION SUBTRACTED
   RER(IN/HR) = NET EXCESS RAINFALL RATE AFTER RETENTION SUBTRACTED

   T(HR)      W(IN)    DELW(IN) IR(IN/HR)  R(IN/HR)  RE(IN/HR)  RER(IN/HR)

    3.250      .420      .420
    3.500      .604      .184      .736     1.000      .264      0.000
    3.750      .734      .130      .519     1.000      .481       .345
    4.000      .841      .108      .431     1.600     1.169      1.169
    4.250      .936      .095      .379     2.000     1.621      1.621
    4.500     1.022      .086      .345     1.400     1.055      1.055
    4.750     1.102      .080      .319     1.000      .681       .681
    5.000     1.177      .075      .299      .800      .501       .501
    5.250     1.248      .071      .284      .320      .036       .036
    5.500     1.316      .068      .270      .280      .010       .010
    5.750     1.366      .050      .200      .200     0.000      0.000
    6.000     1.396      .030      .120      .120     0.000      0.000
    6.250     1.426      .030      .120      .120     0.000      0.000
    6.500     1.456      .030      .120      .120     0.000      0.000
    6.750     1.476      .020      .080      .080     0.000      0.000
    7.000     1.496      .020      .080      .080     0.000      0.000
    7.250     1.516      .020      .080      .080     0.000      0.000
    7.500     1.526      .010      .040      .040     0.000      0.000
    7.750     1.536      .010      .040      .040     0.000      0.000
    8.000     1.546      .010      .040      .040     0.000      0.000

MASS BALANCE CHECK

EXCESS PRECIP=    1.354  IN
CUMULATIVE INFILTRATION=    1.546  IN
RETENTION=     .100  IN
TOTAL PRECIP=   3.000  IN
```

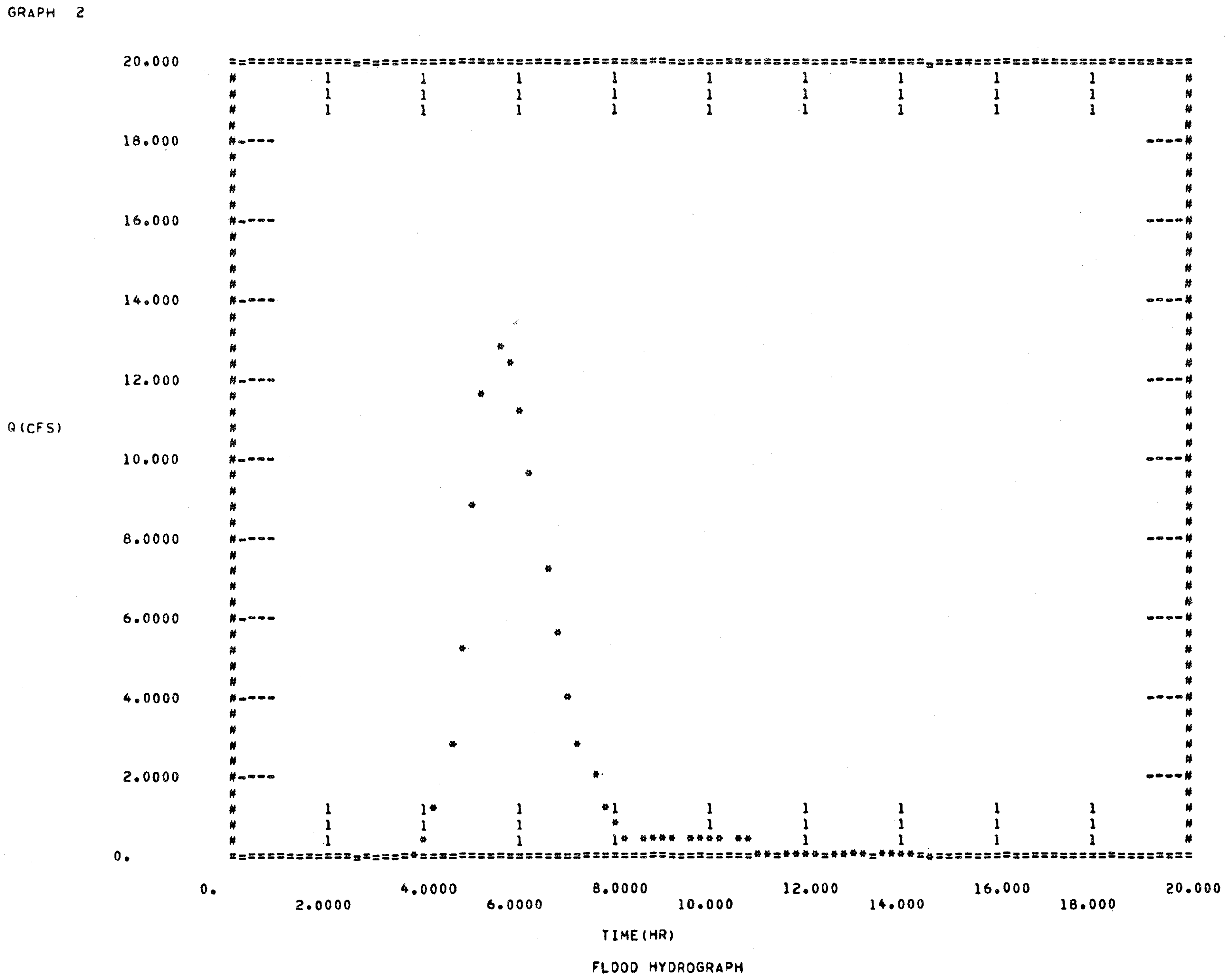
Exhibit 3. (continued).

```
DATA USED TO COMPUTE FLOOD HYDROGRAPH:

T(HR) = TIME IN HOURS
DELP(IN) = INCREMENTAL DEPTH OF EXCESS RAINFALL
DELTA(CFS/IN) = UNIT HYDROGRAPH ORDINATE

T(HR)          DELP(IN)        DELTA(CFS/IN)

  3.750          .086              1.554
  4.000          .292              1.554
  4.250          .405              3.623
  4.500          .264              7.667
  4.750          .170             10.643
  5.000          .125             12.324
  5.250          .009              9.128
  5.500          .002              7.689
  5.750         0.000              6.220
  6.000         0.000              4.856
  6.250         0.000              3.231
  6.500         0.000              2.184
  6.750         0.000              1.623
  7.000         0.000              1.333
  7.250         0.000               .304
  7.500         0.000               .304
  7.750         0.000               .304
  8.000         0.000               .304
  8.250         0.000               .304
  8.500         0.000               .304
  8.750         0.000               .304
  9.000         0.000               .304
  9.250         0.000               .304
  9.500         0.000               .304
  9.750         0.000               .304
 10.000         0.000               .304
 10.250         0.000               .152
 10.500         0.000              0.000
 10.750         0.000              0.000
 11.000         0.000              0.000
 11.250         0.000              0.000
 11.500         0.000              0.000
 11.750         0.000              0.000
 12.000         0.000              0.000
 12.250         0.000              0.000
 12.500         0.000              0.000
 12.750         0.000              0.000
 13.000         0.000              0.000
 13.250         0.000              0.000
 13.500         0.000              0.000
 13.750         0.000              0.000
 14.000         0.000              0.000
 14.250         0.000              0.000
 14.500         0.000              0.000
```

Exhibit 3. (continued).

```
FLOOD HYDROGRAPH

  TIME(HR)              Q(CFS)

   3.750                  .13
   4.000                  .59
   4.250                 1.40
   4.500                 2.76
   4.750                 5.30
   5.000                 8.70
   5.250                11.55
   5.500                12.91
   5.750                12.54
   6.000                11.27
   6.250                 9.46
   6.500                 7.33
   6.750                 5.50
   7.000                 4.02
   7.250                 2.88
   7.500                 1.92
   7.750                 1.18
   8.000                  .78
   8.250                  .56
   8.500                  .42
   8.750                  .41
   9.000                  .41
   9.250                  .41
   9.500                  .41
   9.750                  .41
  10.000                  .41
  10.250                  .40
  10.500                  .34
  10.750                  .24
  11.000                  .13
  11.250                  .07
  11.500                  .02
  11.750                  .00
  12.000                  .00
  12.250                 0.00
  12.500                 0.00
  12.750                 0.00
  13.000                 0.00
  13.250                 0.00
  13.500                 0.00
  13.750                 0.00
  14.000                 0.00
  14.250                 0.00
  14.500                 0.00
```

Exhibit 3. (continued).



4.4 Main Option Four

Once again, the same basic problem as presented in Section 4.1 will be solved here as a means of illustrating the operation of XSRAIN under Main Option Four. Main Option Four is really the same as Main Option Three, only a bit simpler--there is no accounting for soil moisture variation due to seasonality or antecedent rainfall. Field capacity soil moisture (AMC II) is assumed. The lag time estimate, $t_\ell = 1.2$ hr, introduced is Section 4.2 will again be used.

With this example, Suboption 1 will be set to produce hydrographs with all four available methods of calculating excess rainfall (SUBOPT1 = 4). In addition, the user-specified rainfall will be read-in in minutes in inches/hour. This rainfall pattern will be used "as is," rather than have a "balanced hyetograph" formed.

On the following pages, the input and output data are presented.

Input Description for XSRAIN, Main Option Four

Card	Field	Columns	Math Symbol	FORTRAN Symbol	Format	Description
1	1	1		OPTION	I1	Main Option of XSRAIN elected
2	1	1,2		SUBOPT1	I2	Suboption 1 (see Sec. 2.5)
	2	3,4			2X	
	3	5,6		SUBOPT2	I2	Suboption 2 (see Sec. 2.6)
3	1	1-10	$\tilde{K}$	KT	F10.3	Hydraulic conductivity at natural saturation in./hr)
	2	11-20	$(S_f)_{fc}$	SFFC	F10.3	Storage suction factor at field capacity (in.)
	3	21-30	P	P	F10.3	Cumulative depth of precipitation (in.)
	4	30-41	t_D	TD	F10.3	Duration of storm (hr)
	5	41-50	CN	CN	F10.3	SCS curve number

Input Description for XSRAIN, Main Option Four (continued)

Card	Field	Columns	Math Symbol	FORTRAN Symbol	Format	Description
4	1	1		LAGFLAG	I1	If LAGFLAG = 0, t_ℓ (hr) is computed by Eq. (3.3.1) If LAGFLAG = 1, t_ℓ is specified by user.
If LAGFLAG = 0, Card 5 has the following format:						
5	1	1-10		AREA	F10.2	Watershed area (square) miles
	2	11-20	ℓ	L	F10.2	Length to divide (ft)
	3	21-30	Y	Y	F10.2	Average watershed slope (percent)
If LAGFLAG = 1, Card 5 has the following format:						
5	1	1-10		AREA	F10.2	Watershed area (sq. mi.)
	2	11-20	t_ℓ	TL	F10.2	Lag time (hr)
6	1	1-3	N	N	I3	Number of time steps specified by user
	2	4,5			2X	Two blank columns
	3	6		PFLAG	I1	Flag indicating units of user input rain (see Sec. 4.3)
	4	7,8			2X	Two blank columns
	5	9		CFLAG	I1	Flag indicating if a "balanced hyetograph" is formed (see Sec. 4.3)
	6	10,11			2X	Two blank columns
	7	12		TFLAG	I1	Flag indicating units of user input time steps (see Sec. 4.3)

Input Description for XSRAIN, Main Option Four (continued)

Card	Field	Columns	Math Symbol	FORTRAN Symbol	Format	Description
	1	1-10	t_1	T(1)	F6.3	Time (min or hr) at end of 1st time step
	.	.	.	.	.	. . . .
7-16*	.	.	.	.	.	. . . .
	.	.	.	.	.	. . . .
	10	91-100	t_{10}	T(10)	F6.3	Time (min or hr) at end of 10th time step
	1	1-10	r_1	R(1)	F6.3	Rainfall (in. or in./hr) in 1st time step
	.	.	.	.	.	. . . . .
17-26*	.	.	.	.	.	. . . . .
	.	.	.	.	.	. . . . .
	10	91-100	r_{10}	R(10)	F6.3	Rainfall rate (in. or in./hr) in 10th time step

*Number of cards depends on number of time steps of rainfall specified by user. Program is set up to take as many as 50 time steps.

IBM

FORTRAN Coding Form

GX28-7327-6 U/M 050**
Printed in U.S.A.

PROGRAM XSRAIN - MAIN OPTION FOUR - INPUT DATA
PROGRAMMER VERDIN, JAMES P.
DATE Sept. 9, 1980
PUNCHING INSTRUCTIONS
GRAPHIC
PUNCH
PAGE 1 OF 1
CARD ELECTRO NUMBER*

```
4
 4   0
.055      1.537     3.0       8.0       82.6
1
0.03      1.2
 32  0  0  0
15.   30.   45.   60.   75.   90.   105.  120.  135.  150.
165.  180.  195.  210.  225.  240.  255.  270.  285.  300.
315.  330.  345.  360.  375.  390.  405.  420.  435.  450.
465.  480.
0.04  0.04  0.04  0.04  0.04  .08   .12   .12   .12   .16
.20   .20   .80   1.0   1.0   2.0   1.6   1.4   1.0   .32
.32   .28   .28   .12   .12   .12   .08   .08   .08   .08
.08   .04
```

*A standard card form, IBM electro 888157, is available for punching statements from this form

**Number of forms per pad may vary slightly

Figure 13. Coding sheet showing input data for example of Main Option Four.

Exhibit 4. Output of XSRAIN for example of Main Option Four.

```
MAIN OPTION CHOSEN IS   4


IF SUBOPT1 = 1, ONLY INFILTRATION APPROACH IS USED WITH VARIABLE RAINFALL RATES
IF SUBOPT1 = 4, HYDROGRAPHS ARE DERIVED WITH FOUR DIFFERENT MEANS OF CALCULATING EXCESS RAIN

IF SUBOPT2 = 0, USER INPUTS KT AND SFFC
IF SUBOPT2 = 1, KT AND SFFC ARE COMPUTED FROM CN



SUB OPTION 1 =  4          SUB OPTION 2 =  0


HYDRAULIC CONDUCTIVITY, KT =     .055 IN/HR
STORAGE SUCTION FACTOR AT FIELD CAPACITY, SFFC =    1.537 IN
TOTAL PRECIP, P=    3.000 IN
DURATION TIME, TD =    8.000 HR
CURVE NUMBER, CN =     82.6


IF LAGFLAG = 0, LAG TIME IS COMPUTED IN SUBROUTINE UH
IF LAGFLAG = 1, LAG TIME IS PROVIDED BY THE USER

LAGFLAG =  1

AREA=        .03  SQ MI
   USER PROVIDED LAG TIME =   1.200HR


N= 32     PFLAG =  0     CFLAG =  0     TFLAG=  0

N IS THE NUMBER OF TIME STEPS IN THE USER SUPPLIED STORM
IF PFLAG=0, INPUT RAIN IS IN IN/HR
IF PFLAG=1, INPUT RAIN IS IN INCHES

IF CFLAG=0, USER TIME DISTRIBUTION IS UTILIZED AS IS
IF CFLAG=1, CORPS OF ENGINEERS BALANCED HYETOGRAPH IS FORMED FROM INPUT RAINFALL

IF TFLAG = 0, INPUT TIME IS IN MINUTES
IF TFLAG = 1, INPUT TIME IS IN HOURS

TIME STEPS, MINUTES
 15.0  30.0  45.0  60.0  75.0  90.0 105.0 120.0 135.0 150.0 165.0 180.0 195.0 210.0 225.0 240.0 255.0 270.0 285.0 300.0
315.0 330.0 345.0 360.0 375.0 390.0 405.0 420.0 435.0 450.0 465.0 480.0
TIME STEPS, HOURS
 .250  .500  .750 1.000 1.250 1.500 1.750 2.000 2.250 2.500 2.750 3.000 3.250 3.500 3.750 4.000 4.250 4.500 4.750 5.000
5.250 5.500 5.750 6.000 6.250 6.500 6.750 7.000 7.250 7.500 7.750 8.000
RAINFALL INTENSITIES, IN/HR
 .040  .040  .040  .040  .040  .080  .120  .120  .120  .160  .200  .200  .800 1.000 1.000 2.000 1.600 1.400 1.000  .320
 .320  .280  .280  .120  .120  .120  .080  .080  .080  .080  .080  .040
STEPS OF CUMULATIVE PRECIP
 .010  .020  .030  .040  .050  .070  .100  .130  .160  .200  .250  .300  .500  .750 1.000 1.500 1.900 2.250 2.500 2.580
2.660 2.730 2.800 2.830 2.860 2.890 2.910 2.930 2.950 2.970 2.990 3.000

****************************************************************************************************
```

Exhibit 4. (continued).

```
OUTPUT OF SUBROUTINE UH

WATERSHED LAG TIME =   1.200HR
TIME TO PEAK=   1.325HR

           UNIT HYDROGRAPH
 TIME(HR)             ORDINATES IN (CFS/IN)             DIMENSIONLESS ORDINATES

     .250                      1.55                                .020
     .500                      1.55                                .020
     .750                      3.62                                .047
    1.000                      7.67                                .099
    1.250                     10.64                                .137
    1.500                     12.32                                .159
    1.750                      9.13                                .118
    2.000                      7.69                                .099
    2.250                      6.22                                .080
    2.500                      4.86                                .063
    2.750                      3.23                                .042
    3.000                      2.18                                .028
    3.250                      1.62                                .021
    3.500                      1.33                                .017
    3.750                       .30                                .004
    4.000                       .30                                .004
    4.250                       .30                                .004
    4.500                       .30                                .004
    4.750                       .30                                .004
    5.000                       .30                                .004
    5.250                       .30                                .004
    5.500                       .30                                .004
    5.750                       .30                                .004
    6.000                       .30                                .004
    6.250                       .30                                .004
    6.500                       .30                                .004
    6.750                       .15                                .002
```

Exhibit 4. (continued).

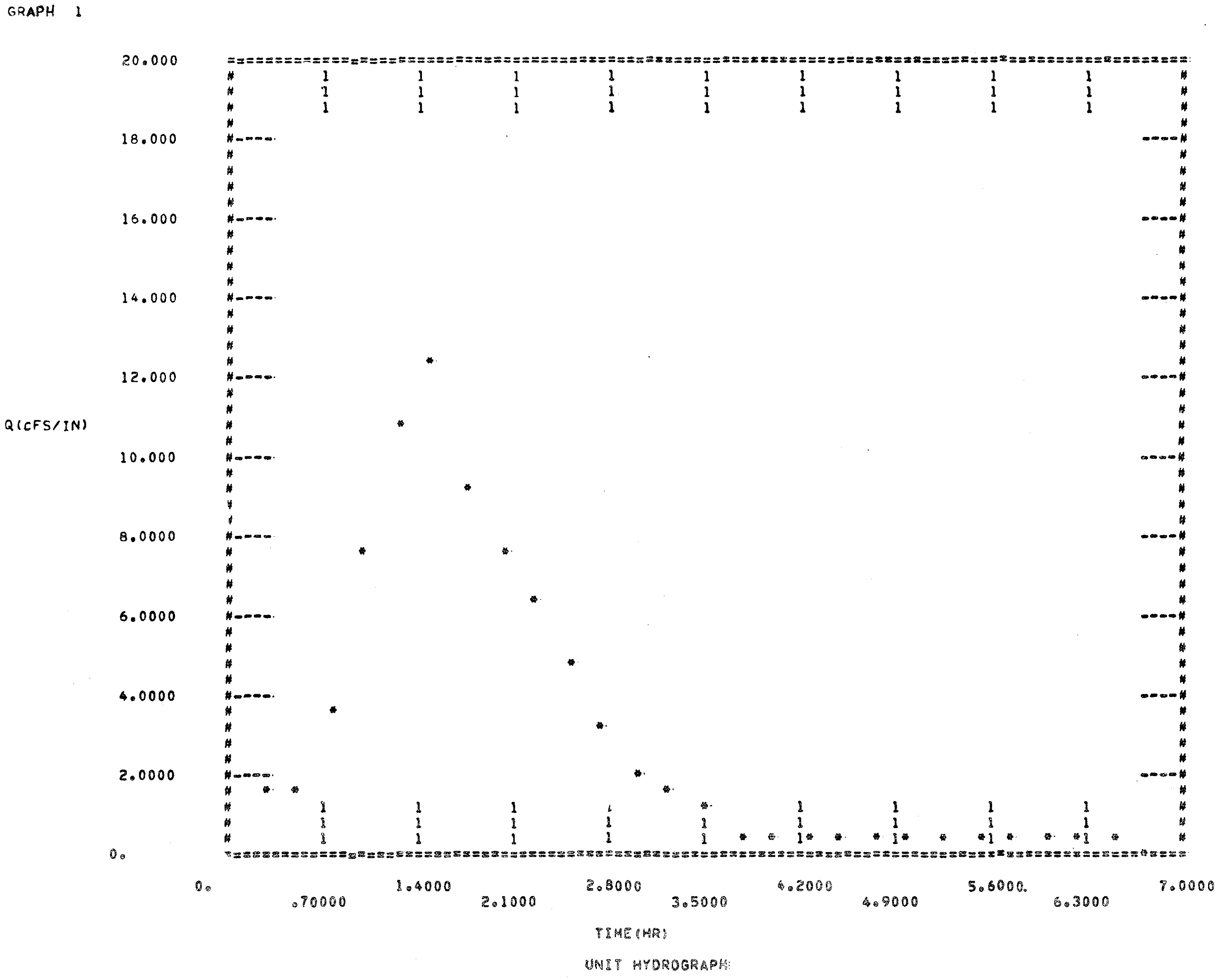


Exhibit 4. (continued).

```
        OUTPUT OF SUBROUTINE PONTIM

PONDING TIME=   3.000 HR     PONDING RAINFALL=    .800 IN/HR     DEPTH OF RAIN INFILTRATED PREVIOUS TO PONDING=    .300 IN
LAST FULL TIME STEP T(12)=   3.000

***************************************************************************************************


        OUTPUT OF SUBROUTINE PPINF, VARIABLE RAINFALL, INFILTRATION APPROACH

   T(HR) = TIME IN HOURS
   W(IN) = CUMULATIVE INFILTRATION IN INCHES
   DELW(IN) = INCREMENTAL INFILTRATION IN INCHES
   IR(IN/HR) = INFILTRATION RATE IN INCHES PER HOUR
   R(IN/HR) = RAINFALL RATE IN INCHES PER HOUR
   RE(IN/HR) = RAINFALL RATE AFTER INFILTRATION SUBTRACTED
   RER(IN/HR) = NET EXCESS RAINFALL RATE AFTER RETENTION SUBTRACTED

   T(HR)      W(IN)    DELW(IN) IR(IN/HR)  R(IN/HR)  RE(IN/HR)  RER(IN/HR)

    3.000      .300      .300
    3.250      .446      .146      .584      .800      .216      0.000
    3.500      .549      .103      .411     1.000      .589       .405
    3.750      .635      .086      .343     1.000      .657       .657
    4.000      .710      .076      .303     2.000     1.697      1.697
    4.250      .780      .069      .277     1.600     1.323      1.323
    4.500      .844      .064      .257     1.400     1.143      1.143
    4.750      .904      .060      .242     1.000      .758       .758
    5.000      .962      .057      .230      .320      .090       .090
    5.250     1.016      .055      .219      .320      .101       .101
    5.500     1.069      .053      .211      .280      .069       .069
    5.750     1.120      .051      .204      .280      .076       .076
    6.000     1.150      .030      .120      .120     0.000      0.000
    6.250     1.180      .030      .120      .120     0.000      0.000
    6.500     1.210      .030      .120      .120     0.000      0.000
    6.750     1.230      .020      .080      .080     0.000      0.000
    7.000     1.250      .020      .080      .080     0.000      0.000
    7.250     1.270      .020      .080      .080     0.000      0.000
    7.500     1.290      .020      .080      .080     0.000      0.000
    7.750     1.310      .020      .080      .080     0.000      0.000
    8.000     1.320      .010      .040      .040     0.000      0.000

MASS BALANCE CHECK

EXCESS PRECIP=   1.580  IN
CUMULATIVE INFILTRATION=   1.320  IN
RETENTION=    .100  IN
TOTAL PRECIP=   3.000  IN
```

Exhibit 4. (continued).

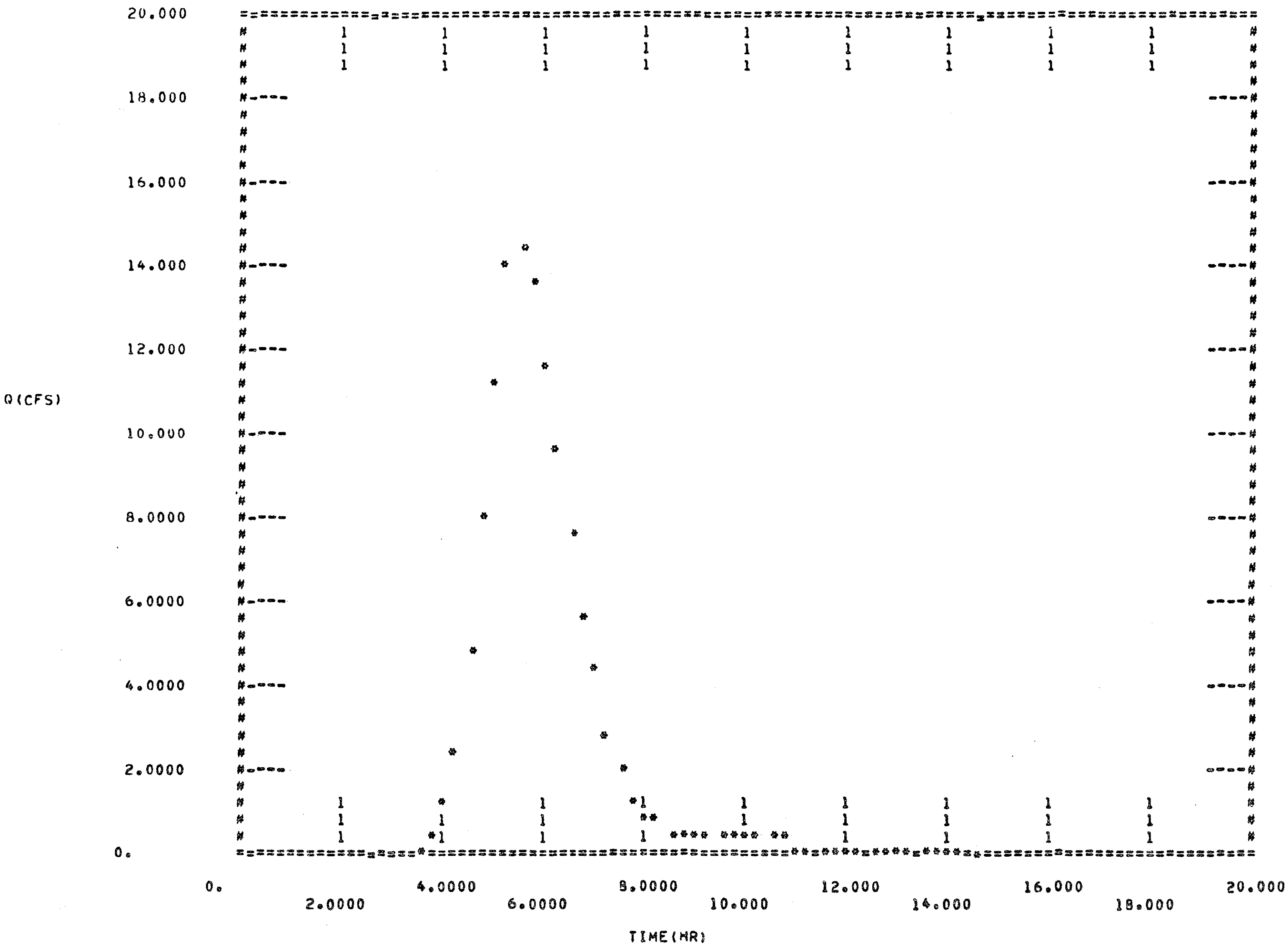
```
DATA USED TO COMPUTE FLOOD HYDROGRAPH:

 T(HR) = TIME IN HOURS
 DELP(IN) = INCREMENTAL DEPTH OF EXCESS RAINFALL
 DELTA(CFS/IN) = UNIT HYDROGRAPH ORDINATE

 T(HR)          DELP(IN)       DELTA(CFS/IN)

   3.500          .101              1.554
   3.750          .164              1.554
   4.000          .424              3.623
   4.250          .331              7.667
   4.500          .286             10.643
   4.750          .190             12.324
   5.000          .023              9.128
   5.250          .025              7.689
   5.500          .017              6.220
   5.750          .019              4.856
   6.000         0.000              3.231
   6.250         0.000              2.184
   6.500         0.000              1.623
   6.750         0.000              1.333
   7.000         0.000               .304
   7.250         0.000               .304
   7.500         0.000               .304
   7.750         0.000               .304
   8.000         0.000               .304
   8.250         0.000               .304
   8.500         0.000               .304
   8.750         0.000               .304
   9.000         0.000               .304
   9.250         0.000               .304
   9.500         0.000               .304
   9.750         0.000               .304
  10.000         0.000               .152
  10.250         0.000              0.000
  10.500         0.000              0.000
  10.750         0.000              0.000
  11.000         0.000              0.000
  11.250         0.000              0.000
  11.500         0.000              0.000
  11.750         0.000              0.000
  12.000         0.000              0.000
  12.250         0.000              0.000
  12.500         0.000              0.000
  12.750         0.000              0.000
  13.000         0.000              0.000
  13.250         0.000              0.000
  13.500         0.000              0.000
  13.750         0.000              0.000
  14.000         0.000              0.000
  14.250         0.000              0.000
  14.500         0.000              0.000
```

Exhibit 4. (continued).

```
FLOOD HYDROGRAPH

   TIME(HR)                Q(CFS)

      3.500                     .16
      3.750                     .41
      4.000                    1.28
      4.250                    2.54
      4.500                    4.83
      4.750                    8.19
      5.000                   11.36
      5.250                   13.98
      5.500                   14.48
      5.750                   13.66
      6.000                   11.78
      6.250                    9.54
      6.500                    7.58
      6.750                    5.78
      7.000                    4.23
      7.250                    2.99
      7.500                    1.98
      7.750                    1.33
      8.000                     .89
      8.250                     .63
      8.500                     .57
      8.750                     .52
      9.000                     .50
      9.250                     .48
      9.500                     .48
      9.750                     .48
     10.000                     .47
     10.250                     .43
     10.500                     .34
     10.750                     .22
     11.000                     .13
     11.250                     .05
     11.500                     .02
     11.750                     .01
     12.000                     .01
     12.250                     .00
     12.500                    0.00
     12.750                    0.00
     13.000                    0.00
     13.250                    0.00
     13.500                    0.00
     13.750                    0.00
     14.000                    0.00
     14.250                    0.00
     14.500                    0.00
```

Exhibit 4. (continued).

GRAPH 2



FLOOD HYDROGRAPH

Exhibit 4. (continued).

```
          OUTPUT OF SUBROUTINE CONSTR, CONSTANT RAINFALL BY INFILTRATION APPROACH

  T(HR)      W(IN)    DELW(IN)  IR(IN/HR)   R(IN/HR)   RE(IN/HR)   RER(IN/HR)

    .704      .264      .264
    .750      .281      .017      .369       .375        .006       0.000
   1.000      .365      .084      .337       .375        .038       0.000
   1.250      .440      .074      .298       .375        .077       0.000
   1.500      .508      .068      .272       .375        .103       0.000
   1.750      .571      .063      .253       .375        .122       0.000
   2.000      .630      .059      .238       .375        .137        .079
   2.250      .687      .056      .226       .375        .149        .149
   2.500      .741      .054      .216       .375        .159        .159
   2.750      .793      .052      .208       .375        .167        .167
   3.000      .843      .050      .201       .375        .174        .174
   3.250      .891      .049      .194       .375        .181        .181
   3.500      .939      .047      .189       .375        .186        .186
   3.750      .985      .046      .184       .375        .191        .191
   4.000     1.030      .045      .180       .375        .195        .195
   4.250     1.074      .044      .176       .375        .199        .199
   4.500     1.117      .043      .172       .375        .203        .203
   4.750     1.159      .042      .169       .375        .206        .206
   5.000     1.200      .041      .166       .375        .209        .209
   5.250     1.241      .041      .163       .375        .212        .212
   5.500     1.281      .040      .160       .375        .215        .215
   5.750     1.320      .039      .158       .375        .217        .217
   6.000     1.359      .039      .156       .375        .219        .219
   6.250     1.398      .038      .153       .375        .222        .222
   6.500     1.436      .038      .151       .375        .224        .224
   6.750     1.473      .037      .150       .375        .225        .225
   7.000     1.510      .037      .148       .375        .227        .227
   7.250     1.546      .037      .146       .375        .229        .229
   7.500     1.583      .036      .145       .375        .230        .230
   7.750     1.618      .036      .143       .375        .232        .232
   8.000     1.654      .035      .142       .375        .233        .233

MASS BALANCE CHECK

EXCESS PRECIP=   1.246  IN
CUMULATIVE INFILTRATION=   1.654  IN
RETENTION=   .100  IN
TOTAL PRECIP=   3.000  IN
```

Exhibit 4. (continued).

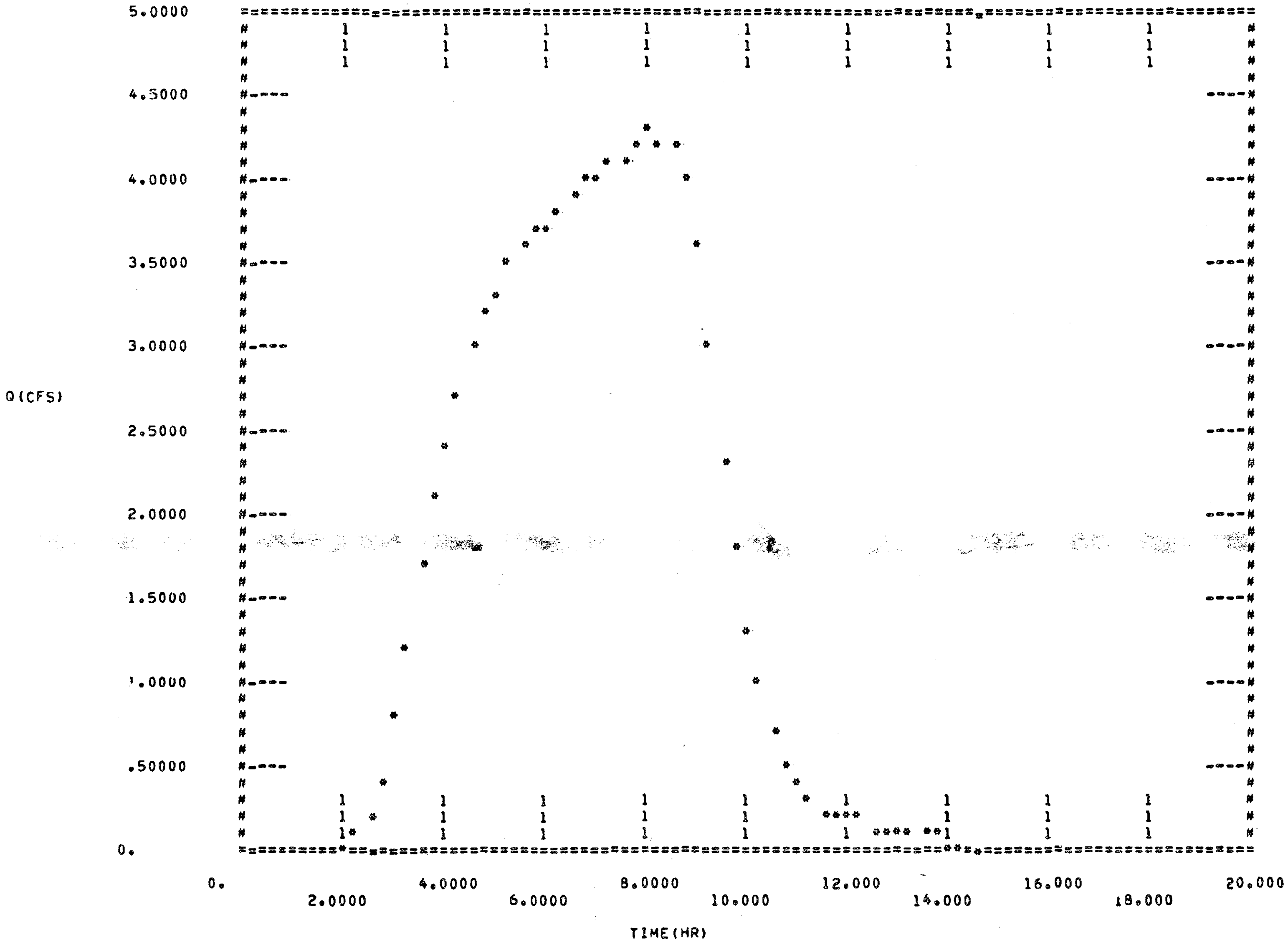
```
DATA USED TO COMPUTE FLOOD HYDROGRAPH:

 T(HR) = TIME IN HOURS
 DELP(IN) = INCREMENTAL DEPTH OF EXCESS RAINFALL
 DELTA(CFS/IN) = UNIT HYDROGRAPH ORDINATE

 T(HR)         DELP(IN)      DELTA(CFS/IN)

   2.000         .020             1.554
   2.250         .037             1.554
   2.500         .040             3.623
   2.750         .042             7.667
   3.000         .044            10.643
   3.250         .045            12.324
   3.500         .047             9.128
   3.750         .048             7.689
   4.000         .049             6.220
   4.250         .050             4.856
   4.500         .051             3.231
   4.750         .052             2.184
   5.000         .052             1.623
   5.250         .053             1.333
   5.500         .054              .304
   5.750         .054              .304
   6.000         .055              .304
   6.250         .055              .304
   6.500         .056              .304
   6.750         .056              .304
   7.000         .057              .304
   7.250         .057              .304
   7.500         .058              .304
   7.750         .058              .304
   8.000         .058              .304
   8.250        0.000              .304
   8.500        0.000              .152
   8.750        0.000             0.000
   9.000        0.000             0.000
   9.250        0.000             0.000
   9.500        0.000             0.000
   9.750        0.000             0.000
  10.000        0.000             0.000
  10.250        0.000             0.000
  10.500        0.000             0.000
  10.750        0.000             0.000
  11.000        0.000             0.000
  11.250        0.000             0.000
  11.500        0.000             0.000
  11.750        0.000             0.000
  12.000        0.000             0.000
  12.250        0.000             0.000
  12.500        0.000             0.000
  12.750        0.000             0.000
  13.000        0.000             0.000
  13.250        0.000             0.000
  13.500        0.000             0.000
  13.750        0.000             0.000
  14.000        0.000             0.000
  14.250        0.000             0.000
  14.500        0.000             0.000
```

Exhibit 4. (continued).

```
FLOOD HYDROGRAPH

  TIME(HR)                Q(CFS)

     2.000                    .03
     2.250                    .09
     2.500                    .19
     2.750                    .41
     3.000                    .77
     3.250                   1.23
     3.500                   1.68
     3.750                   2.07
     4.000                   2.42
     4.250                   2.72
     4.500                   2.96
     4.750                   3.16
     5.000                   3.32
     5.250                   3.47
     5.500                   3.58
     5.750                   3.67
     6.000                   3.75
     6.250                   3.83
     6.500                   3.90
     6.750                   3.96
     7.000                   4.03
     7.250                   4.09
     7.500                   4.15
     7.750                   4.20
     8.000                   4.25
     8.250                   4.21
     8.500                   4.17
     8.750                   3.99
     9.000                   3.58
     9.250                   2.98
     9.500                   2.28
     9.750                   1.76
    10.000                   1.32
    10.250                    .97
    10.500                    .69
    10.750                    .50
    11.000                    .38
    11.250                    .29
    11.500                    .21
    11.750                    .20
    12.000                    .18
    12.250                    .16
    12.500                    .15
    12.750                    .13
    13.000                    .11
    13.250                    .10
    13.500                    .08
    13.750                    .06
    14.000                    .04
    14.250                    .03
    14.500                    .01
```

Exhibit 4. (continued).

GRAPH 3



FLOOD HYDROGRAPH

Exhibit 4. (continued).

```
         OUTPUT OF SUBROUTINE SCS
CN = 82.6   S = 2.107   IA = .421
VARIABLE RAINFALL CASE, SCS METHOD
T(HR)     W(IN)     DELW(IN)     IR(IN/HR)     R(IN/HR)     RE(IN/HR)

 .250      .010       .010          .040          .040         0.000
 .500      .020       .010          .040          .040         0.000
 .750      .030       .010          .040          .040         0.000
1.000      .040       .010          .040          .040         0.000
1.250      .050       .010          .040          .040         0.000
1.500      .070       .020          .080          .080         0.000
1.750      .100       .030          .120          .120         0.000
2.000      .130       .030          .120          .120         0.000
2.250      .160       .030          .120          .120         0.000
2.500      .200       .040          .160          .160         0.000
2.750      .250       .050          .200          .200         0.000
3.000      .300       .050          .200          .200         0.000
3.250      .497       .197          .789          .800          .011
3.500      .706       .208          .834         1.000          .166
3.750      .875       .170          .679         1.000          .321
4.000     1.135       .259         1.038         2.000          .962
4.250     1.290       .155          .622         1.600          .978
4.500     1.400       .110          .440         1.400          .960
4.750     1.468       .067          .269         1.000          .731
5.000     1.487       .020          .080          .320          .240
5.250     1.507       .019          .077          .320          .243
5.500     1.523       .016          .065          .280          .215
5.750     1.538       .016          .063          .280          .217
6.000     1.545       .007          .026          .120          .094
6.250     1.552       .006          .026          .120          .094
6.500     1.558       .006          .026          .120          .094
6.750     1.562       .004          .017          .080          .063
7.000     1.566       .004          .017          .080          .063
7.250     1.571       .004          .017          .080          .063
7.500     1.575       .004          .016          .080          .064
7.750     1.579       .004          .016          .080          .064
8.000     1.581       .002          .008          .040          .032
```

Exhibit 4. (continued).

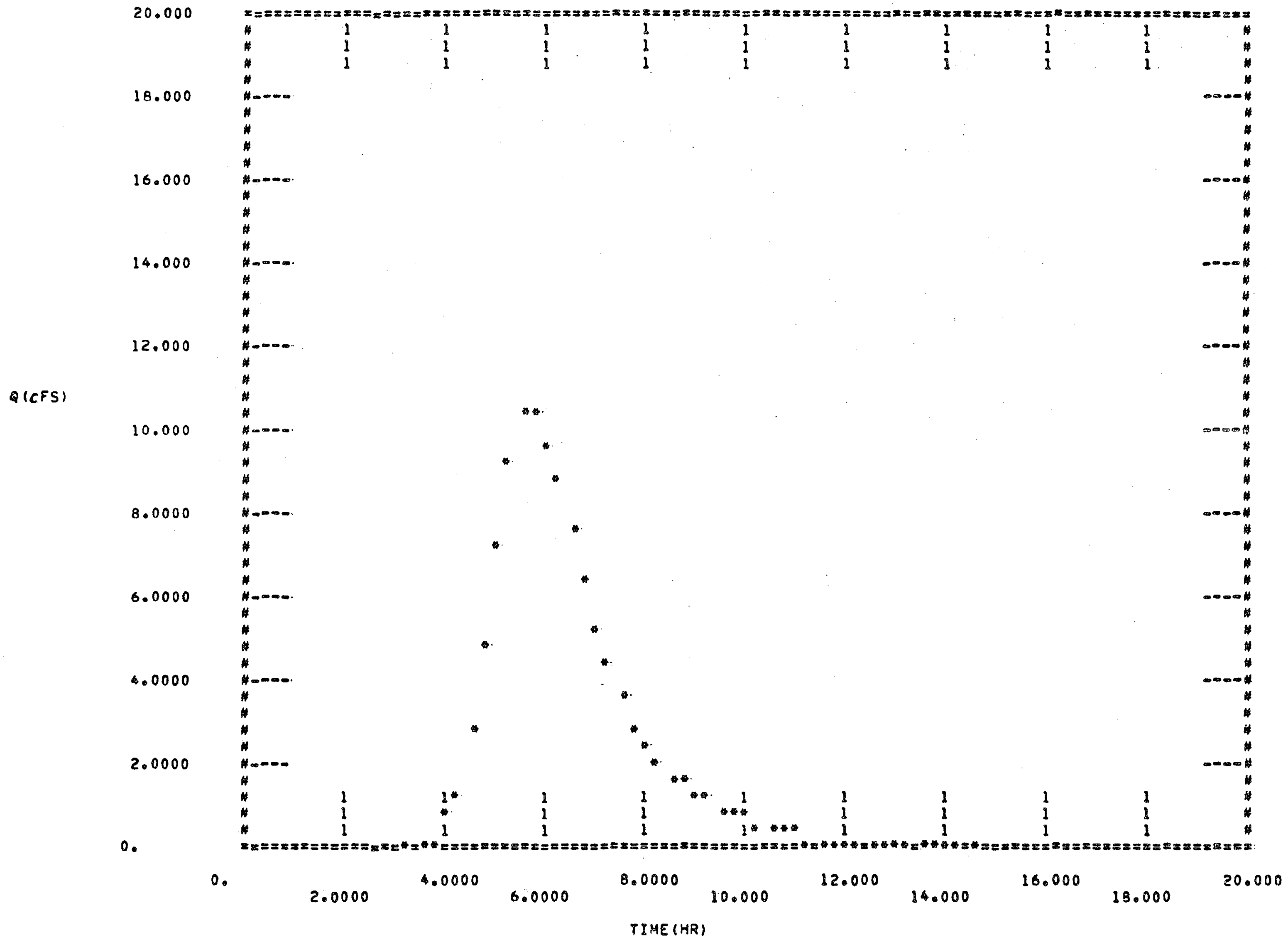
```
DATA USED TO COMPUTE FLOOD HYDROGRAPH:

 T(HR) = TIME IN HOURS
 DELP(IN) = INCREMENTAL DEPTH OF EXCESS RAINFALL
 DELTA(CFS/IN) = UNIT HYDROGRAPH ORDINATE

 T(HR)          DELP(IN)       DELTA(CFS/IN)

   3.250          .003             1.554
   3.500          .042             1.554
   3.750          .080             3.623
   4.000          .241             7.667
   4.250          .245            10.643
   4.500          .240            12.324
   4.750          .183             9.128
   5.000          .060             7.689
   5.250          .061             6.220
   5.500          .054             4.856
   5.750          .054             3.231
   6.000          .023             2.184
   6.250          .024             1.623
   6.500          .024             1.333
   6.750          .016              .304
   7.000          .016              .304
   7.250          .016              .304
   7.500          .016              .304
   7.750          .016              .304
   8.000          .008              .304
   8.250         0.000              .304
   8.500         0.000              .304
   8.750         0.000              .304
   9.000         0.000              .304
   9.250         0.000              .304
   9.500         0.000              .304
   9.750         0.000              .152
  10.000         0.000             0.000
  10.250         0.000             0.000
  10.500         0.000             0.000
  10.750         0.000             0.000
  11.000         0.000             0.000
  11.250         0.000             0.000
  11.500         0.000             0.000
  11.750         0.000             0.000
  12.000         0.000             0.000
  12.250         0.000             0.000
  12.500         0.000             0.000
  12.750         0.000             0.000
  13.000         0.000             0.000
  13.250         0.000             0.000
  13.500         0.000             0.000
  13.750         0.000             0.000
  14.000         0.000             0.000
  14.250         0.000             0.000
  14.500         0.000             0.000
```

Exhibit 4. (continued)

```
FLOOD HYDROGRAPH

   TIME(HR)                Q(CFS)

      3.250                   .00
      3.500                   .07
      3.750                   .20
      4.000                   .67
      4.250                  1.39
      4.500                  2.72
      4.750                  4.78
      5.000                  7.07
      5.250                  9.33
      5.500                 10.45
      5.750                 10.54
      6.000                  9.77
      6.250                  8.63
      6.500                  7.55
      6.750                  6.39
      7.000                  5.27
      7.250                  4.28
      7.500                  3.45
      7.750                  2.81
      8.000                  2.29
      8.250                  1.93
      8.500                  1.74
      8.750                  1.54
      9.000                  1.33
      9.250                  1.10
      9.500                   .92
      9.750                   .78
     10.000                   .66
     10.250                   .56
     10.500                   .45
     10.750                   .34
     11.000                   .24
     11.250                   .15
     11.500                   .11
     11.750                   .09
     12.000                   .07
     12.250                   .06
     12.500                   .04
     12.750                   .04
     13.000                   .03
     13.250                   .02
     13.500                   .02
     13.750                   .01
     14.000                   .01
     14.250                   .00
     14.500                   .00
```

Exhibit 4. (continued).

GRAPH 4



FLOOD HYDROGRAPH

Exhibit 4. (continued).

CONSTANT RAINFALL CASE, SCS METHOD

T(HR)	W(IN)	DELW(IN)	IR(IN/HR)	R(IN/HR)	RE(IN/HR)
.250	.094	.094	.375	.375	0.000
.500	.188	.094	.365	.375	0.000
.750	.281	.094	.375	.375	0.000
1.000	.375	.094	.375	.375	0.000
1.250	.468	.093	.371	.375	.004
1.500	.554	.086	.344	.375	.031
1.750	.663	.079	.316	.375	.059
2.000	.706	.073	.292	.375	.083
2.250	.773	.068	.270	.375	.105
2.500	.836	.063	.251	.375	.124
2.750	.894	.058	.234	.375	.141
3.000	.949	.054	.218	.375	.157
3.250	1.000	.051	.204	.375	.171
3.500	1.048	.048	.191	.375	.184
3.750	1.092	.045	.180	.375	.195
4.000	1.135	.042	.169	.375	.206
4.250	1.175	.040	.159	.375	.216
4.500	1.212	.038	.150	.375	.225
4.750	1.248	.036	.142	.375	.233
5.000	1.281	.034	.135	.375	.240
5.250	1.313	.032	.128	.375	.247
5.500	1.344	.030	.122	.375	.253
5.750	1.373	.029	.116	.375	.259
6.000	1.400	.028	.110	.375	.265
6.250	1.426	.026	.105	.375	.270
6.500	1.451	.025	.100	.375	.275
6.750	1.475	.024	.096	.375	.279
7.000	1.498	.023	.092	.375	.283
7.250	1.520	.022	.088	.375	.287
7.500	1.541	.021	.084	.375	.291
7.750	1.561	.020	.081	.375	.294
8.000	1.581	.019	.077	.375	.298

Exhibit 4.   (continued)

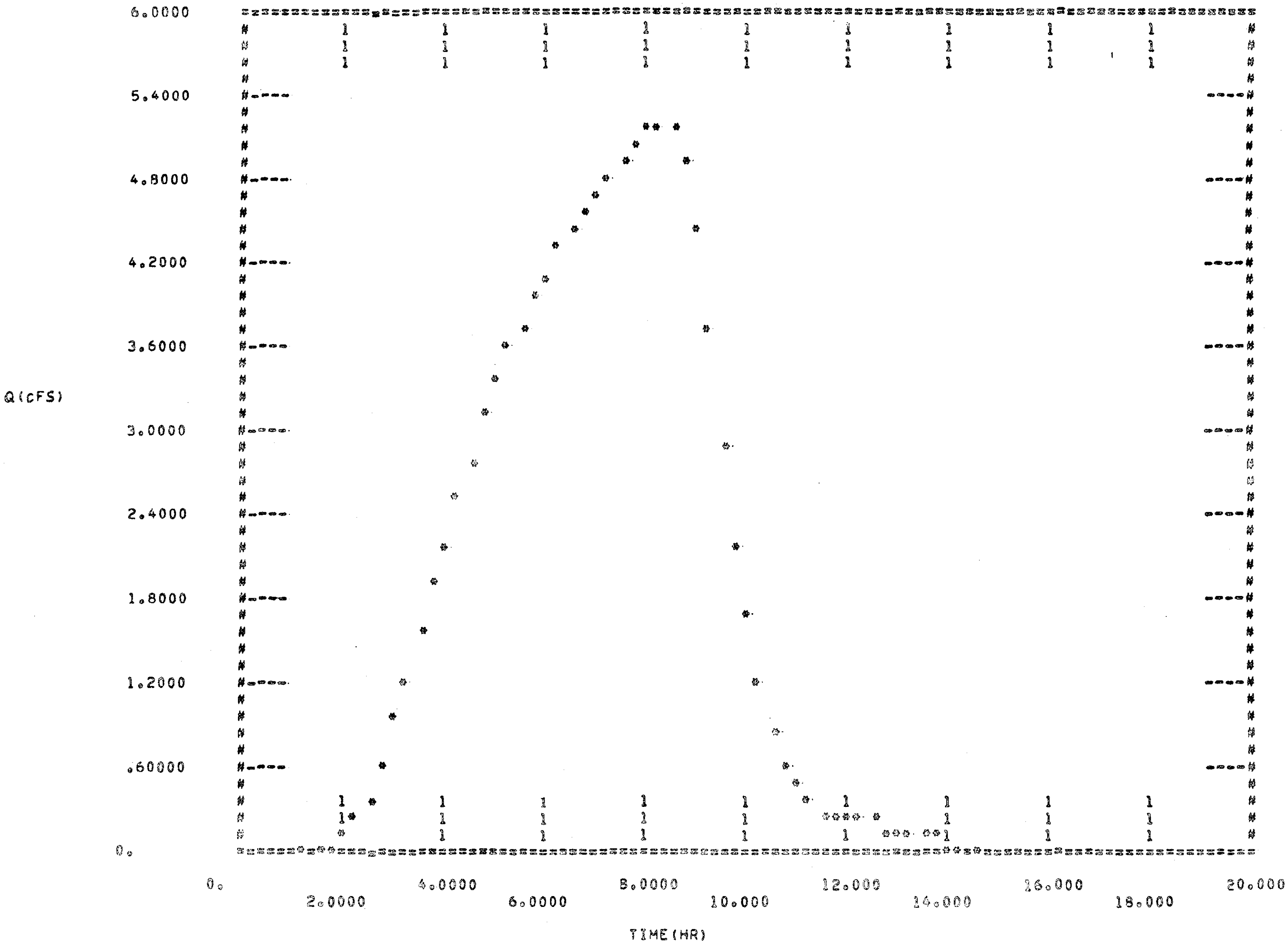
```
DATA USED TO COMPUTE FLOOD HYDROGRAPH:

 T(HR) = TIME IN HOURS
 DELP(IN) = INCREMENTAL DEPTH OF EXCESS RAINFALL
 DELTA(CFS/IN) = UNIT HYDROGRAPH ORDINATE

 T(HR)         DELP(IN)      DELTA(CFS/IN)

   1.250         .001            1.554
   1.500         .008            1.554
   1.750         .015            3.623
   2.000         .021            7.667
   2.250         .026           10.643
   2.500         .031           12.324
   2.750         .035            9.128
   3.000         .039            7.689
   3.250         .043            6.220
   3.500         .046            4.856
   3.750         .049            3.231
   4.000         .052            2.184
   4.250         .054            1.623
   4.500         .056            1.333
   4.750         .058             .304
   5.000         .060             .304
   5.250         .062             .304
   5.500         .063             .304
   5.750         .065             .304
   6.000         .066             .304
   6.250         .068             .304
   6.500         .069             .304
   6.750         .070             .304
   7.000         .071             .304
   7.250         .072             .304
   7.500         .073             .304
   7.750         .074             .152
   8.000         .074            0.000
   8.250        0.000            0.000
   8.500        0.000            0.000
   8.750        0.000            0.000
   9.000        0.000            0.000
   9.250        0.000            0.000
   9.500        0.000            0.000
   9.750        0.000            0.000
  10.000        0.000            0.000
  10.250        0.000            0.000
  10.500        0.000            0.000
  10.750        0.000            0.000
  11.000        0.000            0.000
  11.250        0.000            0.000
  11.500        0.000            0.000
  11.750        0.000            0.000
  12.000        0.000            0.000
  12.250        0.000            0.000
  12.500        0.000            0.000
  12.750        0.000            0.000
  13.000        0.000            0.000
  13.250        0.000            0.000
  13.500        0.000            0.000
  13.750        0.000            0.000
  14.000        0.000            0.000
  14.250        0.000            0.000
  14.500        0.000            0.000
```

Exhibit 4. (continued).

```
FLOOD HYDROGRAPH

  TIME(HR)                      Q(CFS)

     1.250                        .00
     1.500                        .01
     1.750                        .04
     2.000                        .09
     2.250                        .20
     2.500                        .37
     2.750                        .62
     3.000                        .91
     3.250                       1.23
     3.500                       1.56
     3.750                       1.89
     4.000                       2.22
     4.250                       2.52
     4.500                       2.81
     4.750                       3.08
     5.000                       3.33
     5.250                       3.55
     5.500                       3.76
     5.750                       3.95
     6.000                       4.13
     6.250                       4.30
     6.500                       4.45
     6.750                       4.59
     7.000                       4.73
     7.250                       4.85
     7.500                       4.97
     7.750                       5.08
     8.000                       5.19
     8.250                       5.17
     8.500                       5.14
     8.750                       4.95
     9.000                       4.45
     9.250                       3.71
     9.500                       2.84
     9.750                       2.19
    10.000                       1.65
    10.250                       1.20
    10.500                        .85
    10.750                        .62
    11.000                        .47
    11.250                        .36
    11.500                        .26
    11.750                        .24
    12.000                        .22
    12.250                        .20
    12.500                        .18
    12.750                        .16
    13.000                        .14
    13.250                        .12
    13.500                        .10
    13.750                        .08
    14.000                        .06
    14.250                        .03
    14.500                        .01
```

Exhibit 4. (continued)

GRAPH 3



FLOOD HYDROGRAPH

```
EXCESS PRECIP BY SCS METHOD IS     1.419  IN
TOTAL ABSTRACTION=   1.581  IN
TOTAL PRECIP=   3.000  IN
```

4.5 Dimensional Limitations of XSRAIN

Program XSRAIN is set up to handle storms of up to 100 steps of rainfall. If it is desired to use the program with an event of more rainfall steps than this, one must change the dimensions of pertinent arrays as they are defined in DIMENSION and COMMON statements. Specifically, if it is desired to process an event with, say 120 steps, simply change <u>all</u> arrays presently dimensioned to have 100 elements to be able to hold 120 elements. This can be done with one command with an interactive text-editing computer system.

In a like manner, XSRAIN is capable of producing a runoff hydrograph with up to 150 steps of outflow. If this in not enough, simply change <u>all</u> arrays dimensioned for 150 elements to be able to hold the necessary number of elements. In this way, all interacting arrays will be of compatible size.

5. Example Calculated by Hand

The application of infiltration equations for variable intensity rainfall is not so complicated that one must rely on a high-speed digital computer. The following example will show that a pocket calculator is sufficient equipment for solving these problems.

Suppose the following information is given:

CN = 82.6   P = 1.1 in.   AR(1) = AR(3) = AR(4) = AR(5) = 0.0
$\tilde{K}$ = 0.059 in./hr t_D = 2.0 hr   AR(2) = 0.25 in.
$(S_f)_{fc}$ = 0.884   Date = Sept. 29   AREA = 0.03 square miles
ℓ = 1,100 ft   Y = 8 percent

5.1 Calculation of Time Distribution

The next step to take is to impose a time distribution on the 1.1 in. of rainfall over the 2 hr duration. Lets say a knowledge of local conditions suggests that peak rainfall typically occurs in the third quartile of a storm duration. A 20 minute time step is chosen. This is translated into a percentage of the total duration by $\frac{20\text{ min}}{2(60\text{ min})} \times 100$ percent = 16.7 percent. Using Figure 3 for a Huff third-quartile storm, one can tabulate the following values:

Step	1	2	3	4	5	6
Cumulative percent storm time	16.7	33.3	50.0	66.7	83.3	100.0
Cumulative percent precipitation	7.0	15.0	28.0	73.0	95.0	100.0
Incremental percent precipitation	7.0	8.0	13.0	45.0	22.0	5.0
Incremental precipitation (in.)	.08	.09	.14	.50	.24	.05

The values in the first row are found by simply adding 16.7 percent for each time step. Values in the second row are read off using the Huff third-quartile, 50 percent probability curve in Figure 3 to pick off ordinate values corresponding to the first row, abscissa values. The numbers in the third row are just the differences between the successive second row values, for example, the third time step value is 28.0 - 15.0 = 13.0. These in turn are converted into steps of inches of rain in the fourth row by multiplying the total depth of rain by the appropriate percentages, e.g., in time step three

$$\frac{13.0}{100.0} \text{ x } 1.1 \text{ in.} = 0.14 \text{ in.}$$

The length of a time step is computed by $\frac{16.7}{100.0}$ x 2 hr = 0.33 hr.

The mean rainfall intensity for each time step is computed by dividing each increment of rainfall by the length of a time step. For step three this would be:

$$\frac{0.14 \text{ in.}}{0.33 \text{ hr}} = 0.42 \text{ in./hr}$$

Results for all six steps are tabulated below.

Step	1	2	3	4	5	6
t (hr)	.33	.67	1.00	1.33	1.67	2.00
r (in./hr)	0.24	0.27	0.42	1.50	0.72	0.15

With a variable rainfall pattern now established, one may proceed to the calculation of a storage suction factor revised for seasonal and 5 day antecedent rainfall (if this is not desired, one could skip ahead to calculation of ponding time using the field capacity value of storage suction factor).

5.2 Revision of Storage Suction Factor

Calculations in this section follow the procedure programmed in Subroutine DEFICIT of XSRAIN. First calculate the (approximate) Julian date for the day in question:

$$\text{Julian date} = 30 \times (9-1) + 29 = \underline{269}$$

Next, the AMC II value of S:

$$S = \frac{1000}{CN} - 10 = \frac{1000}{82.6} - 10 = \underline{2.11 \text{ in.}}$$

Seasonal S is found next:

$$\text{Seasonal } S = \frac{[\sin(269-5+180)°] + 1}{2} \times (1.3)(2.11) + (0.2)(2.11)$$

$$= \underline{3.16 \text{ in.}}$$

Seasonal S is next modified by the 5 day antecedent rainfall and drying. This is most easily accomplished in a tabular fashion:

A	Day in Sequence	1	2	3	4	5
B	1.06 x Yesterday's Adjusted S	3.16	3.35	3.29	3.48	3.69
C	Antecedent Rain (AR)	0.00	0.25	0.00	0.00	0.00
D	Antecedent Infiltration	0.00	0.25	0.00	0.00	0.00
E	Adjusted S (Row B-Row D)	3.16	3.10	3.29	3.48	3.69

Seasonal S = 3.16 in. is taken as the starting point in Row B, Column 1. There was no rainfall on the first day to change this value. Row B, Column 2 is filled in with 1.06 times the Row E value of S from Column 1, a value of 3.35. This must be modified for rain infiltrated on that day, which is estimated by the SCS method with $I_a = 0.2\ S$ and AMC II:

$$W = AR - \frac{(AR-0.2\ S)^2}{(AR+0.8\ S)}$$

In this case, though, AR = 0.25 < 0.2 (2.11) = 0.42 = I_a so <u>all</u> of AR is assumed infiltrated and the above equation doesn't apply. The adjusted S for day 2 is then calculated as 3.35 - 0.25 = <u>3.10 in.</u> Values for day 3, 4 and 5 are found in a similar manner. The adjusted value of <u>3.69 in.</u> (Row 'E', Column 5) will be used to calculate the moisture deficit for the day of the storm.

Moisture deficit at field capacity is estimated using CN:

$$(\tilde{\theta}-\theta_{fc}) = 0.253 - 0.002\ CN = 0.253 - 0.002\ (82.6) = \underline{0.088}\ .$$

Effective depth of the soil profile is calculated as

$$D_e = \frac{S_{AMCII}}{(\tilde{\theta}-\theta_{fc})} = \frac{2.11}{0.088} = \underline{24.0\text{ in.}}\ ,$$

wetting front suction is found by

$$H_f = \frac{(S_f)_{fc}}{(\theta\tilde{-}\theta_{fc})} = \frac{0.884}{0.088} = \underline{10.04\text{ in.}}$$

The moisture deficit for the day of the storm may now be calculated:

$$(\tilde{\theta}-\theta_i) = \frac{\text{adjusted } S}{D_e} = \frac{3.69\text{ in.}}{24.0\text{ in.}} = \underline{0.15.}$$

This in turn permits the calculation of the revised storage suction factor:

$$S_f = H_f\ (\tilde{\theta}-\theta_i) = (10.04)(0.15) = \underline{1.506\text{ in.}}$$

This value will be used in subsequent calculations of ponding time and post-ponding infiltration.

5.3 <u>Ponding Time Calculations</u>

The formula employed here is

$$t_p = t_{j-1} + \frac{1}{r_j}\left[\frac{S_f}{\frac{r_j}{\tilde{K}} - 1} - \sum_{v=1}^{j-1} r_v\ (t_v - t_{v-1})\right]. \qquad (3.4.1)$$

For the first time step, j = 1, one obtains

$$t_p = 0 + \frac{1}{0.24}\left[\frac{1.506}{\frac{.24}{.059} - 1}\right] - 0 \quad = 2.04 \text{ hr}$$

Since $2.04 > 0.33 = t_1$, the formula is tried with the next time step, $j = 2$, namely:

$$t_p = 0.33 + \frac{1}{0.27}\left[\frac{1.506}{\frac{.27}{.059} - 1} - (0.33)(0.24)\right] = 1.60 \text{ hr}$$

Since $1.60 > 0.67 = t_2$, one must proceed to $j = 3$, with the result:

$$t_p = 0.67 + \frac{1}{.42}\left[\frac{1.506}{\frac{.42}{.059} - 1} - (.24)(.33) - (.27)(.33)\right] = \underline{0.855 \text{ hr}}$$

Since $t_2 = 0.67 < 0.855 < 1.00 = t_3$, ponding time occurs during the third time period, when $t = 0.855$ hr.

5.4 Calculation of Post-Ponding Infiltration

Up to ponding time, all rainfall infiltrates. After ponding, cumulative ponding is calculated by the formula

$$W_j = W_p + S(W_p,\theta_i)\left[\sqrt{t_j - t_p + B} - \sqrt{B}\right] + \tilde{K}(t_j - t_p)$$

where

$$S(W_p,\theta_i) = \sqrt{\frac{2\tilde{K}(S_f + W_p)^2}{S_f}}$$

and

$$B = \frac{1}{2}\,\frac{(S_f + W_p)^2}{\tilde{K}\,S_f\left(\frac{r_p}{R} - 1\right)^2} \tag{3.5.3}$$

In our case

$$W_p = (.24)(.33) + (.27)(.33) + (.42)(.855 - .67) = 0.246 \text{ in.}$$

$r_p = 0.42$ in./hr $\qquad t_p = .855$ hr

Thus, we may calculate

$$S(W_p,\theta_i) = \sqrt{\frac{2(.059)(1.506+0.246)^2}{1.506}} = \underline{0.490\ \frac{\text{in.}}{\text{hr}^{1/2}}}$$

$$B = \frac{1}{2}\ \frac{(1.506+0.246)^2}{(.059)(1.506)\ (\frac{.42}{.059} - 1)^2} = \underline{0.461\ \text{hr}}$$

Substituting, we get

$$W_j = 0.246 + 0.490\left[\sqrt{t_j-0.855+0.461} - \sqrt{0.461}\right] + (.059)(t_j-.855)$$

$$W_j = 0.490\ \sqrt{t_j-.394} + 0.059\ t_j - 0.137$$

Substituting values of t gives values of cumulative infiltration explicitly. The difference between adjacent cumulative infiltration depths gives incremental depths of infiltration. These may be divided by the length of a time step to yield mean infiltration capacity values for each time step. Values are tabulated below.

j	t_j (hr)	W_j (in.)	ΔW_j (in.)	I_j (in./hr)
3	1.00	.303		
4	1.33	.416	.113	0.34
5	1.67	.515	.099	0.30
6	2.00	.602	.087	0.26

The mean infiltration rate between ponding and the end of time step three is found by

$$I = \frac{W_3 - W_p}{t_3 - t_p} = \frac{.303 - .246}{1.00 - .855} = 0.39\ \text{in./hr}$$

Mean excess rainfall rate in any period is now simply found by subtracting the mean infiltration rate from the rainfall rate.

$$r_{e_j} = r_j - I_j$$

If $I_j > r_j$, then $r_{e_j} = 0$ and $I_j = r_j$.

Finally, retention (interception and depression storage) of 0.1 in. is subtracted from the excess rainfall pattern. This quantity is subtracted from the beginning of the r_e pattern to yield the r'_e final excess rainfall pattern. A full tabulation is given below:

j	t (hr)	W (in.)	ΔW (in.)	I (in./hr)	r (in./hr)	r_e (in./hr)	r'_e (in./hr)
1	0.33	0.079	0.079	0.24	0.24	0.00	0.00
2	0.67	0.168	0.089	0.27	0.27	0.00	0.00
ponding	0.855	0.246	0.078	0.42	0.42	0.00	0.00
3	1.00	0.303	0.057	0.39	0.42	0.03	0.00
4	1.33	0.416	0.113	0.34	1.50	1.16	0.88
5	1.67	0.515	0.099	0.30	0.72	0.42	0.42
6	2.00	0.565	0.050	0.15	0.15	0.00	0.00

A diagram of the results is presented in Figure 14.

5.5 Calculation of Runoff Hydrograph

In this section, the excess rainfall pattern computed in Section 5.4 will be converted to a flood hydrograph by means of the SCS dimensionless unit hydrograph (mass curve).

First, the time characteristics of the unit hydrograph are computed. Lag time, t_ℓ, is found by Equation (5.5.1)

$$t_\ell = \frac{\ell^{0.8}(S+1)^{0.7}}{1900\ (Y)^{0.5}} \tag{5.5.1}$$

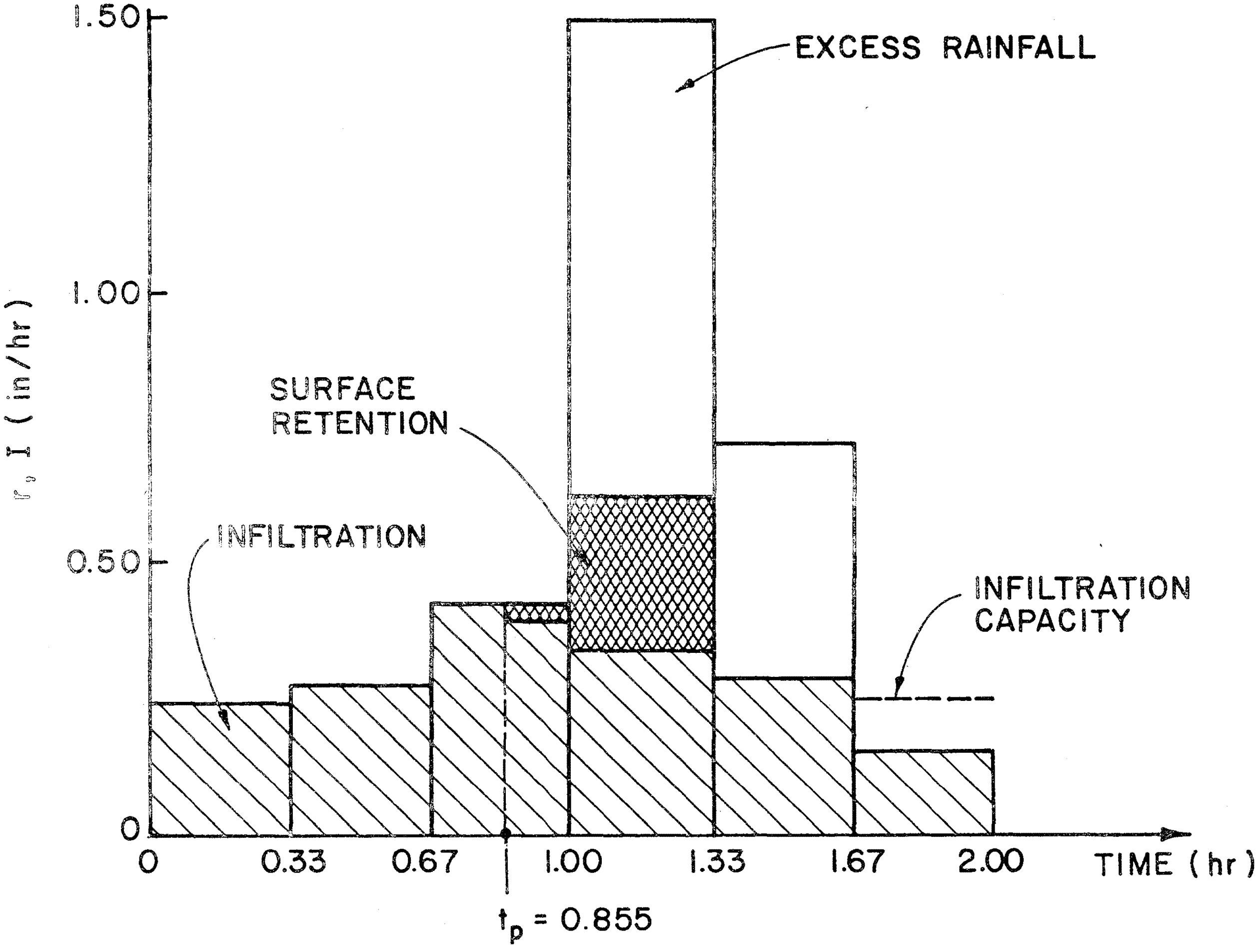


Figure 14. Infiltration computed in example of hand calculations.

where ℓ is the length to the divide (ft),
S is the SCS watershed storage (in.), and
Y is the average watershed slope (percent).

For the selected watershed, this works out to be:

$$t_\ell = \frac{(1100)^{0.8}(2.11+1)^{0.7}}{1900\ (8)^{0.5}} = 0.112 \text{ hr}$$

Next, the time to peak is calculated:

$$T_p = \frac{0.333}{2} + t_\ell \tag{5.5.2}$$

Computing:

$$T_p = \frac{0.333}{2} + 0.112 = 0.28 \text{ hr}$$

It should be noted here that

$$0.333 \text{ hr} = \Delta t > 0.25\ T_p = 0.07 \text{ hr}$$

NEH-4 warns that in such a case the resulting flood hydrograph will be jagged and discontinuous. If this turns out to be so, it may be necessary to make calculations using shorter time steps.

Alternatively, one may estimate lag time by another method of Reference A1 of the Appendix. One may find that lag time is greater than that found by Equation (5.5.1) and that therefore $\Delta t < 0.25\ T_p$. The curve number method was developed from observations on a great many different watersheds and hence may not adequately represent the peculiarities of the watershed in question.

Using 20 min (0.333 hr) time steps, values of t/T_p are computed, and corresponding values of Q_a/Q read from Figure 8 (the SCS mass curve). The results are given here:

t (hr)	.333	.667	1.000	1.333	1.667
t/T_p	1.19	2.38	3.57	4.76	5.95
Q_a/Q	.51	.93	.99	.995	1.00

Differences between successive mass curve (Q_a/Q) values give dimensionless unit hydrograph ordinates, or deltas (δ):

$\delta(1) = 0.51$

$\delta(2) = 0.42$

$\delta(3) = 0.06$

$\delta(4) = 0.005$

$\delta(5) = 0.005$

A flood hydrograph may now be computed by the formula:

$$q(n) = \sum_{j=1}^{n} r_e'(j)\ \delta(n-j+1) \text{ for } n = 1, 2, \ldots, MM \qquad (5.5.3)$$

where $q(n)$ is an outflow in inches/hour (to be converted later to cfs), $r_e'(j)$ is an excess rainfall rate in inches/hour, and MM is the total number of time steps for which flow will occur. MM is the sum of the number of excess rainfall steps and the number of deltas, minus 1. For the considered problem:

$$MM = 2 + 5 - 1 = 6$$

and by Equation (5.5.3) one calculates:

$$q(1) = r_e'(1)\ \delta(1) = (0.88)(0.51) = 0.45$$

$$q(2) = r_e'(1)\ \delta(2) + r_e'(2)\delta(1) = (0.88)(0.42) + (0.42)(0.51)$$
$$= 0.58$$

$$q(3) = r_e'(1)\ \delta(3) + r_e'(2)\delta(2) + r_e'(3)\delta(1)$$
$$= (0.88)(.06) + (.42)(.42) + (.00)(.51) = 0.23$$

$$q(4) = r_e'(1)\ \delta(4) + r_e'(2)\delta(3) + r_e'(3)\delta(2) + r_e'(4)\delta(1)$$
$$= (0.88)(.005)+(.42)(.06)+(0.0)(.42)+(0.0)(5.1) = 0.03$$

$$q(5) = r_e'(1)\ \delta(5)+r_e'(2)\delta(4)+r_e'(3)\delta(3)+r_e'(4)\delta(2)+r_e'(5)\delta(1)$$
$$= (0.88)(.005) + (.42)(.005) + 0 + 0 + 0 = 0.0065$$

$$q(6) = r_e'(1)\ \delta(6)+r_e'(2)\delta(5)+r_e'(3)\delta(4)+r_e'(4)\delta(3)+r_e'(5)\delta(2)$$
$$+ r_e'(6)\delta(1) = (0.88)(.005) + 0 + 0 + 0 + 0 = 0.0044.$$

These flood hydrograph values may be converted to cfs by multiplying by the area (square miles) and the conversion factor 645.3 (cfs/sq.mi.).

It should be noted that $q(1)$ will occur at the same time as $r'_e(1)$, which is the step ending at $t = 1.33$ hr after the onset of rain. A tabulation of the flood hydrograph is presented:

t (hr)	1.33	1.67	2.00	2.33	2.67	3.00
q (cfs)	8.7	11.2	4.4	0.6	0.1	0.1

Figure 15 is a plot of the hydrograph.

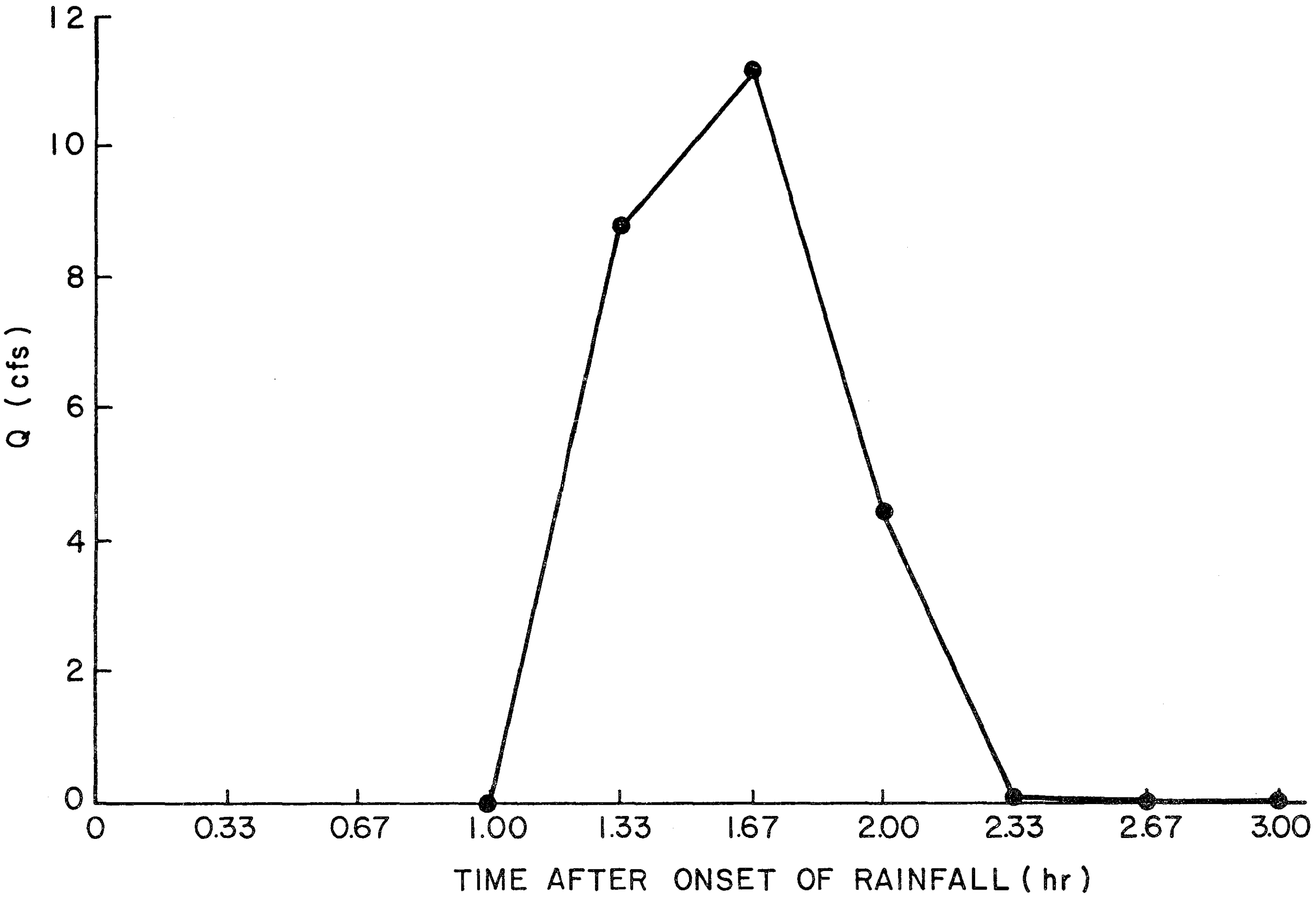


Figure 15. Hydrograph computed in Section 5.5.

III. REFERENCES

Huff, F. A., 1967. Time Distribution of Rainfall in Heavy Storms. Water Resources Research, Volume 3, Number 4.

Morel-Seytoux, H. J. and Sanders, T. G., 1980. Abstractions, Excess Rainfall and Direct Runoff. Chapter 3 of Hydrology for Transportation Engineers, U.S. Department of Transportation, Federal Highway Administration, January 1980, Washington, D.C.

Morel-Seytoux, H. J and Verdin, J. P., 1980. Extension of the Soil Conservation Service Rainfall-Runoff Methodology for Ungaged Watersheds. Federal Highway Administration Report No. FHWA-RD-80-173, 75 p.

Sobhani, G., 1976. Masters Thesis, Utah State University. Cited in Hawkins, R. H., 1978: Runoff Curve Numbers with Varying Site Moisture, Journal of the Irrigation and Drainage Division, ASCE, December 1978.

Soil Conservation Service, 1972. National Engineering Handbook, Section 4, Hydrology. NEH-Notice 4-102, August 1972, U.S. Government Printing Office, Washington, D.C. 20402:

Soil Conservation Service, 1975. Urban Hydrology for Small Watersheds. Technical Release No. 55, USDA, January 1975.

U.S. Army Corps of Engineers, 1975. Hydrologic Engineering Methods for Water Resources Development--Volume 5, Hypothetical Floods. The Hydrologic Engineering Center, Davis, California, March 1975.

U.S. Department of Agriculture, 1967. Evaluation of Agricultural Hydrology by Monolith Lysimeters, 1956-62. Technical Bulletin No. B67, January 1967, Washington, D.C.

Viessman, et al., 1977. Introduction to Hydrology. Second Edition, 1977, IEP series in civil engineering, New York.

APPENDIX

This section consists of four miscellaneous items pertinent to this Manual.

Reference A1 deals with methods of estimation of time of concentration and lag time. It is exerpted from NEH-4, Chapter 15.

Reference A2 deals with moisture deficit prediction from SCS curve number and other relations.

Table A3 lists soil names and their hydrologic classifications.

Exhibit A1 is the complete listing of Program XSRAIN.

Reference A1. Methods of Estimation of Time of Concentration and Lag Time (excerpted from NEH-4, Chapter 15)

Time of concentration

This is the time it takes for runoff to travel from the hydraulically most distant part of the storm area to the watershed outlet or other point of reference downstream. In hydrograph analysis, T_c is the time from the end of excessive rainfall to the point on the falling limb of the hydrograph (point of inflection) where the recession curve begins (see Chapter 16). T_c is generally understood as applying to surface runoff.

The implication in the definitions of L and T_c, that the time factor is only a case of calculating a theoretical velocity of a segment of water moving through a hydraulic system, is an over-simplification. As with lag, T_c may vary because of changes in hydraulic and storage conditions.

Estimating T_c, T_t and L

Each method presented here is in effect a short-cut from which one or more watershed characteristics have been omitted. It is a good practice to consider more than one method, choosing the one that best fits the characteristics of a given watershed. It is not worthwhile averaging estimates made using two or three methods. Instead, the method that appears most applicable because of field and data conditions should be used.

Field observations

At the time field surveys to obtain channel data are made, there is a need to observe the channel system and note items that may affect channel efficiency. Observations such as the type of soil materials in the banks and bottoms of the channel; an estimate of Manning's roughness coefficient; the apparent stability or lack of stability of channel; indications of debris flows as evidenced by deposition of coarse sediments adjacent to channels, size of deposited materials, etc., may be significant.

Indications of channel stability can sometimes be used to bracket the range of velocities that normally occur in the stream channels. Because high sediment concentrations frequently affect both channel velocities and peak rates of runoff, it is important to note when this potential exists.

Intensity of investigations

The purpose for which a study is made is a guide to the amount of work that should be done in securing data to serve as a basis for estimating T_c (Chapter 6). Where the hydrograph is to be the basis for design or for an important conclusion in planning, sufficient surveys should be made to serve as a basis for (a) dividing the main drainage course into reaches that are approximately uniform as to channel sizes, slopes and characteristics and (b) determining average cross sections, roughness coefficients and slopes for each reach. Where the hydrograph is to be the basis for preliminary conclusions, T_c may be estimated by taking the travel distance from maps or aerial photographs and estimating average velocity from general knowledge of the approximate sizes and characteristics of channels in the area under consideration.

Many natural streams have considerable sinuosity, meander, etc. as well as overfalls and eddies. Tendencies are therefore, to underestimate the length of channels and overestimate average velocities through reaches.

Stream hydraulics for estimating travel time and T_c

This method is recommended for the usual case where no usable hydrographs are available. This procedure is most applicable for areas where surface runoff predominates. It can result in too short of T_c for areas where interflow and ground water flow are a major part of runoff.

Stream or valley lengths and flow velocities are used, being taken from field survey data. It is assumed the stream has been divided into reaches.

1. Estimate the 2-year frequency discharge in the stream. When this cannot be done, use the approximate bankfull discharge of the low flow channel.

2. Compute the average velocity. In watersheds with narrow flood plains where the depth of overbank flow may be 10 to 20 feet during a major flood event, it may be desirable to use correspondingly higher velocities for frequencies of 10 to 100 years or greater.

3. Use the average velocity and the valley length of the reach to compute the travel time through the reach by equation 15.1.

4. Add the travel times of step 3 to get the T_c for the watershed. Use of the low flow channel bankfull discharges with valley lengths is a compromise that gives a T_c for average floods. For special cases (channel design, for instance) use whatever average velocities and lengths are appropriate.

In most cases the hydraulic data do not extend upstream to the watershed ridge. The remaining time (to add in step 4) can be estimated by adding the time obtained by the upland method or the T_c obtained by the curve number method. See figures 15.2 and 15.3 respectively. Use the one most applicable to the upper watershed characteristics.

Lag may be estimated in terms of T_c using the empirical relation:

$$L = 0.6\,T_c \quad \ldots\ldots\ldots\ldots \quad \text{Eq. 15.3}$$

This is for average natural watershed conditions and for an approximately uniform distribution of runoff on the watershed. When runoff is not uniformly distributed the watershed can be subdivided into areas within which the runoff is nearly uniform, enough so that equation 15.3 can be applied.

Upland method

Types of flow considered in the upland method are: overland; through grassed waterways; over paved areas; and through small upland gullies. Upland flow employed in this method can be a combination of these various surface runoff conditions. The velocity is determined using figure 15.2.

The most remote segment of runoff that becomes part of the total time of concentration may occur in wide sheets overland rather than in defined channels. This type of flow is of practical importance only in very small watersheds because runoff is usually concentrated into small gullies or terrace channels within less than a thousand feet of its origin. The velocity of overland flow varies greatly with the surface cover and tillage as demonstrated in figure 15.2.

Surface runoff along terrace channels is another type of upland flow. The velocity and distance of flow that relate to time of concentration is based on the terrace gradient and length. A velocity of 1.5 feet per second can be assumed for the average terrace channel. Runoff soon concentrates from sheet flow into small gullies. Their path of flow and location may change from one flood to the next. Ordinary tillage operations may obliterate them after each period of runoff. Still larger gullies are formed which under a good conservation practice are transformed into permanent grassed waterways.

The travel time (T_t) for each type of upland flow can be computed using equation 15.1. The summation of these travel times will equal the T_c in the upland or subwatershed, to the watershed outlet, or down to the point where hydraulic cross sections have been made for the stream hydraulics method.

In a small watershed the elapsed time for overland flow in figure 15.2 may be a substantial percent of the total watershed time of concentration. Conversely, it is a much smaller portion of the total time of concentration in larger watersheds. In watersheds larger than 2000 acres, it can usually be ignored by extrapolating the average measured velocity over the entire hydraulic distance as previously described.

The upland method should be limited to small watersheds (2000 acres or less) and to the sub-watershed portions of larger watersheds above and beyond the point where it is impractical to survey cross sections and make other detailed hydraulic measurements. This upstream limit is usually selected where natural reach storage ceases to be an important element in shaping a unit hydrograph for the watershed in question.

Curve number method

This method was developed for areas of less than 2000 acres.

Equation 15.4 was developed from research watershed data:

$$L = \frac{\ell^{0.8} (S+1)^{0.7}}{1900\, Y^{0.5}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad \text{Eq. } 15.4$$

Where L = lag in hours

ℓ = hydraulic length of watershed in feet

$S = \frac{1000}{CN'} - 10$ where $CN' \cong$ hydrologic soil cover complex number (CN) in Chapter 9.

Y = average watershed land slope in percent

The curve number method was developed to span a broad set of conditions ranging from heavily forested watersheds with steep channels and a high percent of the runoff resulting from subsurface or inter-flow and meadows providing a high retardance to surface runoff, to smooth land surfaces and large paved parking areas. The CN' is a measure of the retardance of surface conditions on the rate at which runoff concentrates at some point in question. This retardance factor (CN') is approximately the same as the CN in Chapter 9. A thick mulch in a forest is associated with a low CN in Chapter 9 and reflects a high degree of retardance as well as a high infiltration rate. A hay meadow has a relative low CN, other factors being equal, and like a thick mulch in a forest provides a high degree of retardance to overland flow in small watersheds. Conversely, bare surfaces with very little retardance to overland flow are represented by a high CN'. Runoff curve number tables in Chapter 9 can be used for approximating the CN' for the "S" in equation 15.4. A CN' of less than 50 or greater than 95 should not be used in the solution of equation 15.4.

The slope (Y) in percent is the average land slope of the watershed. Theoretically, it would be as if slopes were obtained for each corner of a grid system placed over the watershed, and then averaged.

Figure 15.3 provides a quick solution to equation 15.4.

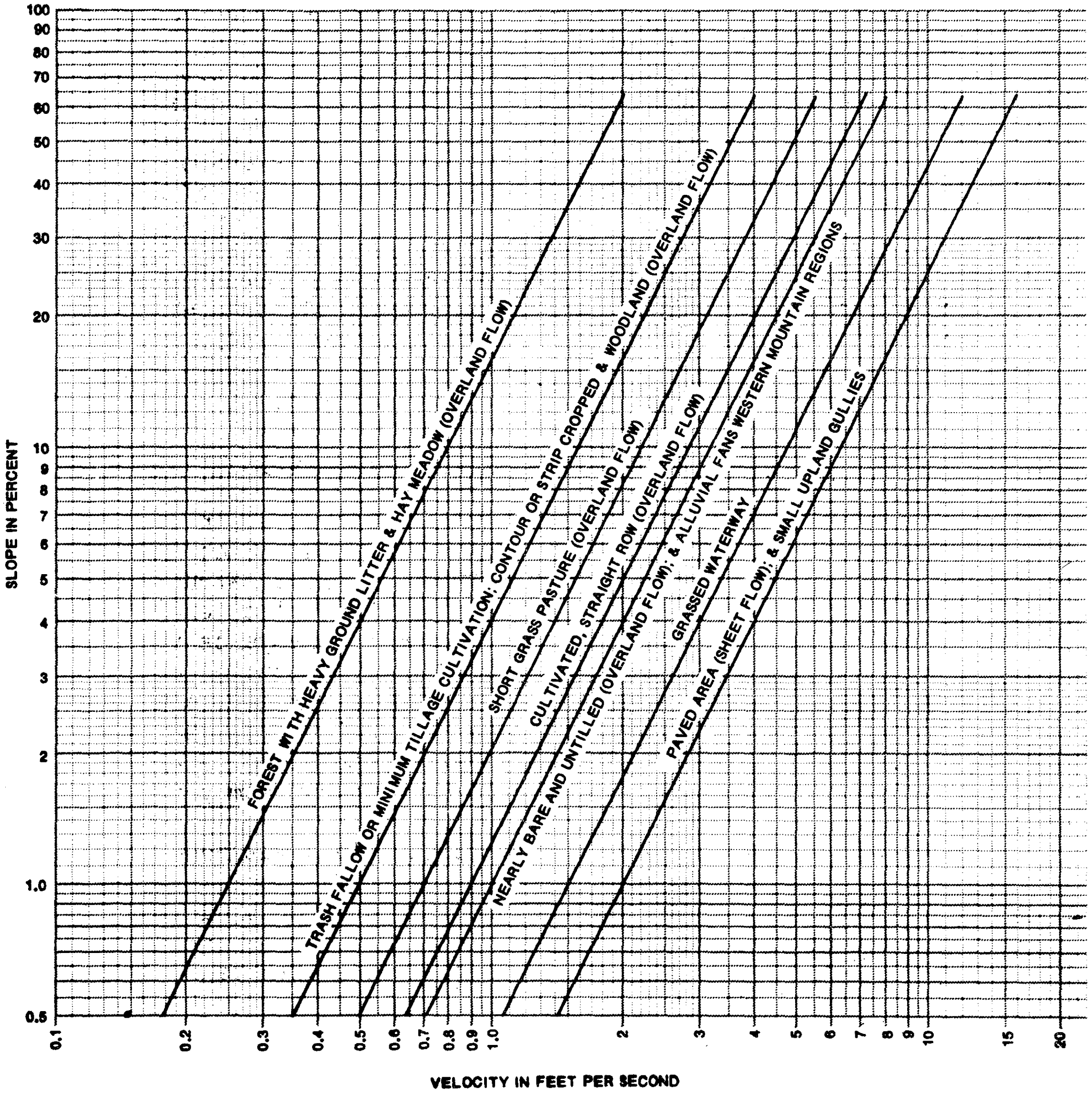


Figure 15.2. Velocities for upland method of estimating T_c.

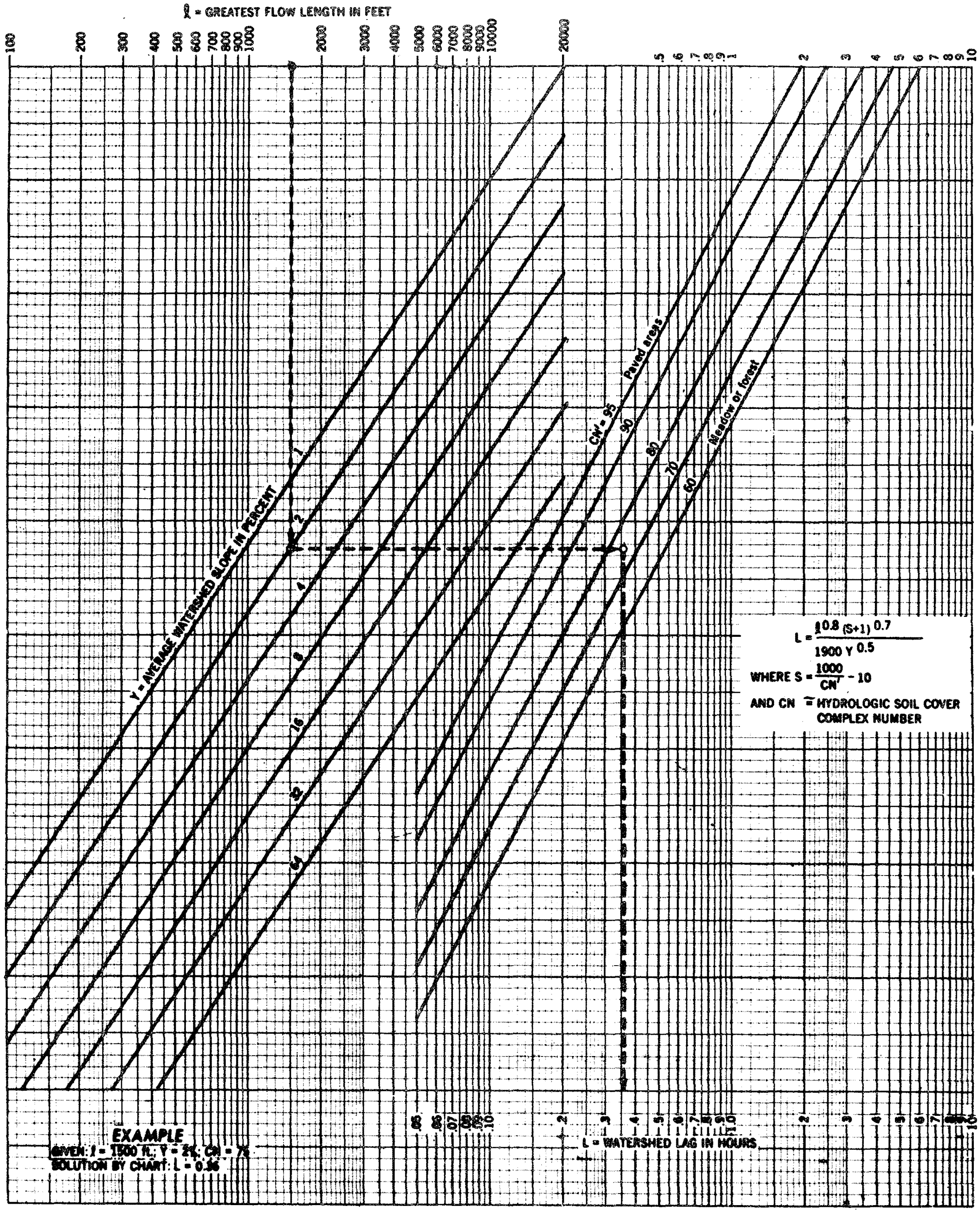


Figure 15.3. Curve number method for estimating lag (L).

Variations in Lag and T_c Due to Urbanization

Investigations have indicated that a significant increase in peak discharge can result from urbanization of a watershed. Such increases in the peak discharge are generally attributed to the construction of collection systems that are more efficient in a hydraulic sense than those provided in nature. These systems increase conveyance velocities so that greater amounts of discharge tend to reach points of concentration concurrently. Where flow once prevailed over a rough terrain and along field gullies and stream channels, urbanization provides hydraulically smooth concrete gutters, streets, storm drains and open channel floodways that convey runoff rapidly to downstream points.

The amount of imperviousness due to urbanization in a watershed varies from about 20 percent in the case of low density residential areas to about 90 percent where business and commercial land use predominates.

Table 15.1 illustrates the degree of imperviousness with land use for typical urban development.

Table 15.1.--Percent of imperviousness for various densities of urban occupancy.

Land Use	% Imperviousness[1]
Low Density Residential	20 - 30
Medium Density Residential	25 - 35
High Density Residential	30 - 40
Business - Commercial	40 - 90
Light Industrial	45 - 65
Heavy Industrial	50 - 70

[1] Effects of Urbanization on Storm Runoff - Cudworth and Bottorf - South Pacific Division - Corps of Engineers. Presented to Water Management Subcommittee, PSIAC, March 1969.

A CN' of 90 or 95 can be used to estimate the impervious portion. CN' for lawns, parks, etc. can be selected from one of the curve number tables in Chapter 9.

Reference A2. Moisture Deficit--CN Regression Equation and Other Relations

Using data available for 9 soil textural classes, a regression equation was developed to permit prediction of field capacity moisture deficit from CN. The CN values used were the transforms of the least-squares S values found for each soil type. (See the discussion of program SCSEXT in the portion of the report (Morel-Seytoux and Verdin, 1980) recounting how the SCS infiltration correspondence was established.) The field capacity moisture deficits, $(\tilde{\theta}-\theta_{fc})$, were those reported in USDA Technical Bulletin No. 1518. A plot of the data points and the line which fit them is shown in Figure A1.

Moisture deficit estimates for AMC III were found by using the CN in column 3 of Table A2, and working backward to find $(\tilde{\theta}-\theta_{III})$. Effective capillary drive was defined by $H_f = (S_f)_{fc}/(\tilde{\theta}-\theta_{fc})$. The sorptivity of Table A1 corresponding to CN (AMC III) and the hydraulic conductivity corresponding to CN (AMC II) was used to solve for a storage suction factor corresponding to AMC III. This was then divided by the effective capillary drive, H_f, to yield an AMC III moisture deficit, $(\tilde{\theta}-\theta_{III})$. The average ratio of $(\tilde{\theta}-\theta_{III})$ to $(\tilde{\theta}-\theta_{fc})$ was found to be 0.2.

The mean ratio of $(\tilde{\theta}-\theta_{wil})/(\tilde{\theta}-\theta_{fc})$, using data of USDA TB 1518, was found to be 2.

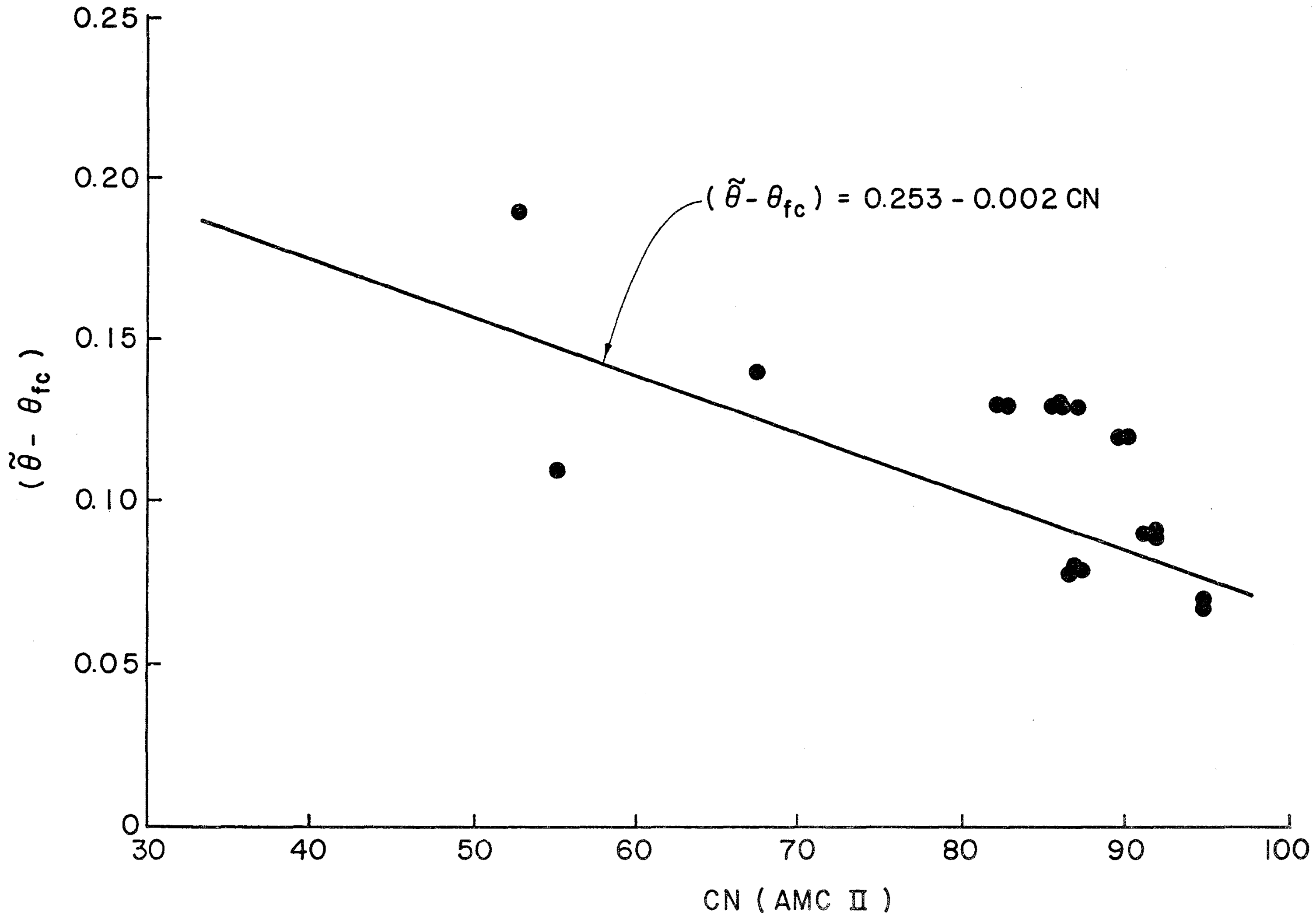


Figure A1. Relation between field capacity moisture deficit and curve number.

Table A1. Table of correspondence.

CURVE NUMBER	KT(IN/HR)	SF(IN)	SORPTIVITY(IN/HR**1/2)
100.0	0.000	I	0.0000
99.0	.003	.088	.0237
98.0	.006	.177	.0473
97.0	.010	.265	.0710
96.0	.013	.353	.0947
95.0	.016	.442	.1183
94.0	.019	.530	.1420
93.0	.022	.618	.1657
92.0	.025	.707	.1893
91.0	.029	.795	.2130
90.0	.032	.883	.2367
89.0	.035	.972	.2603
88.0	.038	1.060	.2840
87.0	.041	1.148	.3077
86.0	.044	1.237	.3313
85.0	.048	1.325	.3550
84.0	.051	1.414	.3787
83.0	.054	1.502	.4023
82.0	.057	1.590	.4260
81.0	.060	1.679	.4497
80.0	.063	1.767	.4734
79.0	.067	1.855	.4970
78.0	.070	1.944	.5207
77.0	.073	2.032	.5444
76.0	.076	2.120	.5680
75.0	.081	2.161	.5917
74.0	.096	1.964	.6154
73.0	.112	1.826	.6390
72.0	.127	1.726	.6627
71.0	.143	1.652	.6864
70.0	.158	1.595	.7100
69.0	.173	1.552	.7337
68.0	.189	1.519	.7574
67.0	.204	1.494	.7810
66.0	.220	1.474	.8047
65.0	.235	1.421	.8173
64.0	.250	1.352	.8230
63.0	.266	1.292	.8288
62.0	.281	1.238	.8345
61.0	.297	1.190	.8403
60.0	.312	1.147	.8460
59.0	.327	1.108	.8518
58.0	.343	1.073	.8575
57.0	.358	1.040	.8633
56.0	.374	1.011	.8690
55.0	.389	.984	.8748
54.0	.404	.959	.8805
53.0	.420	.935	.8863
52.0	.435	.914	.8920
51.0	.451	.894	.8978
50.0	.466	.876	.9035
49.0	.481	.859	.9093
48.0	.497	.843	.9150
47.0	.512	.828	.9208
46.0	.528	.813	.9265
45.0	.543	.800	.9323
44.0	.558	.788	.9380
43.0	.574	.776	.9438
42.0	.589	.765	.9495
41.0	.605	.755	.9553
40.0	.620	.745	.9610
39.0	.635	.735	.9668
38.0	.651	.727	.9725
37.0	.666	.718	.9783
36.0	.687	.705	.9840
35.0	.719	.681	.9898
34.0	.751	.659	.9955
33.0	.784	.640	1.0013
32.0	.816	.621	1.0070
31.0	.849	.604	1.0128
30.0	.881	.589	1.0185
29.0	.913	.574	1.0243
28.0	.946	.561	1.0300
27.0	.978	.548	1.0358
26.0	1.011	.537	1.0415
25.0	1.043	.526	1.0473
24.0	1.075	.516	1.0530
23.0	1.108	.506	1.0588
22.0	1.140	.497	1.0645
21.0	1.173	.488	1.0703
20.0	1.205	.480	1.0760
19.0	1.237	.473	1.0818
18.0	1.270	.466	1.0875
17.0	1.302	.459	1.0933
16.0	1.335	.452	1.0990
15.0	1.367	.446	1.1048
14.0	1.399	.441	1.1105
13.0	1.432	.435	1.1163
12.0	1.464	.430	1.1220
11.0	1.497	.425	1.1278
10.0	1.529	.420	1.1335
9.0	1.561	.416	1.1393
8.0	1.594	.411	1.1450
7.0	1.626	.407	1.1508
6.0	1.659	.403	1.1565
5.0	1.691	.399	1.1623
4.0	1.723	.396	1.1680
3.0	1.756	.392	1.1738
2.0	1.788	.389	1.1795
1.0	1.821	.386	1.1853

Table A2. Table of curve numbers for AMC I and AMC III.

1	2	3	4	5	1	2	3	4	5
CN for condition II	CN for conditions I	III	S values*	Curve* Starts where P =	CN for condition II	CN for conditions I	III	S values*	Curve* starts where P =
			(inches)	(inches)				(inches)	(inches)
100	100	100	0.0	0.0	60	40	78	6.67	1.33
99	97	100	0.101	0.02	59	39	77	6.95	1.39
98	94	99	0.204	0.04	58	38	76	7.24	1.45
97	91	99	0.309	0.06	57	37	75	7.54	1.51
96	89	99	0.417	0.08	56	36	75	7.86	1.57
95	87	98	0.526	0.11	55	35	74	8.18	1.64
94	85	98	0.638	0.13	54	34	73	8.52	1.70
93	83	98	0.753	0.15	53	33	72	8.87	1.77
92	81	97	0.870	0.17	52	32	71	9.23	1.85
91	80	97	0.989	0.20	51	31	70	9.61	1.92
90	78	96	1.11	0.22	50	31	70	10.0	2.00
89	76	96	1.24	0.25	49	30	69	10.4	2.08
88	75	95	1.36	0.27	48	29	68	10.8	2.16
87	73	95	1.49	0.30	47	28	67	11.3	2.26
86	72	94	1.63	0.33	46	27	66	11.7	2.34
85	70	94	1.76	0.35	45	26	65	12.2	2.44
84	68	93	1.90	0.38	44	25	64	12.7	2.54
83	67	93	2.05	0.41	43	25	63	13.2	2.64
82	66	92	2.20	0.44	42	24	62	13.8	2.76
81	64	92	2.34	0.47	41	23	61	14.4	2.88
80	63	91	2.50	0.50	40	22	60	15.0	3.00
79	62	91	2.66	0.53	39	21	59	15.6	3.12
78	60	90	2.82	0.56	38	21	58	16.3	3.26
77	59	89	2.99	0.60	37	20	57	17.0	3.40
76	58	89	3.16	0.63	36	19	56	17.8	3.56
75	57	88	3.33	0.67	35	18	55	18.6	3.72
74	55	88	3.51	0.70	34	18	54	19.4	3.88
73	54	87	3.70	0.74	33	17	53	20.3	4.06
72	53	86	3.89	0.78	32	16	52	21.2	4.24
71	52	86	4.08	0.82	31	16	51	22.2	4.44
70	51	85	4.28	0.86	30	15	50	23.3	4.66
69	50	84	4.49	0.90					
68	48	84	4.70	0.94	25	12	43	30.0	6.00
67	47	83	4.92	0.98	20	9	37	40.0	8.00
66	46	82	5.15	1.03	15	6	30	56.7	11.34
65	45	82	5.38	1.08	10	4	22	90.0	18.00
64	44	81	5.62	1.12	5	2	13	190.0	38.00
63	43	80	5.87	1.17	0	0	0	infinity	infinity
62	42	79	6.13	1.23					
61	41	78	6.39	1.28					

*For CN in column 1

Table A3.' Soil names and hydrologic classifications.

AABERG	C	AHL	C	ALMY	B	ANLAUF	C	AROOSTOOK	
AASTAD	B	AHLSTROM	C	ALOHA	C	ANNABELLA	B	AROSA	C
ABAC	D	AHMEEK	B	ALONSO	B	ANNANDALE	C	ARP	C
ABAJO	C	AHOLT	D	ALOVAR	C	ANNISTON	B	ARRINGTON	B
ABBOTT	D	AHTANUM	C	ALPENA	B	ANOKA	A	ARRITOLA	D
ABBOTTSTOWN	C	AHWAHNEE	C	ALPHA	C	ANONES	C	ARROLIME	C
ABCAL	D	AIBONITO	C	ALPON	B	ANSARI	D	ARRON	D
ABEGG	B	AIKEN	B/C	ALPOWA	B	ANSEL	B	ARROW	B
ABELA	B	AIKMAN	D	ALPS	C	ANSELMO	A	ARROWSMITH	B
ABELL	B	AILEY	B	ALSEA	B	ANSON	B	ARROYO SECO	B
ABERDEEN	D	AINAKEA	B	ALSPAUGH	C	ANTELOPE SPRINGS	C	ARTA	C
ABES	D	AIRMONT	C	ALSTAD	B	ANTERO	C	ARTOIS	C
ABILENE	C	AIROTSA	B	ALSTOWN	B	ANT FLAT	C	ARVADA	D
ABINGTON	B	AIRPORT	D	ALTAMONT	D	ANTHO	B	ARVANA	C
ABIQUA	C	AITS	B	ALTAVISTA	C	ANTHONY	B	ARVESON	D
ABO	B/C	AJO	C	ALTDORF	D	ANTIGO	B	ARVILLA	B
ABOR	D	AKAKA	A	ALTMAR	B	ANTILON	B	ARZELL	C
ABRA	C	AKASKA	B	ALTO	C	ANTIOCH	D	ASA	B
ABRAHAM	B	AKELA	C	ALTOGA	C	ANTLER	C	ASBURY	B
ABSAROKEE	C	ALADDIN	B	ALTON	B	ANTOINE	C	ASCALON	B
ABSCOTA	B	ALAE	A	ALTUS	B	ANTROBUS	B	ASCHOFF	B
ABSHER	D	ALAELOA	B	ALTVAN	B	ANTY	B	ASHBY	C
ABSTED	D	ALAGA	A	ALUM	B	ANVIK	B	ASHCROFT	B
ACACIO	C	ALAKAI	D	ALUSA	D	ANWAY	B	ASHDALE	B
ACADEMY	C	ALAMA	B	~~ALVIN~~	B	ANZA	B	ASHE	B
ACADIA	D	ALAMANCE	B	ALVIRA	C	ANZIANO	C	ASHKUM	C
ACANA	D	ALAMO	D	ALVISO	D	APACHE	D	ASHLAR	B
ACASCO	D	ALAMOSA	C	ALVOR	C	APAKUIE	A	ASHLEY	A
ACEITUNAS	B	ALAPAHA	D	AMADOR	D	APISHAPA	C	ASH SPRINGS	C
ACEL	D	ALAPAI	A	AMAGON	D	APISON	B	ASHTON	B
ACKER	B	ALBAN	B	AMALU	D	APOPKA	A	ASHUE	B
ACKMEN	B	ALBANO	D	AMANA	B	APPIAN	C	ASHUELOT	C
ACME	C	ALBANY	C	AMARGOSA	D	APPLEGATE	C	ASHWOOD	C
ACO	B	ALBATON	D	AMARILLO	B	APPLETON	C	ASKEW	C
ACOLITA	B	ALBEE	C	AMASA	B	APPLING	B	ASO	C
ACOMA	C	ALBEMARLE	B	AMBERSON		APRON	B	ASOTIN	C
ACOVE	C	ALBERTVILLE	C	AMBOY	C	APT	C	ASPEN	B
ACREE	C	ALBIA	C	AMBRAW	C	APTAKISIC	B	ASPERMONT	B
ACRELANE	C	ALBION	B	AMEDEE	A	ARABY		ASSINNIBOINE	B
ACTON	B	ALBRIGHTS	C	AMELIA	B	ARADA	C	ASSUMPTION	B
ACUFF	B	ALCALDE	C	AMENIA	B	ARANSAS	D	ASTATULA	A
ACWORTH	B	ALCESTER	B	AMERICUS	A	ARAPIEN	C	ASTOR	A/D
ACY	C	ALCOA	B	AMES	C	ARAVE	D	ASTORIA	B
ADA	B	ALCONA	B	AMESHA	B	ARAVETON	B	ATASCADERO	C
ADAIR	D	ALCOVA	B	AMHERST	C	ARBELA	C	ATASCOSA	D
ADAMS	A	ALDA	C	AMITY	C	ARBONE	B	ATCO	B
ADAMSON	B	ALDAX	D	AMMON	B	ARBOR	B	ATENCIO	B
ADAMSTOWN		ALDEN	D	AMOLE	C	ARBUCKLE	B	ATEPIC	D
ADAMSVILLE	C	ALDER	B	AMOR	B	ARCATA	B	ATHELWOLD	B
ADATON	D	ALDERDALE	C	AMOS	C	ARCH	B	ATHENA	B
ADAVEN	D	ALDERWOOD	C	AMSDEN	B	ARCHABAL	B	ATHENS	B
ADDIELOU	C	ALDINO	C	AMSTERDAM	B	ARCHER	C	ATHERLY	B
ADDISON	D	ALDWELL	C	AMTOFT	D	ARCHIN	C	ATHERTON	B/D
ADDY	C	ALEKNAGIK	B	AMY	D	ARCO	B	ATHMAR	C
ADE	A	ALEMEDA	C	ANACAPA	B	ARCOLA	C	ATHOL	B
ADEL	A	ALEX	B	ANAHUAC	D	ARD	C	ATKINSON	B
ADELAIDE	D	ALEXANDRIA	C	ANAMITE	D	ARDEN	B	ATLAS	D
ADELANTO	B	ALEXIS	B	ANAPRA	B	ARDENVOIR	B	ATLEE	C
ADELINO	B	ALFORD	B	ANASAZI	B	ARDILLA	C	ATMORE	B/D
ADELPHIA	C	ALGANSEE	B	ANATONE	D	AREDALE	B	ATOKA	C
ADENA	C	ALGERITA	B	ANAVERDE	B	ARENA	C	ATON	B
ADGER	D	ALGIERS	C/D	ANAWALT	D	ARENALES		ATRYPA	C
ADILIS	A	ALGOMA	B/D	ANCHO	B	ARENDTSVILLE	B	ATSION	C
ADIRONDACK	C	ALHAMBRA	B	ANCHORAGE	A	ARENOSA	A	ATTERBERRY	B
ADIV	B	ALICE	A	ANCHOR BAY	D	ARENZVILLE	B	ATTEWAN	A
ADJUNTAS	C	ALICEL	B	ANCHOR POINT	D	ARGONAUT	D	ATTICA	B
ADKINS	B	ALICIA	B	ANCLOTE	D	ARGUELLO	B	ATTLEBORO	
ADLER	C	ALIDA	B	ANCO	C	ARGYLE	B	ATWATER	B
ADOLPH	D	ALIKCHI	B	ANDERLY	C	ARIEL	C	ATWELL	C/D
ADRIAN	A/D	ALINE	A	ANDERS	C	ARIZO	A	ATWOOD	B
AENEAS	B	ALKO	D	ANDERSON	B	ARKABUTLA	C	AUBBEENAUBBEE	B
AETNA	B	ALLAGASH	B	ANDES	C	ARKPORT	B	AUBERRY	B
AFTON	D	ALLARD	B	ANDORINIA	C	ARLAND	B	AUBURN	C/D
AGAR	B	ALLEGHENY	B	ANDOVER	D	ARLE	B	AUBURNDALE	D
AGASSIZ	D	ALLEMANDS	D	ANDREEN	B	ARLING	D	AUDIAN	B
AGATE	D	ALLEN	B	ANDREESON	C	ARLINGTON	C	AU GRES	C
AGAWAM	B	ALLENDALE	C	ANDRES	B	ARLOVAL	C	AUGSBURG	B
AGENCY	C	ALLENS PARK	B	ANDREWS	C	ARMAGH	D	AUGUSTA	C
AGER	D	ALLENSVILLE	C	ANED	D	ARMIJO	D	AULD	D
AGNER	B	ALLENTINE	D	ANETH	A	ARMINGTON	D	AURA	B
AGNEW	B/C	ALLENWOOD	B	ANGELICA	D	ARMO	B	AURORA	C
AGNOS	B	ALLESSIO	B	ANGELINA	B/D	ARMOUR	B	AUSTIN	C
AGUA	B	ALLEY	C	ANGELO	C	ARMSTER	C	AUSTWELL	D
AGUADILLA	A	ALLIANCE	B	ANGIE	C	ARMSTRONG	D	AUXVASSE	D
AGUA DULCE	C	ALLIGATOR	D	ANGLE	A	ARMUCHEE	D	AUZQUI	B
AGUA FRIA	B	ALLIS	D	ANGLEN	B	ARNEGARD	B	AVA	C
AGUALT	B	ALLISON	C	ANGOLA	C	ARNHART	C	AVALANCHE	B
AGUEDA	B	ALLOUEZ	C	ANGOSTURA	B	ARNHEIM	C	AVALON	B
AGUILITA	B	ALLOWAY		ANHALT	D	ARNO	D	AVERY	B
AGUIRRE	D	ALMAC	B	ANIAK	D	ARNOLD	B	AVON	C
AGUSTIN	B	ALMENA	C	ANITA	D	ARNOT	C/D	AVONBURG	D
AHATONE	D	ALMONT	D	ANKENY	A	ARNY	A	AVONDALE	C

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

AWBREY	D
AXTELL	D
AYAR	D
AYCOCK	B
AYON	B
AYR	B
AYRES	D
AYRSHIRE	C
AYSEES	B
AZAAR	C
AZARMAN	C
AZELTINE	B
AZFIELD	B
AZTALAN	B
AZTEC	B
AZULE	C
AZWELL	B
BABB	A
BABBINGTON	B
BABCOCK	C
BABYLON	A
BACA	C
BACH	D
BACHUS	C
BACKBONE	A
BACULAN	A
BADENAUGH	B
BADGER	C
BADGERTON	B
BADO	D
BADUS	C
BAGARD	C
BAGDAD	B
BAGGOTT	D
BAGLEY	B
BAHEM	B
BAILE	D
BAINVILLE	C
BAIRD HOLLOW	C
BAJURA	D
BAKEOVEN	D
BAKER	C
BAKER PASS	B
BALAAM	A
BALCH	D
BALCOM	B
BALD	C
BALDER	C
BALDOCK	B/C
BALDWIN	D
BALDY	B
BALE	C
BALLARD	B
BALLER	D
BALLINGER	C
BALM	B/C
BALMAN	B/C
BALON	B
BALTIC	D
BALTIMORE	B
BALTO	D
BAMBER	B
BAMFORTH	B
BANCAS	B
BANCROFT	B
BANDERA	B
BANGO	C
BANGOR	B
BANGSTON	A
BANKARD	A
BANKS	A
BANNER	C
BANNERVILLE	C/D
BANNOCK	B
BANQUETE	D
BARABOO	B
BARAGA	C
BARBARY	D
BARBOUR	B
BARBOURVILLE	B
BARCLAY	C
BARCO	B
BARCUS	B
BARD	D
BARDEN	C
BARDLEY	C
BARELA	C
BARFIELD	D
BARFUSS	B
BARGE	C
BARISHMAN	C
BARKER	C
BARKERVILLE	C
BARKLEY	B
BARLANE	D
BARLING	C
BARLOW	B
BARNARD	D
BARNES	B
BARNESTON	B
BARNEY	A
BARNHARDT	B
BARNSTEAD	
BARNUM	B
BARRADA	D
BARRETT	D
BARRINGTON	B
BARRON	B
BARRONETT	C
BARROWS	D
BARRY	D
BARSTOW	B
BARTH	C
BARTINE	C
BARTLE	D
BARTLEY	C
BARTON	B
BARTONFLAT	B
BARVON	C
BASCOM	B
BASEHOR	D
BASHAW	D
BASHER	B
BASILE	D
BASIN	C
BASINGER	C
BASKET	C
BASS	A
BASSEL	B
BASSETT	B
BASSFIELD	B
BASSLER	D
BASTIAN	D
BASTROP	B
BATA	A
BATAVIA	B
BATES	B
BATH	C
BATTERSON	D
BATTLE CREEK	C
BATZA	D
BAUDETTE	B
BAUER	C
BAUGH	B/C
BAXTER	B
BAXTERVILLE	B
BAYAMON	B
BAYARD	A
BAYBORO	D
BAYERTON	C
BAYLOR	D
BAYSHORE	B/C
BAYSIDE	C
BAYUCOS	D
BAYWOOD	A
BAZETTE	C
BAZILE	B
BEAD	C
BEADLE	C
BEALES	A
BEAR BASIN	B
BEAR CREEK	C
BEARDALL	C
BEARDEN	C
BEARDSTOWN	C
BEAR LAKE	D
BEARMOUTH	A
BEARPAW	B
BEAR PRAIRIE	B
BEARSKIN	D
BEASLEY	C
BEASON	C
BEATON	C
BEATTY	C
BEAUCOUP	B
BEAUFORD	D
BEAUMONT	D
BEAUREGARD	C
BEAUSITE	B
BEAUVAIS	B
BEAVERTON	A
BECK	C
BECKER	B
BECKET	C
BECKLEY	B
BECKTON	D
BECKWITH	C
BECKWOURTH	B
BECREEK	B
BEDFORD	C
BEDINGTON	B
BEDNER	C
BEEBE	A
BEECHER	C
BEECHY	
BEEHIVE	B
BEEK	C
BEENOM	D
BEEZAR	B
BEGAY	B
BEGOSHIAN	C
BEHANIN	B
BEHEMOTOSH	B
BEHRING	D
BEIRMAN	D
BEJUCOS	B
BELCHER	D
BELDEN	D
BELDING	B
BELEN	C
BELFAST	B
BELFIELD	B
BELFORE	B
BELGRADE	B
BELINDA	D
BELKNAP	C
BELLAMY	C
BELLAVISTA	D
BELLE	B
BELLEFONTAINE	
BELLICUM	B
BELLINGHAM	C
BELLPINE	C
BELMONT	B
BELMORE	B
BELT	D
BELTED	D
BELTON	C
BELTRAMI	B
BELTSVILLE	C
BELUGA	D
BELVOIR	C
BENCLARE	C
BENEVOLA	C
BENEWAH	C
BENFIRLD	C
BENGE	B
BEN HUR	B
BENIN	D
BENITO	D
BENJAMIN	D
BEN LOMOND	B
BENMAN	A
BENNDALE	B
BENNETT	C
BENNINGTON	D
BENOIT	D
BENSON	C/D
BENTEEN	B
BENTONVILLE	C
BENZ	D
BEOTIA	B
BEOWAWE	D
BERCAIL	C
BERDA	B
BEREA	C
BERENICETON	B
BERENT	A
BERGLAND	D
BERGSTROM	B
BERINO	B
BERKELEY	
BERKS	C
BERKSHIRE	B
BERLIN	C
BERMESA	C
BERMUDIAN	B
BERNAL	D
BERNALDO	B
BERNARD	D
BERNARDINO	C
BERNARDSTON	C
BERNHILL	B
BERNICE	A
BERNING	C
BERRENDOS	D
BERRYLAND	D
BERTELSON	B
BERTHOUD	B
BERTIE	C
BERTOLOTTI	B
BERTRAND	B
BERVILLE	D
BERYL	B
BESSEMER	B
BETHANY	C
BETHEL	D
BETTERAVIA	C
BETTS	B
BEULAH	B
BEVENT	B
BEVERLY	B
BEW	D
BEWLEYVILLE	B
BEWLIN	D
BEXAR	C
BEZZANT	B
BIBB	B/D
BIBON	A
BICKELTON	B
BICKLETON	C
BICKMORE	C
BICONDOA	C
BIDDEFORD	D
BIDDLEMAN	C
BIDMAN	C
BIDWELL	B
BIEBER	D
BIENVILLE	A
BIG BLUE	D
BIGEL	A
BIGELOW	C
BIGETTY	C
BIGGS	A
BIGGSVILLE	B
BIG HORN	C
BIGNELL	B
BIG TIMBER	D
BIGWIN	D
BIJOU	A
BILLETT	A
BILLINGS	C
BINDLE	B
BINFORD	B
BINGHAM	B
BINNSVILLE	D
BINS	B
BINTON	C
BIPPUS	B
BIRCH	A
BIRCHWOOD	C
BIRDOW	B
BIRDS	C
BIRDSALL	D
BIRDSBORO	B
BIRDSLEY	D
BIRKBECK	B
BISBEE	A
BISCAY	C
BISHOP	B/C
BISPING	B
BISSELL	B
BISTI	C
BIT	D
BITTERON	A
BITTERROOT	C
BITTER SPRING	C
BITTON	B
BIXBY	B
BJORK	C
BLACHLY	C
BLACKBURN	B
BLACK BUTTE	C
BLACK CANYON	D
BLACKCAP	A
BLACKETT	B
BLACKFOOT	B/C
BLACKHALL	D
BLACKHAWK	D
BLACKLEAF	B
BLACKLEED	A
BLACKLOCK	D
BLACKMAN	C
BLACK MOUNTAIN	D
BLACKOAR	C
BLACKPIPE	C
BLACK RIDGE	D
BLACKROCK	B
BLACKSTON	B
BLACKTAIL	B
BLACKWATER	D
BLACKWELL	B/D
BLADEN	D
BLAGO	D
BLAINE	B
BLAIR	C
BLAIRTON	C
BLAKE	C
BLAKELAND	A
BLAKENEY	C
BLAKEPORT	B
BLALOCK	D
BLAMER	C
BLANCA	B
BLANCHARD	A
BLANCHESTER	B/D
BLAND	C
BLANDFORD	C
BLANDING	B
BLANEY	B
BLANKET	C
BLANTON	A
BLANYON	C
BLASDELL	A
BLASINGAME	C
BLAZON	D
BLENCOE	C
BLEND	D
BLENDON	B
BLETHEN	B
BLEVINS	B
BLEVINTON	B/D
BLICHTON	D
BLISS	D
BLOCKTON	C
BLODGETT	A
BLOMFORD	B
BLOOM	C
BLOOMFIELD	A
BLOOMING	B
BLOOR	D
BLOSSOM	C
BLOUNT	C
BLOUNTVILLE	C
BLUCHER	C
BLUEBELL	C
BLUE EARTH	D
BLUEJOINT	B
BLUE LAKE	A
BLUEPOINT	B
BLUE STAR	B
BLUEWING	B
BLUFFDALE	C
BLUFFTON	D
BLUFORD	D
BLY	B
BLYTHE	D
BOARDTREE	C
BOBS	D
BOBTAIL	B
BOCK	B
BODELL	D
BODENBURG	B
BODINE	B
BOEL	A
BOELUS	A
BOESEL	B
BOETTCHER	C
BOGAN	C
BOGART	B
BOGUE	D
BOHANNON	C
BOHEMIAN	B
BOISTFORT	C
BOLAR	C
BOLD	B
BOLES	C
BOLIVAR	B
BOLIVIA	B
BOLTON	B
BOMBAY	B
BON	B
BONACCORD	D
BONAPARTE	A
BOND	D
BONDRANCH	D
BONDURANT	B
BONE	D
BONG	B

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

BONHAM	C
BONIFAY	A
BONILLA	B
BONITA	D
BONN	D
BONNER	B
BONNET	B
BONNEVILLE	B
BONNICK	A
BONNIE	D
BONO	D
BONSALL	D
BONTA	C
BONTI	C
BOOKER	D
BOOMER	B
BOONE	A
BOONESBORO	B
BOONTON	C
BOOTH	C
BORACHO	C
BORAH	A/C
BORDA	D
BORDEAUX	B
BORDEN	B
BORDER	B
BORNSTEDT	C
BORREGO	C
BORUP	B
BORVANT	D
BORZA	C
BOSANKO	D
BOSCO	B
BOSKET	B
BOSLER	B
BOSQUE	B
BOSS	D
BOSTON	C
BOSTWICK	B
BOSWELL	D
BOSWORTH	D
BOTELLA	B
BOTHWELL	C
BOTTINEAU	C
BOTTLE	A
BOULDER	B
BOULDER LAKE	D
BOULDER POINT	B
BOULFLAT	D
BOURNE	C
BOW	C
BOWBAC	C
BOWBELLS	B
BOWDOIN	D
BOWDRE	C
BOWERS	C
BOWIE	B
BOWMAN	B/D
BOWMANSVILLE	C
BOXELDER	C
BOXWELL	C
BOY	A
BOYCE	B/D
BOYD	D
BOYER	B
BOYNTON	
BOYSAG	D
BOYSEN	D
BOZARTH	C
BOZE	B
BOZEMAN	A
BRACEVILLE	C
BRACKEN	D
BRACKETT	C
BRAD	D
BRADDOCK	C
BRADENTON	B/D
BRADER	D
BRADFORD	B
BRADSHAW	B
BRADWAY	D
BRADY	B
BRADYVILLE	C
BRAHAM	B
BRAINERD	B
BRALLIER	D
BRAM	B
BRAMARD	B
BRAMBLE	C
BRAMWELL	C
BRAND	D
BRANDENBURG	A
BRANDON	B
BRANDYWINE	C
BRANFORD	B
BRANTFORD	B
BRANYON	D
BRASHEAR	C
BRASSFIELD	B
BRATTON	B
BRAVANE	D
BRAXTON	C
BRAYMILL	B/D
BRAYS	D
BRAYTON	C
BRAZITO	A
BRAZOS	A
BREA	B
BRECKENRIDGE	D
BRECKNOCK	B
BREECE	B
BREGAR	D
BREMEN	B
BREMER	B
BREMO	C
BREMS	A
BRENDA	C
BRENNAN	B
BRENNER	C/D
BRENT	C
BRENTON	B
BRENTWOOD	B
BRESSER	B
BREVARD	B
BREVORT	B
BREWER	C
BREWSTER	D
BREWTON	C
BRICKEL	C
BRICKTON	C
BRIDGE	C
BRIDGEHAMPTON	B
BRIDGEPORT	B
BRIDGER	A
BRIDGESON	B/C
BRIDGET	B
BRIDGEVILLE	B
BRIDGPORT	B
BRIEDWELL	B
BRIEF	B
BRIENSBURG	
BRIGGS	A
BRIGGSDALE	C
BRIGGSVILLE	C
BRIGHTON	A/D
BRIGHTWOOD	C
BRILL	B
BRIM	C
BRIMFIELD	C/D
BRIMLEY	B
BRINEGAR	B
BRINKERT	C
BRINKERTON	D
BRISCOT	B
BRITE	C
BRITTON	C
BRIZAM	A
BROAD	C
BROADALBIN	C
BROADAX	B
BROADBROOK	C
BROAD CANYON	B
BROADHEAD	C
BROADHURST	D
BROCK	B
BROCKLISS	C
BROCKMAN	C
BROCKO	B
BROCKPORT	D
BROCKTON	D
BROCKWAY	B
BRODY	C
BROE	B
BROGAN	B
BROGDON	B
BROLLIAR	D
BROMO	B
BRONAUGH	B
BRONCHO	B
BRONSON	B
BRONTE	C
BROOKE	C
BROOKFIELD	B
BROOKINGS	B
BROOKLYN	D
BROOKSIDE	C
BROOKSTON	B/D
BROOKSVILLE	D
BROOMFIELD	D
BROSELEY	B
BROSS	B
BROUGHTON	D
BROWARD	C
BROWNELL	B
BROWNFIELD	A
BROWNLEE	B
BROYLES	B
BRUCE	D
BRUFFY	C
BRUIN	C
BRUNEEL	B/C
BRUNO	A
BRUNT	C
BRUSH	
BRUSSETT	B
BRYAN	A
BRYCAN	B
BRYCE	D
BUCAN	D
BUCHANAN	C
BUCHENAU	C
BUCHER	C
BUCKHOUSE	A
BUCKINGHAM	
BUCKLAND	C
BUCKLEBAR	B
BUCKLEY	B/C
BUCKLON	D
BUCKNER	A
BUCKNEY	A
BUCKS	B
BUCKSKIN	C
BUCODA	C
BUDD	B
BUDE	C
BUELL	B
BUENA VISTA	B
BUFFINGTON	B
BUFFMEYER	B
BUFF PEAK	C
BUICK	C
BUIST	B
BUKREEK	B
BULLION	D
BULLREY	B
BULL RUN	B
BULL TRAIL	B
BULLY	B
BUMGARD	B
BUNCOMBE	A
BUNDO	B
BUNDYMAN	C
BUNEJUG	C
BUNKER	D
BUNSELMEIER	C
BUNTINGVILLE	B/C
BUNYAN	B
BURBANK	A
BURCH	B
BURCHARD	B
BURCHELL	B/C
BURDETT	C
BUREN	C
BURGESS	C
BURGI	B
BURGIN	D
BURKE	C
BURKHARDT	B
BURLEIGH	D
BURLESON	D
BURLINGTON	A
BURMA	
BURMESTER	D
BURNAC	C
BURNETTE	B
BURNHAM	D
BURNSIDE	B
BURNSVILLE	B
BURNT LAKE	B
BURRIS	D
BURT	D
BURTON	B
BUSE	B
BUSH	B
BUSHNELL	C
BUSHVALLEY	D
BUSTER	C
BUTANO	C
BUTLER	D
BUTLERTOWN	C
BUTTE	C
BUTTERFIELD	C
BUTTON	C
BUXIN	D
BUXTON	C
BYARS	D
BYNUM	C
BYRON	A
CABALLO	B
CABARTON	D
CABBA	C
CABBART	D
CABEZON	D
CABIN	C
CABINET	C
CABLE	D
CABO ROJO	C
CABOT	D
CACAPON	B
CACHE	D
CACIQUE	C
CADDO	D
CADEVILLE	D
CADMUS	B
CADOMA	D
CADOR	C
CAGEY	C
CAGUABO	D
CAGWIN	B
CAHABA	B
CAHILL	B
CAHONE	C
CAHTO	C
CAID	B
CAIRO	D
CAJALCO	C
CAJON	A
CALABAR	D
CALABASAS	B
CALAIS	C
CALAMINE	D
CALAPOOYA	C
CALAWAH	B
CALCO	C
CALDER	D
CALDWELL	B
CALEAST	C
CALEB	B
CALERA	C
CALHI	A
CALHOUN	D
CALICO	D
CALIFON	C
CALIMUS	B
CALITA	B
CALIZA	B
CALKINS	C
CALLABO	C
CALLAHAN	C
CALLEGUAS	D
CALLINGS	C
CALLOWAY	C
CALMAR	B
CALNEVA	C
CALOUSE	B
CALPINE	B
CALVERT	D
CALVERTON	C
CALVIN	C
CALVISTA	D
CAM	B
CAMAGUEY	D
CAMARGO	B
CAMARILLO	B/C
CAMAS	A
CAMASCREEK	B/D
CAMBERN	C
CAMBRIDGE	C
CAMDEN	B
CAMERON	D
CAMILLUS	B
CAMP	B
CAMPBELL	B/C
CAMPHORA	B
CAMPIA	B
CAMPO	C
CAMPONE	B/C
CAMPSPASS	C
CAMPUS	B
CAMRODEN	C
CANA	C
CANAAN	C/D
CANADIAN	B
CANADICE	D
CANANDAIGUA	D
CANASERAGA	C
CANAVERAL	C
CANBURN	D
CANDELERO	C
CANE	C
CANEADEA	D
CANEEK	B
CANEL	B
CANELO	D
CANEY	C
CANEYVILLE	C
CANEZ	B
CANFIELD	C
CANISTEO	C
CANNINGER	D
CANNON	B
CANOE	B
CANONCITO	B
CANOVA	B/D
CANTALA	B
CANTON	B
CANTRIL	B
CANTUA	B
CANUTIO	B
CANYON	D
CAPAC	B
CAPAY	D
CAPE	D
CAPE FEAR	D
CAPERS	D
CAPILLO	C
CAPLES	C
CAPPS	B
CAPSHAW	C
CAPULIN	B
CAPUTA	C
CARACO	C
CARALAMPI	B
CARBO	C
CARBOL	D
CARBONDALE	D
CARBURY	B
CARCITY	D
CARDIFF	B
CARDINGTON	C
CARDON	D
CAREY	B
CAREY LAKE	B
CAREYTOWN	D
CARGILL	C
CARIBE	B
CARIBEL	B
CARIBOU	B
CARLIN	D
CARLINTON	B
CARLISLE	A/D
CARLOTTA	B
CARLOW	D
CARLSBAD	C
CARLSBORG	A
CARLSON	C
CARLTON	B
CARMI	B
CARNASAW	C
CARNEGIE	C
CARNERO	C
CARNEY	D
CAROLINE	C
CARR	B
CARRISALITOS	D
CARRIZO	A
CARSITAS	A
CARSLEY	C
CARSO	D
CARSON	D
CARSTAIRS	B
CARSTUMP	C
CART	B
CARTAGENA	D
CARTECAY	C
CARUSO	C
CARUTHERSVILLE	B
CARVER	A
CARWILE	D

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

CARYVILLE	B
CASA GRANDE	C
CASCADE	C
CASCAJO	B
CASCILLA	B
CASCO	B
CASE	B
CASEBIER	D
CASEY	C
CASHEL	C
CASHION	D
CASHMERE	B
CASHMONT	B
CASINO	A
CASITO	D
CASPAR	B
CASPIANA	B
CASS	A
CASSADAGA	
CASSIA	C
CASSIRO	C
CASSOLARY	B
CASSVILLE	
CASTAIC	C
CASTALIA	C
CASTANA	B
CASTELL	C
CASTILE	B
CASTINO	C
CASTLE	D
CASTLEVALE	D
CASTNER	C
CASTO	C
CASTRO	C
CASTROVILLE	B
CASUSE	D
CASWELL	D
CATALINA	B
CATALPA	C
CATANO	A
CATARINA	D
CATAULA	C
CATAWBA	B
CATH	D
CATHCART	C
CATHEDRAL	D
CATHERINE	B/D
CATHRO	D
CATLETT	C/D
CATLIN	B
CATNIP	D
CATOCTIN	C
CATOOSA	B
CATSKILL	A
CATTARAUGUS	C
CAUDLE	B
CAVAL	B
CAVE	D
CAVELT	D
CAVE ROCK	A
CAVO	D
CAVODE	C
CAVOUR	D
CAWKER	B
CAYAGUA	C
CAYLOR	B
CAYUGA	C
CAZADERO	C
CAZADOR	B
CAZENOVIA	B
CEBOLIA	C
CEBONE	C
CECIL	B
CEDA	B
CEDARAN	D
CEDAR BUTTE	C
CEDAREDGE	B
CEDAR MOUNTAIN	D
CEDARVILLE	B
CEDONIA	B
CEDRON	C/D
CELAYA	B
CELETON	D
CELINA	C
CELIO	A/D
CELLAR	D
CENCOVE	B
CENTER	C
CENTER CREEK	B
CENTERFIELD	B
CENTERVILLE	D
CENTRALIA	B
CENTRAL POINT	B
CERESCO	A
CERRILLOS	B
CERRO	C
CHACRA	C
CHAFFEE	C
CHAGRIN	B
CHAIX	B
CHALFONT	C
CHALMERS	C
CHAMA	B
CHAMBER	C
CHAMBERINO	C
CHAMISE	B
CHAMOKANE	B
CHAMPION	B
CHANCE	B/D
CHANDLER	B
CHANEY	C
CHANNAHON	B
CHANNING	B
CHANTA	B
CHANTIER	D
CHAPIN	C
CHAPMAN	
CHAPPELL	B
CHARD	B
CHARGO	D
CHARITON	D
CHARITY	D
CHARLEBOIS	C
CHARLESTON	C
CHARLEVOIX	B
CHARLOS	A
CHARLOTTE	A/D
CHARLTON	B
CHASE	C
CHASEBURG	B
CHASEVILLE	A
CHASKA	C
CHASTAIN	D
CHATBURN	B
CHATFIELD	C
CHATHAM	B
CHATSWORTH	D
CHAUNCEY	C
CHAVIES	B
CHAWANAKEE	C
CHEADLE	C
CHECKETT	D
CHEDEHAP	B
CHEEKTOWAGA	D
CHEESEMAN	C
CHEHALEM	C
CHEHALIS	B
CHEHULPUM	D
CHELAN	B
CHELSEA	A
CHEMAWA	B
CHEMUNG	
CHEN	D
CHENA	A
CHENANGO	A
CHENEY	B
CHENNEBY	C
CHENOWETH	B
CHEQUEST	C
CHEREETE	A
CHERIONI	D
CHEROKEE	D
CHERRY	C
CHERRYHILL	B
CHERRY SPRINGS	C
CHESAW	A
CHESHIRE	B
CHESHNINA	C
CHESNIMNUS	B
CHESTER	B
CHESTERTON	C
CHETCO	D
CHETEK	B
CHEVELON	C
CHEWACLA	C
CHEWELAH	B
CHEYENNE	B
CHIARA	D
CHICKASHA	B
CHICOPEE	B
CHICOTE	D
CHIGLEY	C
CHILCOTT	D
CHILDS	B
CHILGREN	C
CHILHOWIE	C
CHILI	B
CHILKAT	C
CHILLICOTHE	C
CHILLISQUAQUE	
CHILLUM	B
CHILMARK	B
CHILO	B/D
CHILOQUIN	B
CHILSON	D
CHILTON	B
CHIMAYO	D
CHIMNEY	B
CHINA CREEK	B
CHINCHALLO	B/D
CHINIAK	A
CHINO	B/C
CHINOOK	B
CHIPETA	D
CHIPLEY	C
CHIPMAN	D
CHIPPENY	D
CHIPPEWA	B/D
CHIQUITO	C/D
CHIRICAHUA	D
CHISPA	B
CHITINA	B
CHITTENDEN	C
CHITWOOD	C
CHIVATO	D
CHIWAWA	B
CHO	C
CHOBEE	D
CHOCK	B/D
CHOCOLOCCO	B
CHOPAKA	C
CHOPTANK	A
CHOPTIE	D
CHORALMONT	B
CHOSKA	B
CHOTEAU	C
CHRISTIAN	C
CHRISTIANA	B
CHRISTIANBURG	D
CHRISTY	B
CHROME	C
CHUALAR	B
CHUBBS	C
CHUCKAWALLA	B
CHUGTER	B
CHULITNA	B
CHUMMY	C/D
CHUMSTICK	C
CHUPADERA	C
CHURCH	D
CHURCHILL	D
CHURCHVILLE	D
CHURN	B
CHURNDASHER	B
CHUTE	A
CIALES	D
CIBEQUE	B
CIBO	D
CIBOLA	B
CICERO	D
CIDRAL	C
CIENEBA	C
CIMA	C
CIMARRON	C
CINCINNATI	C
CINCO	A
CINDERCONE	B
CINEBAR	B
CINTRONA	D
CIPRIANO	D
CIRCLE	C
CIRCLEVILLE	C
CISNE	D
CISPUS	A
CITICO	B
CLACKAMAS	C
CLAIBORNE	B
CLAIRE	A
CLAIREMONT	B
CLALLAM	C
CLAM GULCH	D
CLAMO	C
CLANTON	C
CLAPPER	B
CLAREMORE	D
CLARENCE	D
CLARESON	C
CLAREVILLE	C
CLARINDA	D
CLARION	B
CLARITA	D
CLARK	B
CLARK FORK	A
CLARKSBURG	C
CLARKSDALE	C
CLARKSON	B
CLARKSVILLE	B
CLARNO	B
CLARY	B
CLATO	B
CLATSOP	D
CLAVERACK	C
CLAWSON	C
CLAYBURN	B
CLAYSPRINGS	D
CLAYTON	B
CLEARFIELD	C
CLEAR LAKE	D
CLEEK	C
CLE ELUM	B
CLEGG	B
CLEMAN	B
CLEMS	B
CLEMVILLE	B
CLEORA	B
CLERF	C
CLERMONT	D
CLEVERLY	B
CLICK	A
CLIFFDOWN	B
CLIFFHOUSE	C
CLIFFORD	B
CLIFFWOOD	C
CLIFTERSON	B
CLIFTON	C
CLIFTY	B
CLIMARA	D
CLIMAX	D
CLIME	C
CLINTON	B
CLIPPER	B/C
CLODINE	D
CLONTARF	B
CLOQUALLUM	C
CLOQUATO	B
CLOQUET	B
CLOUD	D
CLOUDCROFT	D
CLOUD PEAK	C
CLOUD RIM	B
CLOUGH	D
CLOVERDALE	D
CLOVER SPRINGS	B
CLOVIS	B
CLUFF	C
CLUNIE	D
CLURDE	C
CLURO	C
CLYDE	D
CLYMER	B
COACHELLA	B
COAD	B
COAL CREEK	D
COALMONT	C
COAMO	C
COARSEGOLD	B/C
COATICOOK	C
COATSBURG	D
COBB	B
COBEN	D
COBEY	B
COBURG	C
COCHETOPA	C
COCOA	A
COCOLALLA	C
CODORUS	C
CODY	A
COE	A
COEBURN	C
COEROCK	D
COFF	D
COFFEEK	B
COGGON	B
COGSWELL	C
COHASSET	B
COHOCTAH	D
COHOE	B
COIT	C
COKEDALE	B/C
COKEL	B
COKER	D
COKESBURY	D
COKEVILLE	B
COLBATH	C/D
COLBERT	D
COLBURN	B
COLBY	B
COLCHESTER	B
COLDCREEK	B
COLDEN	D
COLD SPRINGS	C
COLE	B/C
COLEBROOK	B
COLEMAN	C
COLEMANTOWN	D
COLETO	A
COLFAX	C
COLIBRO	B
COLINAS	B
COLLAMER	C
COLLARD	B
COLLBRAN	C
COLLEEN	C
COLLEGIATE	C
COLLETT	C
COLLIER	A
COLLINGTON	B
COLLINS	C
COLLINSTON	C
COLLINSVILLE	C
COLMA	B
COLMOR	B
COLO	B
COLOCKUM	B
COLOMA	A
COLOMBO	B
COLONA	C
COLONIE	A
COLORADO	B
COLOROCK	D
COLOSO	D
COLOSSE	A
COLP	D
COLRAIN	B
COLTON	A
COLTS NECK	B
COLUMBIA	B
COLUMBINE	A
COLUSA	C
COLVILLE	B/C
COLVIN	C
COLWOOD	B/D
COLY	B
COLYER	C/D
COMER	B
COMERIO	B
COMETA	D
COMFREY	C
COMITAS	A
COMLY	C
COMMERCE	C
COMO	A
COMODORE	B
COMORO	B
COMPTCHE	B
COMPTON	C
COMSTOCK	C
COMUS	B
CONALB	B
CONANT	C
CONASAUGA	C
CONATA	D
CONBOY	D
CONCHAS	C
CONCHO	C
CONCONULLY	B
CONCORD	D
CONCREEK	B
CONDA	C
CONDIT	D
CONDON	C
CONE	A
CONEJO	C
CONESTOGA	B
CONESUS	B
CONGAREE	B
CONGER	B
CONI	D
CONKLIN	B
CONLEN	B

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

CONLEY	C	COURT	B	CROWLEY	D	DANSKIN	B	DELLROSE	B
CONNEAUT	C	COURTHOUSE	D	CROWN	B	DANT	D	DELM	D
CONNECTICUT		COURTLAND	B	CROWSHAW	B	DANVERS	C	DELMAR	D
CONNERTON	B	COURTNEY	D	CROZIER	C	DANVILLE	C	DELMITA	C
CONOTTON	B	COURTROCK	B	CRUCES	D	DANZ	B	DELMONT	B
CONOVER	B	COUSE	C	CRUCKTON	B	DARCO	A	DELNORTE	C
CONOWINGO	C	COUSHATTA	B	CRUICKSHANK	C	DARGOL	D	DELPHI	B
CONRAD	B	COVE	D	CRUME	B	DARIEN	C	DELPHILL	C
CONROE	B	COVEILO	B	CRUMP	D	DARLING	B	DELPIEDRA	C
CONSER	C/D	COVELAND	C	CRUTCH	B	DARNELL	C	DELPINE	D
CONSTABLE	A	COVELLO	B/C	CRUTCHER	D	DARNEN	B	DELRAY	A/D
CONSTANCIA	D	COVENTRY	B	CRUZE	C	DARR	A	DEL REY	C
CONSUMO	B	COVEYTOWN	C	CRYSTAL LAKE	B	DARRET	C	DEL RIO	B
CONTEE	D	COVINGTON	D	CRYSTAL SPRINGS	D	DARROCH	C	DELSON	C
CONTINE	C	COWAN	A	CRYSTOLA	B	DARROUZETT	C	DELTA	C
CONTINENTAL	C	COWARTS	C	CUBA	B	DART	A	DELTON	B
CONTRA COSTA	C	COWDEN	D	CUBERANT	B	DARVADA	D	DELWIN	A
CONVENT	C	COWDREY	C	CUCHILLAS	D	DARWIN	D	DELYNDIA	A
COOK	D	COWEEMAN	D	CUDAHY	D	DASSEL	D	DEMAST	B
COOKPORT	C	COWERS	B	CUERO	B	DAST	C	DE MASTERS	B
COOLBRITH	B	COWETA	C	CUEVA	D	DATEMAN	C	DE MAYA	C
COOLIDGE	B	COWICHE	B	CUEVITAS	D	DATINO	C	DEMERS	D
COOLVILLE	C	COWOOD	C	CULBERTSON	B	DATWYLER	C	DEMKY	D
COOMBS	B	COX	D	CULLEN	C	DAULTON	D	DEMONA	C
COONEY	B	COXVILLE	D	CULLEOKA	B	DAUPHIN		DEMOPOLIS	C
COOPER	C	COY	D	CULLO	C	DAVEY	A	DEMPSEY	B
COOTER	C	COYATA	C	CULPEPER	C	DAVIDSON	B	DEMPSTER	B
COPAKE	B	COZAD	B	CULVERS	C	DAVIS	B	DENAY	B
COPALIS	B	CRABTON	B	CUMBERLAND	B	DAVISON	B	DENHAWKEN	D
COPELAND	B/D	CRADDOCK	B	CUMLEY	C	DAVTONE	B	DENISON	C
COPITA	B	CRADLEBAUGH	D	CUMMINGS	B/D	DAWES	C	DENMARK	D
COPLAY		CRAFTON	C	CUNDIYO	B	DAWHOO	B/D	DENNIS	C
COPPER RIVER	D	CRAGO	B	CUNICO	C	DAWSON	D	DENNY	D
COPPERTON	B	CRAGOLA	D	CUPPER	B	DAXTY	C	DENROCK	D
COPPOCK	B	CRAIG	C	CURANT	B	DAY	D	DENTON	D
COPSEY	D	CRAIGMONT	C	CURDLI	C	DAYBELL	A	DENVER	C
COQUILLE	C/D	CRAIGSVILLE	A	CURECANTI	B	DAYTON	D	DEODAR	D
CORA	D	CRAMER	D	CURHOLLOW	D	DAYVILLE	B/C	DEPEW	C
CORAL	C	CRANE	B	CURLEW	C	DAZE	D	DEPOE	D
CORBETT	B	CRANSTON	B	CURRAN	C	DEACON	B	DEPORT	D
CORBIN	B	CRARY	C	CURTIS CREEK	D	DEADFALL	B	DERA	B
CORCEGA	C	CRATER LAKE	B	CURTIS SIDING	A	DEAMA	C	DERINDA	C
CORD	C	CRAVEN	C	CUSHING	B	DEAN	C	DERR	C
CORDES	B	CRAWFORD	D	CUSHMAN	C	DEAN LAKE	C	DERRICK	B
CORDOVA	C	CREAL	D	CUSTER	C	DEARDURFF	B	DESAN	A
CORINTH	C	CREBBIN	C	CUTTER	D	DEARY	C	DESART	C
CORKINDALE	B	CREDO	C	CUTZ	D	DEARYTON	B	DESCALABRADO	D
CORLENA	A	CREEDMAN	D	CUYAMA	B	DEATMAN	C	DESCHUTES	C
CORLETT	B	CREEDMOOR	C	CUYON	A	DEAVER	C	DESERET	C
CORLEY	C	CREIGHTON	B	CYAN	D	DEBENGER	C	DESERTER	B
CORMANT	C	CRELDON	B	CYLINDER	B	DEBORAH	D	DESHA	D
CORNHILL	B	CRESBARD	C	CYNTHIANA	C/D	DECAN	D	DESHLER	C
CORNING	D	CRESCENT	B	CYPREMORT	C	DECATHON	D	DESOLATION	C
CORNISH	B	CRESCO	C	CYRIL	B	DECATUR	B	DESPAIN	B
CORNUTT	C	CRESPIN	C			DECCA	B	DETER	C
CORNVILLE	B	CREST	C	DABOB	B	DECKER	C	DETLOR	C
COROZAL	C	CRESTLINE	B	DACONO	C	DECKERVILLE	C	DETOUR	C
CORPENING	D	CRESTMORE		DACOSTA	D	DECLO	B	DETRA	B
CORRALITOS	A	CRESTON	A	DADE	A	DECORRA	B	DETROIT	C
CORRECO	C	CRESWELL	C	DAFTER	B	DECROSS	B	DEV	B
CORRERA	D	CRETE	D	DAGFLAT	C	DEE	C	DEVILS DIVE	D
CORSON	C	CREVA	D	DAGGETT	A	DEEPWATER	C	DEVOE	D
CORTADA	B	CREVASSE	A	DAGLUM	D	DEER CREEK	C	DEVOIGNES	C/D
CORTEZ	D	CREWS	D	DAGOR	B	DEERFIELD	B	DEVOL	B
CORTINA	A	CRIDER	B	DAGUAO	C	DEERFORD	D	DEVON	B
CORUNNA	D	CRIM	B	DAGUEY	C	DEERING	B	DEVORE	B
CORVALLIS	B	CRISFIELD	B	DAHLQUIST	B	DEERLODGE	D	DEVOY	D
CORWIN	B	CRITCHELL	B	DAIGLE	C	DEER PARK	A	DEWART	
CORY	C	CRIVITZ	A	DAILEY	A	DEERTON	B	DEWEY	B
CORYDON	C	CROCKER	A	DAKOTA	B	DEERTRAIL	C	DEWVILLE	B
COSAD	C	CROCKETT	D	DALBO	B	DEFIANCE	D	DEXTER	B
COSH	C	CROESUS	C	DALBY	D	DEFORD	D	DIA	C
COSHOCTON	C	CROFTON	B	DALCAN	C	DEGARMO	B/C	DIABLO	D
COSKI	B	CROGHAN	B	DALE	B	DEGNER	C	DIAMOND	D
COSSAYUNA	C	CROOKED	C	DALHART	B	DE GREY	D	DIAMOND SPRINGS	C
COSTILLA	A	CROOKED CREEK	D	DALIAN	B	DEJARNET	B	DIAMONDVILLE	C
COTACO	C	CROOKSTON	B	DALLAM	B	DEKALB	C	DIANEV	C
COTATI	C	CROOM	B	DALTON	C	DEKOVEN	D	DIANOLA	D
COTITO	C	CROPLEY	D	DALUPE	B	DELA	B	DIAZ	C
COTO	C	CROSBY	C	DAMASCUS	D	DELAKE	B	DIBBLE	C
COTOPAXI	A	CROSS	D	DAMON	D	DELANCO	C	DICK	A
COTT	B	CROSSVILLE	B	DANA	B	DELANEY	A	DICKEY	A
COTTER	B	CROSWELL	A	DANBURY	C	DELANO	B/C	DICKINSON	A
COTTERAL	B	CROT	D	DANBY		DELECO	D	DICKSON	C
COTTIER	B	CROTON	D	DANDREA	C	DELENA	D	DIGBY	C
COTTONWOOD	C	CROUCH	B	DANDRIDGE	D	DELFINA	B	DIGGER	C
COTTRELL	C	CROW	C	DANGBERG	D	DELHI	A	DIGHTON	B
COUCH	C	CROW CREEK	B	DANIC	C	DELICIAS	B	DILL	B
COUGAR	D	CROWFOOT	B	DANIELS	B	DELKS	B/D	DILLARD	C
COULSTONE	B	CROWHEART	D	DANKO	D	DELL	C	DILLDOWN	
COUNTS	C	CROW HEART	D	DANLEY	C	DELLEKER	B	DILLINGER	B
COUPEVILLE	C	CROW HILL	C	DANNEMORA	D	DELLO	A/C	DILLON	D

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

DILLWYN	A	DOUGHTY	A	DU PAGE	B	EGBERT	B/C	EMILY	B
DILMAN	C	DOUGLAS	B	DUPEE	C	EGELAND	B	EMLIN	B
DILTS	D	DOURO	B	DUPLIN	C	EGGLESTON	B	EMMA	C
DILWORTH	D	DOVER	B	DUPO	C	EGNAR	C	EMMERT	A
DIMAL	D	DOVRAY	D	DUPONT	D	EICKS	C	EMMET	B
DIMYAW	C	DOW	B	DUPREE	D	EIFORT	C	EMMONS	C
DINGLE	B	DOWAGIAC	B	DURALDE	C	EKAH	C	EMORY	B
DINGLISHNA	D	DOWDEN	C	DURAND	B	EKALAKA	B	EMPEDRADO	C
DINKELMAN	B	DOWELLTON	D	DURANT	D	ELAM	A	EMPEY	B
DINKEY	A	DOWNER	B	DURELLE	B	ELBERT	D	EMPEYVILLE	C
DINNEN	B	DOWNEY	B	DURHAM	B	ELBURN	B	EMPIRE	C
DINSDALE	B	DOWNS	B	DURKEE	C	ELCO	B	EMRICK	B
DINUBA	B/C	DOXIE	C	DUROC	B	ELD	B	ENCE	B
DINZER	B	DOYCE	C	DURRSTEIN	D	ELDER	B	ENCIERRO	D
DIOXICE	B	DOYLE	A	DUSTON	B	ELDER HOLLOW	D	ENCINA	B
DIPMAN	D	DOYLESTOWN	D	DUTCHESS	B	ELDERON	B	ENDERS	C
DIQUE	B	DOYN	C	DUTSON	D	ELDON	B	ENDERSBY	B
DISABEL	D	DRA	C	DUTTON	D	ELDORADO	C	ENDICOTT	C
DISAUTEL	B	DRACUT	C	DUVAL	B	ELDRIDGE	C	ENET	B
DISCO	B	DRAGE	B	DUZEL	B	ELEPHANT	D	ENFIELD	B
DISHNER	D	DRAGOON	B	DWIGHT	D	ELEROY	B	ENGLE	B
DISTERHEFF	C	DRAGSTON	C	DWYER	A	ELFRIDA	B	ENGLESIDE	B
DITCHCAMP	C	DRAHAT	D	DYE	D	ELIJAH	C	ENGLEWOOD	C
DITHOD	C	DRAIN	D	DYER		ELIOAK	C	ENGLUND	D
DIVERS	B	DRAKE	B	DYKE	B	ELK	B	ENNIS	B
DIVIDE	B	DRANYON	B	DYRENG	D	ELKADER	B	ENOCHVILLE	B/D
DIX	A	DRAPER	C			ELKCREEK	C	ENOLA	B
DIXIE	C	DRESDEN	B	EACHUSTON	D	ELK HOLLOW	B	ENON	C
DIXMONT	C	DRESSLER	C	EAD	C	ELKHORN	B	ENOREE	D
DIXMORE	B	DREWS	B	EAGAR	B	ELKINS	D	ENOS	B
DIXONVILLE	C	DREXEL	B	EAGLECONE	B	ELKINSVILLE	B	ENOSBURG	D
DIXVILLE	A	DRIFTON	C	EAKIN	B	ELKMOUND	C	ENSENADA	B
DOAK	B	DRIGGS	B	EAMES	B	ELK MOUNTAIN	B	ENSIGN	D
DOBBS	C	DRUM	C	EARLE	D	ELKOL	D	ENSLEY	D
DOBEL	D	DRUMMER	B	EARLMONT	B/C	ELKTON	D	ENSTROM	B
DOBROW	D	DRUMMOND	D	EARP	B	ELLABELLE	B/D	ENTENTE	B
DOBY	D	DRURY	B	EASLEY	D	ELLEDGE	C	ENTERPRISE	B
DOCAS	B	DRYAD	C	EAST FORK	C	ELLERY	D	ENTIAT	D
DOCKERY	C	DRYBURG	B	EAST LAKE	A	ELLETT	D	ENUMCLAW	C
DOCT	B	DRY CREEK	C	EASTLAND	C	ELLIBER	A	EPHRAIM	C
DODGE	B	DRYDEN	B	EASTON	C	ELLICOTT	A	EPHRATA	B
DODGEVILLE	B	DRY LAKE	C	EASTONVILLE	A	ELLINGTON	B	EPLEY	B
DODSON	C	DUANE	B	EAST PARK	D	ELLINOR	C	EPOUFETTE	D
DOGER	A	DUART	C	EASTPORT	A	ELLIOTT	C	EPPING	D
DOGUE	C	DUBAKELLA	C	EATONTOWN		ELLIS	D	EPSIE	D
DOLAND	B	DUBAY	D	EAUGALLIE	B/D	ELLISFORDE	C	ERA	B
DOLE	C	DUBBS	B	EBA	C	ELLISON	B	ERAM	C
DOLLAR	B	DUBOIS	C	EBBERT	D	ELLOAM	D	ERBER	C
DOLLARD	C	DUBUQUE	B	EBBS	B	ELLSBERRY	C	ERIC	B
DOLORES	B	DUCEY	B	EBENEZER	C	ELLSWORTH	C	ERIE	C
DOLPH	C	DUCHESNE	B	ECCLES	B	ELLUM	C	ERIN	B
DOMEZ	C	DUCKETT	C	ECHARD	C	ELMA	B	ERNEST	C
DOMINGO	C	DUCOR	D	ECHLER	B	ELMDALE	B	ERNO	B
DOMINGUEZ	C	DUDA	A	ECKERT	D	ELMENDORF	D	ERRAMOUSPE	C
DOMINIC	A	DUDLEY	D	ECKLEY	B	ELMIRA	A	ESCABOSA	C
DOMINO	C	DUEL	B	ECKMAN	B	ELMO	C	ESCAL	B
DOMINSON	A	DUELM	C	ECKRANT	D	ELMONT	B	ESCALANTE	B
DONA ANA	B	DUFFAU	B	ECTOR	D	ELMORE	B	ESCAMBIA	C
DONAHUE	C	DUFFER	D	EDALGO	C	ELMWOOD	C	ESCONDIDO	C
DONALD	B	DUFFIELD	B	EDDS	B	ELNORA	B	ESMOND	B
DONAVAN	B	DUFFSON	B	EDDY	C	ELOIKA	B	ESPARTO	B
DONEGAL		DUFFY	B	EDEN	C	ELPAN	D	ESPIL	D
DONERAIL	C	DUFUR	B	EDENTON	C	EL PECO	C	ESPINAL	A
DONEY	C	DUGGINS	D	EDENVALE	D	EL RANCHO	B	ESPLIN	D
DONICA	A	DUGOUT	D	EDGAR	B	ELRED	B/D	ESPY	C
DONLONTON	C	DUGWAY	D	EDGECUMBE	B	ELROSE	B	ESQUATZEL	B
DONNA	D	DUKES	A	EDGELEY	C	ELS	A	ESS	B
DONNAN	C	DULAC	C	EDGEMONT	B	ELSAH	B	ESSEN	C
DONNARDO	B	DUMAS	B	EDGEWATER	C	ELSINBORO	B	ESSEX	C
DONNYBROOK	D	DUMECQ	C	EDGEWICK	B	ELSINORE	A	ESSEXVILLE	D
DONOVAN	B	DUMONT	B	EDGEWOOD	A	ELSMERE	A	ESTACADO	B
DOOLEY	A	DUNBAR	D	EDGINGTON	C	ELSO	D	ESTELLINE	B
DOONE	B	DUNBARTON	C	EDINA	D	EL SOLYO	C	ESTER	D
DOOR	B	DUNBRIDGE	B	EDINBURG	C	ELSTON	B	ESTERBROOK	B
DORA	D	DUNCAN	D	EDISON	B	ELTOPIA	B	ESTHERVILLE	B
DORAN	C	DUNCANNON	B	EDISTO	C	ELTREE	B	ESTIVE	C
DORCHESTER	B	DUNCOM	D	EDITH	A	ELTSAC	D	ESTO	B
DOROSHIN	D	DUNDAS	C	EDLOE	B	ELWHA	B	ESTRELLA	B
DOROTHEA	C	DUNDAY	A	EDMONDS	D	ELWOOD	C	ETHAN	B
DOROVAN	D	DUNDEE	C	EDMORE	D	ELY	B	ETHETE	B
DORS	B	DUNELLEN	B	EDMUND	C	ELYSIAN	B	ETHRIDGE	C
DORSET	B	DUNE SAND	A	EDNA	D	ELZINGA	B	ETIL	A
DOS CABEZAS	C	DUNGENESS	B	EDNEYVILLE	B	EMBDEN	B	ETNA	
DOSS	C	DUN GLEN	C	EDOM	C	EMBRY	B	ETOE	B
DOSSMAN	B	DUNKINSVILLE	B	EDROY	D	EMBUDO	B	ETOWAH	B
DOTEN	D	DUNKIRK	B	EDSON	C	EMDENT	C	ETOWN	B
DOTHAN	B	DUNLAP	B	EDWARDS	B/D	EMER	C	ETSEL	D
DOTTA	B	DUNMORE	B	EEL	C	EMERALD	B	ETTA	C
DOTY	B	DUNNING	D	EFFINGTON	D	EMERSON	B	ETTER	B
DOUBLETOP	B	DUNPHY	D	EFWUN	A	EMIDA	D	ETTERSBURG	B
DOUDS	B	DUNUL	A	EGAM	C	EMIGRANT	B	ETTRICK	D
DOUGHERTY	A	DUNVILLE	B	EGAN	B	EMIGRATION	D	EUBANKS	B

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

EUDORA	B
EUFAULA	A
EUREKA	D
EUSTIS	A
EUTAW	D
EVANGELINE	C
EVANS	B
EVANSTON	B
EVARO	A
EVART	D
EVENDALE	C
EVERETT	B
EVERGLADES	A/D
EVERLY	B
EVERMAN	C
EVERSON	D
EVESBORO	A
EWA	B
EWAIL	A
EWALL	A
EWINGSVILLE	B
EXCELSIOR	B
EXCHEQUER	D
EXETER	C/D
EXLINE	D
EXRAY	D
EXUM	C
EYERBOW	D
EYRE	B
FABIUS	B
FACEVILLE	B
FAHEY	B
FAIM	C
FAINES	A
FAIRBANKS	B
FAIRDALE	B
FAIRFAX	B
FAIRFIELD	B
FAIRHAVEN	B
FAIRMOUNT	D
FAIRPORT	C
FAIRYDELL	C
FAJARDO	C
FALAYA	C
FALCON	D
FALFA	C
FALFURRIAS	A
FALK	B
FALKNER	C
FALL	B
FALLBROOK	B/C
FALLON	C
FALLSBURG	C
FALLSINGTON	D
FANCHER	C
FANG	B
FANNIN	B
FANNO	C
FANU	C
FARADAY	B
FARALLONE	B
FARAWAY	D
FARB	D
FARGO	D
FARISITA	C
FARLAND	B
FARMINGTON	C/D
FARNHAN	B
FARNHANTON	B/C
FARNUF	B
FARNUM	B
FARRAGUT	C
FARRAR	B
FARRELL	B
FARRENBURG	B
FARROT	C
FARSON	B
FARWELL	C
FASKIN	B
FATIMA	B
FATTIG	C
FAUNCE	A
FAUQUIER	C
FAUSSE	D
FAWCETT	C
FAWN	B
FAXON	D
FAYAL	C
FAYETTE	B
FAYETTEVILLE	B
FAYWOOD	C
FE	D
FEDORA	B
FELAN	A
FELDA	B/D
FELIDA	B
FELKER	D
FELLOWSHIP	D
FELT	B
FELTA	C
FELTHAM	A
FELTON	B
FELTONIA	B
FENCE	B
FENDALL	C
FENWOOD	B
FERA	C
FERDELFORD	C
FERDIG	C
FERDINAND	C
FERGUS	B
FERGUSON	B
FERNANDO	B
FERN CLIFF	B
FERNDALE	B
FERNLEY	C
FERNOW	B
FERNPOINT	C
FERRELO	B
FERRIS	D
FERRON	D
FERTALINE	D
FESTINA	B
FETT	D
FETTIC	D
FIANDER	C
FIBEA	D
FIDALGO	C
FIDDLETOWN	C
FIDDYMENT	C
FIELDING	B
FIELDON	B
FIELDSON	A
FIFE	B
FIFER	D
FILLMORE	D
FINCASTLE	C
FINGAL	C
FINLEY	B
FIRESTEEL	B
FIRGRELL	B
FIRMAGE	B
FIRO	D
FIRTH	B/C
FISH CREEK	B
FISHERS	B
FISHHOOK	D
FISHKILL	
FITCH	A
FITCHVILLE	C
FITZGERALD	B
FITZHUGH	B
FIVE DOT	B
FIVEMILE	B
FIVES	B
FLAGG	B
FLAGSTAFF	C
FLAK	B
FLAMING	B
FLAMINGO	D
FLANAGAN	B
FLANDREAU	B
FLASHER	A
FLATHEAD	A
FLAT HORN	B
FLATTOP	D
FLATWILLOW	B
FLAXTON	A
FLEAK	A
FLECHADO	B
FLEER	D
FLEETWOOD	
FLEISCHMANN	D
FLEMING	C
FLETCHER	B
FLOKE	D
FLOM	C
FLOMATION	A
FLOMOT	B
FLORENCE	C
FLORESVILLE	C
FLORIDANA	B/D
FLORISSANT	C
FLOWELL	C
FLOWEREE	B
FLOYD	B
FLUETSCH	C
FLUSHING	
FLUVANNA	C
FLYGARE	B
FLYNN	D
FOARD	D
FOGELSVILLE	B
FOLA	B
FOLEY	D
FONDA	D
FONDIS	C
FONTAL	D
FONTREEN	B
FOPIANO	D
FORBES	B
FORD	D
FORDNEY	A
FORDTRAN	C
FORDVILLE	B
FORE	D
FORELAND	D
FORELLE	B
FORESMAN	B
FORESTDALE	D
FORESTER	C
FORESTON	C
FORGAY	A
FORMAN	B
FORNEY	D
FORREST	C
FORSEY	C
FORSGREN	C
FORT COLLINS	B
FORT DRUM	C
FORT LYON	B
FORT MEADE	A
FORT MOTT	A
FORT PIERCE	C
FORT ROCK	C
FORTUNA	D
FORTWINGATE	C
FORWARD	C
FOSHOME	B
FOSSUM	B
FOSTER	B/C
FOSTORIA	B
FOUNTAIN	D
FOURLOG	D
FOURMILE	B
FOUR STAR	B/C
FOUTS	B
FOX	B
FOXCREEK	B/D
FOXMOUNT	C
FOXOL	D
FOXPARK	D
FOX PARK	D
FOXTON	C
FRAILEY	B
FRAM	B
FRANCIS	A
FRANCITAS	D
FRANK	D
FRANKFORT	D
FRANKIRK	C
FRANKLIN	B
FRANKSTOWN	B
FRANKTOWN	D
FRANKVILLE	B
FRATERNIDAD	D
FRAZER	C
FRED	C
FREDENSBORG	C
FREDERICK	B
FREDON	C
FREDONIA	C
FREDRICKSON	C
FREEBURG	C
FREECE	D
FREEDOM	C
FREEHOLD	B
FREEL	B
FREEMAN	C
FREEMANVILLE	B
FREEON	B
FREER	C
FREESTONE	C
FREEZENER	C
FREMONT	C
FRENCH	C
FRENCHTOWN	D
FRENEAU	C
FRESNO	C/D
FRIANA	D
FRIANT	D
FRIDLO	C
FRIEDMAN	B
FRIENDS	D
FRIES	D
FRINDLE	B
FRIO	B
FRIZZELL	C
FROBERG	D
FROHMAN	C
FRONDORF	C
FRONHOFER	C
FRONTON	D
FROST	D
FRUITA	B
FRUITLAND	B
FRYE	C
FUEGO	C
FUERA	C
FUGAWEE	B
FULCHER	C
FULDA	C
FULLERTON	B
FULMER	B/D
FULSHEAR	C
FULTON	D
FUQUAY	B
FURNISS	B/D
FURY	B/D
FUSULINA	C
GAASTRA	C
GABALDON	B
GABBS	D
GABEL	C
GABICA	D
GACEY	D
GACHADO	D
GADDES	C
GADES	G
GADSDEN	D
GAGE	
GAGEBY	B
GAGETOWN	C
GAHEE	B
GAINES	C
GAINESVILLE	A
GALATA	D
GALE	B
GALEN	B
GALENA	C
GALEPPI	C
GALESTOWN	A
GALETON	D
GALEY	B
GALISTEO	C
GALLAGHER	B
GALLATIN	A
GALLEGOS	B
GALLINA	C
GALLION	B
GALVA	B
GALVESTON	A
GALVEZ	C
GALVIN	C
GALWAY	B
GAMBLER	A
GAMBOA	B
GANNETT	D
GANSNER	D
GAPO	D
GAPPMAYER	B
GARA	B
GARBER	A
GARBUTT	B
GARCENO	C
GARDELLA	D
GARDENA	B
GARDINER	A
GARDNER'S FORK	B
GARDNERVILLE	D
GARDONE	A
GAREY	C
GARFIELD	C
GARITA	C
GARLAND	B
GARLET	A
GARLOCK	C
GARMON	C
GARMORE	B
GARNER	D
GARO	D
GARR	D
GARRARD	B
GARRETSON	B
GARRETT	B
GARRISON	B
GARTON	C
GARWIN	C
GASCONADE	D
GAS CREEK	C
GASKELL	C
GASS	D
GASSET	D
GATESBURG	A
GATESON	C
GATEVIEW	B
GATEWAY	C
GATEWOOD	D
GAULDY	B
GAVINS	C
GAVIOTA	D
GAY	D
GAYLORD	B
GAYNOR	C
GAYVILLE	B
GAZELLE	D
GAZOS	B
GEARHART	A
GEARY	B
GEE	B
GEEBURG	C
GEER	C
GEFO	A
GELKIE	B
GEM	C
GEMID	C
GEMSON	C
GENESEE	B
GENEVA	C
GENOA	D
GENOLA	B
GEORGEVILLE	B
GEORGIA	B
GERALD	D
GERBER	D
GERIG	B
GERING	B
GERLAND	C
GERMANIA	
GERMANY	B
GERRARD	D
GESTRIN	B
GETTA	C
GETTYS	C
GEYSEN	D
GHENT	C
GIBBLER	C
GIBBON	B
GIBBS	D
GIBBSTOWN	A
GIFFIN	C
GIFFORD	C
GILA	B
GILBY	B
GILCHRIST	B
GILCREST	B
GILEAD	C
GILES	B
GILFORD	B/D
GILHOULY	B
GILISPIE	C
GILLIAM	C
GILLIGAN	B
GILLS	C
GILLSBURG	C
GILMAN	B
GILMORE	C
GILPIN	C
GILROY	C
GILSON	B
GILT EDGE	D
GINAT	D
GINGER	C
GINI	B
GINSER	C
GIRARDOT	D
GIRD	A
GIVEN	C

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

GLADDEN	A	GOTHARD	D	GROWDEN	B	HAMBRIGHT	D	HASTINGS	B
GLADE PARK	C	GOTHIC	C	GROWLER	B	HAMBURG	B	HAT	D
GLADSTONE	B	GOTHO	C	GRUBBS	D	HAMBY	C	HATBORO	D
GLADWIN	A	GOULDING	D	GRULLA	D	HAMEL	C	HATCH	C
GLAMIS	C	GOVAN	C	GRUMMIT	D	HAMERLY	C	HATCHERY	C
GLANN	B/C	GOVE	B	GRUNDY	C	HAMILTON	A	HATFIELD	C
GLASGOW	C	GOWEN	B	GRUVER	C	HAMLET	B	HATHAWAY	B
GLEAN	B	GRABE	B	GRYGLA	C	HAMLIN	B	HATTIE	C
GLEASON	C	GRABLE	B	GUADALUPE	B	HAMMONTON	C	HATTON	C
GLEN	B	GRACEMONT	B	GUAJE	A	HAMPDEN		HAUBSTADT	C
GLENBAR	B	GRACEVILLE	B	GUALALA	D	HAMPSHIRE	C	HAUGAN	B
GLENBERG	B	GRADY	D	GUAMANI	B	HAMPTON	C	HAUSER	D
GLENBROOK	D	GRAFEN	B	GUANABANO	B	HAMTAH	C	HAVANA	B
GLENCOE	D	GRAFTON	B	GUANAJIBO	C	HANA	A	HAVEN	B
GLENDALE	B	GRAHAM	D	GUANICA	D	HANALEI	C	HAVERLY	B
GLENDIVE	B	GRAIL	C	GUAYABO	B	HANAMAULU	A	HAVERSON	B
GLENDORA	D	GRAMM	B	GUAYABOTA	D	HANCEVILLE	B	HAVILLAH	C
GLENELG	B	GRANATH	B	GUAYAMA	D	HANCO	D	HAVINGDON	D
GLENFIELD	D	GRANBY	A/D	GUBEN	B	HAND	B	HAVRE	B
GLENFORD	C	GRANDE RONDE	D	GUCKEEN	C	HANDRAN	C	HAVRELON	B
GLENHALL	B	GRANDFIELD	B	GUELPH	B	HANDSBORO	D	HAW	B
GLENHAM	B	GRANDVIEW	C	GUENOC	C	HANDY	D	HAWES	A
GLENMORA	C	GRANER	C	GUERNSEY	C	HANEY	B	HAWI	B
GLENNALLEN	C	GRANGER	C	GUERRERO	C	HANFORD	B	HAWKEYE	A
GLENOMA	B	GRANGEVILLE	B/C	GUEST	D	HANGAARD	C	HAWKSELL	A
GLENROSE	B	GRANILE	B	GUIN	A	HANGER	B	HAWKSPRINGS	B
GLENSTED	D	GRANO	D	GULER	B	HANIPOE	B	HAXTUN	A
GLENTON	B	GRANT	B	GULKANA	B	HANKINS	C	HAYBOURNE	B
GLENVIEW	B	GRANTSBURG	C	GUMBOOT	C	HANKS	B	HAYBRO	C
GLENVILLE	C	GRANTSDALE	A	GUNBARREL	A	HANLY	A	HAYDEN	B
GLIDE	B	GRANVILLE	B	GUNN	B	HANNA	B	HAYESTON	B
GLIKON	B	GRAPEVINE	C	GUNNUK	C	HANNUM	D	HAYESVILLE	B
GLORIA	C	GRASMERE	B	GUNSIGHT	B	HANOVER	C	HAYFIELD	B
GLOUCESTER	A	GRASSNA	B	GUNTER	A	HANS	C	HAYFORD	C
GLOVER	C/D	GRASSY BUTTE	A	GURABO	D	HANSEL	C	HAYMOND	B
GLYNDON	B	GRATZ	C	GURNEY	C	HANSKA	C	HAYNESS	B
GLYNN	C	GRAVDEN	C	GUSTAVUS	D	HANSON	A	HAYNIE	B
GOBLE	C	GRAVE	B	GUSTIN	C	HANTHO	B	HAYPRESS	A
GODDARD	B	GRAVITY	C	GUTHRIE	D	HANTZ	D	HAYSPUR	B/D
GODDE	D	GRAYCALM	A	GUYTON	D	HAP	B	HAYTER	B
GODECKE	D	GRAYFORD	B	GWIN	D	HAPGOOD	B	HAYTI	D
GODFREY	C	GRAYLING	A	GWINNETT	B	HAPNEY	C	HAYWOOD	B
GODWIN	D	GRAYLOCK	B	GYMER	C	HARBORD	B	HAZEL	C
GOEGLEIN	C	GRAYPOINT	B	GYPSTRUM	B	HARBOURTON		HAZELAIR	D
GOESSEL	D	GRAYS	B			HARCO	B	HAZEN	B
GOFF	C	GREAT BEND	B	HACCKE	C	HARDEMAN	B	HAZLEHURST	C
GOGEBIC	B	GREELEY	B	HACIENDA	D	HARDESTY	B	HAZLETON	B
GOLBIN	C	GREEN BLUFF	B	HACK	B	HARDING	D	HAZTON	D
GOLCONDA	D	GREENBRAE	C	HACKERS	B	HARDSCRABBLE	B	HEADLEY	B
GOLD CREEK	D	GREEN CANYON	B	HACKETTSTOWN	B	HARDY	D	HEADQUARTERS	B
GOLDENDALE	B	GREENCREEK	B	HADAR	A	HARGREAVE	B	HEAKE	D
GOLDFIELD	B	GREENDALE	B	HADES	C	HARKERS	C	HEATH	C
GOLDHILL	B	GREENFIELD	B	HADLEY	B	HARKEY	B	HEATLY	A
GOLDMAN	C	GREENHORN	D	HADO	B	HARLAN	B	HEBBRONVILLE	B
GOLDRIDGE	B	GREENLEAF	B	HAGEN	B	HARLEM	C	HEBER	B
GOLDRUN	A	GREENOUGH	C	HAGENBARTH	B	HARLESTON	C	HEBERT	C
GOLDSBORO	C	GREENPORT		HAGENER	A	HARLINGEN	D	HEBGEN	A
GOLDSTON	C	GREEN RIVER	B	HAGER	C	HARMEHL	C	HEBO	D
GOLDSTREAM	D	GREENSBORO		HAGERMAN	C	HARMONY	C	HEBRON	C
GOLDVALE	C	GREENSON	C	HAGERSTOWN	C	HARNEY	C	HECHT	C
GOLDVEIN	C	GREENTON	C	HAGGA	B	HARPER	D	HECKI	C
GOLIAD	C	GREENVILLE	B	HAGGERTY	B	HARPETH	B	HECLA	B
GOLLAHER	A	GREENWATER	A	HAGSTADT	C	HARPS	B	HECTOR	D
GOLTRY	A	GREENWICH	B	HAGUE	A	HARPSTER	C	HEDDEN	C
GOMEZ	B	GREENWOOD	D	HAIG	C	HARPT	B	HEDRICK	B
GOMM	D	GREER	C	HAIKU	B	HARQUA	C	HEDVILLE	D
GONVICK	B	GREGORY	A	HAILMAN	B	HARRIET	D	HEGNE	D
GOOCH	D	GREHALEM	B	HAINES	B/C	HARRIMAN	B	HEIDEN	D
GOODALE	C	GRELL	D	HAIRE	C	HARRIS	D	HEIDTMAN	C
GOODING	C	GRENADA	C	HALAWA	B	HARRISBURG	D	HEIL	D
GOODINGTON	C	GRENVILLE	B	HALDER	C	HARRISON	C	HEIMDAL	B
GOODLOW	B	GRESHAM	C	HALE	B	HARRISVILLE	C	HEISETON	B
GOODMAN	B	GREWINGK	D	HALEDON	C	HARSTENE	B	HEISLER	B
GOODRICH	B	GREYBACK	B	HALEIWA	B	HARSTINE	C	HEIST	B
GOODSPRINGS	D	GREYBULL	C	HALEY	B	HART	D	HEITT	C
GOOSE CREEK	B	GREYCLIFF	C	HALF MOON	B	HART CAMP	C	HEITZ	D
GOOSE LAKE	D	GREYS	B	HALFORD	A	HARTFORD	A	HEIZER	D
GOOSMUS	B	GRIFFY	B	HALFWAY	D	HARTIG	B	HELDT	C
GORDO	B	GRIGSTON	B	HALGAITOH	B	HARTLAND	B	HELEMANO	C
GORDON	D	GRIMSTAD	B	HALII	B	HARTLETON	B	HELENA	C
GORE	D	GRISWOLD	B	HALIIMAILE	B	HARTLINE	B	HELMER	C
GORGONIO	A	GRITNEY	C	HALIS	B	HARTSBURG	B	HELVETIA	C
GORHAM	B	GRIVER	C	HALL	B	HARTSELLS	B	HELY	B
GORIN	C	GRIZZLY	C	HALLECK	B	HARTSHORN	B	HEMBRE	B
GORING	C	GROGAN	B	HALL RANCH	C	HARVARD	B	HEMMI	C
GORMAN	B	GROSECLOSE	C	HALLVILLE	B	HARVEL	B	HEMPFIELD	
GORUS	A	GROSS	C	HALSEY	D	HARVEY	C	HEMPSTEAD	C
GORZELL	B	GROTON	A	HAMACER	A	HARWOOD	C	HENCRATT	B
GOSHEN	B	GROVE	A	HAMAKUAPOKO	B	HASKI	B	HENDERSON	B
GOSHUTE	D	GROVELAND	B	HAMAN	B	HASKILL	A	HENDRICKS	B
GOSPORT	C	GROVER	B	HAMAR	B	HASKINS	C	HENEFER	C
GOTHAM	A	GROVETON	B	HAMBLEN	C	HASSELL	C	HENKIN	B

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

HENLEY	C	HOBOG	D	HORD	B	HYAT	A	IIAGORA	C
HENLINE	C	HOBSON	C	HOREB	B	HYATTVILLE	C	IZEE	C
HENNEKE	D	HOCHHEIM	B	HORNE	D	HYDABURG	D		
HENNEPIN	B	HOCKING	B	HORNELL	D	HYDE	D	JABU	C
HENNINGSEN	C	HOCKINSON	C	HORNING	A	HYDRO	C	JACAGUAS	B
HENRY	D	HOCKLEY	C	HORNITOS	D	HYMAS	D	JACANA	D
HENSEL	B	HODGE	B	HORROCKS	B	HYRUM	B	JACINTO	B
HENSHAW	C	HODGINS	C	HORSESHOE	B	HYSHAM	D	JACK CREEK	A
HENSLEY	D	HODGSON	C	HORTON	B			JACKLIN	B
HEPLER	D	HOEBE	B	HORTONVILLE	B	IAO	C	JACKNIFE	C
HERBERT	B	HOELZLE	C	HOSKIN	C	IBERIA	D	JACKPORT	D
HEREFORD	B	HOFFMAN	C	HOSKINNINI	D	ICENE	C	JACKS	C
HERKIMER	B	HOFFMANVILLE	C	HOSLEY	D	IDA	B	JACKSON	B
HERLONG	D	HOGANSBURG	B	HOSMER	C	IDABEL	B	JACKSONVILLE	C
HERMISTON	B	HOGELAND	B	HOTAW	C	IDAK	B	JACOB	D
HERMON	A	HOGG	C	HOT LAKE	C	IDANA	C	JACOBSEN	D
HERNDON	B	HOGRIS	B	HOUDEK	B	IDEON	D	JACOBY	C
HERO	B	HOH	B	HOUGHTON	A/D	IDMON	B	JACQUES	C
HERRERA	A	HOHMANN	C	HOUK	C	IGNACIO	C	JACQUITH	C
HERRICK	C	HOKO	C	HOULKA	D	IGO	D	JACWIN	B
HERRON	B	HOLBROOK	B	HOULTON	C/D	IGUALDAD	D	JAFFREY	A
HERSH	A	HOLCOMB	D	HOUNDBY	D	IHLEN	D	JAGUEYES	B
HERSHAL	B/D	HOLDAWAY	D	HOURGLASS	B	IJAM	D	JAL	B
HESCH	B	HOLDEN	A	HOUSATONIC	D	ILDEFONSO	B	JALMAR	A
HESPER	C	HOLDER	B	HOUSE MOUNTAIN	D	ILKA	B	JAMES CANYON	B/C
HESPERIA	B	HOLDERMAN	C	HOUSEVILLE	C	ILLION	B/D	JAMESTOWN	C
HESPERUS	B	HOLDERNESS	C	HOUSTON	D	IMA	B	JANE	C
HESSE	C	HOLDREGE	B	HOUSTON BLACK	D	IMBLER	B	JANISE	C
HESSEL	D	HOLLAND	B	HOVDE	A/C	IMLAY	C	JANSEN	A
HESSELBERG	D	HOLLINGER	B	HOVEN	D	IMMOKALEE	B/D	JARAB	D
HESSELTINE	B	HOLLIS	C/D	HOVENWEEP	C	IMPERIAL	D	JARBOE	C
HESSLAN	C	HOLLISTER	D	HOVERT	D	INAVALE	A	JARITA	C
HESSON	C	HOLLOMAN	C	HOVEY	C	INDART	B	JARRE	B
HETTINGER	D	HOLLOWAY	A	HOWARD	B	INDIAHOMA	D	JARVIS	B
HEXT	B	HOLLY	D	HOWELL	C	INDIAN		JASPER	B
HEZEL	B	HOLLY SPRINGS	D	HOWLAND	C	INDIAN CREEK	D	JAUCAS	A
HIALEAH	D	HOLLYWOOD	D	HOYE	B	INDIANO	C	JAVA	B
HIAWATHA	A	HOLMDEL	C	HOYLETON	C	INDIANOLA	A	JAY	C
HIBBARD	D	HOLMES	B	HOYPUS	A	INDIO	B	JAYEM	B
HIBBING	C	HOLOMUA	B	HOYTVILLE	D	INGA	B	JAYSON	D
HIBERNIA	C	HOLOPAW	B/D	HUBBARD	A	INGALLS	B	JEAN	A
HICKORY	C	HOLROYD	B	HUBERLY	D	INGARD	B	JEANERETTE	D
HICKS	B	HOLSINE	B	HUBERT	B	INGENIO	C	JEAN LAKE	B
HIDALGO	B	HOLST	B	HUBLERSBURG	C	INGRAM	D	JEDD	C
HIDEAWAY	D	HOLSTON	B	HUCKLEBERRY	C	INKLER	B	JEDDO	D
HIDEWOOD	C	HOLT	B	HUDSON	C	INKS	D	JEFFERSON	B
HIERRO	C	HOLTLE	B	HUECO	C	INMACHUK	D	JEKLEY	C
HIGHAMS	D	HOLTVILLE	C	HUEL	A	INMAN	C	JELM	D
HIGHFIELD	B	HOLYOKE	C/D	HUENEME	B/C	INMO	A	JENA	B
HIGH GAP	C	HOMA	C	HUERHUERO	D	INNESVALE	D	JENKINS	B
HIGHLAND	B	HOME CAMP	C	HUEY	D	INSKIP	C	JENKINSON	D
HIGHMORE	B	HOMELAKE	B	HUFFINE	A	INVERNESS	D	JENNESS	B
HIGH PARK	B	HOMER	C	HUGGINS	C	INVILLE	B	JENNINGS	C
HIHIMANU	A	HOMESTAKE	D	HUGHES	B	INWOOD	C	JENNY	D
HIIBNER	C	HOMESTEAD	B	HUGHESVILLE	B	IO	B	JERAULD	D
HIKO PEAK	B	HONAUNAU	C	HUGO	B	IOLA	A	JERICHO	C
HIKO SPRINGS	D	HONCUT	B	HUICHICA	C/D	IOLEAU	C	JEROME	C
HILDRETH	D	HONDALE	D	HUIKAU	A	IONA	B	JERRY	C
HILEA	D	HONDO	C	HULETT	B	IONIA	B	JESBEL	D
HILES	B	HONDOHO	B	HULLS	C	IOSCO	B	JESSE CAMP	C
HILGER	B	HONEOYE	B	HULLT	B	IPAVA	B	JESSUP	C
HILGRAVE	B	HONEY	D	HULUA	D	IRA	C	JETT	B
HILLEMANN	C	HONEYGROVE	C	HUM	B	IREDELL	D	JIGGS	C
HILLERY	D	HONEYVILLE	C	HUMACAO	B	IRETEBA	C	JIM	C
HILLET	D	HONN	B	HUMATAS	C	IRIM	C	JIMENEZ	C
HILLFIELD	B	HONOKAA	A	HUMBARGER	B	IROCK	B	JIMTOWN	C
HILLGATE	D	HONOLUA	B	HUMBIRD	C	IRON BLOSSOM	D	JOB	C
HILLIARD	B	HONOMANU	B	HUMBOLDT	D	IRON MOUNTAIN	D	JOBOS	C
HILLON	B	HONOULIULI	D	HUMDUN	B	IRON RIVER	B	JOCITY	B
HILLSBORO	B	HONUAULU	A	HUME	C	IRONTON	C	JOCKO	A
HILLSDALE	B	HOOD	B	HUMESTON	C	IRRIGON	C	JODERO	B
HILMAR	C/D	HOODLE	B	HUMMINGTON	C	IRVINGTON	C	JOEL	B
HILO	A	HOODSPORT	C	HUMPHREYS	B	IRWIN	D	JOES	B
HILT	B	HOODVIEW	B	HUMPTULIPS	B	ISAAC	C	JOHNS	C
HILTON	B	HOOKTON	C	HUNSAKER	B/C	ISAAQUAH	B/C	JOHNSBURG	D
HINCKLEY	A	HOOLEHUA	B	HUNTERS	B	ISAN	D	JOHNSON	B
HINDES	C	HOOPAL	D	HUNTING	C	ISANTI	D	JOHNSTON	B/D
HINESBURG	C	HOOPER	D	HUNTINGTON	B	ISBELL	C	JOHNSWOOD	B
HINKLE	D	HOOPESTON	B	HUNTSVILLE	B	ISHAM	C	JOICE	D
HINMAN	C	HOOSIC	A	HUPP	B	ISHI PISHI	C	JOLAN	C
HINSDALE		HOOT	D	HURDS	B	ISLAND	B	JOLIET	C
HINTZE	D	HOOTEN	D	HURLEY	D	ISOM	B	JONESVILLE	A
HIPPLE	C	HOOVER	B	HURON	C	ISSAQUAH	B/C	JONUS	B
HISLE	D	HOPEKA	D	HURST	D	ISTOKPOGA	D	JOPLIN	B
HITT	B	HOPETON	C	HURWAL	B	ITCA	D	JOPPA	B
HI VISTA	C	HOPEWELL		HUSE	C	ITSWOOT	B	JORDAN	D
HIWASSEE	B	HOPGOOD	C	HUSSA	B/D	IUKA	C	JORGE	B
HIWOOD	A	HOPKINS	B	HUSSMAN	D	IVA	C	JORNADA	C
HIXTON	B	HOPLEY	B	HUTCHINSON	C	IVAN	B	JORY	C
HOBACKER	B	HOPPER	B	HUTSON	B	IVES	B	JOSE	C
HOBAN	C	HOQUIAM	B	HUXLEY	D	IVIE	A	JOSEPHINE	B
HOBBS	B	HORATIO	D	HYAM	D	IVINS	C	JOSIE	B

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

JOY	B	KARNAK	D	KEOWNS	D	KIPP	C	KOVICH	D
JUANA DIAZ	B	KARNES	B	KEPLER	C	KIPPEN	A	KOYEN	B
JUBILEE	C	KARRO	B	KERBY	B	KIPSON	C	KOYUKUK	B
JUDD	D	KARS	A	KERMEL	B	KIRK	B/D	KRADE	B
JUDITH	B	KARSHNER	D	KERMIT	A	KIRKHAM	C	KRANZBURG	B
JUDKINS	C	KARTA	C	KERMO	A	KIRKLAND	D	KRATKA	C
JUDSON	B	KARTAR	B	KERR	B	KIRKTON	B	KRAUSE	A
JUDY	C	KASCHMIT	D	KERRICK	B	KIRKVILLE	C	KREAMER	C
JUGET	D	KASHWITNA	B	KERRTOWN		KIRTLEY	C	KREMLIN	B
JUGHANDLE	B	KASILOF	A	KERSHAW	A	KIRVIN	C	KRENTZ	C
JULES	B	KASKI	B	KERSICK	D	KISRING	D	KRESSON	C
JULESBURG	A	KASOTA	C	KERSTON	A/D	KISSICK	D	KRUM	D
JULIAETTA	B	KASSLER	A	KERT	C	KISTLER	C/D	KRUSE	D
JUMPE	B	KASSON	C	KERWIN	C	KITCHELL	B	KRUZOF	B
JUNCAL	C	KATAMA	B	KESSLER	C	KITCHEN CREEK	B	KUBE	B
JUNCOS	D	KATEMCY	C	KESWICK	D	KITSAP	C	KUBLER	C
JUNCTION	B	KATO	C	KETCHLY	B	KITTANNING		KUBLI	C
JUNEAU	B	KATRINE	B	KETTLE	B	KITTITAS	D	KUCERA	B
JUNIATA		KATULA	B	KETTLEMAN	B	KITTREDGE	C	KUCK	C
JUNIPERO	B	KATY	C	KETTNER	C	KITTSON	C	KUGRUG	D
JUNIUS	C	KAUFMAN	D	KEVIN	C	KIUP	B	KUHL	D
JUNO	B	KAUPO	A	KEWAUNEE	C	KIVA	B	KUKAIAU	A
JUNQUITOS	C	KAVETT	D	KEWEENAW	A	KIWANIS	A	KULA	B
JURA	C	KAWAIHAE	C	KEYA	B	KIZHUYAK	B	KULAKALA	B/C
JUVA	B	KAWAIHAPAI	B	KEYES	D	KJAR	D	KULLIT	B
JUVAN	D	KAWBAWGAM	C	KEYNER	D	KLABER	C	KUMA	B
		KAWICH	A	KEYPORT	C	KLAMATH	B/D	KUNIA	B
KAALUALU	A	KAWKAWLIN	C	KEYSTONE	A	KLAUS	A	KUNUWEIA	C
KACHEMAK	B	KEAAU	D	KEYTESVILLE	D	KLAWASI	D	KUPREANOF	B
KADAKE	D	KEAHUA	B	KEZAR	B	KLEJ	B	KUREB	A
KADASHAN	B	KEALAKEKUA	C	KIAWAH	C	KLICKER	C	KURO	D
KADE	C	KEALIA	D	KIBBIE	B	KLICKITAT	C	KUSKOKWIM	D
KADIN	B	KEANSBURG	D	KICKERVILLE	B	KLINE	B	KUSLINA	D
KADOKA	B	KEARNS	B	KIDD	D	KLINESVILLE	C/D	KUTCH	D
KAENA	D	KEATING	C	KIDMAN	B	KLINGER	B	KUTZTOWN	B
KAHALUU	D	KEAUKAHA	D	KIEHL	A	KLONDIKE	D	KVICHAK	B
KAHANA	B	KEAWAKAPU	B	KIETZKE	D	KLONE	B	KWETHLUK	A
KAHANUI	B	KEBLER	B	KIEV	B	KLOOCHMAN	C	KYLE	D
KAHLER	B	KECH	D	KIKONI	B	KLOTEN	B	KYLER	D
KAHOLA	B	KECKO	B	KILARC	D	KLUTINA	B		
KAH SHEETS	D	KEDRON	C	KILAUEA	B	KNAPPA	B	LA BARGE	B
KAHUA	D	KEEFERS	C	KILBOURNE	A	KNEELAND	C	LABETTE	C
KAIKLI	D	KEEGAN		KILBURN	B	KNIFFIN	C	LABISH	D
KAILUA	A	KEEI	D	KILCHIS	D	KNIGHT	C	LABOU	D
KAIMU	A	KEEKEE	B	KILDOR	C	KNIK	B	LABOUNTY	C
KAINALIU	A	KEELDAR	B	KILGORE	B/D	KNIPPA	D	LA BOUNTY	C
KAIPOIOI	B	KEENE	C	KILKENNY	B	KNOB HILL	B	LA BRIER	C
KAIWIKI	A	KEENO	C	KILLBUCK	C/D	KNOWLES	B	LABSHAFT	D
KALAE	B	KEESE	D	KILLEY	D	KNOX	B	LACAMAS	C/D
KALALOCH	B	KEG	B	KILLINGWORTH		KNULL	C	LA CASA	C
KALAMA	C	KEHENA	C	KILLPACK	C	KNUTSEN	B	LACITA	B
KALAMAZOO	B	KEIGLEY	C	KILMERQUE	C	KOBAR	C	LACKAWANNA	C
KALAPA	B	KEISER	B	KILN	D	KOBEH	B	LACONA	C
KALAUPAPA	D	KEITH	B	KILOA	A	KOCH	C	LACOTA	D
KALIFONSKY	D	KEKAHA	B	KILOHANA	A	KODAK	C	LACY	D
KALIHI	D	KEKAKE	D	KILWINNING	C	KODIAK	B	LADD	B
KALISPELL	A	KELLER	C	KIM	B	KOEHLER	C	LADDER	D
KALKASKA	A	KELLY	D	KIMAMA	B	KOELE	B	LADELLE	B
KALMIA	B	KELN	C	KIMBALL	C	KOEPKE	[illegible]	LADOGA	C
KALOKO	D	KELSEY	D	KIMBERLY	B	KOERLING	B	LADUE	B
KALOLOCH	B	KELSO	C	KIMBROUGH	D	KOGISH	D	LADYSMITH	D
KALSIN	D	KELTNER	B	KIMMERLING	D	KOHALA	A	LA FARGE	B
KAMACK	B	KELVIN	C	KIMMONS	C	KOKEE	B	LAFE	D
KAMAKOA	A	KEMMERER	C	KIMO	C	KOKERNOT	C	LAFITTE	D
KAMADA	B	KEMOO	B	KINA	D	KOKO	B	LA FONDA	B
KAMADLE	B	KEMPSVILLE	B	KINCO	A	KOKOKAHI	D	LAFONT	B
KAMAY	D	KEMPTON	B	KINESAVA	C	KOKOMO	B/D	LAGLORIA	B
KAMIE	B	KENAI	C	KINGFISHER	B	KOLBERG	B	LAGONDA	C
KAMRAR	B	KENANSVILLE	A	KINGHURST	B	KOLEKOLE	C	LA GRANDE	C
KANABEC	B	KENDAIA	C	KINGMAN	D	KOLLS	D	LAGRANGE	D
KANAKA	B	KENDALL	B	KINGS	C/D	KOLLUTUK	D	LAHAINA	B
KANAPAHA	A/D	KENDALLVILLE	B	KINGSBURY	D	KOLOA	C	LA HOGUE	B
KANDIK	B	KENESAW	B	KINGSLEY	B	KOLOB	C	LAHONTAN	D
KANE	B	KENMOOR	B	KINGS RIVER	C	KOLOKOLO	B	LAHRITY	A
KANEOHE	B	KENNALLY	B	KINGSTON	B	KONA	D	LAIDIG	C
KANEPUU	B	KENNAN	B	KINGSVILLE	C	KONAWA	B	LAIDLAW	B
KANIMA	C	KENNEBEC	B	KINKEAD	C	KONNER	D	LAIL	C
KANLEE	B	KENNEDY	B/C	KINKEL	B	KONOKTI	C	LAIRDSVILLE	D
KANOSH	C	KENNER	D	KINKORA	D	KOOLAU	C	LAIREP	D
KANZA	D	KENNEWICK	B	KINMAN	C	KOOSKIA	C	LAJARA	D
KAPAA	A	KENNEY	A	KINNEAR	B	KOOTENAI	A	LAKE	A
KAPAPALA	B	KENNEY LAKE	C	KINNEY	B	KOPIAH	D	LAKE CHARLES	D
KAPOD	B	KENO	D	KINNICK	C	KOPP	B	LAKE CREEK	C
KAPOWSIN	C	KENOMA	D	KINREAD	D	KOPPES	B	LAKEHELEN	B
KAPUHIKANI	D	KENSAL	B	KINROSS	D	KORCHEA	B	LAKEHURST	A
KARAMIN	B	KENSPUR	A	KINSTON	D	KORNMAN	B	LAKE JANEE	B
KARDE	B	KENT	D	KINTA	D	KOSMOS	D	LAKELAND	A
KARHEEN	D	KENYON	C	KINTON	C	KOSSE	D	LAKEMONT	D
KARLAN	C	KEO	B	KINZEL	B	KUSTER	C	LAKEPORT	B
KARLIN	A	KEOLDAR	B	KIOMATIA	A	KOSZTA	B	LAKESHORE	D
KARLO	D	KEOMAH	C	KIONA	B	KOTEDO	D	LAKESOL	B
KARLUK	D	KEOTA	C	KIPLING	D	KOUTS	B	LAKETON	B

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

LAKEVIEW	C	LATAH	C	LENAWEE	B/D	LINVILLE	B	LORADALE	C
LAKEWIN	B	LATAHCO	C	LENNEP	D	LINWOOD	A/D	LORAIN	C/D
LAKEWOOD	A	LATANG	B	LENOIR	D	LIPAN	D	LORDSTOWN	C
LAKI	B	LATANIER	D	LENOX	B	LIPPINCOTT	B/D	LOREAUVILLE	C
LAKIN	A	LATENE	B	LENZ	B	LIRIOS	B	LORELLA	D
LAKOMA	D	LATHAM	D	LEO	B	LIRRET	D	LORENZO	A
LALAAU	A	LATHROP	C	LEON	A/D	LISADE	B	LORETTO	B
LA LANDE	B	LATINA	D	LEONARD	C	LISAM	D	LORING	C
LALLIE	D	LATOM	D	LEONARDO	B	LISBON	B	LOS ALAMOS	B
LAM	B/D	LATONIA	B	LEONARDTOWN	D	LISMAS	D	LOS BANOS	C
LAMAR	B	LATTY	D	LEONIDAS	B	LISMORE	B	LOSEE	B
LAMARTINE	B	LAUDERDALE	B	LEOTA	C	LITCHFIELD	A	LOS GATOS	B/C
LAMBERT	B	LAUGENOUR	B/D	LEPLEY	D	LITHGOW	C	LOS GUINEOS	C
LAMBETH	C	LAUGHLIN	B	LERDAL	C	LITHIA	C	LOSHMAN	D
LAMBORN	D	LAUMAIA	B	LEROY	B	LITIMBER	C	LOS OSOS	C
LAMINGTON	D	LAUREL	C	LESAGE	B	LITLE	C	LOS ROBLES	B
LAMO	B	LAURELHURST	C	LESHARA	B	LITTLEBEAR	A	LOS TANOS	B
LAMONI	D	LAURELWOOD	B	LESHO	C	LITTLEFIELD	D	LOST CREEK	B
LAMONT	A	LAUREN	B	LESLIE	D	LITTLE HORN	C	LOST HILLS	C
LAMONTA	D	LAVALLEE	B	LESTER	B	LITTLE POLE	D	LOS TRANCOS	D
LAMOURE	C	LAVATE	B	LE SUEUR	B	LITTLETON	B	LOSTWELLS	B
LAMPHIER	B	LAVEEN	B	LETA	C	LITTLE WOOD	B	LOTHAIR	C
LAMPSHIRE	D	LAVELDO	D	LETCHER	D	LITZ	C	LOTUS	B
LAMSON	D	LAVERKIN	C	LETHA	D	LIV	C	LOUDON	C
LANARK	B	LA VERKIN	C	LETHENT	C	LIVERMORE	A	LOUDONVILLE	C
LANCASTER	B	LAVINA	C	LETORT	B	LIVIA	D	LOUIE	C
LANCE	C	LAWAI	B	LETTERBOX	B	LIVINGSTON	D	LOUISA	B
LAND	D	LAWET	C	LEVAN	A	LIVONA	A	LOUISBURG	B
LANDES	B	LAWLER	B	LEVASY	C	LIZE	C	LOUP	D
LANDISBURG	C	LAWRENCE	C	LEVERETT	C	LIZZANT	B	LOURDES	C
LANDLOW	C	LAWRENCEVILLE	C	LEVIATHAN	B	LLANOS	C	LOUVIERS	D
LANDUSKY	D	LAWSHE	C	LEVIS	C	LOBDELL	C	LOVEJOY	C
LANE	C	LAWSON	B	LEWIS	D	LOBELVILLE	C	LOVELAND	C
LANEY	C	LAWTHER	D	LEWISBERRY	B	LOBERG	B	LOVELL	C
LANG	B/D	LAWTON	C	LEWISBURG	C	LOBERT	B	LOVELOCK	C/D
LANGFORD	C	LAX	C	LEWISTON	C	LOBITOS	C	LOWELL	C
LANGHEI	B	LAXAL	B	LEWISVILLE	C	LOCANE	D	LOWRY	B
LANGLEY	C	LAYCOCK	B	LEX	B	LOCEY	C	LOWVILLE	B
LANGLOIS	D	LAYTON	A	LEXINGTON	B	LOCHSA	B	LOYAL	B
LANGOLA	B	LAZEAR	D	LHAZ	B	LOCKE	B	LOYALTON	D
LANGRELL	B	LEA	C	LIBBINGS	D	LOCKERBY	C	LOYSVILLE	D
LANGSTON	C	LEADER	B	LIBBY	B	LOCKHARD	B	LOZANO	B
LANIER	B	LEADPOINT	B	LIBEG	A	LOCKHART	B	LOZIER	D
LANIGER	B	LEADVALE	C	LIBERAL	D	LOCKPORT	D	LUALUALEI	D
LANKBUSH	B	LEADVILLE	B	LIBERTY	C	LOCKWOOD	B	LUBBOCK	C
LANKIN	C	LEAF	D	LIBORY	A	LOCUST	C	LUBRECHT	C
LANKTREE	C	LEAHY	C	LIBRARY	D	LODAR	D	LUCAS	C
LANOAK	B	LEAL	B	LIBUTTE	D	LODEMA	A	LUCE	C
LANSDALE	B	LEAPS	C	LICK	B	LODI	C	LUCEDALE	B
LANSDOWNE	C	LEATHAM	C	LICK CREEK	D	LODO	D	LUCERNE	B
LANSING	B	LEAVENWORTH	B	LICKDALE	D	LOFFTUS	C	LUCIEN	C
LANTIS	B	LEAVITT	B	LICKING	C	LOFTON	D	LUCILE	D
LANTON	D	LEAVITTVILLE	B	LICKSKILLET	D	LOGAN	D	LUCILETON	B
LANTONIA	B	LEBANON	C	LIDDELL	D	LOGDELL	D	LUCKENBACH	C
LANTZ	D	LEBAR	B	LIEBERMAN	C	LOGGERT	A	LUCKY	B
LAP	D	LE BAR	B	LIEN	D	LOGHOUSE	B	LUCKY STAR	B
LA PALMA	C	LEBEC	B	LIGGET	B	LOGY	B	LUCY	A
LAPEER	B	LEBO	C	LIGHTNING	D	LOHLER	C	LUDDEN	D
LAPINE	A	LEBSACK	C	LIGNUM	C	LOHMILLER	C	LUDLOW	C
LAPLATTA	C	LECK KILL	B	LIGON	D	LOHNES	A	LUEDERS	C
LAPON	D	LEDBEDER	B	LIHEN	A	LOIRE	B	LUFKIN	D
LAPORTE	C	LEDGEFORK	A	LIHUE	B	LOLAK	D	LUHON	B
LA POSTA	A	LEDGER	D	LIKES	A	LOLALITA	B	LUJANE	C
LA PRAIRIE	B	LEDRU	D	LILAH	A	LOLEKAA	B	LUKIN	C
LARABEE	B	LEDY		LILLIWAUP	A	LOLETA	C/D	LULA	B
LARAND	B	LEE	D	LIMA	B	LOLO	A	LULING	D
LARCHMOUNT	B	LEEDS	C	LIMANI	B	LOLON	A	LUMBEE	D
LARDELL	C	LEEFIELD	C	LIMBER	B	LOMA	C	LUMMI	B/C
LAREDO	B	LEELANAU	A	LIMERICK	C	LOMALTA	D	LUN	C
LARES	C	LEEPER	D	LIMON	C	LOMAX	B	LUNA	C
LARGENT	D	LEESVILLE	B/C	LIMONES	B	LOMIRA	B	LUNCH	C
LARGO	B	LEETON	C	LIMPIA	C	LOMITAS	D	LUNDIMO	C
LARIM	A	LEETONIA	C	LINCO	B	LONDO	C	LUNDY	D
LARIMER	B	LEFOR	B	LINCOLN	A	LONE	C	LUNT	C
LARKIN	B	LEGLER	B	LINCROFT	A	LONEPINE	C	LUPPINO	C
LARKSON	C	LEGORE	B	LINDLEY	C	LONERIDGE	B	LUPTON	D
LA ROSE	B	LEHEW	C	LINDSEY	D	LONE ROCK	A	LURA	D
LARRY	D	LEHIGH	C	LINDSIDE	C	LONETREE	A	LURAY	C/D
LARSON	D	LEHMANS	D	LINDSTROM	B	LONGFORD	C	LUTE	D
LARUE	A	LEHR	B	LINDY	C	LONGLOIS	B	LUTH	C
LARVIE	D	LEICESTER	C	LINEVILLE	C	LONGMARE	D	LUTHER	B
LAS	C	LEILEHUA	B	LINGANORE	B	LONGMONT	C	LUTIE	B
LAS ANIMAS	C	LELA	D	LINKER	B	LONGRIE	C	LUTON	D
LASAUSES	C	LELAND	D	LINKVILLE	B	LONGVAL	B	LUVERNE	C
LAS FLORES	D	LEMETA	D	LINNE	C	LONG VALLEY	B	LUXOR	D
LASHLEY		LEMING	C	LINNET	D	LONGVIEW	C	LUZENA	D
LASIL	D	LEMM	B	LINNEUS	B	LONOKE	B	LYCAN	B
LAS LUCAS	C	LEMONEX	D	LINO	C	LONTI	C	LYCOMING	C
LAS POSAS	C	LEMPSTER	C/D	LINOYER	B	LOOKOUT	C	LYDA	D
LASSEN	D	LEN	C	LINSLAW	D	LOON	B	LYDICK	B
LASTANCE	B	LENA	A	LINT	B	LOPER	B	LYFORD	C
LAS VEGAS	D	LENAPAH	D	LINTON	B	LOPEZ	D	LYLES	B

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

LYMAN	C/D	MALIN	C/D	MARLETTE	B	MAY DAY	D	MCPHERSON	C
LYMANSON	C	MALJAMAR	B	MARLEY	C	MAYER	D	MCPHIE	B
LYNCH	D	MALLOT	A	MARLIN	D	MAYES	D	MCQUARRIE	D
LYNCHBURG	B/D	MALM	C	MARLOW	C	MAYFIELD	B	MCQUEEN	C
LYNDEN	A	MALO	B	MARLTON	C	MAYFLOWER	C	MCRAE	B
LYNNDYL	A	MALONE	B	MARMARTH	B	MAYHEW	D	MCTAGGART	B
LYNN HAVEN	B/D	MALOTERRE	D	MARNA	D	MAYLAND	C	MCVICKERS	C
LYNNVILLE	C	MALPAIS	C	MARPA	B	MAYMEN	D	MEAD	D
LYNX	B	MALPOSA	C	MARPLEEN	D	MAYNARD LAKE	B	MEADIN	A
LYONMAN	C	MALVERN	C	MARQUETTE	A	MAYO	B	MEADOWVILLE	B
LYONS	D	MAMALA	D	MARR	B	MAYODAN	B	MEADVILLE	C
LYONSVILLE	B	MAMOU	C	MARRIOTT	B	MAYOWORTH	C	MEANDER	D
LYSINE	D	MANAHAA	C	MARSDEN	C	MAYSDORF	B	MECAN	B
LYSTAIR	B	MANALAPAN		MARSELL	B	MAYSVILLE		MECCA	B
LYTELL	B	MANANA	C	MARSHALL	B	MAYTOWN	C	MECKESVILLE	C
		MANASSA	C	MARSHAN	D	MAYVILLE	B	MECKLENBURG	C
MABANK	D	MANASSAS	B	MARSHDALE	C	MAYWOOD	B	MEDA	B
MABEN	C	MANASTASH	C	MARSHFIELD	C	MAZEPPA	B	MEDANO	C
MABI	D	MANATEE	B/D	MARSING	B	MAZON	C	MEDARY	C
MABRAY	D	MANAWA	C	MART	C	MAZUMA	C	MEDFORD	B
MACAR	B	MANCELONA	A	MARTELLA	B	MCAFEE	C	MEDFRA	D
MACEDONIA	C	MANCHESTER	A	MARTIN	C	MCALLEN	B	MEDICINE LODGE	B
MACFARLANE	B	MANDAN	B	MARTINA	A	MCALLISTER	C	MEDINA	B
MACHETE	C	MANDERFIELD	B	MARTINECK	D	MCALPIN	C	MEDLEY	B
MACHIAS	B	MANDEVILLE	B	MARTINEZ	D	MCBEE	B	MEDWAY	B
MACHUELO	D	MANFRED	D	MARTINI	B	MCBETH	D	MEEKS	A
MACK	C	MANGUM	D	MARTINSBURG	B	MCBRIDE	B	MEETEETSE	D
MACKEN	D	MANHATTAN	A	MARTINSDALE	B	MCCABE	B	MEGGETT	D
MACKINAC	B	MANHEIM	C	MARTINSON	D	MCCAFFERY	A	MEGON	C
MACKSBURG	B	MANI	C	MARTINSVILLE	B	MCCAIN	C	MEHL	C
MACOMB	B	MANILA	C	MARTINTON	C	MCCALEB	B	MEHLHORN	C
MACOMBER	B	MANISTEE	B	MARTY	B	MCCALLY	D	MEIGS	
MACON	B	MANITOU	C	MARVAN	D	MCCAMMON	D	MEIKLE	D
MACY	B	MANLEY	B	MARVELL	B	MCCANN	C	MEISS	D
MADALIN	D	MANLIUS	C	MARVIN	C	MCCARRAN	D	MELBOURNE	B
MADAWASKA	B	MANLOVE	B	MARY	C	MCCARTHY	B	MELBY	C
MADDOCK	A	MANNING	B	MARYDEL	B	MCCLAVE	C	MELITA	B
MADDOX		MANOGUE	D	MARYSLAND	D	MCCLEARY	C	MELLENTHIN	D
MADELIA	C	MANOR	B	MASADA	C	MCCLELLAN	B	MELLOR	D
MADELINE	D	MANSFIELD	D	MASCAMP	D	MCCLOUD	C	MELLOTT	B
MADERA	D	MANSIC	B	MASCHETAH	B	MCCOIN	D	MELOLAND	C
MADISON	B	MANSKER	B	MASCOTTE	D	MCCOLL	D	MELROSE	C
MADONNA	C	MANTACHIE	C	MASHEL	C	MCCONNEL	B	MELSTONE	A
MADRAS	C	MANTEO	C/D	MASHULAVILLE	B/D	MCCOOK	B	MELTON	B
MADRID	B	MANTER	B	MASON	B	MCCORMICK	C	MELVILLE	B
MADRONE	C	MANTON	B	MASONVILLE	C	MCCOY	C	MELVIN	D
MADUREZ	B	MANTZ	B	MASSACK	B	MCCREE	B	MEMALOOSE	D
MAFURT	B	MANU	C	MASSENA	C	MCCRORY	D	MEMPHIS	B
MAGALLON	B	MANVEL	C	MASSILLON	B	MCCROSKIE	D	MENAHGA	A
MAGENS	B	MANWOOD	D	MASTERSON	B	MCCULLOUGH	C	MENAN	C
MAGGIE	D	MANZANITA	C	MATAGORDA	D	MCCULLY	C	MENARD	B
MAGINNIS	C	MANZANO	C	MATAMOROS	C	MCCUNE	D	MENCH	C
MAGNA	D	MANZANOLA	C	MATANUSKA	C	MCCUTCHEN	C	MENDEBOURE	C
MAGNOLIA	B	MAPES	C	MATANZAS	B	MCDOLE	B	MENDOCINO	B
MAGNUS	C	MAPLE MOUNTAIN	B	MATAPEAKE	B	MCDONALD	B	MENDON	B
MAGOTSU	D	MAPLETON	C/D	MATAWAN	C	MCDONALDSVILLE	C	MENDOTA	B
MAGUAYO	D	MARAGUEZ	B	MATCHER	A	MCEWEN	B	MENEFEE	D
MAHAFFEY	C/D	MARATHON	B	MATFIELD	C	MCFADDEN	B	MENFRO	B
MAHAFFY	C/D	MARBLE	A	MATHERS	B	MCFAIN	C	MENLO	D
MAHALA	C	MARBLEMOUNT	B	MATHERTON	B	MCFAUL	C	MENO	C
MAHALASVILLE	B/D	MARCELINAS	D	MATHESON	B	MCGAFFEY	B	MENOKEN	C
MAHANA	B	MARCETTA	A	MATHEWS		MCGARR	C	MENOMINEE	B
MAHASKA	B	MARCIAL	D	MATHIS	A	MCGARY	C	MENTO	C
MAHER	C	MARCUM	B	MATHISTON	C	MCGEHEE	C	MENTOR	B
MAHONING	D	MARCUS	C	MATLOCK	D	MCGILVERY	D	MEQUON	C
MAHUKONA	B	MARCUSE	D	MATMON	D	MCGINTY	B	MERCED	C/D
MAIDEN	B	MARCY	D	MATTAPEX	C	MCGIRK	C	MERCEDES	D
MAILE	A	MARDEN	C	MATTOLE	C	MCGOWAN	B	MERCER	C
MAINSTAY	D	MARDIN	C	MAU	D	MCGRATH	B	MERCEY	C
MAJADA	B	MARENGO	C/D	MAUDE	B	MCGREW	A	MEREDITH	B
MAKAALAE	B	MARESUA	B	MAUGHAN	C	MCHENRY	B	MERETA	C
MAKALAPA	D	MARGERUM	B	MAUKEY	C	MCILWAINE	A	MERGEL	B
MAKAPILI	A	MARGUERITE	B	MAUMEE	A/D	MCINTOSH	B	MERIDIAN	B
MAKAWAO	B	MARIA	B/C	MAUNABO	D	MCINTYRE	B	MERINO	D
MAKAWELI	B	MARIANA	C	MAUPIN	C	MCKAMIE	D	MERKEL	B
MAKENA	B	MARIAS	D	MAUREPAS	D	MCKAY	D	MERLIN	D
MAKIKI	B	MARICAO	B	MAURICE	A	MCKENNA	C/D	MERMILL	B/D
MAKLAK	A	MARICOPA	B	MAURINE	D	MCKENZIE	D	MERNA	D
MAKOTI	C	MARIETTA	C	MAURY	B	MCKINLEY	B	MEROS	A
MAL	B	MARILLA	C	MAVERICK	C	MCKINNEY	D	MERRIFIELD	B
MALA	B	MARINA	A	MAVIE	D	MCLAIN	C	MERRILL	C
MALABAR	A/D	MARION	D	MAWAE	A	MCLAURIN	B	MERRILLAN	C
MALABON	C	MARIPOSA	C	MAX	B	MCLEAN	C	MERRIMAC	A
MALACHY	B	MARISSA	C	MAXEY	C	MCLEOD	B	MERRITT	B/C
MALAGA	B	MARKES	D	MAXFIELD	C	MCMAHON	C	MER ROUGE	B
MALAMA	A	MARKEY	D	MAXSON	A	MCMEEN	C	MERTON	B
MALAYA	D	MARKHAM	C	MAXTON	B	MCMULLIN	D	MERTZ	B
MALBIS	B	MARKLAND	C	MAXVILLE	A	MCMURDIE	C	MESA	B
MALCOLM	B	MARKSBORO	C	MAXWELL	D	MCMURPHY	B	MESCAL	B
MALETTI	C	MARLA	A	MAY	B	MCMURRAY	D	MESCALERO	C
MALEZA	B	MARLBORO	B	MAYBERRY	C	MCNARY	D	MESITA	C
MALIBU	D	MARLEAN	B	MAYBESO	D	MCPAUL	B	MESKILL	C

NOTES   A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

MESMAN	C	MINORA	C	MONTOYA	D	MURDOCK	C	NAVARRO	B
MESPUN	A	MINTO	C	MONTPELLIER	C	MUREN	B	NAVESINK	
MESSER	C	MINU	D	MONTROSE	B	MURRILL	B	NAYLOR	
MET	D	MINVALE	B	MONTVALE	D	MURVILLE	D	NAYPED	C
METALINE	B	MIRA	D	MONTVERDE	A/D	MUSCATINE	B	NAZ	B
METAMORA	B	MIRABAL	C	MONTWEL	C	MUSE	C	N-BAR	B
METEA	B	MIRACLE	B	MONUE	B	MUSELLA	B	NEAPOLIS	B/D
METHOW	B	MIRAMAR	B	MOODY	B	MUSICK	B	NEBEKER	C
METIGOSHE	A	MIRANDA	D	MOOHOO	B	MUSINIA	B	NEBGEN	D
METOLIUS	B	MIRES	B	MOOSE RIVER	D	MUSKINGUM	C	NEBISH	B
METRE	D	MIRROR	B	MORA	B	MUSKOGEE	C	NEBO	
METZ	A	MIRROR LAKE	A	MORADO	C	MUSQUIZ	C	NECHE	C
MEXICO	D	MISSION	B	MORALES	D	MUSSEL	B	NEDERLAND	B
MHOON	D	MITCH	B	MORD	C	MUSSELSHELL	B	NEEDHAM	D
MIAMI	B	MITCHELL	B	MOREAU	D	MUSSEY	D	NEEDLE PEAK	C
MIAMIAN	C	MITIWANGA	C	MOREHEAD	C	MUSTANG	A/D	NEEDMORE	C
MICCO	A/D	MITRE	C	MOREHOUSE	C	MUTNALA	B	NEELEY	B
MICHELSON	B	MIZEL	D	MORELAND	D	MUTUAL	B	NEESOPAH	C
MICHIGAMME	C	MIZPAH	C	MORELANDTON	A	MYAKKA	A/D	NEGITA	B
MICK	B	MOANO	D	MORET	D	MYATT	B/D	NEGLEY	B
MIDAS	D	MOAPA	D	MOREY	D	MYERS	D	NEHALEM	B
MIDDLE	C	MOAULA	A	MORFITT	B	MYERSVILLE	B	NEHAR	B
MIDDLEBURY	B	MOBEETIE	B	MORGANFIELD	B	MYLREA	B	NEILTON	A
MIDESSA	B	MOCA	D	MORGNEC		MYRICK	D	NEISSON	B
MIDLAND	D	MOCHO	B	MORIARTY	D	MYRTLE	B	NEKIA	C
MIDNIGHT	D	MODA	D	MORICAL	C	MYSTEN	A	NELLIS	B
MIDVALE	C	MODALE	C	MORLEY	C	MYSTIC	D	NELMAN	B
MIDWAY	D	MODEL	C	MORMON MESA	D	MYTON	B	NELSCOTT	B
MIFFLIN	B	MODENA	B	MOROCCO	A/C			NELSON	B
MIFFLINBURG	B	MODESTO	C	MORONI	D	NAALEHU	B	NEMAH	C
MIGUEL	D	MODOC	C	MOROP	C	NABESNA	D	NEMOTE	A
MIKE	D	MOENKOPIE	D	MORRILL	B	NACEVILLE	C	NENANA	B
MIKESELL	C	MOEPITZ	B	MORRIS	C	NACHES	B	NENNO	B
MILACA	B	MOFFAT	B	MORRISON	B	NACIMIENTO	C	NEOLA	D
MILAN	B	MOGOLLON	B	MORROW	C	NACOGDOCHES	B	NEOTOMA	B
MILES	B	MOGUL	B	MORSE	D	NADEAN	B	NEPALTO	A
MILFORD	C	MOHALL	B	MORTENSON	C	NADINA	D	NEPESTA	C
MILHAM	C	MOHAVE	B	MORTON	B	NAFF	B	NEPHI	B
MILHEIM	C	MOHAWK	B	MORVAL	B	NAGEESI	B	NEPPEL	B
MILL	B	MOIRA	C	MOSBY	C	NAGITSY	C	NEPTUNE	A
MILLARD	B	MOKELUMNE	D	MOSCA	A	NAGLE	B	NERESON	B
MILLBORO	D	MOKENA	C	MOSCOW	C	NAGOS	D	NESDA	A
MILLBROOK	B	MOKIAK	B	MOSEL	C	NAHATCHE	C	NESHAMINY	B
MILLBURNE	B	MOKULEIA	B	MOSHANNON	B	NAHMA	C	NESIKA	B
MILLCREEK	B	MOLAND	B	MOSHER	D	NAHUNTA	C	NESKAHI	B
MILLER	D	MOLCAL	B	MOSHERVILLE	C	NAIWA	B	NESKOWIN	C
MILLERLUX	D	MOLENA	A	MOSIDA	B	NAKAI	B	NESPELEM	B
MILLERTON	D	MOLINOS	B	MOSQUET	D	NAKNEK	D	NESS	D
MILLETT	B	MOLLVILLE	D	MOSSYROCK	B	NALDO	B	NESSEL	B
MILLGROVE	B/D	MOLLY	B	MOTA	B	NAMBE	B	NESSOPAH	B
MILL HOLLOW	B	MOLOKAI	B	MOTLEY	B	NAMON	C	NESTER	C
MILLICH	D	MOLSON	B	MOTOQUA	D	NANAMKIN	A	NESTUCCA	C
MILLIKEN	C	MOLYNEUX	B	MOTTSVILLE	A	NANCY	B	NETARTS	A
MILLINGTON	B	MONAD	A	MOULTON	B/D	NANNY	B	NETCONG	B
MILLIS	C	MONAHAN	D	MOUND	C	NANNYTON	B	NETO	B
MILLRACE	B	MONAHANS	B	MOUNTAINBURG	D	NANSENE	B	NETTLETON	C
MILLSAP	C	MONARDA	D	MOUNTAINVIEW	B/D	NANTUCKET	C	NEUBERT	B
MILLSDALE	B/D	MONCLOVA	B	MOUNTAINVILLE	B	NANUM	C	NEUNS	B
MILLSHOLM	C	MONDAMIN	C	MOUNT AIRY	A	NAPA	D	NEUSKE	B
MILLVILLE	B	MONDOVI	B	MOUNT CARROLL	B	NAPAISHAK	D	NEVADOR	C
MILLWOOD	D	MONEE	D	MOUNT HOME	B	NAPAVINE	B	NEVILLE	B
MILNER	C	MONICO	B	MOUNT HOOD	B	NAPIER	B	NEVIN	C
MILPITAS	C	MONIDA	B	MOUNT LUCAS	C	NAPLENE	B	NEVINE	B
MILROY	D	MONITEAU	D	MOUNT OLIVE	D	NAPLES	B	NEVKA	C
MILTON	C	MONMOUTH	C	MOUNTVIEW	B	NAPPANEE	D	NEVOYER	D
MIMBRES	C	MONO	D	MOVILLE	C	NAPTOWNE	B	NEVTAH	C
MIMOSA	C	MONOLITH	C	MOWATA	D	NARANJITO	C	NEVU	D
MINA	C	MONONA	B	MOWER	C	NARANJO	C	NEWARK	C
MINAM	B	MONONGAHELA	C	MOYERSON	D	NARCISSE	B	NEWART	B
MINATARE	D	MONROE	B	MOYINA	D	NARD	B	NEWAYGO	B
MINCHEY	B	MONROEVILLE	C/D	MUCARA	D	NARLON	C	NEWBERG	B
MINCO	B	MONSE	B	MUCET	C	NARON	B	NEWBERRY	C
MINDALE	B	MONSERATE	C	MUDRAY	D	NARRAGANSETT	B	NEWBY	B
MINDEGO	B	MONTAGUE	D	MUD SPRINGS	C	NARROWS	D	NEW CAMBRIA	C
MINDEMAN	B	MONTALTO	C	MUGHOUSE	C	NASER	B	NEWCASTLE	B
MINDEN	C	MONTARA	D	MUIR	B	NASH	B	NEWCOMB	A
MINE	B	MONTAUK	C	MUIRKIRK	B	NASHUA	A	NEWDALE	B
MINEOLA		MONTCALM	A	MUKILTEO	D	NASHVILLE	B	NEWELL	B
MINER	D	MONTE	B	MULCROW	D	NASON	C	NEWELLTON	D
MINERAL	A	MONTE CRISTO	D	MULKEY	C	NASSAU	C/D	NEWFANE	
MINERAL MOUNTAIN	C	MONTEGRANDE	D	MULLINS	D	NASSET	B	NEWFORK	D
MINERVA	B	MONTELL	D	MULLINVILLE	B	NATALIE	C	NEWKIRK	D
MING	B	MONTELLO	C	MULT	C	NATCHEZ	B	NEWLANDS	B
MINGO	B	MONTEOLA	D	MULTORPOR	A	NATHROP	B	NEWLIN	B
MINIDOKA	C	MONTEROSA	D	MUMFORD	B	NATIONAL	B	NEWMARKET	B
MINNEISKA	C	MONTEVALLO	D	MUNDELEIN	B	NATRONA	B	NEWPORT	C
MINNEOSA	B	MONTGOMERY	D	MUNDOS	B	NATROY	D	NEWRUSS	B
MINNEQUA	B	MONTICELLO	B	MUNISING	B	NATURITA	B	NEWRY	B
MINNETONKA	D	MONTIETH	A	MUNK	C	NAUKATI	D	NEWSKAH	B
MINNEWAUKAN	B	MONTMORENCI	B	MUNSON	D	NAUMBURG	C	NEWSTEAD	D
MINNIECE	D	MONTOSO	B	MUNUSCONG	D	NAVAJO	D	NEWTON	A/D
MINOA	C	MONTOUR	D	MURDO	B	NAVAN	D	NEWTONIA	B

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

NEWTOWN	C	NORTON	C	OKAW	D	ORELLA	D	PACK	C
NEWVILLE	C	NORTONVILLE	C	OKAY	B	OREM	A	PACKARD	B
NEZ PERCE	C	NORTUNE	D	OKEECHOBEE	A/D	ORESTIMBA	C	PACKER	C
NIAGARA	C	NORWALK	B	OKEELANTA	A/D	ORFORD	C	PACKHAM	B
NIART	B	NORWAY FLAT	B	OKEMAH	C	ORIDIA	C	PACKSADDLE	B
NIBLEY	C	NORWELL	C	OKLARED	B	ORIF	A	PACKWOOD	D
NICHOLSON	C	NORWICH	D	OKLAWAHA	A/D	ORIO	C	PACOLET	B
NICHOLVILLE	C	NORWOOD	B	OKMOK	B	ORION	B	PACTOLUS	C
NICKEL	B	NOTI	D	OKO	D	ORITA	B	PADEN	C
NICODEMUS	B	NOTUS	A/C	OKOBOJI	C	ORLAND	B	PADRONI	B
NICOLAUS	C	NOUQUE	D	OKOLONA	D	ORLANDO	A	PADUCAH	B
NICOLLET	B	NOVARA	B	OKREEK	D	ORMAN	C	PADUS	B
NIELSEN	D	NOVARY	B	OKTIBBEHA	D	ORMSBY	B/C	PAESL	B
NIGHTHAWK	B	NOWOOD	C	OLA	C	ORODELL	C	PAGET	B
NIHILL	B	NOYO	C	OLAA	A	ORO FINO	B	PAGODA	C
NIKABUNA	D	NOYSON	C	OLALLA	C	ORO GRANDE	C	PAHRANAGAT	C
NIKEY	B	NUBY	C/D	OLANTA	B	OROND	D	PAHREAH	D
NIKISHKA	A	NUCKOLLS	C	OLATHE	C	OROVADA	C	PAHROC	D
NIKLASON	B	NUCLA	B	OLD CAMP	D	ORPHANT	D	PAIA	C
NIKOLAI	D	NUECES	C	OLDHAM	C	ORR	C	PAICE	C
NILAND	C	NUGENT	A	OLDS	D	ORRVILLE	C	PAINESVILLE	C
NILES	C	NUGGET	C	OLDSMAR	B/D	ORSA	A	PAINTROCK	C
NIMROD	C	NUMA	C	OLDWICK	B	ORSINO	A	PAIT	B
NINCH	C	NUNDA	C	OLELO	B	ORTELLO	A	PAJARITO	B
NINEMILE	D	NUNICA	C	OLENA	B	ORTIGALITA	C	PAJARO	C
NINEVEH	B	NUNN	C	OLEQUA	B	ORTING	C	PAKA	B
NINIGRET	B	NUSS	D	OLETE	C	ORTIZ	C	PAKALA	B
NININGER	B	NUTLEY	C	OLEX	B	ORTLEY	B	PAKINI	B
NINNESCAH	B	NUTRAS	C	OLGA	C	ORWET	A	PALA	B
NIOBELL	C	NUTRIOSO	B	OLI	B	ORWOOD	B	PALACIO	B
NIOTA	D	NUVALDE	C	OLIAGA	B/D	OSAGE	D	PALAPALAI	B
NIPE	B	NYALA	D	OLINDA	B	OSAKIS	B	PALATINE	B
NIPPERSINK	B	NYMORE	A	OLIPHANT	B	OSCAR	D	PALESTINE	B
NIPPT	A	NYSSA	C	OLIVENHAIN	D	OSCURA	C	PALISADE	B
NIPSUM	C	NYSSATON	B	OLIVER	B	OSGOOD	B	PALMA	B
NIRA	B	NYSTROM	C	OLIVIER	C	OSHA	B	PALMAREJO	C
NISHNA	C			OLJETO	A	OSHAWA	D	PALM BEACH	A
NISHON	D	OAHE	B	OLMITO	D	O'SHEA	C	PALMER	D
NISQUALLY	A	OAKDALE	B	OLMITZ	B	OSHKOSH	C	PALMER CANYON	B
NISSWA	B	OAKDEN	D	OLMOS	C	OSHTEMO	B	PALMICH	B
NIU	B	OAKFORD	B	OLMSTED	B/D	OSIER	B/D	PALMS	D
NIULII	C	OAK GLEN	B	OLNEY	B	OSKA	C	PALMYRA	B
NIVLOC	D	OAK GROVE	C	OLOKUI	D	OSMUND	B	PALO	B
NIWOT	C	OAK LAKE	B	OLPE	C	OSO	B	PALODURO	B
NIXA	C	OAKLAND	C	OLSON	D	OSOBB	D	PALOMAS	B
NIXON	B	OAKS RIDGE	C	OLTON	C	OSORIDGE	D	PALOMINO	D
NIXONTON	B	OAKVILLE	A	OLUSTEE	B/D	OSOTE	B	PALOS VERDES	B
NIZINA	A	OAKWOOD	D	OLYIC	B	OSSIAN	C	PALOUSE	B
NOBE	D	OANAPUKA	B	OLYMPIC	B	OST	B	PALSGROVE	B
NOBLE	B	OASIS	B	OMADI	B	OSTRANDER	B	PAMLICO	D
NOBSCOTT	A	OATMAN	B	OMAHA	B	OTERO	B	PAMOA	C
NOCKEN	C	OBAN	C	OMAK	C	OTHELLO	D	PAMSDEL	D
NODAWAY	B	OBARC	B	OMEGA	A	OTIS	C	PAMUNKEY	C
NOEL	D	OBEN	C	OMENA	B	OTISCO	A	PANA	B
NOHILI	D	OBRAST	D	OMNI	C	OTISVILLE	A	PANACA	D
NOKASIPPI	D	OBRAY	D	ONA	A/D	OTLEY	B	PANAEWA	D
NOKAY	C	OBURN	D	ONALASKA	B	OTSEGO	C	PANASOFFKEE	D
NOKOMIS	B	OCALA	D	ONAMIA	B	OTTER	B/D	PANCHERI	B
NOLAM	B	OCEANET	D	ONARGA	B	OTTERBEIN	C	PANCHUELA	C
NOLICHUCKY	B	OCEANO	A	ONAWA	D	OTTERHOLT	B	PANDO	B
NOLIN	B	OCHEYEDAN	B	ONAWAY	B	OTTOKEE	A	PANDOAH	C
NOLO	B	OCHLOCKONEE	B	ONDAWA	B	OTWAY	D	PANDORA	D
NOME	D	OCHO	D	ONEIDA	B	OTWELL	C	PANDURA	D
NONDALTON	B	OCHOCO	C	O'NEILL	B	OUACHITA	C	PANE	B
NONOPAHU	D	OCHOPEE	B/D	ONEONTA	B	OURAY	A	PANGUITCH	B
NOOKACHAMPS	C/D	OCILLA	C	ONITA	C	OUTLET	C	PANHILL	B
NOOKSACK	B	OCKLEY	B	ONITE	B	OVALL	C	PANIOGUE	B
NOONAN	D	OCOEE	A/D	ONOTA	C	OVERGAARD	C	PANKY	C
NORA	B	OCONEE	C	ONOVA	D	OVERLAND	C	PANOCHE	B
NORAD	B	OCONTO	B	ONRAY	C	OVERLY	C	PANOLA	D
NORBERT	D	OCOSTA	D	ONSLOW	B	OVERTON	D	PANSEY	D
NORBORNE	B	OCQUEOC	B	ONTARIO	B	OVID	C	PANTEGO	D
NORBY	B	OCTAGON	B	ONTKO	B/D	OVINA	B	PANTHER	D
NORD	B	ODEE	D	ONTONAGON	D	OWEGO	D	PANTON	D
NORDBY	B	ODELL	B	ONYX	B	OWEN CREEK	C	PAOLA	A
NORDEN	B	ODEM	A	OOKALA	A	OWENS	D	PAOLI	B
NORDNESS	B	ODERMOTT	C	OPAL	D	OWHI	B	PAONIA	C
NORFOLK	B	ODESSA	D	OPEQUON	C/D	OWOSSO	B	PAPAA	D
NORGE	B	ODIN	C	OPHIR	C	OWYHEE	B	PAPAI	A
NORKA	B	ODNE	C	OPIHIKAO	D	OXALIS	C	PAPAKATING	D
NORMA	B/C	O'FALLON	D	OPPIO	D	OXBOW	C	PAPOOSE	C
NORMANGEE	D	OGDEN	D	OQUAGA	C	OXERINE	C	PARADISE	C
NORREST	C	OGEECHEE	C	ORA	C	OXFORD	D	PARADOX	B
NORRIS	C	OGEMAW	C	ORAN	B	OZAMIS	B/D	PARALOMA	C
NORRISTON	B	OGILVIE	C	ORANGE	D	OZAN	D	PARAMORE	D
NORTE	B	OGLALA	B	ORANGEBURG	B	OZAUKEE	C	PARASOL	B
NORTHDALE	C	OGLE	B	ORCAS	D			PARCELAS	D
NORTHFIELD	B	OHAYSI	D	ORCHARD	B	PAAIKI	B	PARDEE	D
NORTHMORE	C	OHIA	A	ORD	A	PAALOA	B	PAREHAT	C
NORTHPORT		OJAI	B	ORDNANCE	C	PAAUHAU	A	PARENT	C
NORTH POWDER	C	OJATA	D	ORDWAY	D	PACHAPPA	B	PARIETTE	C
NORTHUMBERLAND	C/D	OKANOGAN	B	ORELIA	D	PACHECO	B/C	PARIS	

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

PARISHVILLE	C	PELIC	D	PICAYUNE	B	PLEASANT VIEW	B	POS.	D
PARKAY	B	PELLA	D	PICKAWAY	C	PLEDGER	D	POTAMO	D
PARKDALE	B	PELLEJAS	B	PICKENS	D	PLEEK	C	POTH	C
PARKE	B	PELONA	C	PICKETT	B	PLEINE	D	POTLATCH	C
PARKER	B	PELUK	D	PICKFORD	D	PLEVNA	D	POTRATZ	C
PARKFIELD	C	PEMBERTON	A	PICKRELL	D	PLOME	B	POTSDAM	B
PARKHILL	D	PEMBINA	C	PICKWICK	B	PLOVER	B	POTTER	C
PARKHURST		PEMBROKE	B	PICO	B	PLUMAS	B	POTTS	B
PARKINSON	B	PENA	B	PICOSA	C	PLUMMER	B/D	POUDRE	B
PARKVIEW	B	PENCE	A	PICTOU	B	PLUSH	B	POULTNEY	B
PARKVILLE	C	PENDEN	B	PIE CREEK	D	PLUTH	B	POUNCEY	D
PARKWOOD	A/D	PEND OREILLE	B	PIERIAN	A	PLUTOS	C	POVERTY	A
PARLEYS	B	PENDROY	D	PIERPONT	C	PLYMOUTH	A	POWDER	B
PARLIN	C	PENELAS	D	PIERRE	D	POALL	C	POWDERHORN	C
PARLO	B	PENINSULA	C	PIERSONTE	B	POARCH	B	POWELL	C
PARMA	C	PENISTAJA	B	PIIHONUA	A	POCALLA	A	POWER	B
PARNELL	D	PENITENTE	B	PIKE	B	POCATELLO	B	POWHITE	C
PARR	B	PENLAW	C	PILCHUCK	A	POCKER	D	POWLEY	D
PARRAN	D	PENN	C	PILGRIM	B	POCOMOKE	D	POWWATKA	C
PARRISH	C	PENNEL	C	PILOT	B	PODO	D	POY	D
PARSHALL	B	PENNINGTON	B	PILOT ROCK	C	PODUNK	B	POYGAN	D
PARSIPPANY	D	PENO	C	PIMA	B	POE	B/C	POZO	C/D
PARSONS	D	PENOYER	C	PIMER	B	POEVILLE	D	POZO BLANCO	B
PARTRI	C	PENROSE	D	PINAL	D	POGAL	B	PRAG	C
PASAGSHAK	D	PENSORE	D	PINALENO	B	POGANEAB	D	PRATHER	B
PASCO	B/C	PENTHOUSE	D	PINAMT	B	POGUE	B	PRATLEY	C
PASO SECO	D	PENTZ	D	PINATA	C	POHAKUPU	A	PRATT	A
PASQUETTI	C/D	PENWELL	A	PINAVETES	A	POINDEXTER	C	PREACHER	B
PASQUOTANK	B/D	PENWOOD	A	PINCHER	C	POINSETT	B	PREAKNESS	D
PASSAR	C	PEOGA	C	PINCKNEY	C	POINT	B	PREBISH	D
PASS CANYON	D	PEOH	C	PINCONNING	D	POINT ISABEL	C	PREBLE	C
PASSCREEK	C	PEONE	B/C	PINCUSHION	B	POJOAQUE	B	PRENTISS	C
PASTURA	D	PEORIA	D	PINEDA	B/D	POKEGEMA	B	PRESQUE ISLE	B
PATAHS	B	PEOTONE	C	PINEDALE	B	POKEMAN	B	PRESTO	A
PATENT	C	PEPOON	B	PINEGUEST	B	POKER	C	PRESTON	A
PATILLAS	B	PEQUEA	C	PINELLOS	A/D	POLAND	B	PREWITT	B
PATILO	C	PERCHAS	D	PINETOP	C	POLAR	B	PREY	D
PATIT CREEK	B	PERCIVAL	C	PINEVILLE	B	POLATIS	C	PRICE	C
PATNA	B	PERELLA	C	PINEY	C	POLE	A	PRIDA	D
PATOUTVILLE	C	PERHAM	C	PINICON	B	POLEBAR	C	PRIDHAM	D
PATRICIA	B	PERICO	B	PINKEL	C	POLELINE	B	PRIETA	D
PATRICK	B	PERITSA	C	PINKHAM	B	POLEO	B	PRIMEAUX	C
PATROLE	C	PERKINS	C	PINKSTON	B	POLEY	C	PRIMGHAR	B
PATTANI	D	PERKS	A	PINNACLES	C	POLICH	B	PRINCETON	B
PATTENBURG	B	PERLA	C	PINO	C	POLLARD	C	PRINEVILLE	C
PATTER	C	PERMA	A	PINOLA	C	POLLASKY	C	PRING	B
PATTERSON	C	PERMANENTE	C	PINOLE	B	POLLY	B	PRINS	C
PATTON	B/D	PERRIN	B	PINON	C	POLO	B	PRITCHETT	C
PATWAY	C	PERRINE	D	PINONES	D	POLSON	C	PROCTOR	B
PAUL	B	PERROT	D	PINTAS	D	POLVADERA	B	PROGRESSO	C
PAULDING	D	PERRY	D	PINTLAR	A	POMAT	C	PROMISE	D
PAULINA	D	PERRYPARK	B	PINTO	C	POMELLO	C	PROMO	D
PAULSELL	D	PERRYVILLE	B	PINTURA	A	POMPANO	A/D	PROMONTORY	B
PAULSON	B	PERSANTI	C	PINTWATER	D	POMPONIO	C/D	PRONG	C
PAULVILLE	B	PERSAYO	D	PIOCHE	D	POMPTON	B	PROSPECT	B
PAUMALU	B	PERSHING	C	PIOPOLIS	D	POMROY	B	PROSPER	B
PAUNSAUGUNT	D	PERSIS	B	PIPER	B/C	PONCA	B	PROSSER	C
PAUSANT	B	PERT	D	PIROUETTE	D	PONCENA	D	PROTIVIN	C
PAUWELA	B	PERU	C	PIRUM	B	PONCHA	A	PROUT	C
PAVANT	D	PESCADERO	C/D	PISGAH	C	POND	B/C	PROVIDENCE	C
PAVILLION	B	PESET	C	PISHKUN	B	POND CREEK	B	PROVO	D
PAVOHROO	B	PESHASTIN	B	PISTAKEE	B	PONDILLA	A	PROVO BAY	D
PAWCATUCK	D	PESO	C	PIT	D	PONIL	D	PROWERS	B
PAWLET	B	PETEETNEET	D	PITTMAN	D	PONTOTOC	B	PTARMIGAN	B
PAWNEE	D	PETERBORO	B	PITTSFIELD	B	PONZER	D	PUAULU	A
PAXTON	C	PETERS	D	PITTSTOWN	C	POOKU	A	PUCHYAN	A
PAXVILLE	D	PETOSKEY		PITTWOOD	B	POOLE	B/D	PUDDLE	D
PAYETTE	B	PETRIE	D	PITZER	C	POOLER	D	PUERCO	D
PAYMASTER	B	PETROLIA	D	PIUTE	D	POORMA	B	PUERTA	D
PAYNE	C	PETTONS	C	PLACEDO	D	POPE	B	PUETT	D
PAYSON	D	PEWAMO	B/D	PLACENTIA	D	POPPLETON	A	PUGET	B/C
PEACHAM	D	PEYTON	B	PLACERITOS	C	POQUONOCK	C	PUGSLEY	B
PEARL HARBOR	D	PFEIFFER	B	PLACID	A/D	PORRETT	B/D	PUHI	A
PEARMAN		PHAGE	B	PLACK	D	PORT	B	PUHIMAU	D
PEARSOLL	D	PHANTOM	C	PLAINFIELD	A	PORTAGEVILLE	D	PULASKI	B
PEAVINE	C	PHARO	B	PLAINVIEW	C	PORTALES	B	PULEHU	B
PECATONICA	B	PHAROLIO	D	PLAISTED	C	PORTALTO	B	PULLMAN	D
PECOS	D	PHEBA	C	PLANO	B	PORT BYRON	B	PULS	D
PEDEE	C	PHEENEY	B	PLASKETT	D	PORTERS	B	PULSIPHER	D
PEDERNALES	C	PHELAN	B	PLATA	B	PORTERVILLE	D	PULTNEY	C
PEDIGO	B/C	PHELPS	B	PLATEA	C	PORTHILL	C	PUMEL	C
PEDLAR	D	PHIFERSON	B	PLATEAU	B	PORTINO	C	PUMPER	C
PEDOLI	C	PHILBON	B/D	PLATNER	C	PORTLAND	D	PUNA	A
PEDRICK	B	PHILIPSBURG	B	PLATO	C	PORTNEUF	B	PUNALUU	D
PEEBLES	C	PHILLIPS	C	PLATORO	B	PORTOLA	C	PUNOHU	A
PEEL	C	PHILO	B	PLATTE	D	PORTSMOUTH	D	PURDAM	C
PEELER	B	PHILOMATH	D	PLATTVILLE	B	PORUM	C	PURDY	D
PEEVER	C	PHIPPS	C	PLAZA	B/C	POSANT	C	PURGATORY	D
PEGLER	D	PHOEBE	B	PLEASANT	C	POSEY	B	PURNER	D
PEGRAM	B	PHOENIX	D	PLEASANT GROVE	B	POSITAS	D	PURSLEY	B
PEKIN	C	PIASA	D	PLEASANTON	B	POSKIN	C	PURVES	D
PELHAM	B/D	PICACHO	C	PLEASANT VALE	B	POSOS	C	PUSTOI	A

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

PUTNAM	D	RANDMAN	D	REELFOOT	C	RIFFE	B	ROLETTE	C
PUUKALA	D	RANDOLPH	D	REESER	C	RIFLE	A/D	ROLFE	C
PUUONE	C	RANDS	C	REESVILLE	C	RIGA	D	ROLISS	D
PUU OO	A	RANGER	D	REEVES	C	RIGGINS	A	ROLLA	C
PUU OPAE	B	RANIER	C	REFUGE	C	RIGLEY	B	ROLLIN	D
PUU PA	B	RANKIN	C	REGAN	B	RILEY	C	ROLOFF	C
PUYALLUP	B	RANTOUL	D	REGENT	C	RILLA	B	ROMBERG	B
PYLE	A	RANYHAN	B	REHM	C	RILLITO	B	ROMBO	C
PYLON	D	RAPELJE	C	REICHEL	B	RIMER	C	ROMEO	C
PYOTE	A	RAPHO	B	REIFF	B	RIMINI	A	ROMNEY	C
PYRAMID	D	RAPIDAN	B	REILLY	A	RIMROCK	D	ROMULUS	D
PYRMONT	D	RAPLEE	C	REINACH	B	RIN	B	ROND	C
		RARDEN	C	REKOP	D	RINCON	C	RONNEBY	B
QUACKENBUSH	C	RARICK	B	RELAN	A	RINCONADA	C	RONSON	B
QUAKER	C	RARITAN	C	RELAY	B	RINDGE	D	ROOSET	B
QUAKERTOWN	B	RASBAND	B	RELIANCE	C	RINGLING	C	ROOTEL	D
QUAMBA	D	RASSET	B	RELIZ	D	RINGO	D	ROSACHI	C
QUAMON	A	RATAKE	C	RELSE	B	RINGOLD	B	ROSAMOND	B
QUANAH	B	RATHBUN	C	REMBERT	D	RINGWOOD	B	ROSANE	C
QUANDAHL	B	RATLIFF	B	REMMIT	A	RIO	D	ROSANKY	C
QUARLES	D	RATON	D	REMSEN	D	RIO ARRIBA	D	ROSARIO	C
QUARTZBURG	C	RATTLER	B	REMUDAR	B	RIOCONCHO	C	ROSCOE	D
QUATAMA	C	RATTO	D	REMUNDA	C	RIO GRANDE	B	ROSCOMMON	D
QUAY	B	RAUB	B	RENBAC	D	RIO KING	C	ROSEBERRY	B/D
QUAZO	D	RAUVILLE	D	RENCALSON	C	RIO LAJAS	A	ROSEBLOOM	D
QUEALY	D	RAUZI	B	RENCOT	A	RIO PIEDRAS	B	ROSEBUD	B
QUEBRADA	C	RAVALLI	C	RENFROW	D	RIPLEY	B	ROSEBURG	B
QUEENY	D	RAVENDALE	D	RENICK	D	RIPON	B	ROSE CREEK	C
QUEETS	B	RAVENNA	C	RENNIE	C/D	RIRIE	B	ROSEGLEN	B
QUEMADO	C	RAVOLA	B	RENO	D	RISBECK	B	ROSEHILL	D
QUENZER	D	RAWAH	B	RENOHILL	C	RISLEY	D	ROSELAND	D
QUICKSELL	D	RAWHIDE	D	RENOVA	B	RISTA	C	ROSELLA	D
QUIETUS	C	RAWSON	B	RENOX	B	RISUE	D	ROSELMS	D
QUIGLEY	B	RAY	B	RENSHAW	B	RITCHEY	B	ROSEMOUNT	B
QUILCENE	C	RAYADO	C	RENSLOW	B	RITNER	C	ROSENDALE	B
QUILLAYUTE	B	RAYENOUF	B	RENSSELAER	C	RITO	B	ROSE VALLEY	C
QUIMBY	B	RAYMONDVILLE	D	RENTIDE	C	RITTER	B	ROSEVILLE	B
QUINCY	A	RAYNE	B	RENTON	B/C	RITTMAN	C	ROSEWORTH	C
QUINLAN	C	RAYNESFORD	B	RENTSAC	C	RITZ	B/D	ROSHE SPRINGS	D
QUINN	D	RAYNHAM	C	REPARADA	D	RITZCAL	B	ROSITAS	A
QUINNEY	C	RAYNOR	D	REPP	A	RITZVILLE	B	ROSLYN	B
QUINTON		RAZOR	C	REPPART	B	RIVERHEAD	B	ROSMAN	B
QUITMAN	C	RAZORT	B	REPUBLIC	B	RIVERSIDE	A	ROSNEY	C
QUONSET	A	READING	C	RESCUE	C	RIVERTON	C	ROSS	B
		READINGTON	C	RESERVE	B	RIVERVIEW	B	ROSS FORK	C
RABER	C	READLYN	B	RESNER	B	RIVRA	A	ROSSI	C
RABEY	A	REAGAN	B	RET	B/C	RIXIE	C	ROSSMOYNE	C
RABIDEUX	B	REAKOR	B	RETRIEVER	D	RIXON	C	ROSS VALLEY	C
RABUN	B	REAL	C	RETSOF	C	RIZ	D	ROTAN	C
RACE	D	REAP	D	RETSOK	B	ROANOKE	D	ROTHIEMAY	B
RACHERT	D	REARDAN	C	REXBURG	B	ROBANA	B	ROTHSAY	B
RACINE	B	REAVILLE	C	REXFORD	C	ROBBINS	B	ROTTULEE	B
RACOON	D	REBA	C	REXOR	A	ROBBS	D	ROUBIDEAU	C
RAD	C	REBEL	B	REYES	C/D	ROBERTS	D	ROUEN	C
RADERSBURG	B	REBUCK		REYNOLDS		ROBERTSDALE	C	ROUND BUTTE	D
RADFORD	B	RECAL	D	REYNOSA	B	ROBERTSVILLE	D	ROUNDLEY	C
RADLEY	C	RECLUSE	C	REYWAT	D	ROBIN	B	ROUNDTOP	C
RADNOR	D	REDBANK	B	RHAME	B	ROBINSON	D	ROUNDUP	C
RAFAEL	D	RED BAY	B	RHEA	B	ROBINSONVILLE	B	ROUNDY	C
RAGER	B	RED BLUFF	C	RHINEBECK	D	ROBLEDO	D	ROUSSEAU	A
RAGLAN	C	RED BUTTE	B	RHOADES	D	ROB ROY	C	ROUTON	D
RAGNAR	B	REDBY	C	RHOAME	C	ROBY	C	ROUTT	C
RAGO	C	REDCHIEF	C	RIB	C	ROCA	D	ROVAL	D
RAGSDALE	B/D	REDCLOUD	B	RICCO	D	ROCHE	C	ROWE	D
RAGTOWN	D	REDDICK	C	RICETON	B	ROCHELLE	C	ROWENA	C
RAHAL	C	REDDING	D	RICEVILLE	C	ROCHEPORT	C	ROWLAND	C
RAHM	C	REDFIELD	B	RICHARDSON	B	ROCKAWAY	C	ROWLEY	B
RAIL	C/D	RED HILL	C	RICHEAU	C	ROCKCASTLE	D	ROXAL	D
RAINBOW	C	RED HOOK	C	RICHEY	C	ROCK CREEK	D	ROXBURY	B
RAINEY	B	REDLAKE	D	RICHFIELD	C	ROCKFORD	B	ROY	B
RAINS	B/D	REDLANDS	B	RICHFORD	A	ROCKHOUSE	A	ROYAL	B
RAINSBORO	C	REDLODGE	D	RICHLIE	A	ROCKINGHAM	C/D	ROYALTON	C
RAKE	D	REDMANSON	B	RICHMOND	D	ROCKLIN	C/D	ROYCE	B
RALSEN	B/C	REDMOND	C	RICHTER	B	ROCKLY	D	ROYSTONE	B
RAMADA	C	REDNUN	C	RICHVALE	B	ROCKPORT	C	ROZA	D
RAMADERO	B	REDOLA	B	RICHVIEW	C	ROCK RIVER	B	ROZELLVILLE	B
RAMBLER	B	REDONA	B	RICHWOOD	B	ROCKTON	B	ROZETTA	B
RAMELLI	C	REDRIDGE	B	RICKMORE	C	ROCKWELL	B	ROZLEE	C
RAMIRES	D	REDROB	D	RICKS	A	ROCKWOOD	B	RUARK	C
RAMMEL	C	RED ROCK	B	RICO	C	ROCKY FORD	B	RUBICON	A
RAMO	C	RED SPUR	B	RICREST	B	RODDY		RUBIO	C
RAMONA	B	REDSTOE	B	RIDD	C	RODMAN	A	RUBY	B
RAMPART	B	REDTHAYNE	B	RIDGEBURY	C	ROE	B	RUBYHILL	C
RAMPARTAR	A	REDTOM	C	RIDGECREST	C	ROEBUCK	D	RUCH	B
RAMPARTER	A	REDVALE	C	RIDGEDALE	B	ROELLEN	D	RUCKLES	D
RAMSEY	D	REDVIEW	C	RIDGELAND	D	ROEMER	C	RUCLICK	C
RAMSHORN	B	REE	B	RIDGELAWN	A	ROESIGER	B	RUDD	D
RANCE	C	REEBEX	C	RIDGELY	B	ROGERT	D	RUDEEN	B
RANCHERIA	B	REED	D	RIDGEVILLE	B	ROHNERVILLE	B	RUDOLPH	C
RAND	B	REEDER	B	RIDGEWAY	D	ROHRERSVILLE	C	RUDYARD	D
RANDADO	C	REEDPOINT	C	RIDIT	C	ROIC	D	RUELLA	B
RANDALL	D	REEDY	D	RIETBROCK	C	ROKEBY	D	RUGGLES	B

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

RUIDOSO	C	SALVISA	C	SAUK	B	SEDAN		SHELBY	B
RUKO	D	SALZER	D	SAULICH	D	SEDILLO	B	SHELBYVILLE	B
RULE	B	SAMBA	D	SAUM	C	SEDWELL	C	SHELDON	
RULICK	C	SAMISH	C/D	SAUNDERS	C	SEEDSKADEE	D	SHELIKOF	D
RUMBO	C	SAMMAMISH	C	SAUVIE	C/D	SEES	C	SHELLABARGER	B
RUMFORD	B	SAMPSEL	D	SAUVOLA	C	SEEWEE	B	SHELLDRAKE	A
RUMNEY	C	SAMPSON	B	SAVAGE	C	SEGAL	D	SHELLROCK	A
RUMPLE	C	SAMSIL	D	SAVANNAH	C	SEGNO	C	SHELMADINE	D
RUM RIVER	C	SAN ANDREAS	C	SAVENAC	C	SEHORN	D	SHELOCTA	B
RUNE	C	SAN ANTON	B	SAVO	C	SEITZ	C	SHELTON	C
RUNGE	B	SAN ANTONIO	C	SAVOIA	B	SEJITA	D	SHENA	C
RUNNELLS	C	SAN ARCACIO	B	SAWABE	D	SEKIL	C	SHENANDOAH	C
RUNNYMEDE	B	SAN BENITO	B	SAWATCH	C	SEKIU	D	SHEP	B
RUPERT	A	SANCHEZ	D	SAWCREEK	B	SELAH	C	SHEPPARD	A
RUSCO	C	SANDALL	C	SAWMILL	C	SELDEN	C	SHERANDO	A
RUSE	D	SANDERSON	B	SAWYER	C	SELEGNA	D	SHERAR	C
RUSH	C	SANDLAKE	C	SAXBY	D	SELFRIDGE	C	SHERBURNE	B
RUSHTOWN	A	SANDLEE	A	SAXON	B	SELKIRK	D	SHERIDAN	B
RUSHVILLE	D	SANELI	D	SAYBROOK	B	SELLE	B	SHERLOCK	B
RUSS	B	SAN EMIGDIO	B	SAYLESVILLE	C	SELLERS	A/D	SHERM	D
RUSSELL	B	SANFORD	A	SAYLOR	A	SELMA	B	SHERRYL	B
RUSSELLVILLE	C	SANGER	B	SCALA	B	SEMIAHMOO	D	SHERWOOD	B
RUSSLER	C	SAN GERMAN	D	SCAMMAN	C	SEMIHMOO	D	SHIBLE	B
RUSTON	B	SANGO	C	SCANDIA	B	SEMINARIO	D	SHIELDS	C
RUTLAND	C	SANGREY	A	SCANTIC	C	SEMIX	C	SHIFFER	B
RUTLEGE	D	SANILAC	C	SCAR	A	SEN	B	SHILOH	C
RYAN	D	SAN ISABEL	B	SCARBORO	D	SENECAVILLE	C	SHINAKU	D
RYAN PARK	B	SAN JOAQUIN	D	SCAVE	C	SEQUATCHIE	B	SHINGLE	D
RYDE	B/D	SAN JON	C	SCHAFFENAKER	A	SEQUIM	A	SHINGLETOWN	C
RYDER	C	SAN JOSE	B	SCHAMBER	A	SEQUIN	B	SHINN	B
RYEGATE	B	SAN JUAN	A	SCHAMP	C	SEQUOIA	C	SHINROCK	C
RYELL	A	SAN LUIS	B	SCHAPVILLE	C	SERENE	D	SHIOCTON	B
RYEPATCH	D	SAN MATEO	B	SCHEBLY	D	SERNA	D	SHIPLEY	C
RYER	C	SAN MIGUEL	C	SCHERRARD	D	SEROCO	A	SHIPROCK	B
RYORP	C	SANPETE	B	SCHLEY	B	SERPA	C/D	SHIRAT	B
RYUS	C	SANPITCH	C	SCHMUTZ	B	SERVOSS.	D	SHIRK	C
		SAN POIL	B	SCHNEBLY	D	SESAME	C	SHOALS	C
SABANA	D	SAN SABA	D	SCHNEIDER	C	SESPE	C	SHOEBAR	B
SABANA SECA	D	SAN SEBASTIAN	B	SCHNOORSON	B/D	SESSIONS	C	SHOEFFLER	B
SABENYO	B	SANTA	C	SCHNORBUSH	C	SESSUM	D	SHONKIN	D
SABINA	C	SANTA CLARA	C	SCHODACK		SETTERS	C	SHOOFLIN	C
SABINE	A	SANTA FE	D	SCHODSON	C	SETTLEMEYER	D	SHOOK	A
SABLE	D	SANTA ISABEL	D	SCHOFIELD	B	SEVAL	D	SHOREWOOD	C
SAC	B	SANTA LUCIA	C	SCHOHARIE	C	SEVERN	B	SHOREY	B
SACO	D	SANTA MARTA	C	SCHOLLE	B	SEVILLE	D	SHORN	B
SACRAMENTO	C/D	SANTANA	C	SCHOOLEY	C/D	SEVY	C	SHORT CREEK	D
SACUL	D	SANTAQUIN	A	SCHOONER	D	SEWARD	B	SHOSHONE	D
SADDLE	B	SANTA YNEZ	C	SCHRADER	D	SEWELL	B	SHOTWELL	D
SADDLEBACK	B	SANTEE	D	SCHRAP	D	SEXTON	D	SHOUNS	B
SADER	D	SANTIAGO	B	SCHRIER	B	SEYMOUR	C	SHOWALTER	C
SADIE	B	SANTIAM	C	SCHROCK	B	SHAAK	D	SHOWLOW	C
SADLER	C	SAN TIMOTEO	C	SCHUMACHER	B	SHADELAND	C	SHREWSBURY	D
SAFFELL	B	SANTONI	D	SCHUYLKILL	B	SHAFFER	A	SHRINE	B
SAGANING	D	SANTOS	C	SCIO	B	SHAKAN	B	SHROE	D
SAGE	D	SANTO TOMAS	B	SCIOTOVILLE	C	SHAKESPEARE	C	SHROUTS	D
SAGEHILL	B	SAN YSIDRO	D	SCISM	B	SHAKOPEE	C	SHUBUTA	C
SAGEMOOR	C	SAPINERO	B	SCITUATE	C	SHALCAR	D	SHULE	B
SAGERTON	C	SAPP	D	SCOBEY	C	SHALET	D	SHULLSBURG	C
SAGINAW		SAPPHIRE	B	SCOOTENEY	B	SHAM	D	SHUMWAY	D
SAGO	D	SAPPHO	B	SCORUP	C	SHAMBO	B	SHUPERT	C
SAGOUSPE	C	SAPPINGTON	B	SCOTT	D	SHAMEL	B	SHUWAH	B
SAGUACHE	A	SARA	C	SCOTT LAKE	B	SHANAHAN	B	SI	B
SAHALIE	B	SARALBGUI	B	SCOUT	B	SHANDON		SIBLEYVILLE	B
SAINT HELENS	A	SARANAC	D	SCOWLALE	C	SHANE	D	SIBYLEE	D
SAINT MARTIN	C	SARAPH	D	SCRANTON	B/D	SHANO	B	SICILY	B
SALADO	B	SARATOGA	B	SCRAVO	A	SHANTA	B	SICKLESTEETS	C
SALADON	D	SARATON	B	SCRIBA	C	SHAPLEIGH	C/D	SIDELL	B
SALAL	B	SARBEN	A	SCRIVER	B	SHARATIN	B	SIEANCIA	B
SALAMATOF	D	SARCO	B	SCROGGIN	C	SHARKEY	D	SIEBER	A
SALAS	C	SARDINIA	C	SCULLIN	C	SHARON	B	SIELO	C
SALCHAKET	B	SARDO	B	SEABROOK	C	SHARPSBURG	B	SIEROCLIFF	D
SALEM	B	SARGEANT	D	SEAMAN	C	SHARROTT	D	SIERRA	B
SALEMSBURG	B	SARITA	A	SEAQUEST	C	SHARVANA	C	SIERRAVILLE	B
SALGA	C	SARKAR	D	SEARCHLIGHT	C	SHASKIT	B/C	SIESTA	D
SALIDA	A	SARPY	A	SEARING	B	SHASTA	A	SIFTON	B
SALINAS	C	SARTELL	A	SEARLA	B	SHAVANO	B	SIGNAL	C
SALISBURY	D	SASKA	B	SEARLES	C	SHAVER	B	SIGURD	B
SALIX	B	SASPAMCO	B	SEATON	B	SHAWA	B	SIKESTON	D
SALKUM	C	SASSAFRAS	B	SEATTLE	D	SHAWANO	A	SILCOX	B
SALLISAW	B	SASSER	B	SEAWILLOW	B	SHAWMUT	B	SILENT	D
SALLYANN	C	SATANKA	C	SEBAGO	D	SHAY	D	SILER	B
SALMON	B	SATANTA	B	SEBASTIAN	D	SHEAR	C	SILERTON	B
SALOL	D	SATELLITE	C	SEBASTOPOL	C	SHECKLER	C	SILI	D
SALONIE	D	SATT	D	SEBEKA	D	SHEDADO	B	SILSTID	A
SALREE	C/D	SATTLEY	B	SEBEWA	B/D	SHEDD	C	SILVER	C
SALTAIR	D	SATTRE	B	SEBREE	D	SHEEGE	D	SILVERADO	C
SALT CHUCK	A	SATURN	B	SEBRING	D	SHEEP CREEK	C	SILVERBOW	D
SALTER	B	SATUS	B	SEBUD	B	SHEEPHEAD	C	SILVER CREEK	D
SALTERY	D	SAUCIER	B	SECATA	C/D	SHEEPROCK	A	SILVERTON	C
SALT LAKE	D	SAUDE	B	SECCA	C	SHEETIRON	B	SILVIES	D
SALUDA	C	SAUGATUCK	C	SECRET	C	SHEFFIELD	D	SIMAS	C
SALUVIA		SAUGUS	B	SECRET CREEK	B	SHELBURNE	C	SIMCOE	C

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

SIMEON	A	SNOW	B	SQUALICUM	B	STISSING	C	SURGH	B
SIMMLER	D	SNOWDEN	C	SQUAW	B	STIVERSVILLE	B	SURPRISE	B
SIMMONT	C	SNOWLIN	B	SQUILLCHUCK	B	STOCKBRIDGE	B	SURRENCY	B/D
SIMNER	A	SNOWVILLE	D	SQUIMER	B	STOCKLAND	B	SURVYA	C
SIMON	C	SNOWY	A	SQUIRES	B	STOCKPEN	D	SUSIE CREEK	D
SIMONA	D	SOAKPAK	B	ST. ALBANS	B	STOCKTON	D	SUSITNA	B
SIMOTE	C	SOAP LAKE	B	ST. CHARLES	B	STODICK	D	SUSQUEHANNA	D
SIMPERS	B	SOBOBA	A	ST. CLAIR	D	STOKES	D	SUTHER	C
SIMPSON	C	SOBRANTE	C	ST. ELMO	A	STOMAR	C	SUTHERLIN	C
SIMS	D	SODA LAKE	B	ST. GEORGE	C	STONER	B	SUTLEW	B/C
SINAI	C	SODHOUSE	D	ST. HELENS	A	STONEWALL	A	SUTPHEN	D
SINCLAIR	C	SODUS	C	ST. IGNACE	C	STONO	B/D	SUTTLER	B
SINE	C	SOELBERG	B	ST. JOE	B/D	STONYFORD	D	SUTTON	B
SINGLETREE	C	SOFIA	B	ST. JOHNS	B/D	STOOKEY	B	SVEA	B
SINGSAAS	B	SOGN	D	ST. LUCIE	A	STORDEN	B	SVERDRUP	B
SINNIGAM	C	SOGZIE	B	ST. MARTIN	C	STORLA	B	SVOLD	C
SINOMAX	B	SOKOLOF	B	ST. MARYS	B	STORMITT	B	SWAGER	C
SINTON	B	SOLANO	D	ST. NICHOLAS	D	STORM KING	D	SWAKANE	C
SINUK	D	SOLDATNA	B	ST. PAUL	B	STORY	C	SWAN	C
SION	B	SOLDIER	C	ST. THOMAS	D	STOSSEL	C	SWANBOY	D
SIOUX	A	SOL DUC	B	STAATSBURG		STOUGH	C	SWANNER	D
SIPPLE	A	SOLDUC	B	STABLER	B	STOWELL	D	SWANSON	B
SIRI	B	SOLLEKS	C	STACY	B	STOY	D	SWANTON	B/D
SISKIYOU	B	SOLLER	D	STADY	B	STRAIGHT	C	SWANTOWN	C
SISSETON	B	SOLOMON	D	STAFFORD	C	STRAIN	B	SWAPPS	C
SISSON	B	SOLONA	B	STAGECOACH	B	STRASBURG	C	SWARTSWOOD	C
SITES	C	SOMBRERO	D	STAHL	C	STRATFORD	B	SWARTZ	D
SITKA	B	SOMERS	B	STALEY	C	STRAUSS	C	SWASEY	D
SIXMILE	B	SOMERSET	D	STAMBAUGH	B	STRAW	B	SWASTIKA	C
SIZEMORE	B	SOMERVELL	B	STAMFORD	D	STRAWN	B	SWATARA	A
SIZER	B	SOMSEN	C	STAMPEDE	D	STREATOR	C	SWAUK	C
SKAGGS	B	SONOITA	B	STAN	B	STROLE	B	SWAWILLIA	A
SKAGIT	B/C	SONOMA	D	STANDISH	C/D	STRONGHURST	B	SWEATMAN	C
SKAHA	A	SONTAG	D	STANEY	D	STRONTIA	B	SWEDE	B
SKALAN	C	SOPER	B/C	STANFIELD	C	STROUPE	C	SWEDEN	B
SKAMANIA	B	SOQUEL	B	STANLEY	C	STRYKER	B	SWEEN	C
SKAMOKAWA	B	SORDO	C	STANSBURY	D	STUBBS	C	SWEENEY	B
SKANEE	C	SORF	C	STANTON	D	STUCKCREEK	B	SWEET	C
SKELLOCK	B	SORRENTO	B	STAPLETON	B	STUKEL	D	SWEETGRASS	B
SKERRY	C	SORTER	B/D	STARBUCK	D	STUKEY	B	SWEETWATER	D
SKIDMORE	B	SOSA	C	STARGO	B	STUMBLE	A	SWENODA	B
SKILLET	C	SOTELLA	C	STARICHKOF	D	STUMPP	D	SWIFTCREEK	B
SKINNER	C	SOTIM	B	STARKS	C	STUMP SPRINGS	B	SWIFTON	A
SKIYOU	C	SOUTHFORK	D	STARLEY	D	STUNNER	B	SWIMS	A
SKOKOMISH	B/C	SOUTHGATE	D	STARR	B	STUTTGART	D	SWINGLER	C
SKOOKUMCHUCK	B	SOUTHWICK	C	STASER	B	STUTZMAN	C	SWINK	D
SKOWHEGAN	B	SPAA	D	STATE	B	STUTZVILLE	B/C	SWISBOB	D
SKULL CREEK	D	SPACE CITY	A	STATEN	D	SUBLETTE	B	SWITCHBACK	C
SKUMPAH	D	SPADE	B	STATLER	B	SUDBURY	B	SWITZERLAND	B
SKUTUM	C	SPALDING	D	STAVE	D	SUDDUTH	C	SWOPE	C
SKYBERG	C	SPAN	D	STAYTON	D	SUFFIELD	C	SWYGERT	C
SKYHAVEN	D	SPANAWAY	B	STEAMBOAT	D	SUGARLOAF	B	SYCAMORE	B/C
SKYKOMISH	B	SPANEL	D	STEARNS	D	SUISUN	D	SYCAN	A
SKYLICK	C	SPARTA	A	STECUM	A	SULA	B	SYLACAUGA	B/D
SKYLINE	D	SPEARFISH	B	STEED	A	SULLY	B	SYLVAN	B
SKYWAY	B	SPEARMAN	C	STEEDMAN	D	SULPHURA	D	SYMERTON	B
SLAB	D	SPEARVILLE	C	STEEKEE	C	SULTAN	B	SYNAREP	B
SLATE CREEK	C	SPECK	D	STEELE	B	SUMAS	B/C	SYRACUSE	B
SLAUGHTER	C	SPECTER	D	STEESE	C	SUMDUM	D	SYRENE	D
SLAVEN	D	SPEELYAI	C	STEFF	C	SUMMA	B	SYRETT	C
SLAWSON	B	SPEIGLE	B	STEGALL	C	SUMMERFIELD	C		
SLAYTON	D	SPENARD	D	STEIGER	A	SUMMERS	B	TABERNASH	B
SLEETH	C	SPENCER	B	STEINAUER	B	SUMMERVILLE	C	TABIONA	B
SLETTEN	D	SPENLO	B	STEINBECK	B	SUMMIT	C	TABLE MOUNTAIN	B
SLICKROCK	B	SPERRY	C	STEINMETZ	D	SUMMITVILLE	B	TABLER	D
SLIGHTS	D	SPICER	C	STEINSBURG	C	SUMTER	C	TABOR	D
SLIGO	B	SPILLVILLE	B	STEIWER	C	SUN	D	TACAN	B
SLIKOK	D	SPINKS	A	STELLAR	C	SUNBURST	C	TACOMA	D
SLIP	B	SPIRES	D	STEMILT	C	SUNBURY	B	TACOOSH	D
SLIPMAN	B/C	SPIRIT	B	STENDAL	C	SUNCOOK	A	TAFT	C
SLOAN	D	SPIRO	B	STEPHEN	C	SUND	C	TAGGERT	C
SLOCUM	B	SPLENDORA	C	STEPHENSBURG	B	SUNDELL	C	TAHOMA	B
SLODUC	C	SPLITRO	D	STEPHENVILLE	B	SUNDERLAND	C/D	TAHQUAMENON	D
SLOSS	C	SPOFFORD	C	STERLING	B	SUNDOWN	B	TAHQUATS	C
SLUICE	B	SPOKANE	B	STERLINGTON	B	SUNFIELD	B	TAINTOR	C
SMARTS	B	SPONSELLER	B	STETSON	B	SUNNILAND	C	TAJO	C
SMITH CREEK	A	SPOON BUTTE	D	STETTER	D	SUNNYHAY	D	TAKEUCHI	C
SMITHDALE	B	SPOONER	C	STEUBEN	B	SUNNYSIDE	B	TAKILMA	B
SMITHNECK	B	SPOTTSWOOD	B	STEVENS	B	SUNNYVALE	C	TAKOTNA	B
SMITHTON	D	SPRAGUE	B/C	STEVENSON	B	SUNRAY	B	TALAG	D
SMOLAN	C	SPRECKELS	C	STEWART	D	SUNRISE	D	TALANTE	C
SMOOT	D	SPRING	C/D	STICKNEY	C	SUNSET	B	TALAPUS	B
SNAG	B	SPRING CREEK	C	STIDHAM	A	SUNSHINE	C	TALBOTT	C
SNAHOPISH	B	SPRINGDALE	B	STIGLER	C	SUNSWEET	C	TALCOT	C
SNAKE	C	SPRINGER	B	STILLMAN	A	SUNUP	D	TALIHINA	D
SNAKE HOLLOW	B	SPRINGERVILLE	D	STILLWATER	D	SUPAN	B	TALKEETNA	C
SNAKELUM	B	SPRINGFIELD	D	STILSON	B	SUPERIOR	C	TALLAC	B
SNEAD	D	SPRINGMEYER	C	STIMSON	B/C	SUPERSTITION	A	TALLADEGA	C
SNELL	C	SPRINGTOWN	C	STINGAL	B	SUPERVISOR	C	TALLAPOOSA	C
SNELLING	B	SPROUL	D	STINSON	C	SUPPLEE	B	TALLEYVILLE	B
SNOHOMISH	D	SPUR	B	STIRK	D	SUR	B	TALLS	B
SNOQUALMIE	B	SPURLOCK	B	STIRUM	B	SURGEM	C	TALLULA	B

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

TALLY	B	TENINO	B	TIGERON	A	TOMERA	D	TRENTON	D
TALMAGE	A	TENNO	D	TIGIWON	B	TOMICHI	A	TREP	B
TALMO	B	TENORIO	B	TIGRETT		TOMOKA	A/D	TRES HERMANOS	B
TALOKA	D	TENOT	C	TIGUA	D	TONASKET	B	TRETTEN	C
TALPA	D	TENRAG	B	TIJERAS	B	TONATA	C	TREVINO	D
TAMA	B	TENSAS	D	TILFORD	B	TONAWANDA	C	TREXLER	C
TAMAHA	C	TENSED	C	TILLEDA	B	TONEY	D	TRIAMI	C
TAMALCO	D	TENSLEEP	B	TILLICUM	B	TONGUE RIVER	C	TRIASSIC	
TAMBA	C/D	TEOCULLI	B	TILLMAN	C	TONINI	B	TRICON	C
TAMELY	[illegible]	TEPEE	D	TILMA	C	TONKA	C	TRIDELL	B
TAMMANY CREEK	B	TEPETE	B/D	TILSIT	C	TONKEY	D	TRIDENT	D
TAMMANY RIDGE	B	TERBIES	C	TILTON	B	TONKIN	C	TRIGO	C
TAMMS	C	TERESA	C	TIMBERG	C	TONKS	B/D	TRIMBLE	B
TAMPICO	B	TERINO	D	TIMBERLY	B	TONOPAH	B	TRIMMER	B
TANAMA	D	TERMINAL	D	TIMBLIN	D	TONOR	C	TRINCHERA	C
TANANA	D	TERMO	C	TIMENTWA	B	TONOWEK	B	TRINITY	D
TANBERG	D	TEROUGE	D	TIMKEN	D	TONRA	A	TRIOMAS	B
TANDY	C	TERRA CEIA	A/D	TIMMERMAN	B	TONSINA	B	TRIPIT	C
TANEUM	C	TERRAD	D	TIMMONS	B	TONUCO	C	TRIPLEN	B
TANEY	C	TERRERA	C	TIMPAHUTE	D	TOOLE	D	TRIPOLI	C
TANGAIR	C	TERRETON	C	TIMPANOGOS	B	TOOMES	D	TRIPP	B
TANNA	C	TERRIL	B	TIMPER	D	TOP	C	TRITON	C
TANNER	C	TERRY	B	TIMPOONEKE	B	TOPIA	D	TRIX	B
TANSEM	B	TERWILLIGER	C	TIMULA	B	TOPPENISH	B/C	TROJAN	B
TANTALUS	A	TESAJO	A	TINA	C	TOPTON		TROMMALD	D
TANWAX	D	TESCOTT	C	TINDAHAY	A	TOQUERVILLE	C	TROMP	C
TAOPI	C	TESUQUE	B	TINE	A	TOQUOP	A	TRONSEN	C
TAOS	D	TETON	A	TINGEY	B	TORBOY	B	TROOK	B
TAPIA	C	TETONIA	B	TINSLEY	A	TORCHLIGHT	C	TROPAL	D
TAPPEN	D	TETONKA	C	TINTON	A	TORDIA	D	TROSI	D
TARA	B	TETOTUM	C	TINYTOWN	B	TORHUNTA	C	TROUP	A
TARKIO	D	TEW	B/D	TIOCANO	D	TORNING	B	TROUT CREEK	C
TARKLIN	C	TEX	B	TIOGA	B	TORODA	B	TROUTDALE	B
TARPO	C	TEXLINE	B	TIPPAH	C	TORONTO	C	TROUT LAKE	C
TARRANT	D	TEZUMA	C	TIPPECANOE	B	TORPEDO LAKE	D	TROUT RIVER	A
TARRETE	D	THACKERY	B	TIPPER	A	TORREON	C	TROUTVILLE	B
TARRYALL	B	THADER	C	TIPPERARY	A	TORRES	B	TROXEL	B
TASCOSA	B	THAGE	C	TIPPIPAH	D	TORRINGTON	B	TROY	C
TASSEL	D	THANYON	A	TIPPO	C	TORRO	C	TRUCE	C
TATE	B	THATCHER	B	TIPTON	B	TORSIDO	D	TRUCKEE	C
TATIYEE	C	THATUNA	C	TIPTONVILLE	B	TORTUGAS	D	TRUCKTON	B
TATU	C	THAYNE	B	TIRO	C	TOSTON	D	TRUEFISSURE	A
TATUM	C	THEBES	B	TISBURY	B	TOTELAKE	A	TRUESDALE	C
TAUNTON	C	THEBO	D	TISCH	C	TOTEM	B	TRULL	C
TAVARES	A	THEDALUND	C	TISH TANG	B	TOTTEN	B	TRULON	B
TAWAS	A/D	THENAS	C	TITUSVILLE	C	TOUCHET	B	TRUMAN	B
TAWCAW	C	THEO	C	TIVERTON	A	TOUHEY	B	TRUMBULL	D
TAYLOR	C	THERESA	B	TIVOLI	A	TOULON	B	TRUMP	D
TAYLOR CREEK	D	THERIOT	D	TIVY	C	TOURN	C	TRYON	D
TAYLORSFLAT	D	THERMAL	C	TOA	C	TOURNQUIST	B	TSCHIGOMA	B
TAYLORSVILLE	C	THERMOPOLIS	D	TOBICO	D	TOURS	B	TUB	C
TAYSOM	B	THESS	B	TOBIN	B	TOUTLE	A	TUBAC	C
TAZLINA	A	THETFORD	A	TOBISH	C	TOWER	D	TUCANNON	C
TEAL	D	THIEL	A	TOBLER	B	TOWHEE	D	TUCKERMAN	D
TEALSON	C	THIOKOL	C	TOBOSA	D	TOWNER	B	TUCSON	B
TEALWHIT	C	THOENY	D	TOBY	B	TOWNLEY	C	TUCUMCARI	B
TEANAWAY	C	THOMAS	D	TOCCOA	B	TOWNSBURY	B	TUFFIT	D
TEAPO	B	THORNDALE	D	TODD	B	TOWNSEND	C	TUGHILL	D
TEAS	C	THORNDIKE	C/D	TODDLER	B	TOWSON	B	TUJUNGA	A
TEASDALE	B	THORNOCK	D	TODDVILLE	B	TOXAWAY	D	TUKEY	C
TEBO	B	THORNTON	D	TOEHEAD	C	TOY	D	TUKWILA	D
TECHICK	B	THORNWOOD	B	TOEJA	C	TOYAH	B	TULA	C
TECOLOTE	B	THOROUGHFARE	B	TOEM	C	TOZE	B	TULANA	C/D
TECUMSAH	B	THORP	C	TOGO	B	TRABUCO	C	TULARE	C/D
TEDROW	B	THORR	B	TOGUS	D	TRACK	B/C	TULAROSA	B
TEEL	B	THORREL	B	TOHONA	C	TRACY	B	TULIA	B
TEHACHAPI	D	THOW	B	TOINE	C	TRAER	C	TULLAHASSEE	C
TEHAMA	C	THREE MILE	D	TOISNOT	D	TRAIL	A	TULLER	D
TEJA	C	THROCK	C	TOIYABE	C	TRAIL CREEK	B	TULLOCK	B
TEJON	B	THUNDERBIRD	D	TOKEEN	B	TRAM	B	TULLY	C
TEKOA	C	THURBER	C	TOKUL	C	TRANSYLVANIA	B	TULUKSAK	D
TELA	B	THURLONI	C	TOLBY	A	TRAPPER	A	TUMBEZ	D
TELEFONO	C	THURLOW	C	TOLEDO	D	TRAPPIST	C	TUMEY	D
TELEPHONE	D	THURMAN	A	TOLICHA	D	TRAPPS	B	TUMITAS	B
TELFER	A	THURMONT	B	TOLKE	B	TRASK	C	TUMWATER	A
TELFERNER	D	THURSTON	B	TOLL	A	TRAVELERS	D	TUNEHEAN	D
TELIDA	D	TIAGOS	B	TOLLGATE	B	TRAVER	B/C	TUNICA	D
TELL	B	TIAK	C	TOLLHOUSE	D	TRAVESSILLA	D	TUNIS	D
TELLER	B	TIBAN	B	TOLMAN	D	TRAVIS	C	TUNITAS	B
TELLICO	B	TIBBITTS	B	TOLNA	B	TRAWICK	B	TUNKHANNOCK	A
TELLMAN	B	TICA	D	TOLO	B	TRAY	C	TUNNEL	B
TELSTAD	B	TICE	C	TOLSONA	D	TREADWAY	D	TUPELO	D
TEMESCAL	D	TICHIGAN	C	TOLSTOI	D	TREASURE	B	TUPUKNUK	D
TEMPLE	B/C	TICHNOR	D	TOLT	D	TREBLOC	D	TUQUE	B
TEMVIK	B	TICKAPOO	D	TOLTEC	C	TREGO	C	TURBEVILLE	C
TENABO	D	TICKASON	B	TOLUCA	B	TRELONA	D	TURBOTVILLE	C
TENAHA	B	TIDWELL	D	TOLVAR	B	TREMANT	B	TURBYFILL	B
TENAS	C	TIERRA	D	TOMAH	C	TREMBLES	B	TURIN	B
TENCEE	D	TIETON	B	TOMAS	B	TREMPE	A	TURK	D
TENERIFFE	C	TIFFANY	C	TOMAST	C	TREMPEALEAU	B	TURKEYSPRINGS	C
TENEX	A	TIFTON	B	TOME	B	TRENARY	B	TURLEY	C
TENIBAC	B	TIGER CREEK	B	TOMEL	D	TRENT	B	TURLIN	B

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

TURNBOW	C
TURNER	B
TURNERVILLE	B
TURNEY	B
TURRAH	D
TURRET	B
TURRIA	C
TURSON	B/C
TUSCAN	D
TUSCARAWAS	C
TUSCARORA	C
TUSCOLA	B
TUSCUMBIA	D
TUSEL	C
TUSKEEGO	C
TUSLER	B
TUSQUITEE	B
TUSTIN	B
TUSTUMENA	B
TUTHILL	B
TUTNI	B
TUTWILER	B
TUXEDO	
TUXEKAN	B
TWIN CREEK	B
TWINING	C
TWISP	B
TWO DOT	C
TYBO	D
TYEE	D
TYGART	D
TYLER	D
TYNDALL	B/C
TYNER	A
TYRONE	C
TYSON	C
UANA	D
UBAR	C
UBLY	B
UCOLA	D
UCOLO	C
UCOPIA	B
UDEL	D
UDOLPHO	C
UFFENS	D
UGAK	D
UHLAND	B
UHLIG	B
UINTA	B
UKIAH	C
ULEN	B
ULLOA	B
ULM	B
ULRICHER	B
ULUPALAKUA	B
ULY	B
ULYSSES	B
UMA	A
UMAPINE	B/C
UMIAT	D
UMIKOA	B
UMIL	D
UMNAK	B
UMPA	B
UMPQUA	B
UNA	D
UNADILLA	B
UNAWEEP	B
UNCOM	B
UNCOMPAHGRE	D
UNEEDA	B
UNGERS	B
UNION	C
UNIONTOWN	B
UNIONVILLE	C
UNISON	C
UPDIKE	D
UPSAL	C
UPSATA	A
UPSHUR	C
UPTON	C
URACCA	B
URBANA	C
URBO	D
URICH	D
URNE	B
URSINE	D
URTAH	C
URWIL	D
USAL	B
USHAR	B
USINE	B
USKA	D
UTALINE	B
UTE	C
UTICA	A
UTLEY	B
UTUADO	B
UVADA	D
UVALDE	C
UWALA	B
VACHERIE	C
VADER	B
VADO	B
VAIDEN	D
VAILTON	B
VALBY	C
VALCO	C
VALDEZ	B/C
VALE	B
VALENCIA	B
VALENT	A
VALENTINE	A
VALERA	C
VALKARIA	B/D
VALLAN	D
VALLECITOS	C/D
VALLEONO	B
VALLERS	C
VALMONT	C
VALMY	B
VALOIS	B
VAMER	D
VANAJO	D
VANANDA	D
VAN BUREN	
VANCE	C
VANDA	D
VANDALIA	C
VANDERDASSON	D
VANDERGRIFT	C
VANDERHOFF	D
VANDERLIP	A
VAN DUSEN	B
VANET	D
VANG	B
VANHORN	B
VAN NOSTERN	B
VANNOY	B
VANOSS	B
VANTAGE	C
VAN WAGONER	D
VARCO	C
VARELUM	C
VARICK	D
VARINA	C
VARNA	C
VARRO	B
VARYSBURG	B
VASHTI	C
VASQUEZ	B
VASSALBORO	D
VASSAR	B
VASTINE	C
VAUCLUSE	C
VAUGHNSVILLE	C
VAYAS	D
VEAL	B
VEAZIE	B
VEBAR	B
VECONT	D
VEGA	C
VEGA ALTA	C
VEGA BAJA	C
VEKOL	D
VELDA	B
VELMA	B
VELVA	B
VENA	C
VENANGO	C
VENATOR	D
VENETA	C
VENEZIA	D
VENICE	D
VENLO	D
VENUS	B
VERBOORT	D
VERDE	C
VERDEL	D
VERDELLA	D
VERDICO	D
VERDIGRIS	B
VERDUN	D
VERGENNES	D
VERHALEN	D
VERMEJO	D
VERNAL	B
VERNALIS	B
VERNIA	A
VERNON	D
VERONA	C
VESSER	C
VESTON	D
VETAL	A
VETERAN	B
VEYO	D
VIA	B
VIAN	B
VIBORAS	D
VIBORG	B
VICKERY	C
VICKSBURG	B
VICTOR	A
VICTORIA	D
VICTORY	B
VICU	D
VIDA	B
VIDRINE	C
VIEJA	D
VIENNA	B
VIEQUES	B
VIEW	C
VIGAR	C
VIGO	D
VIGUS	C
VIKING	D
VIL	D
VILAS	A
VILLA GROVE	B
VILLARS	B
VILLY	D
VINA	B
VINCENNES	C
VINCENT	C
VINEYARD	C
VINGO	B
VINING	C
VINITA	C
VINLAND	C
VINSAD	C
VINT	B
VINTON	B
VIRA	C
VIRATON	C
VIRDEN	C
VIRGIL	B
VIRGIN PEAK	D
VIRGIN RIVER	D
VIRTUE	C
VISALIA	B
VISTA	C
VIVES	B
VIVI	B
VLASATY	C
VOCA	C
VODERMAIER	B
VOLADORA	B
VOLCO	D
VOLENTE	C
VOLGA	D
VOLIN	B
VOLINIA	B
VOLKE	C
VOLKMAR	B
VOLMER	D
VOLNEY	B
VOLPERIE	C
VOLTAIRE	D
VOLUSIA	C
VONA	B
VORE	B
VROOMAN	B
VULCAN	C
VYLACH	D
WABANICA	D
WABASH	D
WABASHA	D
WABASSA	B/D
WABEK	B
WACA	C
WACOTA	B
WACOUSTA	C
WADAMS	B
WADDELL	B
WADDOUPS	B
WADELL	B
WADENA	B
WADESBORO	B
WADLEIGH	D
WADMALAW	D
WADSWORTH	C
WAGES	B
WAGNER	D
WAGRAM	A
WAHA	C
WAHEE	D
WAHIAWA	B
WAHIKULI	B
WAHKEENA	B
WAHKIACUS	B
WAHLUKE	B
WAHMONIE	D
WAHPETON	C
WAHTIGUP	B
WAHTUM	D
WAIAHA	D
WAIAKOA	C
WAIALEALE	D
WAIALUA	B
WAIAWA	D
WAIHUNA	D
WAIKALOA	B
WAIKANE	B
WAIKAPU	B
WAIKOMO	D
WAILUKU	B
WAIMEA	B
WAINEE	B
WAINOLA	A
WAIPAHU	C
WAISKA	B
WAITS	B
WAKE	D
WAKEEN	B
WAKEFIELD	B
WAKELAND	B/D
WAKONDA	C
WAKULLA	A
WALCOTT	B
WALDECK	C
WALDO	D
WALDRON	D
WALDROUP	D
WALES	B
WALFORD	C
WALKE	C
WALL	B
WALLACE	B
WALLA WALLA	B
WALLER	B/D
WALLINGTON	C
WALLIS	B
WALLKILL	C/D
WALLMAN	C
WALLOWA	C
WALLPACK	C
WALLROCK	B/C
WALLSBURG	D
WALLSON	B
WALPOLE	C
WALSH	B
WALSHVILLE	D
WALTERS	A
WALTON	C
WALUM	B
WALVAN	B
WAMBA	B/C
WAMIC	B
WAMPSVILLE	B
WANATAH	B
WANBLEE	D
WANDO	A
WANETTA	A
WANILLA	C
WANN	A
WAPAL	B
WAPATO	C/D
WAPELLO	B
WAPINITIA	B
WAPPING	B
WAPSIE	B
WARBA	B
WARD	D
WARDBORO	A
WARDELL	D
WARDEN	B
WARDWELL	C
WARE	B
WAREHAM	C
WARMAN	D
WARM SPRINGS	C
WARNERS	A/D
WARREN	
WARRENTON	B/D
WARRIOR	
WARSAW	B
WARSING	B
WARWICK	A
WASATCH	A
WASEPI	B
WASHBURN	
WASHINGTON	B
WASHOE	C
WASHOUGAL	B
WASHTENAW	C/D
WASILLA	D
WASIOJA	B
WASSAIC	B
WATAB	C
WATAUGA	B
WATCHAUG	B
WATCHUNG	D
WATERBORO	
WATERBURY	D
WATERINO	C
WATERS	C
WATKINS	B
WATKINS RIDGE	B
WATO	B
WATOPA	B
WATROUS	B
WATSEKA	C
WATSON	C
WATSONIA	D
WATSONVILLE	D
WATT	D
WATTON	C
WAUBAY	B
WAUBEEK	B
WAUBONSIE	B
WAUCHULA	B/D
WAUCOMA	B
WAUCONDA	B
WAUKEE	B
WAUKEGAN	B
WAUKENA	D
WAUKON	B
WAUMBEK	B
WAURIKA	D
WAUSEON	B/D
WAVERLY	B/D
WAWAKA	C
WAYCUP	B
WAYDEN	D
WAYLAND	C/D
WAYNE	B
WAYNESBORO	B
WAYSIDE	
WEA	B
WEAVER	C
WEBB	C
WEBER	B
WEBSTER	C
WEDEKIND	D
WEDERTZ	C
WEDGE	A
WEDOWEE	D
WEED	B
WEEDING	A/C
WEEDMARK	B
WEEKSVILLE	B/D
WEEPON	D
WEHADKEE	D
WEIKERT	C/D
WEIMER	D
WEINBACH	C
WEIR	D
WEIRMAN	B
WEISER	C
WEISHAUPT	D
WEISS	A
WEITCHPEC	B
WELAKA	A
WELBY	B
WELCH	C
WELD	C
WELDA	C

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Table A3. (continued).

WELDON	D
WELDONA	B
WELLER	C
WELLINGTON	D
WELLMAN	B
WELLNER	B
WELLSBORO	C
WELLSTON	B
WELLSVILLE	B
WELRING	D
WEMPLE	B
WENAS	B/C
WENATCHEE	C
WENDEL	B/C
WENHAM	
WENONA	C
WENTWORTH	B
WERLOW	C
WERNER	B
WESO	C
WESSEL	B
WESTBROOK	D
WESTBURY	C
WESTCREEK	B
WESTERVILLE	C
WESTFALL	C
WESTFIELD	
WESTFORD	
WESTLAND	B/D
WESTMINSTER	C/D
WESTMORE	B
WESTMORELAND	B
WESTON	D
WESTPHALIA	B
WESTPLAIN	C
WESTPORT	A
WESTVILLE	B
WETHERSFIELD	C
WETHEY	B/C
WETTERHORN	C
WETZEL	D
WEYMOUTH	B
WHAKANA	B
WHALAN	B
WHARTON	C
WHATCOM	C
WHATELY	D
WHEATLEY	D
WHEATRIDGE	C
WHEATVILLE	B
WHEELER	B
WHEELING	B
WHEELON	D
WHELCHEL	B
WHETSTONE	B
WHIDBEY	C
WHIPPANY	C
WHIPSTOCK	C
WHIRLO	B
WHIT	B
WHITAKER	C
WHITCOMB	C
WHITE BIRD	C
WHITECAP	D
WHITEFISH	B
WHITEFORD	B
WHITEHORSE	B
WHITE HOUSE	C
WHITELAKE	B
WHITELAW	B
WHITEMAN	D
WHITEROCK	D
WHITESBURG	C
WHITE STORE	D
WHITE SWAN	C
WHITEWATER	B
WHITEWOOD	C
WHITLEY	B
WHITLOCK	B
WHITMAN	D
WHITNEY	B
WHITORE	A
WHITSOL	B
WHITSON	D
WHITWELL	C
WHOLAN	C
WIBAUX	C
WICHITA	C
WICHUP	D
WICKERSHAM	B
WICKETT	C
WICKHAM	B
WICKIUP	C
WICKLIFFE	D
WICKSBURG	B
WIDTSOE	C
WIEHL	C
WIEN	D
WIGGLETON	B
WIGTON	A
WILBRAHAM	C
WILBUR	C
WILCO	C
WILCOX	D
WILCOXSON	C
WILDCAT	D
WILDER	B
WILDERNESS	C
WILDROSE	D
WILDWOOD	D
WILEY	C
WILKES	C
WILKESON	C
WILKINS	D
WILL	D
WILLACY	B
WILLAKENZIE	C
WILLAMAR	D
WILLAMETTE	B
WILLAPA	C
WILLARD	B
WILLETTE	A/D
WILLHAND	B
WILLIAMS	B
WILLIAMSBURG	B
WILLIAMSON	C
WILLIS	C
WILLITS	B
WILLOUGHBY	B
WILLOW CREEK	B
WILLOWDALE	B
WILLOWS	D
WILLWOOD	A
WILMER	C
WILPAR	D
WILSON	D
WILTSHIRE	C
WINANS	B/C
WINBERRY	D
WINCHESTER	A
WINCHUCK	C
WINDER	B/D
WINDHAM	B
WINDMILL	B
WINDOM	B
WIND RIVER	B
WINDSOR	A
WINDTHORST	C
WINDY	C
WINEG	C
WINEMA	C
WINETTI	B
WINFIELD	C
WING	D
WINGATE	B
WINGER	C
WINGVILLE	B/D
WINIFRED	C
WINK	B
WINKEL	D
WINKLEMAN	C
WINKLER	A
WINLO	D
WINLOCK	C
WINN	C
WINNEBAGO	B
WINNEMUCCA	B
WINNESHIEK	B
WINNETT	D
WINONA	D
WINOOSKI	B
WINSTON	A
WINTERS	C
WINTERSBURG	C
WINTERSET	C
WINTHROP	A
WINTONER	C
WINU	C
WINZ	C
WIOTA	B
WISHARD	A
WISHEYLU	C
WISHKAH	C
WISKAH	C
WISNER	D
WITBECK	D
WITCH	D
WITHAM	D
WITHEE	C
WITT	B
WITZEL	D
WODEN	B
WODSKOW	B/C
WOLCOTTSBURG	
WOLDALE	C/D
WOLF	B
WOLFESEN	C
WOLFESON	C
WOLFORD	B
WOLF POINT	D
WOLFTEVER	C
WOLVERINE	A
WOODBINE	B
WOODBRIDGE	C
WOODBURN	C
WOODBURY	D
WOODCOCK	B
WOODENVILLE	C
WOODGLEN	D
WOODHALL	B
WOODHURST	A
WOODINVILLE	C/D
WOODLY	B
WOODLYN	C/D
WOODMANSIE	B
WOODMERE	B
WOOD RIVER	D
WOODROCK	C
WOODROW	C
WOODS CROSS	D
WOODSFIELD	C
WOODSIDE	A
WOODSON	D
WOODSTOCK	C/D
WOODSTOWN	C
WOODWARD	B
WOOLMAN	B
WOOLPER	C
WOOLSEY	C
WOOSLEY	C
WOOSTER	C
WOOSTERN	B
WOOTEN	A
WORCESTER	B
WORF	D
WORK	C
WORLAND	B
WORLEY	C
WORMSER	C
WOROCK	B
WORSHAM	D
WORTH	C
WORTHEN	B
WORTHING	D
WORTHINGTON	C
WORTMAN	C
WRENTHAM	C
WRIGHT	C
WRIGHTMAN	C
WRIGHTSVILLE	D
WUNJEY	B
WURTSBORO	C
WYALUSING	D
WYARD	B
WYARNO	B
WYATT	C
WYEAST	C
WYEVILLE	C
WYGANT	C
WYKOFF	B
WYMAN	B
WYMORE	C
WYNN	B
WYNDOSE	D
WYO	B
WYOCENA	B
XAVIER	B
YACOLT	B
YAHARA	B
YAHOLA	B
YAKI	D
YAKIMA	B
YAKUS	D
YALLANI	B
YALMER	B
YAMAC	B
YAMHILL	C
YAMPA	C
YAMSAY	D
YANA	B
YANCY	C
YARDLEY	C
YATES	D
YAUCO	C
YAWDIM	D
YAWKEY	C
YAXON	B
YEARY	C
YEATES HOLLOW	C
YEGEN	B
YELM	B
YENRAB	A
YEOMAN	B
YESUM	B
YETULL	A
YODER	B
YOKOHL	D
YOLLABOLLY	D
YOLO	B
YOLOGO	D
YOMBA	C
YOMONT	B
YONCALLA	C
YONGES	D
YONNA	B/D
YORDY	B
YORK	C
YORKVILLE	D
YOST	C
YOUGA	B
YOUMAN	C
YOUNGSTON	B
YOURAME	A
YOVIMPA	D
YSIDORA	D
YTURBIDE	A
YUBA	D
YUKO	C
YUKON	D
YUNES	D
YUNQUE	C
ZAAR	D
ZACA	D
ZACHARIAS	B
ZACHARY	D
ZAFRA	B
ZAHILL	B
ZAHL	B
ZALESKI	C
ZALLA	A
ZAMORA	B
ZANE	C
ZANEIS	B
ZANESVILLE	C
ZANONE	C
ZAPATA	C
ZAVALA	B
ZAVCO	C
ZEB	B
ZEESIX	C
ZELL	B
ZEN	C
ZENDA	C
ZENIA	B
ZENIFF	B
ZEONA	A
ZIEGLER	C
ZIGWEID	B
ZILLAH	B/C
ZIM	D
ZIMMERMAN	A
ZING	C
ZINZER	B
ZION	C
ZIPP	C/D
ZITA	B
ZOAR	C
ZOATE	D
ZOHNER	B/D
ZOOK	C
ZORRAVISTA	A
ZUFELT	B/D
ZUKAN	D
ZUMBRO	B
ZUMWALT	C
ZUNDELL	B/C
ZUNHALL	B/C
ZUNI	D
ZURICH	B
ZWINGLE	D

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

Exhibit A1. Complete listing of Program XSRAIN.

```
      PROGRAM XSRAIN(INPUT,OUTPUT,TAPE5,TAPE6=OUTPUT)
      COMMON/A/DELT,Q,N,P,TD,CN
      COMMON/B/KT,TP,RP,WP,K
      COMMON/C/MO,DAY,SFFC,S
      COMMON/D/T(100),R(100),RE(100)
      COMMON/E/AR(5)
      COMMON/F/SF
      COMMON/G/CUMP(100),OPTION
      COMMON/H/AREA,L,Y,NN,NF
      COMMON/I/DELTA(150)
      COMMON/J/DELP(150),QA(150),TM(150)
      COMMON/K/SUBOPT2
      COMMON/L/LAGFLAG,TL
      INTEGER OPTION,Q,SUBOPT1,SUBOPT2,PFLAG,CFLAG,TFLAG
      REAL KT,L
C
C
C     THIS PROGRAM CAN COMPUTE EXCESS RAINFALL PATTERNS FOR FOUR CASES
C     - BY INFILTRATION EQUATIONS FOR VARIABLE AND CONSTANT RAINFALL
C     -BY SCS METHOD FOR VARIABLE AND CONSTANT RAINFALL
C     FLOOD HYDROGRAPHS ARE COMPUTED FOR ALL FOUR PATTERNS WITH
C     THE SCS DIMENSIONLESS UNIT HYDROGRAPH MASS CURVE
C
C     MAIN OPTION 1 IMPOSES A HUFF TIME DISTRIBUTION AND ASSUMES FIELD
C        CAPACITY SOIL MOISTURE (AMCII)
C
C     MAIN OPTION 2 IMPOSES A HUFF TIME DISTRIBUTION AND ACCOUNTS FOR
C        SEASON AND FIVE DAY ANTECEDENT RAIN
C
C     MAIN OPTION 3 READS IN A USER SPECIFIED RAINFALL DISTRIBUTION
C        AND ACCOUNTS FOR SEASON AND FIVE DAY ANTECEDENT RAIN
C
C     MAIN OPTION 4 READS IN A USER-SPECIFIED RAINFALL DISTRIBUTION
C        AND ASSUMES FIELD CAPACITY SOIL MOISTURE (AMCII)
C
C     ALL FORTRAN SYMBOLS ARE DEFINED IN THE ACCOMPANYING USERS MANUAL
      READ(5,1)OPTION
    1 FORMAT(I1)
      WRITE(6,14)OPTION
   14 FORMAT(2X,"MAIN OPTION CHOSEN IS",I4)
      WRITE(6,51)
   51 FORMAT(//,2X,"IF SUBOPT1 = 1, ONLY INFILTRATION APPROACH IS USED W
     !ITH VARIABLE RAINFALL RATES"
     !,/,2X,"IF SUBOPT1 = 4, HYDROGRAPHS ARE DERIVED WITH FOUR DIFFERENT
     ! MEANS OF CALCULATING EXCESS RAIN",//,2X,"IF SUBOPT2 = 0, USER INP
     !UTS KT AND SFFC",/,2X,"IF SUBOPT2 = 1, KT AND SFFC ARE COMPUTED FR
     !OM CN",//)
      READ(5,38)SUBOPT1,SUBOPT2
   38 FORMAT(I2,2X,I2)
C
C     IF SUBOPT1 = 1, EXCESS RAIN IS ONLY CALCULATED BY INFILTRATION
C     EQUATIONS FOR A VARIABLE PATTERN
C     IF SUBOPT1 = 4, EXCESS RAIN IS CALCULATED BY FOUR METHODS
C     FOR PURPOSES OF COMPARISON: BY INFILTRATION APPROACH AND
C     SCS METHOD FOR BOTH VARIABLE AND CONSTANT RAIN
C
C     IF SUBOPT2 = 0, THE USER INPUTS HYDRAULIC CONDUCTIVITY, KT,AND
```

Exhibit A1. (continued).

```
      PROGRAM XSRAIN      73/73    OPT=0 TRACE                        FTN 4.8+508         80/10/(

C     STORAGE SUCTION FACTOR AT FIELD CAPACITY, SFFC. IF SUBOPT2=1,
C     THE PROGRAM CALLS SUBROUTINE TABLE TO COMPUTE KT AND SFFC FROM
C     THE WATERSHED CURVE NUMBER.
C
      WRITE(6,39)SUBOPT1,SUBOPT2
   39 FORMAT(/,2X,"SUB OPTION 1 =",I3,10X,"SUB OPTION 2 =",I3,/)
      IF(SUBOPT2.EQ.0)GO TO 40
      READ(5,41)P,TD,CN
   41 FORMAT(3F10.3)
      WRITE(6,42)P,TD,CN
   42 FORMAT(2X,"STORM DEPTH P =",F10.3,2X,"IN",5X,"STORM DURATION TD ="
     !,F10.3,2X,"HR",5X,"CURVE NUMBER CN =",F10.3,/)
      CALL TABLE
      GO TO 43
   40 READ(5,2)KT,SFFC,P,TD,CN
    2 FORMAT(5F10.3)
      WRITE(6,15)KT,SFFC,P,TD,CN
   15 FORMAT(/,2X,"HYDRAULIC CONDUCTIVITY, KT =",F8.3,1X,"IN/HR",/,
     !2X,"STORAGE SUCTION FACTOR AT FIELD CAPACITY, SFFC =",F8.3,
     !1X,"IN",/,2X,"TOTAL PRECIP, P=",F8.3,1X,"IN",/,2X,
     !"DURATION TIME, TD =",F8.3,1X,"HR",/,2X,
     !"CURVE NUMBER, CN =",F8.1,/)
   43 READ(5,54)LAGFLAG
   54 FORMAT(I1)
C
C     MEANING OF LAG TIME FLAG:
C     IF LAGFLAG=0, TL IS COMPUTED FROM CN,L, AND Y IN SUBROUTINE UH.
C     IF LAGFLAG=1,TL IS PROVIDED BY THE PROGRAM USER
C
      WRITE(6,55)
   55 FORMAT(/,2X,"IF LAGFLAG = 0, LAG TIME IS COMPUTED IN SUBROUTINE UH
     !",/,2X,"IF LAGFLAG = 1, LAG TIME IS PROVIDED BY THE USER",/)
      WRITE(6,56)LAGFLAG
   56 FORMAT(2X,"LAGFLAG =",I3,/)
      IF(LAGFLAG.EQ.1)GOTO 57
      READ(5,27)AREA,L,Y
   27 FORMAT(3F10.2)
      WRITE(6,28)AREA,L,Y
   28 FORMAT(2X,"AREA=",F10.2,2X,"SQ MI",
     !/,5X,"LENGTH TO DIVIDE=",F10.2,2X,"FT",5X,
     !"AVG WATERSHED SLOPE =",F10.2,2X,"PERCENT")
      GO TO 58
   57 READ(5,59)AREA,TL
   59 FORMAT(2F10.2)
      WRITE(6,60)AREA,TL
   60 FORMAT(2X,"AREA=",F10.2,2X,"SQ MI",
     !/,5X,"USER PROVIDED LAG TIME =",F8.3,"HR",/)
   58 IF(OPTION.GT.2)GO TO 3
      READ(5,4)Q,DELT
    4 FORMAT(I1,2X,F10.1)
      WRITE(6,16)Q,DELT
   16 FORMAT(2X,"HUFF QUARTILE=",I4,5X,"TIME STEP=",F10.1,"MIN")
      IF(OPTION.EQ.1)GO TO 5
    3 IF(OPTION.EQ.4)GO TO 8
      READ(5,6)MO,DAY
    6 FORMAT(I2,2X,I2)
      WRITE(6,17)MO,DAY
```

Exhibit A1. (continued).

```
   17 FORMAT(2X,"MONTH=",I4,5X,"DAY=",I4)
      READ(5,7)(AR(I),I=1,5)
    7 FORMAT(5F10.3)
      WRITE(6,50)
   50 FORMAT(/,2X,"ARRAY OF ANTECEDENT RAINFALL DEPTHS",/)
      DO 18 J=1,5
      WRITE(6,19)J,AR(J)
   19 FORMAT(2X,"AR(",I2,")=",F10.3)
   18 CONTINUE
      IF(OPTION.EQ.2)GO TO 5
C
C     IF PFLAG = 0, INPUT RAIN IS IN IN/HR
C     IF PFLAG = 1,INPUT RAIN IS IN INCHES
C
C     IF CFLAG = 0, USER TIME DISTRIBUTION IS USED AS IS
C     IF CFLAG = 1, CORPS OF ENGINEERS BALANCED HYETOGRAPH IS FORMED
C      FROM INPUT RAINFALL
C
C     IF TFLAG = 0, TIME IS INPUT IN MINUTES
C     IF TFLAG = 1, TIME IS INPUT IN HOURS
C
    8 READ(5,9)N,PFLAG,CFLAG,TFLAG
    9 FORMAT(I3,2X,I1,2X,I1,2X,I1)
      WRITE(6,20)N,PFLAG,CFLAG,TFLAG
   20 FORMAT(/,2X,"N=",I3,5X,"PFLAG =",I3,5X,"CFLAG =",I3,5X,"TFLAG=",I3
     1,/)
      WRITE(6,49)
   49 FORMAT(2X,"N IS THE NUMBER OF TIME STEPS IN THE USER SUPPLIED STORM
     1M")
      WRITE(6,44)
   44 FORMAT(2X,"IF PFLAG=0, INPUT RAIN IS IN IN/HR",/,
     12X,"IF PFLAG=1, INPUT RAIN IS IN INCHES",/,/,
     12X,"IF CFLAG=0, USER TIME DISTRIBUTION IS UTILIZED AS IS",/,
     12X,"IF CFLAG=1, CORPS OF ENGINEERS BALANCED HYETOGRAPH IS FORMED F
     1ROM INPUT RAINFALL",/)
      WRITE(6,53)
   53 FORMAT(2X,"IF TFLAG = 0, INPUT TIME IS IN MINUTES",/,
     12X,"IF TFLAG = 1, INPUT TIME IS IN HOURS",/)
      READ(5,34)(T(I),I=1,N)
   34 FORMAT(10F6.1)
      READ(5,10)(R(I),I=1,N)
   10 FORMAT(10F6.3)
      IF(CFLAG.EQ.0)GO TO 48
      CALL BALANCE
   48 CONTINUE
      IF(TFLAG.EQ.1)GO TO 52
      WRITE(6,21)
   21 FORMAT(2X,"TIME STEPS, MINUTES")
      WRITE(6,37)(T(I),I=1,N)
   37 FORMAT(1X,20F6.1,/,20F6.1,/,10F6.1,/)
   32 FORMAT(1X,20F6.3,/,1X,20F6.3,/,1X,10F6.3,/)
C
C     CONVERT TIME STEPS FROM MINUTES TO HOURS
C
      DO 35 I=1,N
   35 T(I)=T(I)/60.
   52 WRITE(6,36)
```

Exhibit A1. (continued).

```
                PROGRAM XSRAIN      73/73    OPT=0 TRACE

         36 FORMAT(2X,"TIME STEPS, HOURS")
            WRITE(6,32)(T(I),I=1,N)
            DELT=T(1)
            IF(PFLAG.EQ.0)GO TO 45
            WRITE(6,46)
         46 FORMAT(2X,"RAINFALL DEPTH INCREMENTS")
            WRITE(6,32)(R(I),I=1,N)
      C
      C     CONVERT DEPTHS TO INTENSITIES
      C
            DO 47 I=1,N
         47 R(I)=R(I)/DELT
         45 WRITE(6,23)
         23 FORMAT(2X,"RAINFALL INTENSITIES, IN/HR")
            WRITE(6,32)(R(I),I=1,N)
      C     COMPUTE CUMULATIVE STEP PRECIP,CUMP
            DO 24 I=1,N
            IF(I.EQ.1)GO TO 25
            CUMP(I)=CUMP(I-1)+R(I)*(T(I)-T(I-1))
            GO TO 24
         25 CUMP(I)=R(I)*T(I)
         24 CONTINUE
            WRITE(6,26)
         26 FORMAT(2X,"STEPS OF CUMULATIVE PRECIP")
            WRITE(6,32)(CUMP(I),I=1,N)
            IF(OPTION.EQ.3)GO TO 11
            IF(OPTION.EQ.4)SF=SFFC
            IF(OPTION.EQ.4)GO TO 12
          5 CALL HUFF
            IF(OPTION.EQ.1)SF=SFFC
            IF(OPTION.EQ.1)GO TO 12
         11 CALL DEFICIT
         12 CALL UH
            CALL PONTIM
            CALL PPINF
            IF(SUBOPT1.EQ.1)GO TO 30
            CALL CONSTR
            CALL SCS
         30 WRITE(6,33)
         33 FORMAT(/,100(1H*),/)
            STOP
            END
```

Exhibit A1. (continued).

```
SUBROUTINE HUFF       73/73   OPT=0 TRACE                     FTN 4.8+508

      SUBROUTINE HUFF
      COMMON/A/DELT,Q,N,P,TD,CN
      COMMON/D/T(100),R(100),RE(100)
      COMMON/G/CUMP(100),OPTION
      COMMON/H/AREA,L,Y,NN,NF
      INTEGER OPTION
      INTEGER Q
      DIMENSION PP(10),PT(10)
C
C     THIS SUBROUTINE IMPOSES A HUFF TIME DISTRIBUTION ON AN EVENT
C     OF SPECIFIED DEPTH AND DURATION
C
      WRITE(6,33)
   33 FORMAT(/,100(1H*),/)
      WRITE(6,28)
   28 FORMAT(/,10X,"OUTPUT OF SUBROUTINE HUFF",/)
      DELT=DELT/60.
C
C     COMPUTE TEN PERCENT TIME STEPS
C
      PT(1)=0.1*TD
      DO 15 I=2,10
   15 PT(I)=PT(I-1)+(0.1*TD)
      IF(Q.GT.1)GO TO 50
C
C     COMPUTE FIRST QUARTILE STEPS OF PRECIP FOR TEN PERCENT TIME STEPS
C
      PP(1)=0.17*P
      PP(2)=0.48*P
      PP(3)=0.71*P
      PP(4)=0.80*P
      PP(5)=0.86*P
      PP(6)=0.91*P
      PP(7)=0.94*P
      PP(8)=0.96*P
      PP(9)=0.98*P
      PP(10)=P
      GO TO 53
   50 IF(Q.GT.2)GO TO 51
C
C     COMPUTE SECOND QUARTILE STEPS OF PRECIP FOR TEN PERCENT TIME STEPS
C
      PP(1)=0.03*P
      PP(2)=0.13*P
      PP(3)=0.31*P
      PP(4)=0.53*P
      PP(5)=0.72*P
      PP(6)=0.87*P
      PP(7)=0.93*P
      PP(8)=0.96*P
      PP(9)=0.98*P
      PP(10)=P
      GO TO 53
   51 IF(Q.GT.3)GO TO 52
C
C     COMPUTE THIRD QUARTILE STEPS OF PRECIP FOR TEN PERCENT TIME STEPS
C
```

Exhibit A1. (continued).

```
SUBROUTINE HUFF       73/73    OPT=0 TRACE                    FTN 4.8+508

      PP(1)=0.03*P
      PP(2)=0.10*P
      PP(3)=0.14*P
      PP(4)=0.17*P
      PP(5)=0.28*P
      PP(6)=0.54*P
      PP(7)=0.78*P
      PP(8)=0.93*P
      PP(9)=0.98*P
      PP(10)=P
      GO TO 53
C
C     COMPUTE FOURTH QUARTILE STEPS OF PRECIP FOR TEN PERCENT TIME STEPS
C
   52 PP(1)=0.03*P
      PP(2)=0.06*P
      PP(3)=0.10*P
      PP(4)=0.14*P
      PP(5)=0.18*P
      PP(6)=0.25*P
      PP(7)=0.35*P
      PP(8)=0.54*P
      PP(9)=0.92*P
      PP(10)=P
C
C     COMPUTE NUMBER OF TIME STEPS DICTATED BY USER CHOICE OF TIME
C     INTERVAL LENGTH
C
   53 N=INT(TD/DELT)
      XN=TD/DELT
      IF(XN.GT.FLOAT(N))N=N+1
C
C     IN LOOP 10, INTERPOLATE CUMULATIVE DEPTHS FOR USER TIME STEPS
C     FROM CUMULATIVE DEPTHS FOR TEN PERCENT TIME STEPS
C
      DO 10 I=1,N
      IF(I.EQ.N)GO TO 25
      IF(I.GT.1)GO TO 20
      T(I)=DELT
      GO TO 21
   20 T(I)=T(I-1)+DELT
   21 IFLAG=1
      DO 11 J=1,10
      IF(T(I).LE.PT(J))GO TO 11
      IFLAG=IFLAG+1
   11 CONTINUE
      IF(IFLAG.GT.1)GO TO 12
      CUMP(I)=(T(I)/PT(1))*PP(1)
      GO TO 10
   12 CUMP(I)=(((T(I)-PT(IFLAG-1))/(0.1*TD))*(PP(IFLAG)-PP(IFLAG-1)
     1))+PP(IFLAG-1)
      GO TO 10
   25 CUMP(N)=P
      T(N)=TD
   10 CONTINUE
C
C     IN LOOP 30, COMPUTE MEAN RAINFALL INTENSITIES FOR EACH USER
```

Exhibit A1. (continued).

```
C      TIME STEP
C
       DO 30 I=1,N
       IF(I.EQ.N)GO TO 26
       IF(I.GT.1)GO TO31
       R(I)=CUMP(I)/DELT
       GO TO 30
    31 R(I)=(CUMP(I)-CUMP(I-1))/DELT
       GO TO 30
    26 R(N)=(P-CUMP(I-1))/(TD-T(I-1))
    30 CONTINUE
       WRITE(6,27)
    27 FORMAT(10X,"HUFF HYETOGRAPH",/,10X,15(1H=),/)
       WRITE(6,22)
    22 FORMAT(2X,"TIME (HR)",5X,"CUMULATIVE PRECIP (IN)",5X,
      !"RAINFALL INTENSITY (IN/HR)",/)
       WRITE(6,23)(T(I),CUMP(I),R(I),I=1,N)
    23 FORMAT(1X,F10.3,12X,F10.3,20X,F10.3)
       RETURN
       END
```

Exhibit A1. (continued).

```
SUBROUTINE DEFICIT    73/73   OPT=0 TRACE                        FTN 4.8+508

      SUBROUTINE DEFICIT
      COMMON/A/DELT,Q,N,P,TD,CN
      COMMON/C/MO,DAY,SFFC,S
      COMMON/E/AR(5)
      COMMON/F/SF
      REAL JDATE,IA
      INTEGER MO,DAY
C
C     THIS SUBROUTINE MODIFIES THE STORAGE SUCTION FACTOR DUE TO
C     CHANGE IN MOISTURE DEFICIT DUE TO SEASONALITY AND ANTECEDENT RAIN
C
      WRITE(6,33)
   33 FORMAT(/,100(1H*),/)
      WRITE(6,15)
   15 FORMAT(/,10X,"OUTPUT OF SUBROUTINE DEFICIT",/)
C
C     COMPUTE S FOR AMC II
C
      S=(1000./CN)-10.
      WRITE(6,12)S
   12 FORMAT(2X,"S=",F10.3,2X,"IN")
C
C     COMPUTE MOISTURE AT FIELD CAPACITY
C
      DFC=0.253-(.002*CN)
C
C     COMPUTE EFFECTIVE DEPTH OF SOIL PROFILE
C
      DEPTH=S/DFC
C
C     COMPUTE WETTING FRONT SUCTION (EFFECTIVE CAPILLARY DRIVE)
C
      HF=SFFC/DFC
C
C     COMPUTE JULIAN DATE
C
      JDATE=(30.*FLOAT(MO-1))+FLOAT(DAY)
C
C     COMPUTE SEASONAL S BY SINUSOIDAL APPROXIMATION
C
      SB=((SIN(((JDATE-5.+180.)/360.)*2.*3.1416)+1.)/2.)*1.3*S
     1+(0.2*S)
      WRITE(6,13)DEPTH,HF,JDATE,SB
   13 FORMAT(2X,"EFFECTIVE DEPTH=",F10.2,2X,"IN",3X,
     !"WETTING FRONT SUCTION,HF,=",F10.3,2X,"IN",3X,"JULIAN DATE =",
     !F5.0,3X,"SEASONAL S =",F10.3,2X,"IN")
      SA=SB
      IA=0.2*S
C
C     IN LOOP 10, MODIFY SEASONAL S (SB) ACCORDING TO 5 DAY ANTECEDENT
C     CONDITION TO OBTAIN ADJUSTED S (SA)
C     SA INCREASES DUE TO DRYING BY A FACTOR 1.06 PER DAY. SA DECREASES
C     BY THE INFILTRATED DEPTH (AR(I)-AQ), APPROXIMATED ON EACH
C     RAIN DAY BY THE SCS METHOD (AMC II)
C
      DO 10 I=1,5
      IF(AR(I).EQ.0.0)GO TO 11
      IF(AR(I).LE.IA)GO TO 16
      AQ=((AR(I)-0.2*S)**2)/(AR(I)+0.8*S)
      SA=(1.06*SA)-(AR(I)-AQ)
      GO TO 10
   16 SA=(1.06*SA)-AR(I)
      GO TO 10
   11 SA=1.06*SA
   10 CONTINUE
      IF(SA.LE.0.0)SA=0.05
      SMAX=2.*S
      IF(SA.GT.SMAX)SA=SMAX
      DA=SA/DEPTH
      SF=HF*DA
      WRITE(6,14)DA,SF
   14 FORMAT(2X,"ADJUSTED DEFICIT=",F10.3,5X,"STORAGE SUCTION FACTOR
     !,SF,=",F10.3,2X,"IN")
      RETURN
      END
```

Exhibit A1. (continued).

```
SUBROUTINE PONTIM      73/73    OPT=0 TRACE                        FTN 4.8+508

      SUBROUTINE PONTIM
      COMMON/A/DELT,Q,N,P,TD,CN
      COMMON/B/KT,TP,RP,WP,K
      COMMON/D/T(100),R(100),RE(100)
      COMMON/F/SF
      DIMENSION PT(100)
      REAL KT
C
C     THIS SUBROUTINE CALCULATES PONDING TIME FOR A VARIABLE RAINFALL
C     INTENSITY EVENT
C
      WRITE(6,33)
   33 FORMAT(/,100(1H*),/)
      WRITE(6,27)
   27 FORMAT(/,10X,"OUTPUT OF SUBROUTINE PONTIM",/)
      I=0
C
C     I IS THE COUNTER INDICATING THE TIME STEP OF CONSIDERATION
C
   10 I=I+1
      IF(I.GT.N)GO TO 18
C
C     TEST RAINFALL INTENSITY W.R.T. HYDRAULIC CONDUCTIVITY
C
      IF(R(I).LE.KT)GO TO 10
      IF(I.EQ.1)GO TO 11
      II=I-1
      SUMP=0.
C
C     IN LOOP 12, SUM UP PRECIP FALLING IN ALL TIME STEPS PREVIOUS
C     TO STEP OF CONSIDERATION
C
      DO 12 J=1,II
      IF(J.EQ.1)GO TO 14
      SUMP=SUMP+R(J)*(T(J)-T(J-1))
      GO TO 12
   14  SUMP=SUMP+R(J)*T(J)
   12 CONTINUE
      PT(I)=T(I-1)+(1./R(I))*((SF/((R(I)/KT)-1.))-SUMP)
C
C     TEST COMPUTED PONDING TIME AGAINST TIME AT END OF PREVIOUS STEP
C
      IF(PT(I)-T(I-1))13,13,17
   13 TP=T(I-1)
      RP=R(I)
      GO TO 23
C
C     TEST COMPUTED PONDING TIME AGAINST TIME STEP OF CONSIDERATION
C
   17 IF(PT(I)-T(I))15,15,10
   11 PT(I)=(1./R(I))*(SF/((R(I)/KT)-1.))
      IF(PT(I).GT.T(I))GO TO 10
   15 TP=PT(I)
      RP=R(I)
   23 K=0
      WP=0.0
C
```

Exhibit A1. (continued).

```
SUBROUTINE PONTIM      73/73   OPT=0 TRACE                       FTN 4.8+508

C     LOOP 20 COMPUTES CUMULATIVE INFILTRATION OCCURRING IN WHOLE
C     TIME STEPS PREVIOUS TO PONDING
C
      DO 20 J=1,N
      IF(T(J).GT.TP)GO TO 20
      IF(J.EQ.1)GO TO 21
      WP=WP+R(J)*(T(J)-T(J-1))
      GO TO 22
   21 WP=WP+R(J)*T(J)
   22 K=K+1
   20 CONTINUE
C
C     NEXT FOUR STATEMENTS TAKE CARE OF FINDING TOTAL INFILTRATION
C     OCCURRING UP THROUGH  PONDING TIME
C
      IF(K.EQ.0)GO TO 25
      WP=WP+RP*(TP-T(K))
      GO TO 26
   25 WP=RP*TP
   26 WRITE(6,24)TP,RP,WP
   24 FORMAT(2X,"PONDING TIME=",F8.3,1X,"HR",5X,"PONDING RAINFALL=",F8.3
     1,1X,"IN/HR",5X,"DEPTH OF RAIN INFILTRATED PREVIOUS TO PONDING=",F8
     1.3,1X,"IN")
C
C     K IS THE INDEX OF THE LAST FULL TIME STEP BEFORE PONDING
C      (IT IS PASSED TO SUBROUTINE PPINF)
C
      IF(K.GT.0)GO TO 28
      GO TO 16
   28 WRITE(6,29)K,T(K)
   29 FORMAT(2X,"LAST FULL TIME STEP T(",I2,")=",F8.3)
      GO TO 16
   18 WRITE(6,19)
   19 FORMAT(2X,"PONDING NEVER OCCURS")
   16 RETURN
      END
```

Exhibit A1. (continued).

```
SUBROUTINE PPINF      73/73    OPT=0 TRACE                        FTN 4.8+508

      SUBROUTINE PPINF
      COMMON/A/DELT,Q,N,P,TD,CN
      COMMON/B/KT,TP,RP,WP,K
      COMMON/F/SF
      COMMON/D/T(100),R(100),RE(100)
      COMMON/H/AREA,L,Y,NN,NF
      COMMON/J/DELP(150),QA(150),TM(150)
      DIMENSION W(100),DELW(100),IR(100),RER(100)
      REAL IR
      REAL KT
C
C     THIS SUBROUTINE COMPUTES POST-PONDING INFILTRATION FOR A
C     VARIABLE INTENSITY RAINFALL EVENT
C
      WRITE(6,33)
   33 FORMAT(/,100(1H*),/)
      WRITE(6,21)
   21 FORMAT(/,10X,"OUTPUT OF SUBROUTINE PPINF, VARIABLE RAINFALL, INFIL
     1TRATION APPROACH",/)
C
C     COMPUTE RAINFALL SORPTIVITY
C
      RSORP=SQRT(2.*KT*((SF+WP)**2)/SF)
C
C     COMPUTE NORMALIZED PONDING RAINFALL INTENSITY
C
      RSTARP=RP/KT
C
C     COMPUTE "B" TERM
C
      B=0.5*((SF+WP)**2)/(KT*SF*((RSTARP-1.)**2))
C
C     K IS THE INDEX OF THE LAST FULL TIME STEP BEFORE PONDING,
C     (PASSED FROM SUBROUTINE PONTIM). M IS THEN THE INDEX OF THE
C     FIRST FULL TIME STEP AFTER PONDING
C
      M=K+1
C
C     IN LOOP 10, COMPUTE STEPS OF CUMULATIVE INFILTRATION(W),INCREMENTAL
C     INFILTRATION(DELW),MEAN INFILTRATION RATE(IR),AND MEAN EXCESS
C     RAINFALL RATE(RE)
C
      DO 10 I=M,N
      W(I)=WP+RSORP*(SQRT(T(I)-TP+B)-SQRT(B))+KT*(T(I)-TP)
      IF(I.EQ.M)GO TO 11
      DELW(I)=W(I)-W(I-1)
      IR(I)=DELW(I)/(T(I)-T(I-1))
      GO TO 12
   11 DELW(I)=W(I)-WP
      IR(I)=DELW(I)/(T(I)-TP)
   12 CONTINUE
      IF(R(I)-IR(I))13,13,14
   13 IR(I)=R(I)
      RE(I)=0.0
      IF(I.EQ.M)GO TO 15
      DELW(I)=R(I)*(T(I)-T(I-1))
      W(I)=W(I-1)+DELW(I)
```

Exhibit A1. (continued).

```
      GO TO 10
   15 DELW(I)=R(I)*(T(I)-TP)
      W(I)=W(I-1)+DELW(I)
      GO TO 10
   14 RE(I)=R(I)-IR(I)
   10 CONTINUE
C
C     SUBTRACT RETENTION (0.1 IN) FROM EXCESS RAINFALL PATTERN
C
      RET=0.1
      DO 27 I=M,N
      IF(I.EQ.M)GO TO 23
      PS=RE(I)*(T(I)-T(I-1))
      IF(RET-PS)26,25,25
   26 RER(I)=(PS-RET)/(T(I)-T(I-1))
      RET=0.0
      GO TO 27
   23 PS=RE(I)*(T(I)-TP)
      IF(RET-PS)24,25,25
   24 RER(I)=(PS-RET)/(T(I)-TP)
      RET=0.0
      GO TO 27
   25 RER(I)=0.0
      RET=RET-PS
   27 CONTINUE
C
C     DEFINE DELP ARRAY OF INCREMENTS OF EXCESS RAIN (IN)
C
      IFLAG=0
      DO 28 I=M,N
      IF(RER(I).EQ.0.0.AND.IFLAG.EQ.0)GO TO 28
      IFLAG=IFLAG+1
      IF(I.EQ.M)GO TO 29
      DELP(IFLAG)=RER(I)*DELT
      TM(IFLAG)=T(I)
      GO TO 28
   29 DELP(IFLAG)=RER(I)*(T(I)-TP)
      TM(IFLAG)=T(I)
   28 CONTINUE
      NF=IFLAG
      WRITE(6,9)
    9 FORMAT(5X,"T(HR) = TIME IN HOURS",/,
     15X,"W(IN) = CUMULATIVE INFILTRATION IN INCHES",/,
     15X,"DELW(IN) = INCREMENTAL INFILTRATION IN INCHES",/,
     15X,"IR(IN/HR) = INFILTRATION RATE IN INCHES PER HOJR",/,
     15X,"R(IN/HR) = RAINFALL RATE IN INCHES PER HOUR",/,
     15X,"RE(IN/HR) = RAINFALL RATE AFTER INFILTRATION SJBTRACTED",/,
     15X,"RER(IN/HR) = NET EXCESS RAINFALL RATE AFTER RETENTION SUBTRACT
     1ED",/)
      WRITE(6,17)
   17 FORMAT(5X,"T(HR)",6X,"W(IN)",3X,"DELW(IN)",1X,"IR(IN/HR)",2X,"R(IN/HR)",5X,"RE(IN/HR
     1/HR)",2X,"RE(IN/HR)",2X,"RER(IN/HR)",/)
      WRITE(6,18)TP,WP,WP
   18 FORMAT(1X,3F10.3)
      DO 16 I=M,N
      WRITE(6,19)T(I),W(I),DELW(I),IR(I),R(I),RE(I),RER(I)
   19 FORMAT(1X,7F10.3)
   16 CONTINUE
C
C     CHECK MASS BALANCE
C
      WRITE(6,7)
    7 FORMAT(/,2X,"MASS BALANCE CHECK",/)
      PE=0.
      IF(NF.EQ.0)GO TO 6
      DO 8 I=1,NF
    8 PE=PE+DELP(I)
    6 RET=0.1-RET
      WRITE(6,20)PE,W(N),RET,P
   20 FORMAT(2X,"EXCESS PRECIP=",F8.3,2X,"IN",/,
     12X,"CUMULATIVE INFILTRATION=",F8.3,2X,"IN",/,
     12X,"RETENTION=",F8.3,2X,"IN",/,
     12X,"TOTAL PRECIP=",F8.3,2X,"IN")
      IF(NF.EQ.0)GO TO 5
      CALL ROUTE
      GO TO 3
    5 WRITE(6,4)
    4 FORMAT(/,5X,"ALL RAINFALL INFILTRATES - NO RUNOFF IS PRODUCED",/)
    3 RETURN
      END
```

Exhibit A1. (continued).

```
SUBROUTINE CONSTR      73/73    OPT=0 TRACE                         FTN 4.8+508

      SUBROUTINE CONSTR
      COMMON/A/DELT,Q,N,P,TD,CN
      COMMON/B/KT,TP,RP,WP,K
      COMMON/D/T(100),R(100),RE(100)
      COMMON/F/SF
      COMMON/H/AREA,L,Y,NN,NF
      COMMON/J/DELP(150),QA(150),TM(150)
      DIMENSION W(100),DELW(100),IR(100),RER(100)
      REAL KT,IR
C
C     THIS SUBROUTINE COMPUTES EXCESS RAINFALL BY INFILTRATION EQUATION
C     FOR A CONSTANT INTENSITY EVENT
C
      WRITE(6,33)
   33 FORMAT(/,100(1H*),/)
      WRITE(6,21)
   21 FORMAT(/,10X,"OUTPUT OF SUBROUTINE CONSTR, CONSTANT RAINFALL BY IN
     1FILTRATION APPROACH",/)
C
C     COMPUTE CONSTANT RAINFALL RATE FROM DEPTH AND DURATION
C
      CR=P/TD
C
C     COMPUTE SORPTIVITY
C
      SORP=SQRT(2.*KT*SF)
C
C     COMPUTE NORMALIZED RAINFALL RATE
C
      RSTAR=CR/KT
      IF(RSTAR.LE.1.)GO TO 4
C
C     COMPUTE MEIN AND LARSON PONDING TIME
C
      TP=SF/(CR*(RSTAR-1.))
      IF(TP.GE.TD)GO TO 4
      KK=0
C
C     LOOP 22 FINDS INDEX, KK, OF LAST FULL TIME STEP BEFORE PONDING
C
      DO 22 I=1,N
      IF(T(I).GE.TP)GO TO 22
      KK=KK+1
   22 CONTINUE
C
C     CALCULATE RATIO, A CONVENIENCE TERM
C
      RATIO=RSTAR/(RSTAR-1.)
C
C     CALCULATE DEPTH INFILTRATED UP TO PONDING TIME, WP
C
      WP=CR*TP
      B=0.5*TP*(RATIO**3)
C
C     M IS THE INDEX OF THE FIRST FULL TIME STEP AFTER PONDING
C
      M=KK+1
```

Exhibit A1. (continued).

```
SUBROUTINE CONSTR      73/73    OPT=0 TRACE                        FTN 4.8+508

C
C     LOOP 20 FINDS STEPS OF CUMULATIVE INFILTRATION(W), INCREMENTAL
C     INFILTRATION(DELW), MEAN INFILTRATION RATE(IR),AND MEAN EXCESS
C     RAINFALL RATE(RE)
C
      DO 20 I=M,N
      W(I)=WP+SORP*RATIO*(SQRT(T(I)-TP+B)-SQRT(B))+KT*(T(I)-TP)
      IF(I.EQ.M)GO TO 11
      DELW(I)=W(I)-W(I-1)
      IR(I)=DELW(I)/(T(I)-T(I-1))
      GO TO 12
   11 DELW(I)=W(I)-WP
      IR(I)=DELW(I)/(T(I)-TP)
   12 CONTINUE
      IF(CR-IR(I))13,13,14
   13 IR(I)=CR
      RE(I)=0.0
      IF(I.EQ.M)GO TO 15
      DELW(I)=CR*(T(I)-T(I-1))
      W(I)=W(I-1)+DELW(I)
      GO TO 20
   15 DELW(I)=CR*(T(I)-TP)
      W(I)=W(I-1)+DELW(I)
      GO TO 20
   14 RE(I)=CR-IR(I)
   20 CONTINUE
C     SUBTRACT RETENTION (0.1 IN) FROM EXCESS RAINFALL PATTERN
C
      RET=0.1
      DO 27 I=M,N
      IF(I.EQ.M)GO TO 23
      PS=RE(I)*(T(I)-T(I-1))
      IF(RET-PS)26,25,25
   26 RER(I)=(PS-RET)/(T(I)-T(I-1))
      RET=0.0
      GO TO 27
   23 PS=RE(I)*(T(I)-TP)
      IF(RET-PS)24,25,25
   24 RER(I)=(PS-RET)/(T(I)-TP)
      RET=0.0
      GO TO 27
   25 RER(I)=0.0
      RET=RET-PS
   27 CONTINUE
C
C     DEFINE DELP ARRAY OF INCREMENTS OF EXCESS RAIN DEPTH(IN)
C
    5 IFLAG=0
      DO 28 I=M,N
      IF(RER(I).EQ.0.0.AND.IFLAG.EQ.0)GO TO 28
      IFLAG=IFLAG+1
      IF(I.EQ.M)GO TO 29
      DELP(IFLAG)=RER(I)*DELT
      TM(IFLAG)=T(I)
      GO TO 28
   29 DELP(IFLAG)=RER(I)*(T(I)-TP)
      TM(IFLAG)=T(I)
```

Exhibit A1. (continued).

```
SUBROUTINE CONSTR      73/73    OPT=0 TRACE                       FTN 4.8+508

             28 CONTINUE
                NF=IFLAG
                WRITE(6,17)
             17 FORMAT(5X,"T(HR)",6X,"W(IN)",3X,"DELW(IN)",1X,"IR(IN/HR)",2X,"R(IN/HR)";5X,"RE(IN/HR
               !/HR)",2X,"RE(IN/HR)",2X,"RER(IN/HR)",/)
                WRITE(6,18)TP,WP,WP
             18 FORMAT(1X,3F10.3)
                DO 16 I=M,N
                WRITE(6,19)T(I),W(I),DELW(I),IR(I),CR,RE(I),RER(I)
             19 FORMAT(1X,7F10.3)
             16 CONTINUE
          C
          C     CHECK MASS BALANCE
          C
                WRITE(6,7)
              7 FORMAT(/,2X,"MASS BALANCE CHECK",/)
                PECONS=0.
                IF(NF.EQ.0)GO TO 6
                DO 8 I=1,NF
              8 PECONS=PECONS+DELP(I)
              6 RET=0.1-RET
                WRITE(6,10)PECONS,W(N),RET,P
             10 FORMAT(2X,"EXCESS PRECIP=",F8.3,2X,"IN",/,
               !2X,"CUMULATIVE INFILTRATION=",F8.3,2X,"IN",/,
               !2X,"RETENTION=",F8.3,2X,"IN",/,
               !2X,"TOTAL PRECIP=",F8.3,2X,"IN")
                IF(NF.EQ.0)GO TO 4
                CALL ROUTE
                GO TO 2
              4 WRITE(6,3)
              3 FORMAT(/,5X,"ALL RAINFALL INFILTRATES - NO RUNOFF IS PRODUCED",/)
              2 RETURN
                END
```

Exhibit A1. (continued).

```
SUBROUTINE SCS        73/73   OPT=0 TRACE                        FTN 4.8+508

            SUBROUTINE SCS
            COMMON/A/DELT,Q,N,P,TD,CN
            COMMON/C/MO,DAY,SFFC,S
            COMMON/D/T(100),R(100),RE(100)
            COMMON/E/AR(5)
            COMMON/G/CUMP(100),OPTION
            COMMON/H/AREA,L,Y,NN,NF
            COMMON/J/DELP(150),QA(150),TM(150)
            DIMENSION W(100),DELW(100),IR(100)
            REAL IA,IR
            INTEGER OPTION
      C
      C     THIS SUBROUTINE COMPUTES EXCESS RAINFALL BY THE STANDARD SCS
      C     METHOD FOR VARIABLE RAINFALL AND FOR CONSTANT RAINFALL
      C
            WRITE(6,35)
         35 FORMAT(/,100(1H*),/)
            WRITE(6,21)
         21 FORMAT(/,10X,"OUTPUT OF SUBROUTINE SCS",/)
      C
      C     IF OPTION IS 1 OR 4, CN FOR AMC II IS USED
      C
            IF(OPTION.EQ.1.OR.OPTION.EQ.4)GO TO 12
            AMC=0.0
      C
      C     LOOP 10 ADDS UP 5 DAY ANTECEDENT RAINFALL
      C
            DO 10 I=1,5
         10 AMC=AMC+AR(I)
      C
      C     TEST FOR SEASON BY MONTH IN WHICH EVENT OCCURS
      C
            IF(MO.GT.4.AND.MO.LT.10)GO TO 11
      C
      C     APPLY SOBHANI EQUATIONS TO MODIFY CN IF AMC CRITERIA DICTATE
      C
            IF(AMC.LT.0.5)CN=CN/(2.334-0.01334*CN)
            IF(AMC.GT.1.1)CN=CN/(0.4036+0.0059*CN)
            GO TO 12
         11 IF(AMC.LT.1.4)CN=CN/(2.334-0.01334*CN)
            IF(AMC.GT.2.1)CN=CN/(0.4036+0.0059*CN)
         12 CONTINUE
      C
      C     IFLAG IS ZERO FOR THE CASE OF VARIABLE RAIN, ONE FOR CONSTANT RAIN
      C
            IFLAG=0
            S=(1000./CN)-10.
            IA=0.2*S
            WRITE(6,1)CN,S,IA
          1 FORMAT(2X,"CN=",F8.1,3X,"S=",F8.3,3X,"IA=",F8.3)
            WRITE(6,2)
          2 FORMAT(/,2X,"VARIABLE RAINFALL CASE, SCS METHOD",/)
      C
      C     LOOP 16 COMPUTES CUMULATIVE INFILTRATION(W),INCREMENTAL
      C     INFILTRATION(DELW), MEAN INFILTRATION RATE(IR),AND MEAN EXCESS
      C     RAINFALL RATE(RE)
      C
```

Exhibit A1. (continued).

```
   34 DO 16 I=1,N
      IF(CUMP(I).LE.IA)GO TO 14
      W(I)=CUMP(I)-(((CUMP(I)-IA)**2)/(CUMP(I)+0.8*S))
      IF(I.EQ.1)GO TO 15
      DELW(I)=W(I)-W(I-1)
      IR(I)=DELW(I)/(T(I)-T(I-1))
      IF(R(I).GT.IR(I))GO TO 6
      RE(I)=0.0
      GO TO 16
    6 RE(I)=R(I)-IR(I)
      GO TO 16
   15 DELW(I)=W(I)
      IR(I)=DELW(I)/T(I)
      IF(R(I).GT.IR(I))GO TO 7
      RE(I)=0.0
      GO TO 16
    7 RE(I)=R(I)-IR(I)
      GO TO 16
   14 W(I)=CUMP(I)
      IF(I.EQ.1)GO TO 5
      DELW(I)=W(I)-W(I-1)
      IR(I)=R(I)
      RE(I)=0.0
      GO TO 16
    5 DELW(I)=W(I)
      IR(I)=R(I)
      RE(I)=0.0
   16 CONTINUE
C
C     DEFINE DELP ARRAY OF INCREMENTS OF, EXCESS RAIN DEPTH(IN)
C     AND TM ARRAY OF TIMES AT WHICH THEY OCCUR
C
      ICOUNT=0
      DO 28 I=1,N
      IF(RE(I).EQ.0.0.AND.ICOUNT.EQ.0)GO TO 28
      ICOUNT=ICOUNT+1
      DELP(ICOUNT)=RE(I)*DELT
      TM(ICOUNT)=T(I)
   28 CONTINUE
      NF=ICOUNT
      WRITE(6,17)
   17 FORMAT(3X,"T(HR)",6X,"W(IN)",3X,"DELW(IN)",1X,"IR(IN/HR)",
     14X,"R(IN/HR)",5X,"RE(IN/HR)",/)
      DO 18 I=1,N
      WRITE(6,19)T(I),W(I),DELW(I),IR(I),R(I),RE(I)
   19 FORMAT(1X,6F10.3)
   18 CONTINUE
      IF(NF.EQ.0)GO TO 36
      CALL ROUTE
   36 IF(IFLAG.EQ.1)GO TO 33
      WRITE(6,31)
   31 FORMAT(/,2X,"CONSTANT RAINFALL CASE, SCS METHOD",/)
C     RE-DEFINE CUMP ARRAY,CUMULATIVE CONSTANT PRECIP IN LOOP 22
C
C     ALSO IN LOOP 22, REDEFINE R ARRAY FOR CONSTANT RAINFALL CASE
C
      CR=P/TD
```

Exhibit A1. (continued).

```
      DO 22 I=1,N
      IF(I.EQ.N)GO TO 24
      IF(I.EQ.1)GO TO 23
      CUMP(I)=CUMP(I-1)+(P/FLOAT(N))
      GO TO 22
   23 CUMP(I)=(P/FLOAT(N))
      GO TO 22
   24 CUMP(I)=P
   22 R(I)=CR
      IFLAG=IFLAG+1
      GO TO 34
C     CALCULATE DEPTH OF CUMULATIVE EXCESS PRECIP
   33 PESCS=((P-IA)**2)/(P+0.8*S)
      TABS=P-PESCS
      WRITE(6,20)PESCS,TABS,P
   20 FORMAT(2X,"EXCESS PRECIP BY SCS METHOD IS",F10.3,2X,"IN",
     1/,2X,"TOTAL ABSTRACTION=",F8.3,2X,"IN",
     1/,2X,"TOTAL PRECIP=",F8.3,2X,"IN")
      RETURN
      END
```

Exhibit A1. (continued).

```
SUBROUTINE UH          73/73    OPT=0 TRACE                      FTN 4.8+508

      SUBROUTINE UH
      COMMON/A/DELT,Q,N,P,TD,CN
      COMMON/D/T(100),R(100),RE(100)
      COMMON/H/AREA,L,Y,NN,NF
      COMMON/I/DELTA(150)
      COMMON/J/DELP(150),QA(150),TM(150)
      COMMON/L/LAGFLAG,TL
      DIMENSION RATIOT(20),RATIOQ(20),QQT(150)
      DIMENSION MT(8),DD(150)
      REAL L
      DATA XT,YT,MT/"TIME(HR)  ","Q(CFS/IN) ","UNIT HYDROGRAPH
     !                                                            "/
      WRITE(6,33)
   33 FORMAT(/,100(1H*),/)
      WRITE(6,20)
   20 FORMAT(/,2X,"OUTPUT OF SUBROUTINE UH",/)
C
C     COMPUTE S FROM CN
C
      S=(1000./CN)-10.
      IF(LAGFLAG.EQ.1)GO TO 5
C
C
C     COMPUTE WATERSHED LAG TIME
      TL=(L**0.8)*((S+1.)**0.7)/(1900.*(Y**0.5))
C
C     COMPUTE TIME TO PEAK
C
    5 TTP=(DELT/2.)+TL
C
C     COMPUTE UPPER LIMIT OF DELT
C
      D=0.25*TTP
C
C     CHECK THAT DELT IS NOT GREATER THAN UPPER LIMIT (D)
C
      IF(DELT.LE.D)GO TO 9
      WRITE(6,6)DELT,D
    6 FORMAT(2X,"USER TIME STEP OF",F7.3,1X,
     !"HR IS GREATER THAN 0.25 TIME TO PEAK WHICH IS",F7.3,1X,"HR",/,2X,
     !"RESULTING HYDROGRAPH MAY BE JAGGED",/)
    9 CONTINUE
      WRITE(6,24)TL,TTP
   24 FORMAT(2X,"WATERSHED LAG TIME =",F8.3,"HR",/,2X,"TIME TO PEAK="
     !,F8.3,"HR")
C
C     DEFINE SCS MASS CURVE IN DISCRETE 5 PERCENT STEPS OF MASS
C     RATIOQ CONTAINS CONTAINS VALUES FROM DIMENSIONLESS MASS CURVE
C
      DO 10 I=1,20
      IF(I.EQ.1)GO TO 11
      RATIOQ(I)=RATIOQ(I-1)+0.05
      GO TO 10
   11 RATIOQ(I)=0.05
   10 CONTINUE
      RATIOT(1)=.47
      RATIOT(2)=.60
```

Exhibit A1. (continued).

```
     SUBROUTINE UH         73/73    OPT=0 TRACE                    FTN 4.8+508

      RATIOT(3)=.69
      RATIOT(4)=.78
      RATIOT(5)=.85
      RATIOT(6)=.92
      RATIOT(7)=.97
      RATIOT(8)=1.02
      RATIOT(9)=1.08
      RATIOT(10)=1.16
      RATIOT(11)=1.24
      RATIOT(12)=1.32
      RATIOT(13)=1.41
      RATIOT(14)=1.51
      RATIOT(15)=1.62
      RATIOT(16)=1.75
      RATIOT(17)=1.91
      RATIOT(18)=2.15
      RATIOT(19)=2.60
      RATIOT(20)=5.00
C
C     QQT(I) IS THE VALUE, AT TIME I, OF THE RATIO OF THE
C     INSTANTANEOUS CUMULATIVE FLOW OVER THE TOTAL CUMULATIVE FLOW.
C     IT IS DIMENSIONLESS
C     INTERPOLATE A QQT VALUE FOR EACH TIME STEP (UP TO 5 TTP)
C     USING VALUES IN RATIOQ
      NN=INT(5*TTP/DELT)
      XNN=5*TTP/DELT
      IF(XNN.GT.FLOAT(NN))NN=NN+1
C
C     ENSURE THAT THERE ARE NN TIME STEPS OF LENGTH DELT
C
      IF(NN.LE.N)GO TO 27
      NPLUS=N+1
      DO 28 I=NPLUS,NN
   28 T(I)=T(I-1)+DELT
   27 CONTINUE
C
C     INTERPOLATE QQT VALUES FOR TIME STEPS OF USE
C
      DO 12 I=1,NN
      TTTP=T(I)/TTP
      IF(TTTP.GE.5.)GO TO 15
      IFLAG=1
      DO 13 J=1,20
      IF(TTTP.LE.RATIOT(J))GO TO 13
      IFLAG=IFLAG+1
   13 CONTINUE
      IF(IFLAG.GT.1)GO TO 14
      QQT(I)=(TTTP/RATIOT(1))*RATIOQ(1)
      GO TO 12
   14 QQT(I)=((TTTP-RATIOT(IFLAG-1))/(RATIOT(IFLAG)-RATIOT(IFLAG-1))
     1)*(RATIOQ(IFLAG)-RATIOQ(IFLAG-1))+RATIOQ(IFLAG-1)
      GO TO 12
   15 QQT(I)=1.0
   12 CONTINUE
C
C     CONVERT QQT RATIO VALUES TO DIMENSIONLESS UH ORDINATES
C
```

Exhibit A1.   (continued).

```
SUBROUTINE UH          73/73    OPT=0 TRACE                      FTN 4.8+5

      DO 16 I=1,NN
      IF(I.EQ.1)GO TO 25
      DELTA(I)=(QQT(I)-QQT(I-1))
      GO TO 16
   25 DELTA(I)=QQT(I)
   16 CONTINUE
C
C     ENSURE THAT DELTAS ADD UP TO ONE
C
      SUMDEL=0.
      DO 21 I=1,NN
   21 SUMDEL=SUMDEL+DELTA(I)
      DO 23 I=1,NN
   23 DELTA(I)=DELTA(I)/SUMDEL
C
C     COPY DIMENSIONLESS DELTAS INTO DD
C
      DO 7 I=1,NN
    7 DD(I)=DELTA(I)
C
C     CONVERT DIMENSIONLESS DELTAS TO CFS PER INCH
C
      DO 26 I=1,NN
   26 DELTA(I)=DELTA(I)*AREA*645.3/DELT
C
C     WRITE OUT THE UNIT HYDROGRAPH
C
      WRITE(6,8)
    8 FORMAT(/,10X,"UNIT HYDROGRAPH",/,3X,"TIME(HR)",10X,
     1"ORDINATES IN (CFS/IN)",10X,"DIMENSIONLESS ORDINATES"/)
      DO 22 I=1,NN
      WRITE(6,17)T(I),DELTA(I),DD(I)
   17 FORMAT(1X,F10.3,16X,F10.2,25X,F10.3)
   22 CONTINUE
      CALL MAPA(5,T,DELTA,1,NN,XMIN,XMAX,YMIN,YMAX,XT,YT,MT,1)
      RETURN
      END
```

```
SUBROUTINE ROUTE       73/73    OPT=0 TRACE                       FTN 4.8+508

      SUBROUTINE ROUTE
      COMMON/A/DELT,Q,N,P,TD,CN
      COMMON/D/T(100),R(100),RE(100)
      COMMON/H/AREA,L,Y,NN,NF
      COMMON/I/DELTA(150)
      COMMON/J/DELP(150),QA(150),TM(150)
      DIMENSION MT(8)
      DATA XT,YT,MT/"TIME(HR)  ","Q(CFS)    ","FLOOD HYDROGRAPH
     !                                    "/
C
C     COMPUTE TOTAL NUMBER OF TIME STEPS FOR WHICH THERE WILL BE  FLOW
C     NF IS THE NUMBER OF STEPS AFTER THE ONSET OF EXCESS RAIN
C
      MM=NN+NF-1
C
C     DEFINE TIME STEPS AND ZERO INFLOWS FROM STEP NF TO MM
      NPLUS=NF+1
      DO 10 I=NPLUS,MM
      TM(I)=TM(I-1)+DELT
   10 DELP(I)=0.0
C
C     DEFINE ZERO HYDROGRAPH ORDINATES (DELTAS) FROM NN TO MM
      NPLUS=NN+1
      DO 11 I=NPLUS,MM
   11 DELTA(I)=0.0
C
C     WRITE OUT DELP,TM, AND DELTA ARRAYS
      WRITE(6,17)
   17 FORMAT(/,1X,"DATA USED TO COMPUTE FLOOD HYDROGRAPH:",/,/,
     !2X,"T(HR) = TIME IN HOURS",/,2X,
     !"DELP(IN) = INCREMENTAL DEPTH OF EXCESS RAINFALL",/,
     !2X,"DELTA(CFS/IN) = UNIT HYDROGRAPH ORDINATE",/,/
     !2X,"T(HR)",8X,"DELP(IN)",5X,"DELTA(CFS/IN)",/)
      DO 16 I=1,MM
      WRITE(6,18)TM(I),DELP(I),DELTA(I)
   18 FORMAT(1X,F8.3,2X,F10.3,8X,F10.3)
   16 CONTINUE
C
C     COMPUTE OUTFLOWS OF THE FLOOD HYDROGRAPH
      DO 13 I=1,MM
      QA(I)=0.0
      DO 13 J=1,I
      QA(I)=QA(I)+DELP(J)*DELTA(I-J+1)
   13 CONTINUE
C
C     PRINT OUT RESULTS
      WRITE(6,19)
   19 FORMAT(/,2X,"FLOOD HYDROGRAPH",/,/,5X,"TIME(HR)",16X,"Q(CFS)",/)
      DO 9 I =1,MM
      WRITE(6,8)TM(I),QA(I)
    8 FORMAT(2X,F10.3,14X,F10.2)
    9 CONTINUE
C
C     PLOT FLOOD HYDROGRAPH
      CALL MAPA(5,TM,QA,1,MM,XMIN,XMAX,YMIN,YMAX,XT,YT,MT,1)
      RETURN
      END
```

Exhibit A1. (continued).

```
SUBROUTINE TABLE       73/73    OPT=0 TRACE                          FTN 4.8+508

      SUBROUTINE TABLE
      COMMON/A/DELT,Q,N,P,TD,CN
      COMMON/B/KT,TP,RP,WP,K
      COMMON/C/MO,DAY,SFFC,S
      COMMON/K/SUBOPT2
      INTEGER SUBOPT2
      REAL KT
      WRITE(6,33)
   33 FORMAT(/,100(1H*),/)
      WRITE(6,28)
   28 FORMAT(/,10X,"OUTPUT OF SUBROUTINE TABLE",/)
C     THIS SUBROUTINE COMPUTES HYDRAULIC CONDUCTIVITY, KT, AND
C     STORAGE SUCTION FACTOR AT FIELD CAPACITY, SFFC, GIVEN A
C     CURVE NUMBER, CN.
C
C     USE REGRESSION EQUATIONS TO COMPUTE HYDRAULIC
C     CONDUCTIVITY, KT, AND SORPTIVITY, SORP
C
      IF(CN.LE.75.)GO TO 11
      KT=(100.-CN)/315.43
      GO TO 12
   11 IF(CN.LE.36.)GO TO 13
      KT=1.236-.0154*CN
      GO TO 12
   13 KT=1.853-.0324*CN
   12 CONTINUE
      IF(CN.LE.65.)GO TO 14
      SORP=(100.-CN)/42.252
      GO TO 15
   14 SORP=1.191-.00575*CN
   15 CONTINUE
C
C     COMPUTE STORAGE SUCTION FACTOR AT FIELD CAPACITY FROM KT AND
C     SORP
C
      SFFC=(SORP**2)/(2.*KT)
C     PRINT OUT RESULTS
      WRITE(6,19)KT,SFFC
   19 FORMAT(/,2X,"HYDRAULIC CONDUCTIVITY, KT =",F10.3,2X,"IN/HR",/,2X,
     !"STORAGE SUCTION FACTOR AT FIELD CAPACITY, SFFC =",F10.3,1X,"IN",/
     !)
      WRITE(6,33)
      RETURN
      END
```

Exhibit A1. (continued).

```
SUBROUTINE BALANCE     73/73    OPT=0 TRACE                    FTN 4.8+508

            SUBROUTINE BALANCE
            COMMON/A/DELT,Q,N,P,TD,CN
            COMMON/D/T(100),R(100),RE(100)
            DIMENSION BR(100)
            INTEGER CTR
      C
      C     THIS SUBROUTINE RE-ARRANGES USER SUPPLIED INCREMENTS OF RAIN
      C     (DEPTH OR INTENSITY) ACCORDING TO THE CORPS OF ENGINEERS
      C     "BALANCED" HYETOGRAPH. THE USER MAY INPUT THE RAIN STEPS
      C     IN THE R ARRAY IN ANY ORDER
      C
      C     SORT ELEMENTS OF R INTO BR SO THAT BR(1) IS OF GREATEST
      C     MAGNITUDE, BR(2) IS NEXT GREATEST, ETC.
      C
            DO 40 I=1,N
            CHECK=R(1)
            ICHECK=1
            DO 50 J=2,N
            IF(CHECK.GE.R(J))GO TO 50
            CHECK=R(J)
            ICHECK=J
         50 CONTINUE
            BR(I)=CHECK
            R(ICHECK)=-99.
         40 CONTINUE
      C
      C     ARRANGE ELEMENTS OF BR INTO A BALANCED HYETOGRAPH
      C
            CTR=(N/2)+1
            R(CTR)=BR(1)
            DO 90 I=2,N
            IF(MOD(I,2).EQ.0)GO TO 91
            R(CTR+(I/2))=BR(I)
            GO TO 90
         91 R(CTR-(I/2))=BR(I)
         90 CONTINUE
            RETURN
            END
```

*U.S. GOVERNMENT PRINTING OFFICE: 1981-0-730-115/2200

FEDERALLY COORDINATED PROGRAM (FCP) OF HIGHWAY RESEARCH AND DEVELOPMENT

The Offices of Research and Development (R&D) of the Federal Highway Administration (FHWA) are responsible for a broad program of staff and contract research and development and a Federal-aid program, conducted by or through the State highway transportation agencies, that includes the Highway Planning and Research (HP&R) program and the National Cooperative Highway Research Program (NCHRP) managed by the Transportation Research Board. The FCP is a carefully selected group of projects that uses research and development resources to obtain timely solutions to urgent national highway engineering problems.*

The diagonal double stripe on the cover of this report represents a highway and is color-coded to identify the FCP category that the report falls under. A red stripe is used for category 1, dark blue for category 2, light blue for category 3, brown for category 4, gray for category 5, green for categories 6 and 7, and an orange stripe identifies category 0.

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems associated with the responsibilities of the FHWA under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion, and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by balancing the demand-capacity relationship through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements that affect the quality of the human environment. The goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge and technology of materials properties, using available natural materials, improving structural foundation materials, recycling highway materials, converting industrial wastes into useful highway products, developing extender or substitute materials for those in short supply, and developing more rapid and reliable testing procedures. The goals are lower highway construction costs and extended maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural and hydraulic designs, fabrication processes, and construction techniques to provide safe, efficient highways at reasonable costs.

6. Improved Technology for Highway Construction

This category is concerned with the research, development, and implementation of highway construction technology to increase productivity, reduce energy consumption, conserve dwindling resources, and reduce costs while improving the quality and methods of construction.

7. Improved Technology for Highway Maintenance

This category addresses problems in preserving the Nation's highways and includes activities in physical maintenance, traffic services, management, and equipment. The goal is to maximize operational efficiency and safety to the traveling public while conserving resources.

0. Other New Studies

This category, not included in the seven-volume official statement of the FCP, is concerned with HP&R and NCHRP studies not specifically related to FCP projects. These studies involve R&D support of other FHWA program office research.

---

* The complete seven-volume official statement of the FCP is available from the National Technical Information Service, Springfield, Va. 22161. Single copies of the introductory volume are available without charge from Program Analysis (HRD-3), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.