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USERS GUIDE FOR DISTRIBUTED ROUTING RAINFALL-RUNOFF MODEL

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CONTENTS

	Page
Metric conversions-----	IV
Abstract-----	1
Introduction-----	1
Structure of the model-----	1
Soil-moisture-accounting component-----	2
Rainfall-excess component-----	2
Impervious surfaces-----	2
Pervious surfaces-----	4
Routing component-----	4
Channel and overland-flow segments-----	7
The kinematic-wave equations-----	7
The finite-difference scheme-----	9
Selecting Δx and Δt -----	10
Estimation of parameters α and m -----	13
Special notes on circular pipes-----	13
Reservoir segments-----	15
Nodal segments-----	17
Optimization component-----	17
Data input specifications-----	19
Computer requirements-----	33
Program output-----	33
References-----	35
Attachments-----	36
A. Generalized program flow chart-----	37
B. List of selected variables-----	44
C. Program listing-----	58
D. Schematic of program deck setup-----	94
E. Sample runs-----	97

ILLUSTRATIONS

Figure 1. Schematic flow chart of the soil-moisture-accounting component-----	3
2. Graph showing the relation which determines the effective value of soil-moisture potential (PS) for use in the infiltration equation-----	5
3. Graph showing the relation which determines rainfall excess (QR) as a function of maximum-infiltration capacity (FR) and supply rate of rainfall (SR)-----	5
4. Sketch showing discretization of an urban catchment into segments-----	8
5. Sketch showing four-point finite-difference mesh-----	12
6. Graph showing relation between $\frac{Q}{Q_{FULL}}$ and $A/AMAX$ for circular pipes-----	16

ILLUSTRATIONS (Continued)

		Page
Figure 7.	Flow chart of initial program setup-----	38
8.	Flow chart of main program-----	39
9.	Flow chart of daily water balance-----	40
10.	Flow chart of rainfall excess-----	41
11.	Flow chart of unit-time water balance during periods of no rainfall-----	42
12.	Flow chart of routing routine-----	43
13.	Aerial photograph of Sand Creek Tributary Basin at Denver, Colorado-----	102
14.	Schematic of Sand Creek Tributary Basin at Denver, Colorado, showing segmentation for rainfall-runoff modeling-----	103

TABLES

Table 1.	Parameters for soil-moisture accounting and infiltration-	6
2.	Relations for estimating α and m on basis of physical characteristics of overland-flow and channel segments--	14
3.	List of soil-moisture and infiltration parameters in order of input-----	25
4.	Summary of runoff periods at Sand Creek Tributary Basin at Denver, Colorado, 1973 and 1974-----	100
5.	Overland-flow segment characteristics for Sand Creek Tributary Basin at Denver, Colorado-----	105
6.	Channel-segment characteristics for Sand Creek Tributary Basin at Denver, Colorado-----	106
7.	Comparison of measured and simulated runoff volumes and peak flows for Sand Creek Tributary Basin at Denver, Colorado-----	111

METRIC CONVERSIONS

U.S. Customary units used in this report may be converted to metric units by the following conversion factors:

<u>Multiply U.S. Customary units</u>	<u>By</u>	<u>To obtain metric units</u>
cubic foot per second	0.02832	cubic meter per second
foot	.3048	meter
square foot	.0929	square meter
inch	25.4	millimeter
square mile	2.590	square kilometer

USERS GUIDE FOR DISTRIBUTED ROUTING RAINFALL-RUNOFF MODEL

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ABSTRACT

A computer program of a watershed model for routing urban flood discharges through a branched system of pipes or natural channels using rainfall as input has been developed and documented. The model combines soil-moisture-accounting and rainfall-excess components developed by Dawdy and others (1972) with the kinematic-wave routing method presented by Leclerc and Schaake (1973).

INTRODUCTION

The model presented here combines the soil-moisture-accounting and rainfall-excess components of the model developed by Dawdy and others (1972) with the kinematic-wave routing components of the model developed by Leclerc and Schaake (1973). Input to the model includes daily rainfall, unit rainfall (any multiple of 5 minutes), and daily pan evaporation. During unit-rainfall days, the model generates a simulated discharge hydrograph based on input data from as many as three rain gages, and a physical definition of the drainage basin discretized into as many as 50 segments, including overland flow, channel and reservoir segments^{1/}. The model maintains a daily soil-moisture accounting between unit-rainfall days.

The model uses a deterministic mathematical approach, which includes, as much as possible, approximations to physical laws. Wherever possible, a physical interpretation is placed upon the parameters used in the model. A particular effort was made to use model parameters which can be estimated on the basis of physical features alone.

STRUCTURE OF THE MODEL

The model described in this report can be divided into four major components: a soil-moisture-accounting component, a rainfall-excess component, a routing component, and an optimization component.

^{1/} If one description fits more than one segment, then there can be more than 50 segments.

Soil-Moisture-Accounting Component

The soil-moisture-accounting component determines the effect of antecedent conditions on infiltration. Soil moisture is modeled as a two-layered system, one representing the antecedent base-moisture storage (BMS)^{2/}, and the other, the upper wetted part caused by infiltration into a saturated moisture storage (SMS).

During unit-rainfall days, moisture is added to SMS based on the Philip infiltration equation (Philip, 1954). On other days, a specified proportion of daily rainfall (RR) infiltrates into the soil. Irrigation (for example, lawn watering) can be accounted for in the daily water balance. This is achieved through user-supplied irrigation rates for each month. If a daily precipitation is less than the daily irrigation rate, the daily precipitation is reset equal to the irrigation rate.

Evapotranspiration takes place from SMS, based on availability, otherwise from BMS, with the rate determined from pan evaporation multiplied by a pan coefficient (EVC). Moisture in SMS drains into BMS with a controlling parameter (DRN) determining the rate. Storage in BMS has a maximum value (BMSN) equivalent to the field-capacity moisture storage of an active soil zone. Zero storage in BMS is assumed to correspond to wilting-point conditions in the active soil zone. When storage in BMS exceeds BMSN, the excess is spilled to deeper storage. These spills could be the basis for routing interflow and baseflow components, if desired. However, this option is not included in the present version of the model. A schematic flow chart of the soil-moisture-accounting component is shown in figure 1.

Rainfall-Excess Component

Impervious Surfaces

Two types of impervious surfaces are considered by the model. The first type, effective impervious surfaces, are those impervious areas which are directly connected to the channel drainage system, such as streets and roofs which drain onto driveways and streets. The second type, noneffective impervious surfaces, are those impervious areas which drain to pervious areas. An example of a noneffective impervious area is a roof which drains onto a lawn.

The only abstraction from rainfall on effective impervious areas is impervious retention. This retention, which is user specified, must be filled before runoff from effective impervious areas can occur. Evaporation occurs from impervious retention during periods of no rainfall.

^{2/} Definitions of selected model variables can be found in attachment B.

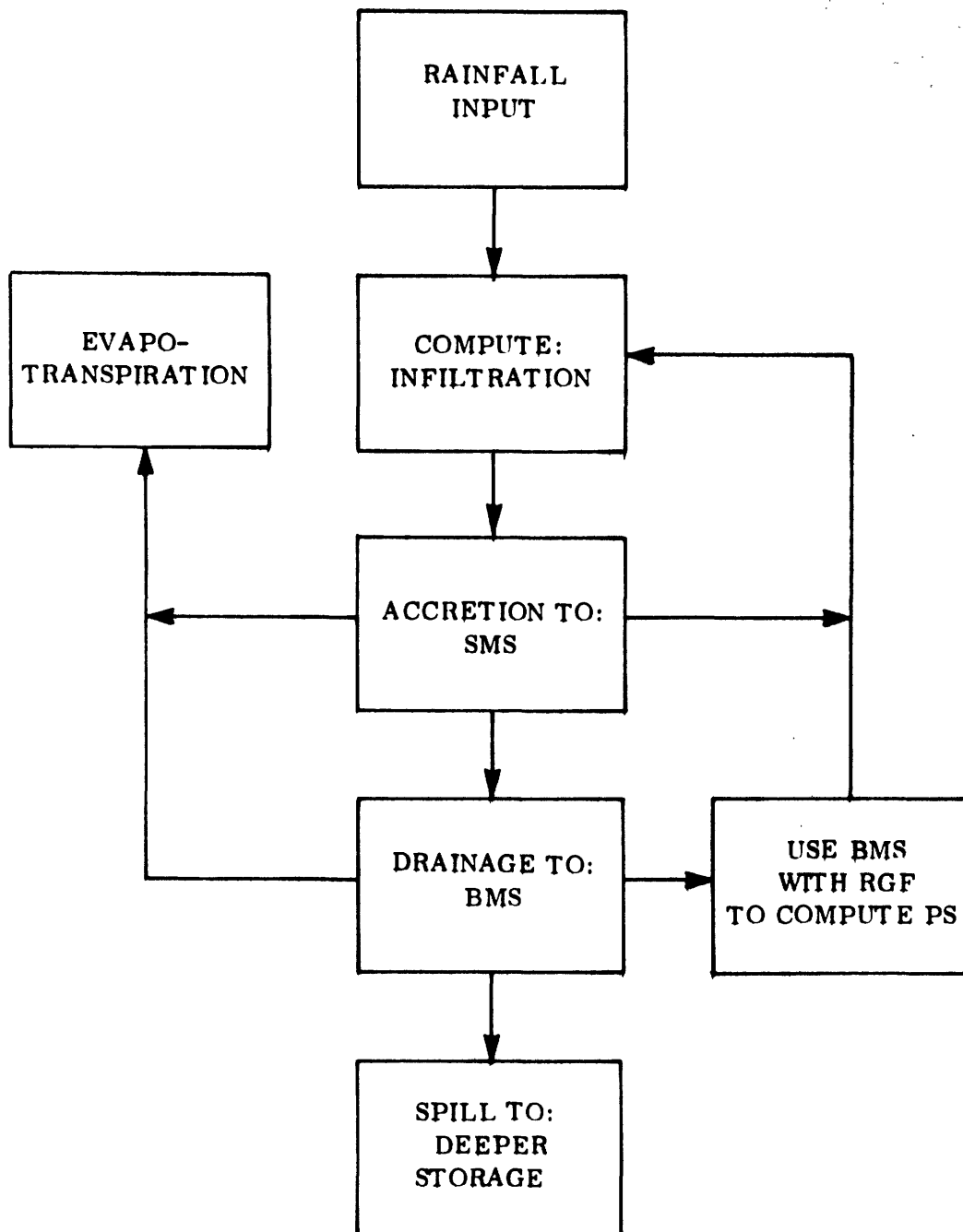


Figure 1.--Schematic flow chart of the soil-moisture-accounting component.

Rain falling on noneffective impervious areas is assumed to run off onto the surrounding pervious area. The model assumes that this occurs instantaneously and that the volume of runoff is uniformly distributed over the contributing pervious area. This volume expressed as inches over the pervious area is added to the rain falling on the pervious areas prior to computation of pervious-area rainfall excess.

Pervious Surfaces

The point-potential infiltration (FR) is computed by a variation of the Green-Ampt equation (Green and Ampt, 1911) known as the Philip equation (Philip, 1954): The Philip equation is

$$FR = KSAT (1 + PS/SMS) \quad (1)$$

where *KSAT* is the effective saturated soil capillary conductivity and *PS* is the capillary potential at the wetting front. *PS* is varied over the range from field capacity to wilting point by the linear function

$$PS = PSP [RGF - (RGF - 1) BMS/BMSN] \quad (2)$$

where *PSP* is the suction at the wetting front at field capacity, *RGF* is the ratio of suction at wilting point to that at field capacity, and *BMSN* is the effective soil-moisture storage at field capacity (fig. 2).

Point-potential infiltration (FR) computed by the Philip equation is converted to effective infiltration over the basin using a scheme first presented by Crawford and Linsley (1966). Letting *SR* represent the supply rate of rainfall for infiltration, and *QR* represent the rate of generation of rainfall excess, the equations are

$$QR = SR^2/2FR \quad SR < FR \quad (3a)$$

$$QR = SR - (FR/2) \quad SR > FR \quad (3b)$$

The schematic representation of the relations is shown in figure 3. The parameters for soil-moisture accounting and infiltration are summarized in table 1. Two different soil types can be handled by the model with separate soil-moisture accounting and infiltration parameters for each soil type.

Routing Component

A drainage basin is represented in this model as a set of segments which jointly describe all sub-basins in the total basin. There are four basic types of segments: overland-flow segments, channel segments, reservoir segments and nodal segments. There is wide flexibility to the approach one can take in dividing a basin into segments for runoff computations. At present, it remains largely an art to characterize the total basin in terms of a number of segments which account for the essential basin properties. An example of basin segmentation is illustrated in attachment E.

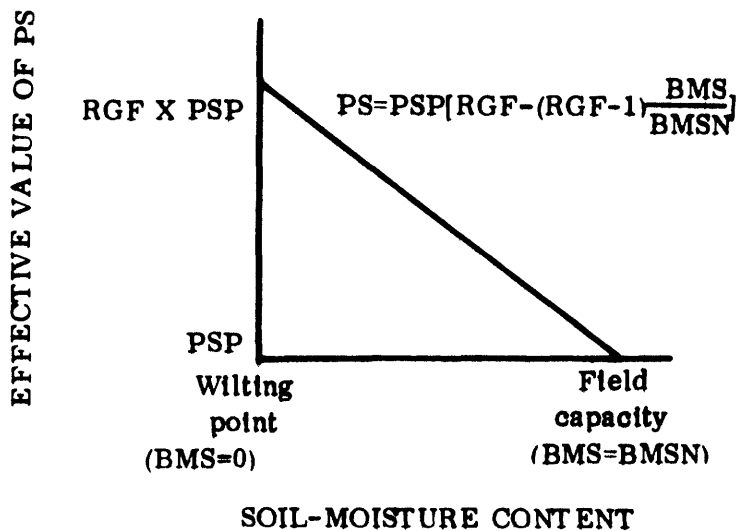


Figure 2.--The relation which determines the effective value of soil-moisture potential (PS) for use in the infiltration equation.

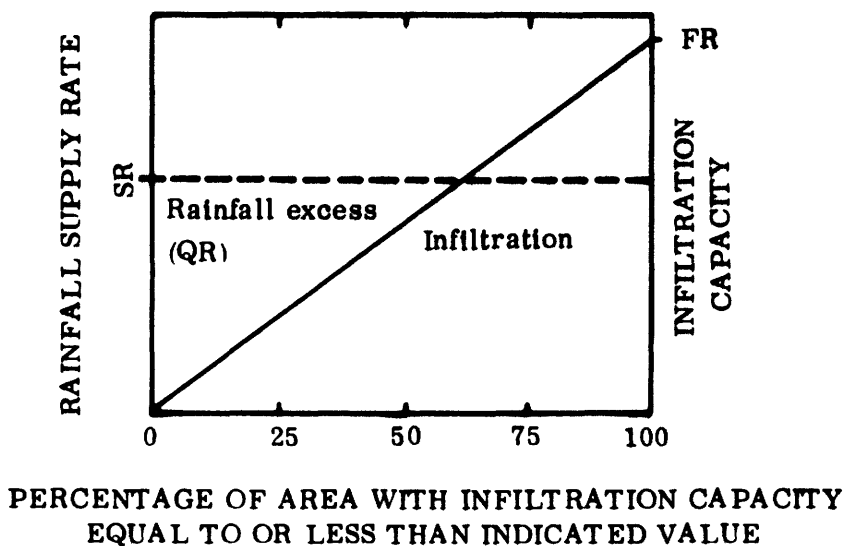


Figure 3.--The relation which determines rainfall excess (QR) as a function of maximum-infiltration capacity (FR) and supply rate of rainfall (SR).

Table 1.--Parameters for soil-moisture accounting and infiltration

Soil-Moisture Accounting

Parameters:

DRN--A constant drainage rate for redistribution of soil moisture
between SMS and BMS, in inches per day

EVC--A pan coefficient for converting measured pan evaporation to
potential evapotranspiration

RR--The proportion of daily rainfall that infiltrates into the
soil for the period of simulation excluding unit-rainfall days.

BMSN--Soil-moisture storage at field capacity, in inches

Infiltration

Parameters:

KSAT--The effective saturated value of hydraulic conductivity, in
inches per hour

RGF--Ratio of suction at the wetting front for soil moisture at
wilting point to that at field capacity

PSP--Suction at wetted front for soil moisture at field capacity,
in inches of pressure

Channel and Overland-Flow Segments

A channel segment is permitted to receive upstream inflow from as many as three other segments, including combinations of other channel segments, reservoir segments, and nodal segments. It also may receive lateral inflow from as many as four overland-flow segments. The overland-flow segments receive uniformly distributed lateral inflow from excess precipitation. A schematic illustrating the relationships between channel and overland-flow segments is shown in figure 4.

Kinematic-wave theory is applied for both overland-flow and channel routing. The kinematic-wave equations are difficult to solve analytically. For practical catchment configurations and natural storms, the analytical solutions are untractable; therefore, numerical solutions must be used. One approach is to solve a finite-difference equation which converges to the differential equation as the step size decreases. That approach has been taken here. The finite-difference scheme used (Leclerc and Schaake, 1973) is unconditionally stable for any values of Δx and Δt .

The Kinematic-Wave Equations

The partial differential equation to be solved for each channel and overland-flow segment is

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = q \quad (4)$$

in which A is the area of flow, Q is the rate of flow, q is the rate of lateral inflow, t denotes time, and x denotes distance along the segment increasing in the downstream direction. The dependent variables are A and Q , and these are functions of the two independent variables x and t .

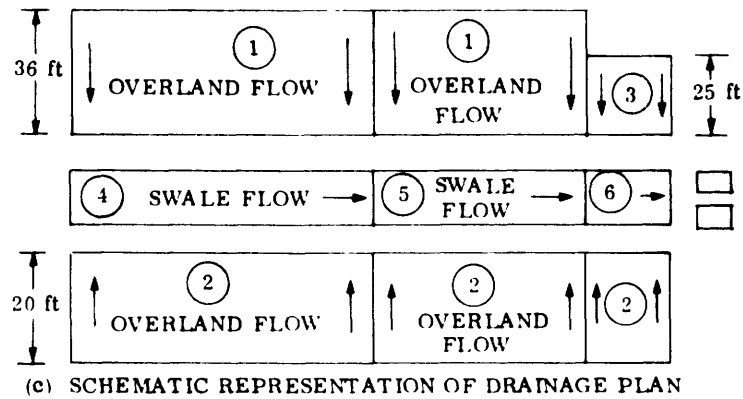
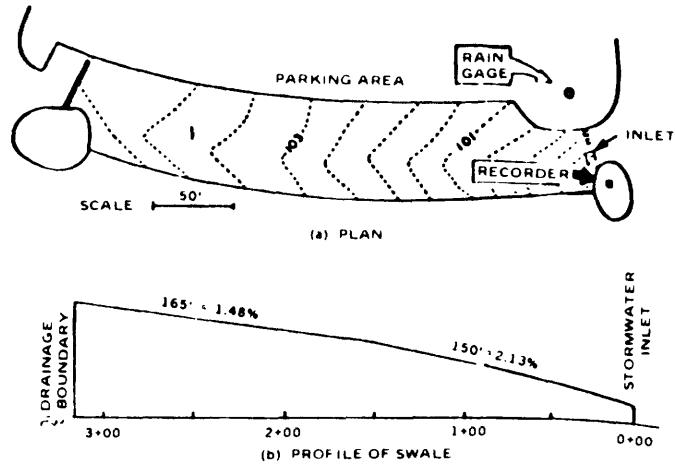
The rate of lateral inflow, q , is generally a function of both x and t , and it serves as an input function, or "forcing function", of the differential equation. In this model the value of q for any particular segment is the same everywhere along the length of that segment, so in this case, q is a function of t but not of x .

The relationship between A and Q is given as

$$Q = \alpha A^m. \quad (5)$$

If the length of the segment is L , the outflow hydrograph from the segment is $Q(L,t)$. The inflow hydrograph to the upstream end of the segment is $Q(0,t)$, and this is the boundary condition needed to solve equation 5. In the case where there is an upstream inflow, the solution will also depend on that inflow. Therefore, the solution must be some function of x , t , q , and $Q(0,t)$. The outflow hydrograph is given by

$$Q(L,t) = f[Q(0,t), q(t)] \quad (6)$$



Segment	Length (ft)	Slope (ft/ft)	Inflow to Segment	
			Lateral Inflow	Upstream Inflow
①	36	.019	Rainfall	—
②	20	.0167	Rainfall	—
③	25	.019	Rainfall	—
④	165	.0148	① and ②	—
⑤	100	.0213	① and ②	④
⑥	50	.0213	② and ③	⑤

(d) PHYSICAL CHARACTERISTICS OF COMPONENTS IN THE SCHEMATIC REPRESENTATION

Figure 4.--Discretization of an urban catchment into segments.

The Finite-Difference Scheme

Because $Q(0,t)$ and $q(t)$ are difficult to manage by analytical methods, numerical techniques are used to approximate $Q(x,t)$ at discrete locations in the x - t plane. In this case, a rectangular grid of points was selected. These are spaced at intervals of time, Δt ; and distance, Δx . The value of Δx varies from segment to segment, but the value of Δt is constant for all segments.

Four points of a finite-difference mesh are illustrated in figure 5. The purpose of the finite-difference equations is to solve for A and Q at point d , given values of A and Q at points a , b , and c .

In an attempt to keep the solution errors small while maintaining an unconditionally stable solution, the model contains two different finite-difference equations and selects the appropriate one at each point in the solution. The decision depends on the parameter

$$\theta = m \frac{\Delta t}{\Delta x} \frac{Q_b}{A_b} = \alpha m A^{m-1} \left(\frac{\Delta t}{\Delta x} \right) \quad (7)$$

If θ is greater than or equal to unity, the equations used are

$$Q_d = Q_c + q\Delta x - \frac{\Delta x}{\Delta t} (A_c - A_a) \quad (8)$$

and

$$A_d = (Q_d/\alpha)^{1/m} \quad (9)$$

This involves only mesh points a , c , and d . It was derived by substituting $(A_c - A_a)/\Delta t$ for $\partial A/\partial t$ and $(Q_d - Q_c)/\Delta x$ for $\partial Q/\partial x$.

If θ is less than unity, the equations used are

$$A_d = A_b + q\Delta t + \frac{\Delta t}{\Delta x} (Q_a - Q_b) \quad (10)$$

and

$$Q_d = \alpha A_d^m \quad (11)$$

Equations 8 to 11 are solved by the model beginning with $x = \Delta x$ and proceeding downstream to $x = L$. Initial values of A and Q are given along the entire x - axis. At $t = 0$, the model sets $A = 0$ and $Q = 0$ everywhere. During the solution, upstream inflows are given and equation 5 is used to compute the upstream boundary condition for A .

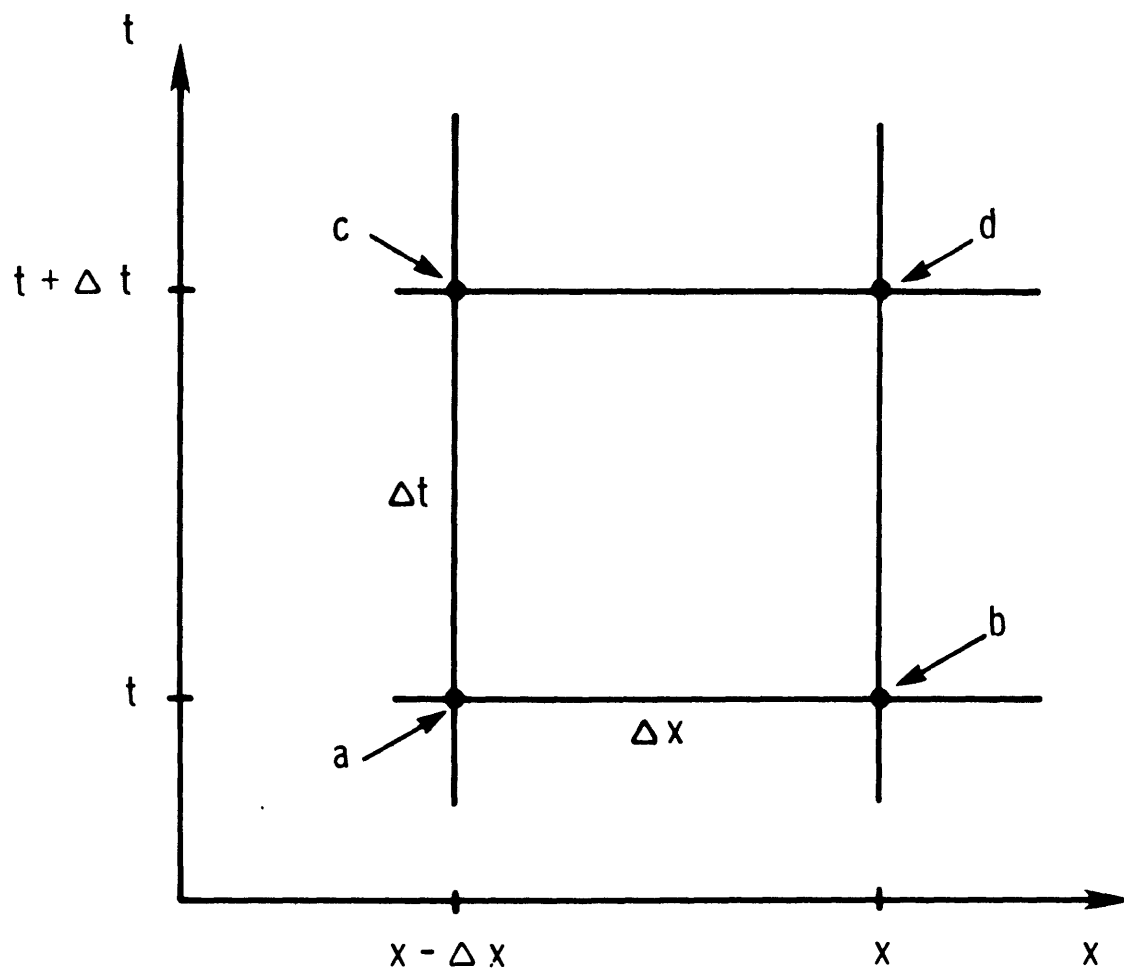


Figure 5.--Four-point finite-difference mesh.

One of the computational problems often encountered in finite-difference approximation is failure to conserve volume. Indeed, there are certain finite-difference approximations of the kinematic-wave equations that lose water during the solution. It can be proved for the special linear case, when $m = 1$, that equations 8 to 11 will conserve volume. Computational experience for $m > 1$ also gives empirical evidence that volume is conserved.

Selecting Δx and Δt

There is obviously no "best" way to select Δx and Δt . One approach would be to choose Δt first and then fix Δx to keep computational errors within acceptable bounds.

Two factors are important for Δt . One is the frequency of the rainfall input to the catchment. The other is the frequency response characteristics of the catchment. If the rainfall input contains many high frequency components, the runoff hydrograph will contain frequency components limited by the high frequency response characteristics of the catchment. A convenient rule of thumb in unit-hydrograph theory is to select Δt so there are about 10 nonzero ordinates. This appears to be a reasonable value to use in the kinematic-wave model also. Applying this rule to a basin having: a typical overland-flow length equal to L_o , overland-flow kinematic-wave parameters α_o and m_o , a main channel length equal to L_c , and channel flow parameters α_c and m_c gives the rule

$$\Delta t \approx 0.1 (t_o + t_c) \quad (12)$$

where

$$t_o = \left[\frac{L_o}{\alpha_o (i_e / 43200)^{m_o - 1}} \right]^{1/m_o} \quad (13)$$

$$t_c = \left[\frac{L_c}{\alpha_c (N i_e L_o / 43200)^{m_c - 1}} \right]^{1/m_c} \quad (14)$$

i_e = maximum rainfall intensity, and

N = number of sides of channel with overland-flow segments contributing lateral inflow (1 or 2).

The units are t (seconds), L_o and L_c (feet), and i_e (inches per hour).

After a value of Δt is selected, choose Δx for each segment. This is done by specifying the number, NDX , of Δx increments in each segment. The value of NDX may vary from segment to segment.

The finite-difference solution will be an exact solution if Δx and Δt are selected so that the characteristic passing through point a also passes through point d (fig. 5). Then, the solution A_d, Q_d depends only on A_a, Q_a and the lateral inflow along the characteristic curve between a and d. In the special linear case where $m = 1$, it is possible to achieve the exact solution by setting the ratio $\Delta x/\Delta t$ equal to α . In the general, nonlinear case the ratio $\Delta x/\Delta t$ would need to be equal to α^* where

$$\alpha^* = \alpha m A^{m-1} \quad (15)$$

Hence, the rule is

$$\Delta x \approx \alpha^* \Delta t \quad (16)$$

The parameter α^* is the effective value of α that would be used for a linear approximation ($m = 1$) to a given kinematic-flow segment. For overland flow

$$\alpha_o^* \approx \frac{L_o}{t_o} \quad (17)$$

and for channel flow

$$\alpha_c^* \approx \frac{L_c}{t_c} \quad (18)$$

Thus,

$$\Delta x_o \approx \frac{L_o}{t_o} \Delta t \quad (19)$$

$$\Delta x_c \approx \frac{L_c}{t_c} \Delta t \quad (20)$$

Finally,

$$NDX_o = \frac{L_o}{\Delta x_o} \approx \frac{t_o}{\Delta t} \quad (21)$$

$$NDX_c = \frac{L_c}{\Delta x_c} \approx \frac{t_c}{\Delta t} \quad (22)$$

In general, the smallest subarea of interest and the highest intensity rainfall should be used to estimate Δt . If detailed output from the basin outlet is all that is required, the Δt computed as above may be based on the entire channel length through the basin and average basin overland-flow length.

Example to select Δt and Δx

Given the example shown in figure 4,

$$L_O = 30 \text{ feet}$$

$$L_C = 315 \text{ feet}$$

$$\alpha_O \approx 7.8$$

$$m_O = 1.67$$

$$\alpha_C \approx 2.0$$

$$m_C = 1.33$$

$i_e = 2$ inches per hour and $N = 2$.

Substituting in equations 13 and 14

$$t_O = \left[\frac{30}{7.8(2/43200)^{.67}} \right]^{1/1.67} = 123 \text{ seconds}$$

and

$$t_C = \left[\frac{315}{2[(2)(2)(30)/43200]^{.33}} \right]^{1/1.33} = 193 \text{ seconds}$$

Then from equation 12

$$\Delta t \approx 0.1(123 + 193) = 31.6 \text{ seconds}$$

Let,

$$\Delta t = 30 \text{ seconds} = 0.5 \text{ minutes}$$

Then,

$$NDX_C \approx 193/30 = 6.4, \text{ say } 7$$

$$NDX_O \approx 123/30 = 4.1, \text{ say } 4.$$

Estimation of Parameters α and m

The kinematic-wave model contains two parameters, α and m . These parameters have no particular physical significance, directly, but they can be determined by analysis of the physical characteristics of the basin segments. The particular functional relationships of α and m for channel and overland-flow segments are listed in table 2.

Special Notes on Circular Pipes

The exact relation between A and Q for circular pipes, assuming the kinematic-wave theory is valid, does not follow the simple algebraic relation (5) with constant values of α and m . Rather, these parameters are, in fact, functions of A . However, this exact relation may be approximated by (5) with values of α and m selected to give a "good fit."

The approximation selected for this model was derived by first recognizing that the dimensionless relation between flow area and flow rate was nearly linear. Let Q_{FULL} be the flow rate when the pipe is flowing full.

Table 2.--Relations for estimating α and m on basis of physical characteristics of overland-flow and channel segments

Type of segment	ITYPE(I)	$\frac{1}{\alpha}$	m	Definition of PARAM(I,1)
Rectangular Conduit	1	$\frac{1.49 \sqrt{SL\emptyset PE(I)}}{FRN(I) * [PARAM(I,1)]^{2/3}}$	1.67	Width of conduit
Circular pipe	2	$\frac{1.49}{FRN(I)} \left(\frac{PARAM(I,1)}{4} \right)^{2/3} \sqrt{SL\emptyset PE(I)}$	1.0	Diameter of pipe
Triangular cross section	3	$\frac{1.41 \sqrt{SL\emptyset PE(I)}}{FRN(I) * (PARAM(I,1))^{1/3}}$	1.33	Width at 1-foot depth
External specification of α and m	4	PARAM(I,1)	PARAM(I,2)	α
Overland flow (turbulent)	5 or 15	$\frac{1.49 \sqrt{SL\emptyset PE(I)}}{FRN(I)}$	1.67	----
Overland flow (laminar)	6 or 16	$\frac{64.4 SL\emptyset PE(I)}{.0000141 * FRN(I)}$	3.0	----

$\frac{1}{FRN(I)}$ = Friction coefficient for segment I.

$SL\emptyset PE(I)$ = Slope of segment I.

Let A_{MAX} be the cross-sectional area of the pipe. The approximation is then

$$\frac{Q}{Q_{FULL}} \approx \frac{A}{A_{MAX}} \quad (23)$$

Assuming an equality relation, and rearranging (23), gives

$$Q = \frac{Q_{FULL}}{A_{MAX}} A \quad (24)$$

so that the parameters are

$$\alpha = \frac{Q_{FULL}}{A_{MAX}} \quad (25)$$

$$m = 1 \quad (26)$$

The relation between these two curves is illustrated in figure 6.

The capacity of rectangular-conduit and circular-pipe segments is limited to nonpressurized-flow capacity. If that capacity is exceeded during a storm, provision is made to store the water arriving at the upstream end of the segment in excess of the segment capacity. The volume stored increases without upper limit as long as the upstream inflow exceeds segment capacity. After the upstream inflow drops below segment capacity, the volume stored is released to the segment. The upstream inflow to the segment remains at the maximum capacity until the water stored at the upper end of that segment has been released. In the real world, the capacity of a sewer may be controlled by inlets which restrict flow in the sewer to less than full-pipe flow. A second possibility is that a sewer may flow under pressure, thus having more capacity than predicted using kinematic-wave theory. A third possibility is that once a sewer is flowing full, additional inflow to the sewer is transferred to streets parallel to the sewer system. These situations can, at times, be approximated by adjusting the size of the circular segment appropriately. A modified-Puls reservoir segment, described in the next section, can be used to simulate culverts which detain water due to limited capacity and for which outflows are uniquely described as a single-valued function of storage behind the culvert. More complex situations may call for revision of the model.

Reservoir Segments

Provision is made in the model for two types of reservoir routing. The first type is linear-storage routing in which outflow is a linear relation of storage. The user specifies a value of K for the relationship

$$S = KO \quad (27)$$

where,

S = storage, and
 O = outflow.

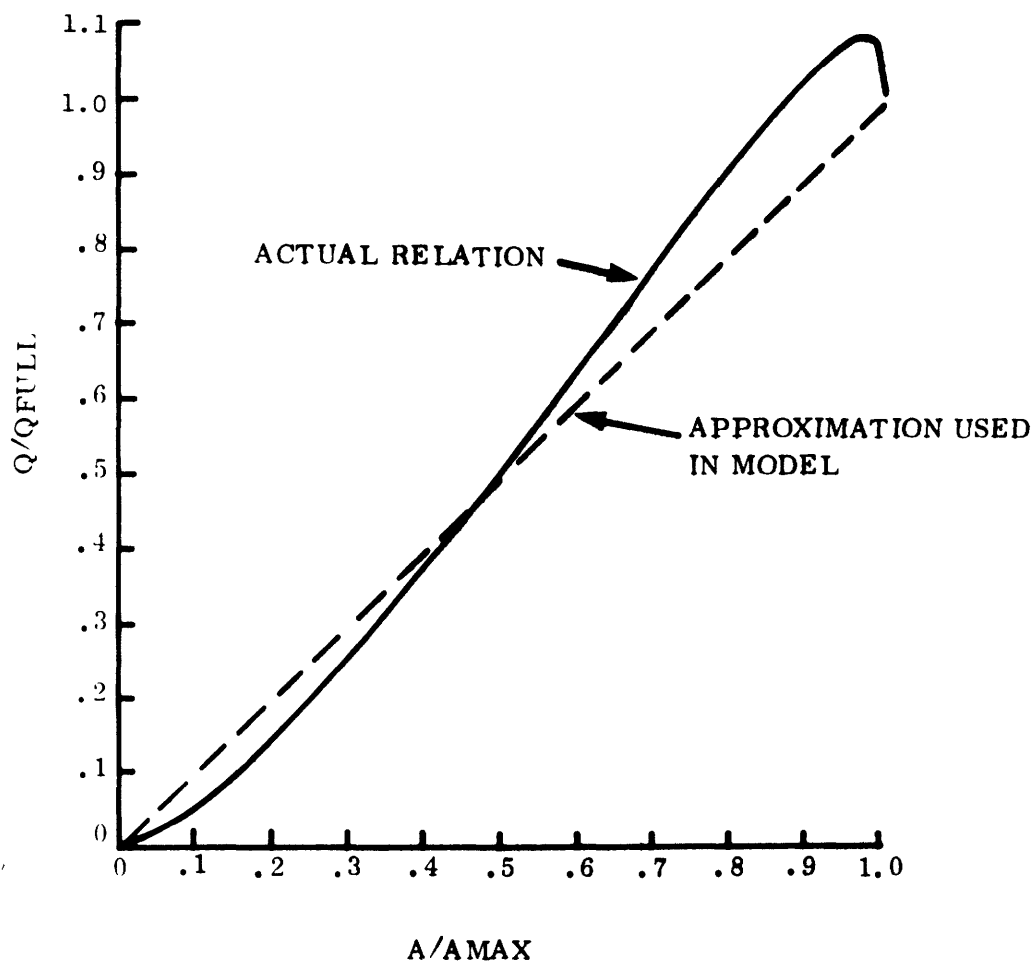


Figure 6.--Relation between $\frac{Q}{Q_{FULL}}$ and A/A_{MAX} for circular pipes.

A second type of reservoir routing is modified-Puls routing (Soil Conservation Service, 1972) based on the continuity equation

$$\bar{O} = \bar{I} - \frac{\Delta S}{\Delta t} \quad (28)$$

where,

\bar{O} = average outflow during the time interval Δt ,
 \bar{I} = average inflow during the time interval Δt , and
 ΔS = the change in storage during the time interval Δt .

Equation 28 can be rearranged to

$$\left(\frac{2S_2}{\Delta t} + O_2 \right) = (I_2 + I_1) + \left(\frac{2S_1}{\Delta t} - O_1 \right) \quad (29)$$

At the beginning of a routing period, all terms on the right-hand side are known. From a user-specified table of storage versus outflow, a table of outflow versus $\left(\frac{2S}{\Delta t} + O \right)$ is determined by the model. Entering this table with the value of $\left(\frac{2S_2}{\Delta t} + O_2 \right)$ computed using equation 29, outflow (O_2) at the end of the routing period (Δt) can be determined.

An assumption of the above procedure is that the water surface in the reservoir is level and responds instantaneously to inflows and (or) outflows. The reservoirs are also assumed to be detention reservoirs with no storage in the reservoir at the start of a storm unless the storm immediately follows a previous storm. Direct rainfall on the storage surface, evaporation, bank storage, and leakage are not accounted for by the model.

Nodal Segments

Two types of nodal segments are used by the model. The first type is a junction segment. Junction segments are used when more than three segments contribute inflow to the upstream end of a segment. A second type of nodal segment is an input-hydrograph point where the user may specify an input hydrograph for each storm event. Only one input hydrograph point in the basin is permitted. Nodal segments (both types) do not have a routing component; therefore, the output from the segment is equivalent to the input.

Optimization Component

An option is included in the model to calibrate the soil-moisture and infiltration parameters for drainage basins having observed rainfall-runoff data. The method of determining optimum parameter values is based on an optimization technique devised by Rosenbrock (1960). The utility of the procedure, as related to system identification in hydrologic

modeling, was discussed by Dawdy and O'Donnell (1965). The method revises the parameter magnitudes and recomputes the objective function, using the revised set of parameter magnitudes. If the result is an improvement, the revised set is accepted; if not, the method returns to the previous best set of parameters. The objective function is the sum of the squared deviations of the logarithms of computed and measured storm-runoff volumes. Thus, the fitting procedure develops a nonlinear least-squares solution.

Rosenbrock's method of optimization proceeds by stages. During the first stage, each parameter represents one axis in an orthogonal set of search directions until arbitrary end-of-stage criteria are satisfied. At the end of each stage, a new set of orthogonal directions is computed, based on the experience of parameter movement during the preceding stage. The major feature of this procedure is that, after the first stage, one axis is aligned in a direction reflecting the net parameter movement experienced during the previous stage.

To start the fitting process, the model is assigned an initial set of parameter values and upper and lower bounds for each parameter. The objective function is calculated and then stored in the computer memory bank as a reference value. A step of user-specified length is attempted in the first-search direction. If the resulting value of the objective function is less than or equal to the reference value, the trial is registered as a success, and the appropriate step size, e , for each parameter is multiplied by β ($\beta > 1$). If a failure results, the step is not allowed and e is multiplied by $-\beta$, where $0 < \beta < 1$. An attempt is made in the next search direction, and the process continues until the end-of-stage criteria are met. At this point, a new orthogonal search pattern is determined, and another stage of optimization undertaken. The objective function value and associated parameter values are printed for each successful trial. Also, a listing by flood event of the simulated hydrologic response and of observed data are output at the start of each stage.

The observed values of runoff volume may be either user specified or computed by the model using unit-discharge data. If unit-discharge data are supplied to the model, surface runoff is calculated by a simple hydrograph-separation technique which assumes a constant base flow equal to the lowest observed discharge for the storm event. The simulated volume of surface runoff is based on rainfall excess. The user can select all storms or any subset of storms to be included in the calculation of the objective function values.

Impervious area is not included as a parameter to be optimized, but is a parameter to which simulated runoff volumes are very sensitive. Therefore, values of imperviousness should be accurately determined before using the optimization option. If initial estimates of imperviousness are grossly in error, resulting volumes and peaks will be grossly in error. In that case, estimates of imperviousness must be adjusted by the modeler, and optimization achieved by trial and error for the estimates of effective and noneffective impervious areas.

DATA INPUT SPECIFICATIONS

Input for this program must be on punched cards.

All listing of numeric data is right justified. All listing of alphabetic data is left justified. The letter "Oh" is written Ø to contrast with the number zero--written 0.

The format F5.0 means that the floating-point magnitude of the variable contains no significant digits to the right of the decimal point. No decimal point need be punched in the card listing. If a significant digit is required to the right of the decimal point, the point must be punched in card listing. The format F4.2 implies that two significant digits lie to the right of the decimal point.

Experience with the program has indicated that great care must be exercised in preparing the input card deck. A schematic of program deck setup is shown in attachment D.

Input item	Program variable	Format	Card columns
<u>Card Group 1</u> (1 card)			
Option to list data If ØPTION = LIST all input rainfall, runoff and evaporation data are printed.	ØPTION	A4	1-4
If no unit-discharge data are to be read-in either because storm-runoff volumes are supplied for optimization or no optimization is to be performed, set ØPT = 1. Otherwise, leave blank.	ØPT	I1	5
If daily rainfalls are to be modified for irrigation, set NØPT1 = 1. Otherwise, leave blank.	NØPT1	I1	6

Input item	Program variable	Format	Card columns
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Card Group 2 (1 card)

Include Card 2 only if
NØPT1 = 1.

Irrigation rate (inches/
week) for

January	IRR(1)	F5.3	1-5
February	IRR(2)	F5.3	6-10
March	IRR(3)	F5.3	11-15
April	IRR(4)	F5.3	16-20
May	IRR(5)	F5.3	21-25
June	IRR(6)	F5.3	26-30
July	IRR(7)	F5.3	31-35
August	IRR(8)	F5.3	36-40
September	IRR(9)	F5.3	41-45
October	IRR(10)	F5.3	46-50
November	IRR(11)	F5.3	51-55
December	IRR(12)	F5.3	56-60

Card Group 3 (1 card)

Streamflow station number	STAD	I8	1-8
Name of streamflow station	TITLD	50A1	9-58
Drainage area of basin (square miles)	DA	F6.2	59-64

Card Group 4 (1 card)

Daily-rainfall station number	STAP	I8	1-8
Name of daily-rainfall station	TITLP	50A1	9-58

Card Group 5 (1 card)

Daily-evaporation station number	STAE	I8	1-8
Name of daily-evaporation station	TITLE	50A1	9-58

Card Group 6 (1 card)

Beginning year,	BYR	I3	21-23
month, and	BMØ	I3	24-26
day of record	BDY	I3	27-29
Ending year,	EYR	I3	33-35
month, and	EMØ	I3	36-38
day of record	EDY	I3	39-41

Input item	Program variable	Format	Card columns
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Card Group 7 (1 card for each station)

Unit-rainfall station number	STAUP	I8	1-8
Name of unit-rainfall station	TITLUP	50A1	9-58
Time increments for input of unit rainfall and unit discharge, in minutes. (Must be a multiple of 5.)	PTIME	F6.0	59-64

If more than one rain gage is used, a Card 7 must be placed in front of the data for each rain gage.

The following types of cards contain input data of unit rainfall, unit discharge, daily rainfall, and daily evaporation. The cards must be arranged in chronologic sequence for each data type, in the order listed below. If more than one rain gage is used, all data for one rain gage must be read in chronologic order before the data for another rain gage are input. The number of cards depends upon the number of days of record and the number of flood events. In column 80 of each data card, the type of data will be identified by the CODE number as follows:

Type of data	Program variable	CODE
Unit rainfall	UP	1
Unit discharge	UD	2
Daily rainfall	DP	3
Daily evaporation	DE	4

The number of cards required to list a complete day of unit rainfall (UP) or unit discharge (UD) is $120/PTIME$. The card format for listing UP and UD provides 12 fields for these data. Each set of 12 units of data is numbered in chronologic sequence by the variable CN. The arrays UP and UD are initialized to zero. Hence, if all 12 units of data for UP and UD are zero, the card may be omitted from the input card deck, but its card sequence number for this day must be taken into account in listing CN on subsequent cards. However, at least one unit-rainfall card must be included for each rain gage for every unit-rainfall day even if no rain occurred during that day.

Input item	Program variable	Format	Card columns
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Card Group 8

Cards for unit-rainfall data (CODE=1 in column 80)

Station number	STAUP	I8	1-8
Date on which rainfall occurred:			
year	YR	I2	9-10
month	MØ	I2	11-12
day	DY	I2	13-14
Unit-time interval in minutes for			
listing data	CT	I2	15-16
Card sequence number	CN	I2	17-18
Unit rainfall expressed in			
hundredths of an inch			
(12 data items per card)	UP	12F5.0	19-78
Data type	CØDE	I1	80

At the end of data for a rain gage, when data for another rain gage are to be used, insert a card between the sets of rain-gage data with a CØDE of 8 punched in column 80. If no unit-discharge data are to be read-in (ØPT = 1), insert a card at the end of the final rain-gage data with a CØDE of 9 punched in column 80.

Card Group 9

Cards for unit-discharge data (CØDE=2 in column 80)

If ØPT=1, skip to Card Group 10

Station number	STAD	I8	1-8
Date on which discharge occurred:			
year	YR	I2	9-10
month	MØ	I2	11-12
day	DY	I2	13-14
Unit-time interval in minutes for			
listing data	CT	I2	15-16
Card sequence number	CN	I2	17-18
Unit discharge in cubic feet per			
second (12 data items per card)	UD	12F5.0	19-78
Data type	CØDE	I1	80

At the end of the unit-discharge data, insert a card with a CØDE of 9 punched in column 80.

Input item	Program variable	Format	Card columns
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Card Group 10

Cards for daily-rainfall data (CØDE=3 in column 80)

Station number	STAP	I8	1-8
Year and month for data	YR	I2	9-10
	MØ	I2	11-12
Card sequence number (1 or 2)	CN	I1	13
Daily rainfall in inches (up to and including 16 items per card)	DP	16F4.2	14-77
Data type	CØDE	I1	80

Two cards are required for listing a complete month of daily precipitation or daily evaporation. Use as many cards as necessary to list data for all months. The card format for listing these daily data provides 16 fields: the first 16 days of data are listed on the first card, identified by the card sequence number CN=1, and the remaining days of data in the month on the second card CN=2.

For unit-rainfall days insert -100 (right justified) as the daily rainfall for that day on the daily-rainfall card. Any negative value signals that unit rainfall is listed for that day. (Therefore, you may alternatively insert negative the sum of the rainfall if the width of field permits). It may be desirable to skip a large gap in time rather than continue with daily soil-moisture accounting (for example, no winter records). In such cases a 9999 should be punched as the daily rainfall for the first and last day of the gap in record. No daily-rainfall cards are required for intervening days. SMS and BMS are set equal to zero at the start of simulation and immediately following a gap in the daily-precipitation record. Therefore, the model should be run for one to two months on a daily soil-moisture accounting basis prior to the first unit-rainfall day and between the end of a gap in record and the first subsequent unit-rainfall day.

Card Group 11

Cards for daily-evaporation data (CØDE=4 in column 80)

Station number	STAE	I8	1-8
Year and month for data	YR	I2	9-10
	MØ	I2	11-12
Card sequence number (1 or 2)	CN	I1	13
Daily evaporation in inches (up to and including 16 items per card)	DE	16F4.2	14-77
Data type	CØDE	I1	80

At the end of the daily-evaporation data, insert a card with a CØDE of 9 punched in column 80.

Input item	Program variable	Format	Card columns
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Card Group 12

Card specifying details for optimization round

Number of parameters in the soil-moisture accounting and infiltration components	EØ	I4	1-4
Number of parameters to be adjusted	FØ	I4	5-8
Number of trial adjustments per parameter	K	I4	9-12
Initial step size for parameter adjustment	EPSLN	F8.0	13-20

EØ should be 7 if the basin is to be treated uniformly or 14 if the basin is to be divided into parts with differing infiltration and soil-moisture parameters. If two different soil types are used, each sub-basin is assigned one or the other soil type by Card Group 16. If two soil types are used, up to 14 parameters can be optimized; however, this is not a recommended procedure. A basin with two very different soil types should most probably not be used to calibrate the model.

The initial magnitude and the magnitudes for the upper and lower limits for all parameters must be furnished. Suggested magnitudes are given in table 3. These magnitudes are grouped in the following order for each parameter: initial, lower limit, upper limit. The groups are listed for each parameter according to the order shown in table 3. EVC may be estimated as 0.7 if it is an adjustment of pan evaporation to potential evapotranspiration. EVC may differ from 0.7 by a considerable amount if the pan-evaporation data are collected at a site outside the basin. In that case EVC may include an adjustment to make the pan evaporation representative for the basin. RR is an estimate of the proportion of daily rainfall which infiltrates into pervious surfaces for the period of simulation excluding unit-rainfall days.

Input items	Program variable	Format	Card columns
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Card Group 13

Cards furnishing initial magnitude, upper and lower limits of parameters

Initial magnitude	X(I)	F10.0	1-10
Lower limit	G(I)	F10.0	11-20
Upper limit	H(I)	F10.0	21-30

There should be one card for each parameter. Upper and lower limits of parameters should be specified, even if no optimization is performed.

Table 3.--List of soil-moisture and infiltration parameters in order of input

Parameter	X-array identifier	Initial	Lower limit	Upper limit	Unit
PSP	X (1)	5.0	1.0	15.0	inches
KSAT	X (2)	0.10	0.01	1.0	inches per hour
RGF	X (3)	10.0	5.0	20.0	dimensionless
BMSN	X (4)	5.0	1.0	15.0	inches
EVC	X (5)	.7	.5	1.0	dimensionless
RR	X (6)	.9	.65	1.0	dimensionless
DRN/(24.0*X[2])	X (7)	.5	.1	1.0	dimensionless

If EØ equals 14, the second set of parameters is as above, but numbered X(8) to X(14).

Input item	Program variable	Format	Card columns
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Card Group 14

Parameter-adjustment card

Subscripts for parameters to be optimized (should be FØ in number, can be in any order). If no optimization is performed, insert a blank card.	ØPTNØ	14I2	1-2 3-4 etc.
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DETAILED MODEL DESCRIPTION

The model description cards supply the program with information about the physical features of the catchment and the spatial and temporal properties of one or more storms which are to be simulated on the catchment.

The total input data set is divided into several parts. The following is an explanation of the data in each part.

Card Group 15

Model-Control Card

Number of different segments used to describe basin (1 to 50)	NSEG	I5	1-5
Time interval, in minutes, used in finite-difference calculations (Δt) (Maximum of 5 minutes)	DT	F5.0	6-10
Sampling interval, in minutes, for detailed output. The value is not constrained in anyway by the value of DT	ØSI	F5.0	11-15
Number of rain gages (1 to 3)	NRG	I5	16-20
Maximum impervious retention (inches)	IMP	F5.0	21-25

Card Group 16

Segment Characteristics

There is one card for each segment, and cards may be arranged in any sequence.

Input item	Program variable	Format	Card columns
Alphanumeric identification for segment (Required for all segments; any alphanumeric identification can be used.)	ISEG(I)	A4	1-4
Alphanumeric identification for up to 3 segments which contribute inflow to the upstream end of this segment (leave blank where upstream segments are not present.)	IUP(I,J) J = 1, 3	3A4	5-8 9-12 13-16
Alphanumeric identification for up to 4 segments which contribute uniform lateral inflow into this segment (leave blank where lateral inflow segments are not present.)	ILAT(I,J) J = 1,4	4A4	17-20 21-24 25-28 29-32
Type of segment	ITYPE(I)	I2	33-34
1 = a rectangular open channel			
2 = a pipe			
3 = a triangular cross section			
4 = to specify explicitly the kinematic channel parameters α and m			
5 or 15 = overland-flow segment (turbulent)			
6 or 16 = overland-flow segment (laminar)			

Only one roughness parameter can be specified for an overland-flow segment. For sub-basins with short distances of pervious runoff from lawns to streets, use of one roughness parameter may be the best approach and ITYPE(I) should be specified as 5 or 6. For sub-basins of mixed pervious and impervious surfaces and comparable distances of flow for reach, two sub-basins can be specified, a pervious and an impervious sub-basin, by the use of ITYPE(I) of 15 or 16, depending upon whether the sections are turbulent or laminar overland flow. In such a case, the ITYPE(I) = 15 (or 16) must immediately follow the ITYPE(I) = 5 (or 6) segment of identical description except for roughness. Any channel which receives lateral inflow from one of the pair must receive lateral inflow from the other. The ITYPE(I) = 5 (or 6) segment must contain the pervious roughness; the ITYPE(I) = 15 (or 16) segment, the impervious roughness.

- 7 = a junction
- 8 = a detention reservoir (modified-Puls routing)
- 9 = a detention reservoir (linear-storage routing)
- 10 = an input-hydrograph point (only 1 input-hydrograph point is accepted by the model)

Input item	Program variable	Format	Card columns
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Outflow print-out indicator	IPR(I)	I2	35-36
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1 = if the outflow hydrograph for this segment is to be printed out.

0 = if the outflow hydrograph for this segment is not to be printed out.

For segment types 1-6, 15, 16:
 number of intervals into which
 total length of this segment is
 to be divided for finite-dif-
 ference calculations.
 (Maximum of 10).

NDX(I)	I2	37-38
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For segment type 8:
 number of points in the
 storage-outflow relationship.
 (Maximum of 30).

For segment types 7, 9, 10:
 leave blank

Length of segment (feet)	FLGTH(I)	F5.0	39-43
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For overland-flow segments the length can be computed as area, in square feet, of the overland-flow segment divided by the length, in feet, of the channel segment into which it contributes lateral inflow. The model computes a basin drainage area based on the length of channels and their adjacent overland-flow segment lengths. If this computed drainage area differs by more than 1 percent from the drainage area input from Card Group 3, a comparison of computed versus input basin drainage area is included in the output. The model uses the computed drainage area for all computations.

Slope of segment (feet/feet)	SLØPE(I)	F5.0	44-48
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Roughness parameter for segment	FRN(I)	F5.0	49-53
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For segments of type 1, 2, 3,
 4, 5, or 15, this is a parameter
 similar to Manning n . For
segments of type 6 or 16, this
is an empirical coefficient for
laminar overland flow. Leave
 blank for segments of type 7
 to 10.

Input item	Program variable	Format	Card columns
A pair of parameters which depend on type of segment	PARAM(I,J) J = 1,2	2F5.0	54-58 59-63

<u>Segment Type</u>	<u>Special Parameters</u>
1	PARAM(I,1) = width (feet) PARAM(I,2) = height (feet)
2	PARAM(I,1) = diameter (feet) PARAM(I,2) = leave blank
3	PARAM(I,1) = width of cross section (feet) at 1-foot depth PARAM(I,2) = leave blank
4	PARAM(I,1) = α PARAM(I,2) = m
5 or 15	PARAM(I,1) = perviousness PARAM(I,2) = effective imperviousness. For example, for a segment of type 5 consisting of 25 percent pervious land cover, 60 percent effective impervious land cover, and 15 percent noneffective impervious land cover, set PARAM(I,1) = .25 and PARAM(I,2) = .60.
6 or 16	PARAM(I,1) = perviousness (same as type 5) PARAM(I,2) = effective imperviousness (same as type 5)
7	PARAM(I,1) = leave blank PARAM(I,2) = leave blank
8	PARAM(I,1) = leave blank PARAM(I,2) = leave blank
9	PARAM(I,1) = constant K in $S=KO$ relationship (hours) PARAM(I,2) = leave blank
10	PARAM(I,1) = leave blank PARAM(I,2) = leave blank

Input item	Program variable	Format	Card columns
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Designation of parameter set for overland-flow segments.	KPSET(I)	I2	64-65
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For segment types 5, 6, 15, or 16: If EØ = 7, enter 1. If EØ = 14, KPSET(I) equals 1 if X(1) to X(7) apply, KPSET(I) equals 2 if X(8) to X(14) apply. Otherwise, leave blank.

"Thiessen coefficients" for overland-flow segments in same order as station data input by Card Groups 7 and 8.	RCØFF(I,J) J = 1, NRG	3F5.0	66-70 71-75 76-80
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The "Thiessen coefficients" are not truly such, because they need not sum to 1.0 for a sub-basin. Rather they are adjustment coefficients for weighting the rainfall at each rain gage. Thus, if only one rain gage is available, its adjusted rainfall over the basin may be distributed by the "Thiessen coefficients," all of which may be less than 1.0 if the rain gage is on a ridge at a higher elevation with a higher rainfall than the basin or all less than 1.0 if the rain gage is at the lower end or below the basin. If more than one rain gage is available, each may be adjusted and then weighted by means of the "Thiessen coefficients."

Card Group 17

Cards specifying outflow-storage relationship for segments of type 8

If there are no segments of type 8, skip to storm-sequencing card. Otherwise for each modified-Puls detention reservoir, in the order in which the detention reservoirs are read in Card Group 16, input the outflow-storage relationship. There should be NDX (I) cards for each detention reservoir (I).

Outflow (in cubic feet per second)	Ø2 (I,II)	F10.0	1-10
Storage (in cubic feet per second-hours)	S2 (I,II) II = 1, NDX (I)	F10.0	11-20

Card Group 18

Storm-sequencing card

Number of storms	I	I2	1-2
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Input item	Program variable	Format	Card columns
Number of storms in the sequence of days containing a given storm (up to 6) For example, if the first sequence of consecutive storm days contains 1 storm, NF(1) = 1; if the first sequence contains 3 storms, NF(1) = NF(2) = NF(3) = 3.	NF(K) K=1, I	39I2	3-4, 5-6, etc.

Card Group 19

Storm-separation cards

Starting time increment for storm	KS	I4	1-4
Ending time increment for storm	KE	I4	5-8
If the computed and/or measured outflow from the drainage basin is to be plotted for this storm, set IPL = 1. Otherwise, leave blank.	IPL	I1	9
If volumes are supplied, set VØLI equal to runoff volume (inches). Otherwise, leave blank.	VØLI	F6.2	10-15

There should be one storm-separation card for each of the I storms shown on the storm-sequencing card. Starting and ending time increments are specified as the number of the unit-time interval in the sequence of days containing the storm. For example, if the unit-time interval is 15 minutes and the starting time of the storm is 0700 on the first day of a sequence of days, KS should be specified as 28. Likewise, if the starting time was 0700 on the second day of a sequence of days, KS should be specified as 124. If unit-discharge data are input to the model, the starting and ending time increments for each storm must envelope the entire runoff period in order that the correct storm-runoff volumes are calculated. The model stops routing at the ending time increment for each storm.

Input item	Program variable	Format	Card columns
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Card Group 20

Routing Card

1 = routing performed for storm	KOUT(I)	40I2	1-2
0 = no routing for storm	I = 1,NØFE		3-4 etc.

Card Group 21

Optimization card

1 = storm used in computation of objective function	TESTNØ(I)	40I2	1-2
0 = storm not used in computation of objective function	I = 1,NØFE		3-4 etc.

Card Group 22

Input-hydrograph-indicator card

1 = storm has input hydrograph	IHYD(I)	40I2	1-2
0 = storm has no input hydrograph	I = 1,NØFE		3-4 etc.

Card Group 23

Cards specifying input hydrograph

No cards are necessary if there are no input-hydrograph segments (ITYPE(I) = 10 on card group 16). Otherwise the input hydrographs for each storm should be read in the order in which the storms occur. An inflow of 0 cubic feet per second is assumed if no values for a time period are read.

1 = last input hydrograph card for storm	ICØDE	I2	1-2
0 = not last input hydrograph card for storm			

Input item	Program variable	Format	Card columns
Starting time increment for values of inflow read (Same convention as storm-separation cards)	JJJ	I3	3-5
Inflow (in cubic feet per second) (10 values per card)	X2(I) I = 1,10	10F5.3	6-55

COMPUTER REQUIREMENTS

The computer program has been written in FORTRAN IV programming language and was developed and tested on CDC 7600 equipment. The plotting routine included in the program listing of attachment C is IBM-system^{3/} dependent. Instructions are included in the program listing to eliminate the plotting routine (see lines A24 and A921 in attachment C). With the exception of the plotting routine, the program can be run on any Fortran-based computer.

The program, as dimensioned, will handle up to 50 different segments. A single simulation will analyze a period of record spanning as many as 1,000 days. The maximum number of unit-rainfall days is equal to 5 times the unit-time increment in minutes. All of these limits can be changed easily by redimensioning the program. The program, as dimensioned, requires 302 K bytes of storage on IBM 360 equipment. It takes about 15 to 17 seconds of CPU time for compilation. The first and second runs in attachment E executed in 6 seconds and 12 seconds, respectively.

PROGRAM OUTPUT

Examples of the output listing are given in attachment E. The general output format consists of:

- (1) Station numbers and names, drainage area, unit-time interval, period of record, and, if NØPT1 = 1, daily irrigation rates.
- (2) All input rainfall, runoff, and evaporation data. (If ØPTIØN = LIST).
- (3) List of initial soil-moisture-parameter values and infiltration-parameter values, with identification of those parameters that are to be optimized.
- (4) Initial step-size increments for each parameter to be optimized, maximum number of trials used in the optimization, and initial step size for parameter adjustment. (If optimization option is used.)

^{3/} The use of brand names in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

- (5) Number of segments, time interval used in finite-difference calculations, output sampling interval, number of rain gages, number of soil types and maximum impervious retention.
- (6) List of segments and their characteristics
- (7) Segment computation sequence and segment α 's and m 's for kinematic-wave routing.
- (8) Number of storms, number of storms in the sequence of days containing a given storm, starting and ending time increment for each storm, identification of storms for which routing is performed and identification of storms which have an input hydrograph.
- (9) List of flood events used in the objective function (If optimization is performed.)
- (10) Progress report on optimization (if performed)
 - a. Value of objective function for initial parameter values and a listing of the parameter values.
 - b. For each storm event a listing of measured surface-runoff volume and simulated surface-runoff volume, measured rainfall at each rain gage, and contribution to objective function for each storm event.
 - c. Objective function and soil-moisture and infiltration parameter values at each step in the optimization technique that results in a decrease in the objective function.
 - d. A repetition of (a) to (c) each time a new orthogonal search pattern in optimization is initiated.
- (11) Outflow hydrographs for user-selected segments for routed storm events. Also, the maximum storage required of each detention reservoir for each routed storm event is listed.
- (12) Line-printer plot of computed and (or) measured outflow from drainage basin for user-selected storm events.
- (13) Value of objective function and soil-moisture and infiltration parameter values for last successful trial.
- (14) For each storm event a listing of measured and simulated peak discharge, measured and simulated surface-runoff volume, measured rainfall at each rain gage, and contribution to objective function.

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ATTACHMENTS

A. GENERALIZED PROGRAM FLOW CHART

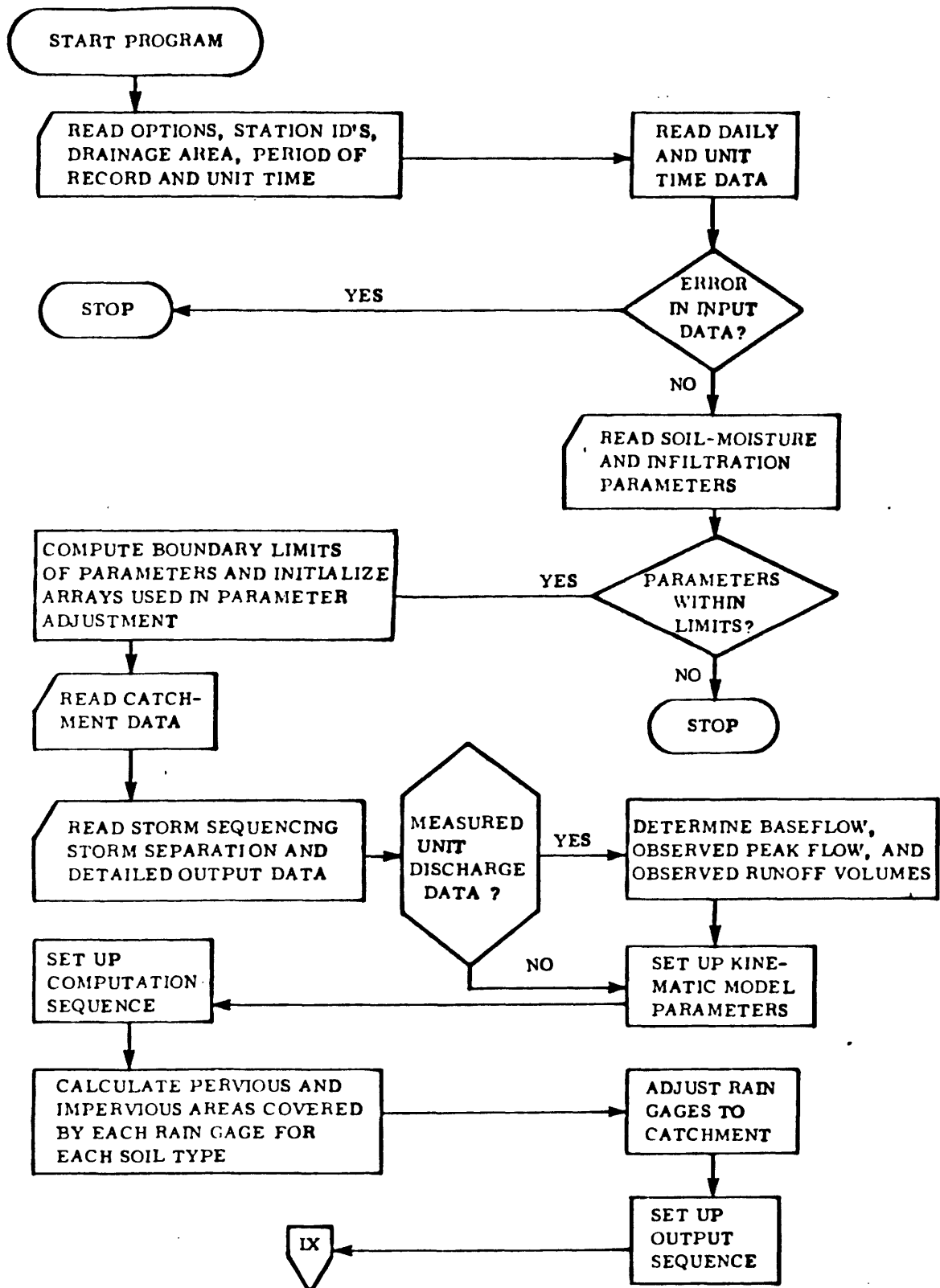


Figure 7.--Flow chart of initial program setup.

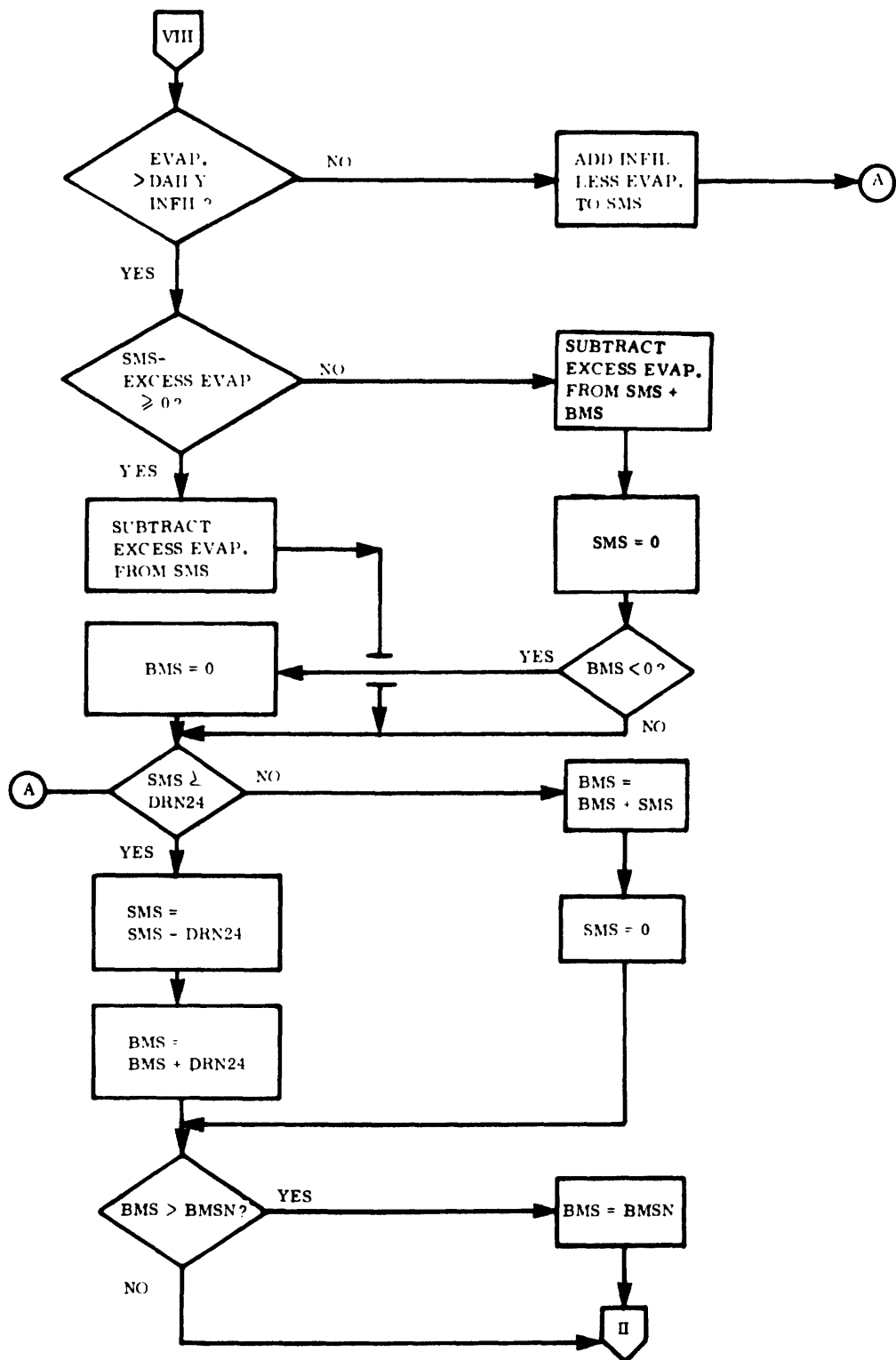


Figure 9.--Flow chart of daily water balance.

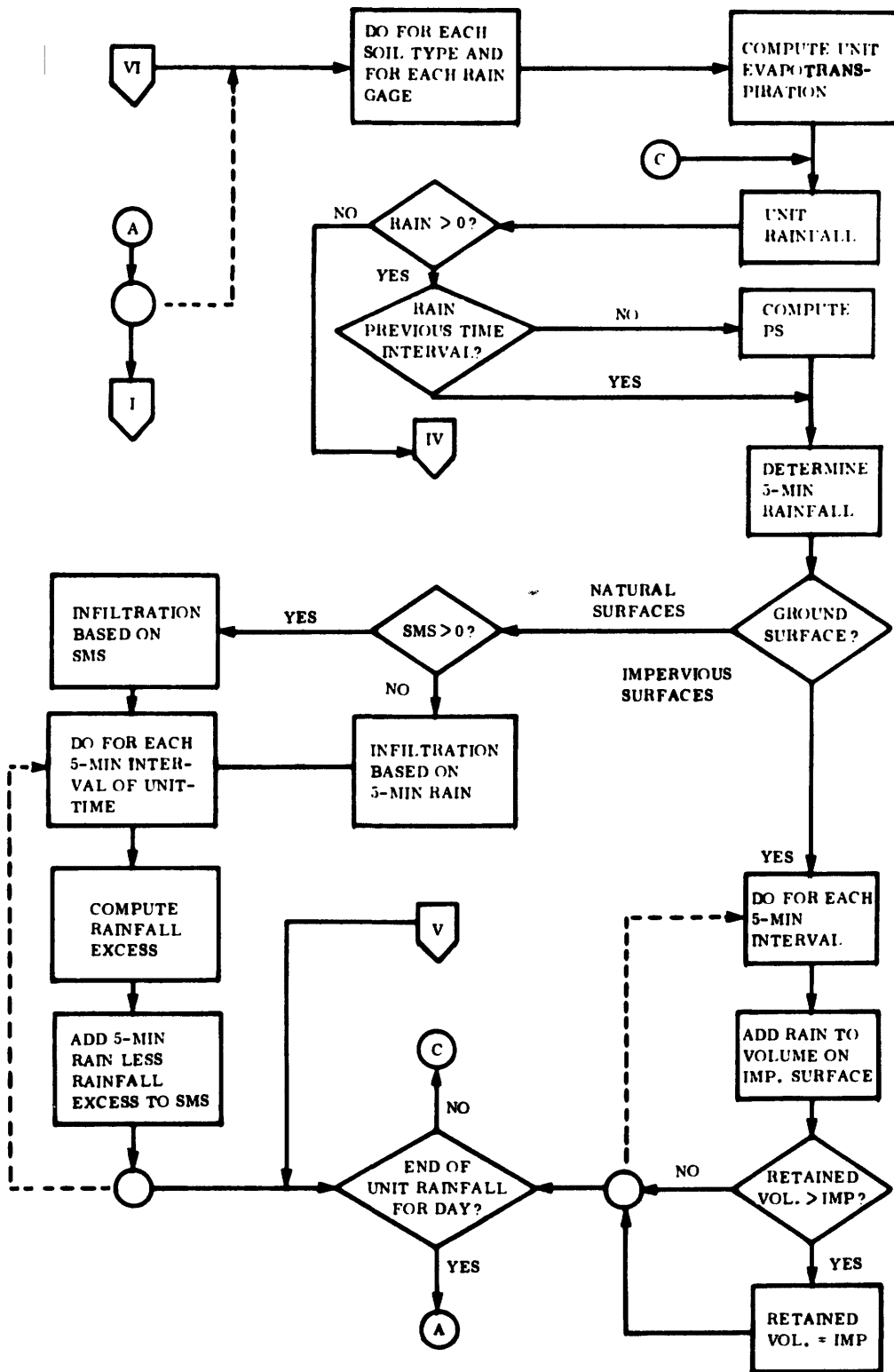


Figure 10.--Flow chart of rainfall excess.

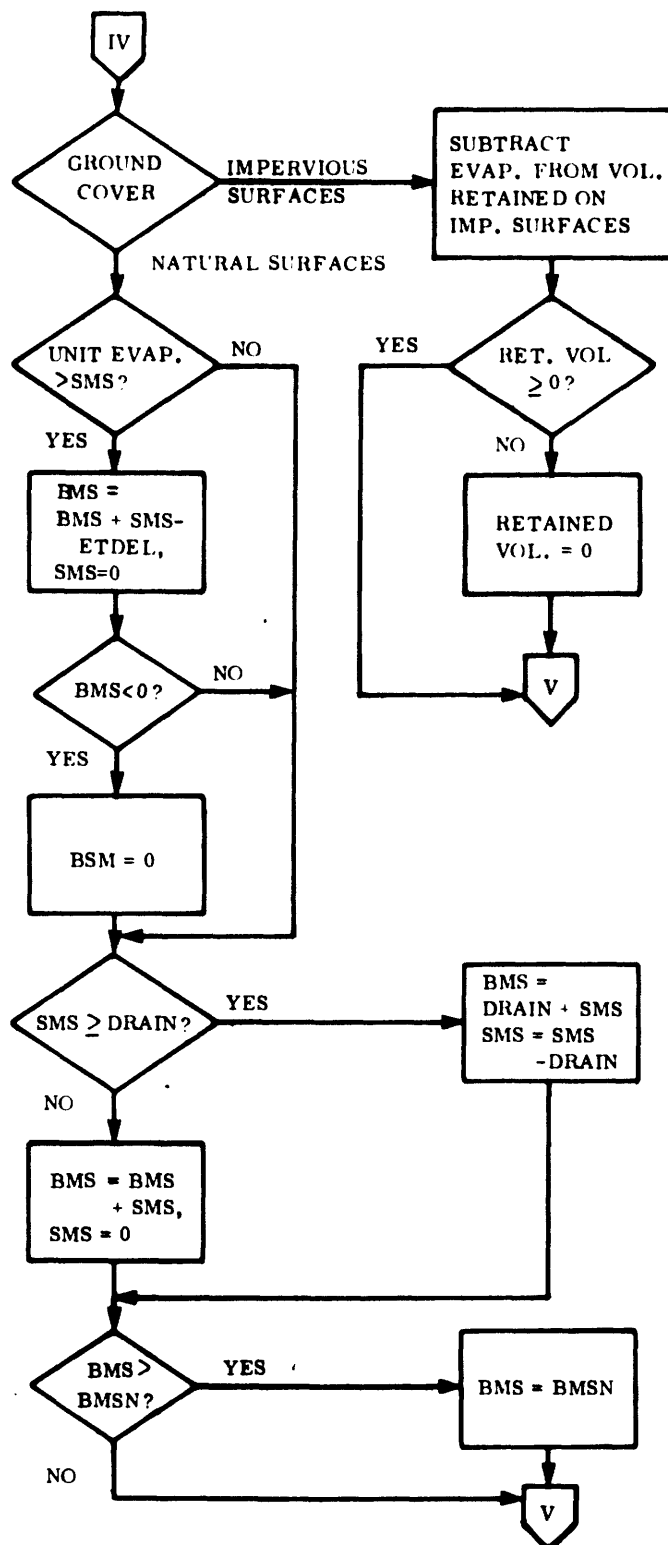


Figure 11.--Flow chart of unit-time water balance during periods of no rainfall.

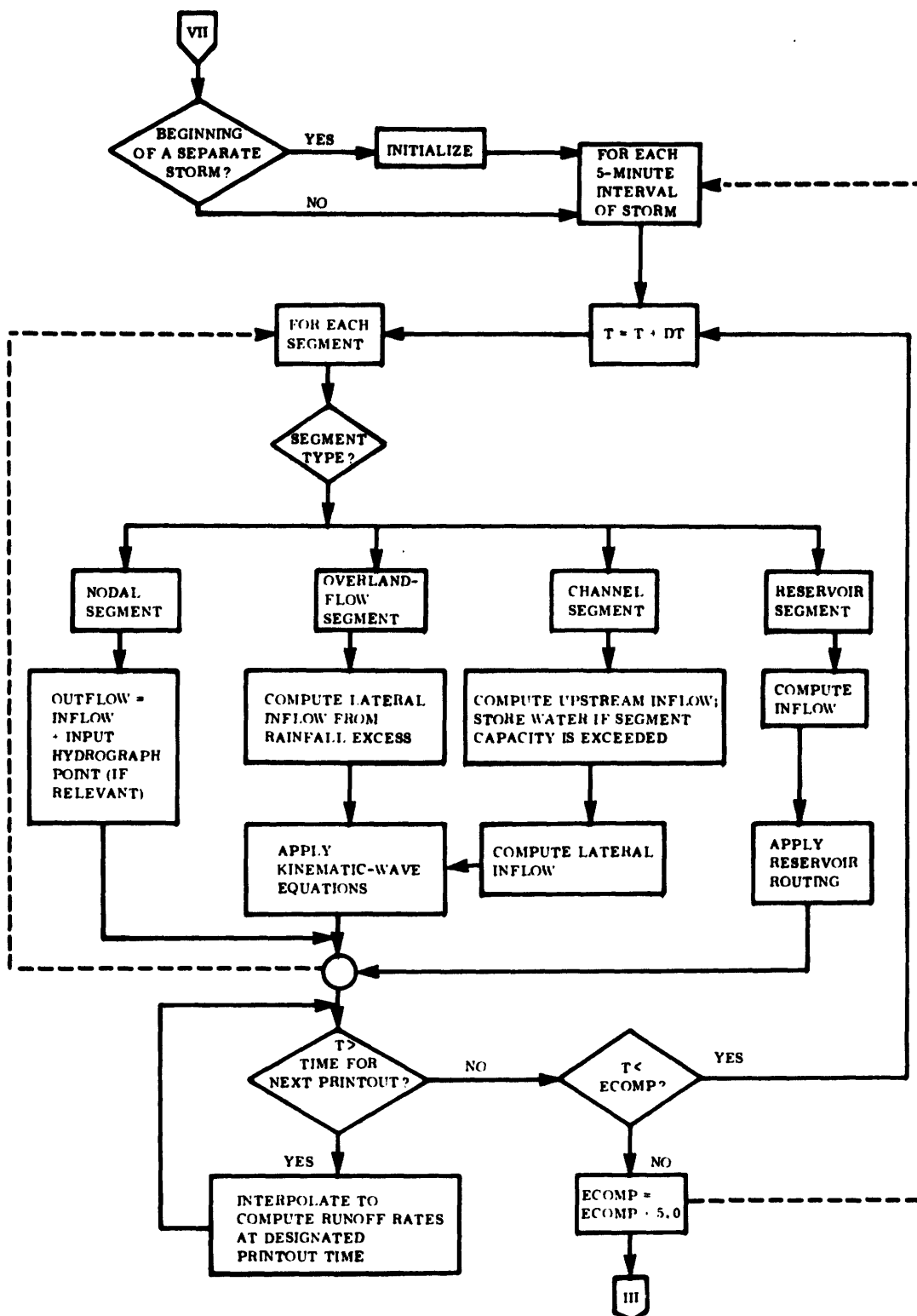


Figure 12.--Flow chart of routing routine.

B. LIST OF SELECTED VARIABLES

(A) Alphanumeric, (I) Integer, (R) Real

A -- Array containing step lengths and orthonormal search vectors used in optimization. First FO elements are step lengths to be applied to various vectors. The next FO x FO elements are used to define search pattern. (R)

ALAT -- Discharge per unit width (q) from lateral segment multiplied by Δt . (R)

ALP -- α . (R)

ALPHA -- Array of α 's for segments. (R)

AP -- Excess precipitation per minute on impervious area of a segment. (R)

AMAX -- Array of maximum cross-sectional areas of flow from segments. (R)

AVIN -- Average inflow to a detention reservoir. (R)

BD -- Dummy variable used in orthonormalization. (R)

BDY -- Beginning day of daily rainfall and daily-evaporation data. (I)

BMØ -- Beginning month of daily rainfall and daily-evaporation data. (I)

BMS -- Base soil-moisture storage. (R)

BMSB -- Array of BMS's for rain gages and soil types. (R)

BTIME -- Unit-time interval, in minutes. (I)

BYR -- Beginning year of daily rainfall and daily-evaporation data (last two digits). (I)

B1,B2 -- Dummy variables used in orthonormalization (reflect efficiency of optimization procedures). (R)

B3 -- Indicator of continuing parameter adjustment (0--continuing, 1--terminated). (I)

CHG -- Indicator of whether rain occurred in preceeding time interval or not (0--Yes, 1--No). A 1 requires re-evaluation of PS. (I)

CN -- Card sequence number for various data types. (I)

CØDE -- Identifier of data type. (I)

CØEF -- Factor used in computation of infiltration rate, equivalent to $(RGF-1.0)/BMSN$. (R)

CØEF2 -- Same as CØEF, but for soil type 2. (R)
 CT -- Recording interval of unit data, in minutes. (I)
 D -- Array containing cumulative step length taken in direction of
 each search vector during a stage of optimization. (R)
 DA -- Drainage area of basin, in square miles. (R)
 DAT -- Computed drainage area of basin, in square miles. (R)
 DATE -- Julian date relative to January 1, 1901. (I)
 DATERF -- Julian date for beginning of record. (I)
 DATERL -- Julian date for end of record. (I)
 DCCN -- Dummy variable used to check unit-discharge data. (I)
 DE -- Array containing daily evaporation. (R)
 DED -- Julian date for observation of daily evaporation. (I)
 DELTAT -- Time interval, in fraction of an hour, for reservoir routing. (R)
 DEL5 -- Number of 5-minute intervals in unit-time interval. (I)
 DEL5P -- DEL5 + 1. (I)
 DIMP -- A two-dimensional array of drainage areas. (R)
 DIMP(NRGI,1) is total effective impervious area covered by
 rain gage NRGI
 DIMP(NRGI,2) is total effective impervious area covered by
 rain gage NRGI on subbasins of soil type 2
 DIMP(NRGI+3,1) is pervious area covered by rain gage NRGI on
 subbasins of soil type 1.
 DIMP(NRGI+3,2) is pervious area covered by rain gage NRGI on
 subbasins of soil type 2.
 DIMP(NRGI+6,1) is noneffective impervious area covered by
 rain gage NRGI on subbasins of soil type 1.
 DIMP(NRGI+6,2) is noneffective impervious area covered by
 rain gage NRGI on subbasins of soil type 2.
 DP -- Array containing daily precipitation. (R)
 DPD -- Julian date for daily precipitation. (I)
 DRAIN -- Volume of water drained from saturated zone of soil type 1
 in unit time. (R)

DRAIN2 -- Volume of water drained from saturated zone of soil type 2 in unit time. (R)

DRN24 -- Volume of water drained from saturated zone in 24 hours for soil type 1. (R)

DRN242 -- Volume of water drained from saturated zone in 24 hours for soil type 2. (R)

DT -- (a) Time interval (Δt) used in finite-difference calculations, in minutes. (R)
 (b) Three-dimensional array of interim drainage areas used in the calculation of DIMP's and drainage area basin. (R)

DTEMP -- Drainage area of overland-flow segment to channel, used in calculation of DT's. (R)

DTEMP1 -- Drainage area used in adjustment of rain gage to basin. (R)

DTS -- Time interval (Δt) used in finite-difference calculations, in seconds. (R)

DX -- Array of length intervals (Δx), in feet, used in finite-difference calculations. (R)

DY -- Day of observed record. (I)

E -- Array containing switches (0,1) used in optimization to test for end of stage criterion (1--all switches). (I)

ECØMP -- Parameter to indicate end of 5-minute routing interval for a particular 5-minute precipitation interval in a detailed storm. (R)

EDY -- Ending day of daily rainfall and evaporation data. (I)

EM -- Array of m 's for segments. (R)

EMØ -- Ending month of daily rainfall and evaporation data. (I)

EØ -- Number of infiltration parameters. (I)

EP -- Excess precipitation per minute on pervious area. (R)

EPSLN -- Step size for parameter adjustment at beginning of each stage in optimization. (R)

ETDEL -- Potential unit-time evapotranspiration. (R)

ETW	-- Potential daily evapotranspiration for soil type 1. (R)
ETW2	-- Potential daily evapotranspiration for soil type 2. (R)
EVC	-- Pan coefficient for soil type 1. (R)
EVC2	-- Pan coefficient for soil type 2. (R)
EYR	-- Ending year of daily rainfall and evaporation data (last two digits). (I)
FILE	-- File number used to print plots on. (I)
FLAG	-- Indicator of change from daily rainfall to unit-rainfall day (0--Yes, 1--No). (I)
FLGTH	-- Array of segment flow lengths. (R)
FMTA,FMTB	-- Formatting variables for outputting which flood events are used in the objective function. (A)
FMTF,FMTPL	-- Formatting variables for outputting initial infiltration parameter values and which of these parameters are to be optimized. (A)
FØ	-- Number of parameters to be adjusted in current round. (I)
FPK	-- Array of observed peaks for flood events. (R)
FR	-- Infiltration rate, in inches per 5-minutes. (R)
FRN	-- Array of friction coefficients for segments. (R)
FVØL	-- Array of measured flood volumes for flood events, in inches. (R)
G	-- Array containing lower limits of infiltration parameters. (R)
GD,GØE	-- Dummy variables used in determining bounds of solution space for optimization. (R)
H	-- Array containing upper limits of parameters. (R)
HD	-- Dummy variable used in determining bounds of solution space for optimization. (R)
ICØDE	-- Indicator for termination of input-hydrograph data for a flood event (1--termination, 0--continuing). (I)
IFØPL	-- Do-loop counter for identifying infiltration parameters not to be adjusted in optimization. (I)

IHYD	-- Array containing indicator of whether or not flood event has an input hydrograph (1--Yes, 0--No). (I)
IJK	-- Five-minute interval within sequence of days at which a storm ends. (I)
IJKS	-- Five-minute interval within sequence of days at which a storm starts. (I)
ILAT	-- Array of lateral inflow segments into indexed downstream segment. (A)
IMP	-- Maximum impervious retention depth, in inches. (R)
IMPRET	-- Array of 5-minute incremental depths added to impervious retention, in inches. (R)
IMPSTØ	-- Array of impervious retention storage for rain gages during previous time interval, in inches. (R)
IMPSTT	-- Impervious retention storage for a given rain gage during current time interval. (R)
INC	-- Difference between daily infiltrated rainfall and daily evapotranspiration for soil type 1. (R)
INC2	-- Difference between daily infiltrated rainfall and daily evapotranspiration for soil type 2. (R)
INDP	-- Array of starting and ending days of gap in daily record. (I)
IN1	-- Array of inflows to detention reservoir segments at beginning of given time interval. (R)
IN2	-- Array of inflows to detention reservoir segments at end of given time interval. (R)
IØUT	-- Array used with ØPTION to determine whether daily and unit data are to be listed. (A)
IPAR	-- Dummy variable used to identify soil type for excess precipitation calculation on a segment. (I)
IPL	-- Array containing indicator of whether or not outflow from the drainage basin is to be plotted for a flood event. (1--Yes, 0--No). (I)
IPR	-- Array of indicators of outflow hydrograph printing for segments (1--print outflow hydrograph, 0--do not print outflow hydrograph). (I)

IPRNT	-- Counter for printing hydrograph. (I)
IRR	-- Array of monthly irrigation rates, in inches per week. (R)
ISEG	-- Alphanumeric identifier for segment. (A)
ITEST	-- Array of indicators of whether or not segment has been sequenced (1--Yes, 0--No). (I)
ITRAN	-- Dummy variable used in renumbering lateral and upstream inflow segments. (I)
ITYPE	-- Array of segment types. (I)
IUP	-- Array of upstream inflow segments into indexed downstream segment. (A)
IW	-- Counter for days during simulation. (I)
I2CFSP	-- Conversion factor for converting runoff in inches per unit time per unit area to discharge in cubic feet per second. (R)
JLAT	-- Array of lateral inflow segments which have been renumbered from ILAT to correspond to ISEG identifications. (I)
JØUT	-- Array of segments with output hydrographs. (I)
JUP	-- Array of upstream inflow segments which have been renumbered from IUP to correspond to ISEG identifications. (I)
KDAY	-- Five-minute precipitation interval in a detailed storm. (I)
KDY	-- Five-minute precipitation interval in a detailed storm. (I)
KE	-- Ending unit-time interval for storm. (I)
KI	-- Counter for channel segments. (I)
KINIT	-- Indicator for calling subroutine INIT to initialize catchment (1--Yes, 0--No). (I)
KIT	-- Dummy variable used in printing time of peak flow during a flood event. (I)
KNN	-- Number of flood events used in optimization. (I)
KØUT	-- Indicator of whether or not detailed output is printed for a storm (1--Yes, 0--No). (I)
KPSET	-- Array of soil types for segments (1--soil type 1, 2--soil type 2). (I)

KR -- Indicator of whether or not excess precipitation occurred during a 5-minute time interval (1--Yes, 0--No). (I)
 KS -- (a) Starting unit-time interval for storm,
 (b) Array of segments which are not overland-flow segments. (I)
 KSAT -- Effective hydraulic conductivity of saturated soil type 1. (R)
 KSAT2 -- Effective hydraulic conductivity of saturated soil type 2. (R)
 KSEG -- Array of segments ordered in downstream order. (I)
 KTEMP -- Day of unit-time simulation. (I)
 K1 -- Array of beginning times of detailed storms. (I)
 K2 -- Array of ending times of detailed storms. (I)
 K4DAY -- Number of unit-time increments in a flood event. (I)
 LABEL -- Array containing the string of characters to be printed at left edge of all plots. (A)
 LEAP -- Indicator of leap year (1--Yes, 0--No). (I)
 MAXL -- Maximum lines per page of printed output (55). (I)
 MN -- Array containing cumulative numbers of days (in nonleap year) to end of preceding month. (I)
 MØ -- Month of observed record. (I)
 N -- (a) Dummy variable used for boundary in finite-difference calculations,
 (b) Indicator of whether segment has an upstream segment which has not been sequenced in downstream order yet (1--Yes, 0--No). (I)
 NDATE -- Array of storm dates. (I)
 NDELS -- Number of unit-time intervals in a day. (I)
 NDX -- (a) Number of intervals (Δx) for finite-difference routing. (I)
 (b) Number of points in storage-outflow relationship for a modified-Puls detention reservoir.
 NF -- Array of number of storms in the sequence of days containing a given storm. (I)
 NFD -- Number of storm sequence. (I)

NFD1 -- Number of days of routing thus far in given storm sequence. (I)
 NFE -- Array of ending 5-minute intervals for storms. (I)
 NF11 -- Number of storms remaining to be analyzed for observed volume
 and peak in given storm sequence. (I)
 NFS -- Array of starting 5-minute intervals for storms. (I)
 NHL -- Number of horizontal grid lines in the graph. (I)
 NIT -- Number of iterations during segment sequencing. (I)
 NK -- Total number of iterations in an optimization round. (I)
 NL -- Number of lines of output on a given page. (I)
 NN -- Subscript for objective function used. (I)
 NØ -- Sequence counter to identify current search vector. (I)
 NØFE -- Number of flood events. (I)
 NØPT1 -- Indicator of whether or not daily rainfalls are to be modified
 for irrigation (1--Yes, 0--No). (I)
 NØUD -- Array containing sequence date for I-th day of unit discharge,
 I = 1,...,NUDD. (I)
 NØUP -- Array containing sequence date of I-th day of unit precipi-
 tation, I = 1,...,NUPD. (I)
 NØUT -- Number of segments with outflow hydrograph to be printed. (I)
 NØ8 -- Number of modified-Puls detention reservoir segments. (I)
 NØ9 -- Ten + the number of linear-storage detention reservoir
 segments. (I)

 NPAGE -- Page number used by subroutine PAGE to number output pages. (I)
 NPAR -- Number of soil types. (I)
 NRG -- Number of rain gages. (R)
 NRG1 -- Rain gage I. (I)
 NRG1 -- NRG + 1. (I)
 NSBH -- Number of spaces between horizontal grid lines. (I)

NSBV	--	Number of spaces between vertical grid lines. (I)
NSCALE	--	Variable used to define the format of the ordinate and abscissa label scaling factor. (I)
NSEG	--	Number of segments. (I)
NUDD	--	Number of days of unit discharge. (I)
NUPD	--	Number of days of unit rainfall. (I)
ØF	--	Dummy variable containing minimum of error function determined prior to current iteration in optimization. (R)
ØPT	--	Option to read in storm volume. (A)
ØPTIØN	--	Option to list data (ØPTIØN = LIST--all input data are printed. (A)
ØPTNØ	--	Array containing subscripts to identify parameters to be adjusted in round of optimization. (I)
ØSI	--	Output sampling interval. (R)
Ø1	--	Indicator of whether current flow is first flow of storm. (0--Yes, 1--No). (I)
Ø2	--	Array of outflows in outflow-storage relationship for modified-Puls detention reservoir segments. (R)
P	--	Array of excess precipitation during 5-minute intervals from each rain gage. (R)
PARAM	--	Pair of parameters for a segment. (R)
PCCN	--	Dummy variable used to check unit-precipitation data. (I)
PDEL	--	Unit-time interval expressed as a fraction of a day. (R)
PDT	--	Dummy variable used in the calculation of storage due to surcharging. (R)
PIMP	--	Array of excess precipitation volumes from pervious surfaces for flood events. (R)
PK	--	Indicator of whether or not overland-flow segment is of a particular soil type. (1--Yes, 0--No). (R)
PØBS	--	Array of observed rainfall volumes for flood events. (R)

PS	-- Product of capillary suction and moisture differential at wetting front. (R)
PSP	-- Minimum effective magnitude of PS for soil type 1 (occurs at field capacity, BMS=BMSN). (R)
PSP2	-- Minimum effective magnitude of PS for soil type 2. (R)
PSUM	-- Array of total excess precipitation for each flood event and rain gage. (R)
PTIME	-- Time increment for unit data, in minutes. (R)
PW	-- Amount of daily precipitation which infiltrates for soil type 1. (R)
PW2	-- Amount of daily precipitation which infiltrates for soil type 2. (R)
Q	-- Array of times for plotting. (R)
QCW	-- Simulated runoff volume in square feet-inches for a flood event. (R)
QFULL	-- Discharge at full-pipe flow. (R)
QIH	-- Array of input-hydrograph discharges. (R)
QIND	-- Current outflow from drainage basin. (R)
QLAT	-- Variable for lateral inflow onto a segment (q) in finite-difference routing. (R)
QMAX	-- Array of maximum possible discharges for segments. (R)
QMX	-- Peak flow during a storm. (R)
QOUT	-- Array of computed output discharges for segments. (R)
QPR	-- (a) In subroutine LAT,-- $q(t)$ in finite-difference routing; (b) In subroutine UP-- $Q(o,t)$ in finite-difference routing. (R)
QR	-- (a) Excess rainfall in 5-minute interval, (b) Baseflow. (R)
QSUM	-- Array of sum of upstream inflows to segments. (R)
QSUML	-- Array of sum of lateral inflows to segments. (R)
QUP	-- $Q(o, t+\Delta t)$ in finite-difference routing. (R)

Q1 -- Outflow from a segment at time t. (R)

Q2 -- Outflow from a segment at time t + Δt . (R)

Q3 -- Variable set to current unit discharge when computing baseflow, measured peak flow, and measured discharge volume. (R)

R -- Array of discharges for plotting. (R)

RAT -- Array of ratios of pervious area + noneffective impervious area to pervious area for each rain gage and soil type. (R)

RATIØ -- Dummy variable used in comparing computed drainage area with furnished drainage area. (R)

RCØEF -- Array of "Theissen coefficients" for segments. (R)

RGF -- Ratio of maximum PS (at wilting point) to minimum PS (at field capacity) for soil type 1. (R)

RGF2 -- Ratio of maximum PS to minimum PS for soil type 2. (R)

RITE -- Indicator of progress in parameter adjustment (0--continuing, 1--end of stage in optimization, print results). (I)

RK -- Sum of "Thiessen coefficients" for all rain gages on a segment. (R)

RØDYS -- Number of days from start to end of record. (I)

RR -- Ratio of daily infiltration to daily rainfall for soil type 1. (R)

RR2 -- Ratio of daily infiltration to daily rainfall for soil type 2. (R)

SEG -- Array of segments for outputting hydrographs. (R)

SF -- Scale factor to determine initial step lengths in a stage of optimization. (R)

SFPK -- Array containing maximum simulated discharge for flood events, in cubic feet per second. (R)

SFVØL -- Array containing simulated runoff volume for flood events, in basin inches. (R)

SLØPE -- Array of segment slopes. (R)

SMAX -- Array of maximum storage during a flood event for detention reservoirs. (R)

SMS	-- Soil moisture storage in saturated zone (volume of infiltration during period). (R)
SMSB	-- Array of SMS's for soil types and rain gages. (R)
SR	-- Five-minute rainfall supply rate to pervious surfaces (adjusted for contribution from noneffective impervious surfaces). (R)
SRP	-- Five-minute rainfall supply rate to effective impervious surfaces. (R)
SRV	-- Dummy variable for simulated runoff volume. (R)
S2	-- Array of storages in outflow-storage relationship for modified-Puls detention reservoir segments. (R)
T	-- Time in finite-difference routing. (R)
TEMP	-- Dummy variable used in sequencing nonoverland-flow segments in downstream order. (R)
TESTNØ	-- Array containing indicator of whether or not flood event is used (1--Yes, 0--No). (I)
TØUT	-- Array of times (from beginning of storm) of output hydrograph point. (R)
TRYCT	-- Iteration count for set of parameters. (I)
U	-- Array containing objective functions. (R)
UD	-- Array containing unit-discharge data. (R)
UDD	-- Sequence date of unit discharge. (I)
UNN1	-- Boundary value of root mean square error. (R)
UNN2	-- Boundary value of root mean square error. (R)
UPD	-- Sequence date of unit rainfall. (I)
UPR	-- Array containing unit-precipitation data. (R)
UU	-- Dummy variable for objective function in current iteration. (R)
U1,U2	-- Dummy variables for specific objective functions. (R)
VØLI	-- Furnished volume of storm runoff, in inches. (R)

W -- Counter for day of record. (I)

X -- (a) Array containing magnitudes of infiltration parameters.
 (b) Array of abscissa coordinates for plotting. (R)

XMAX -- Value of abscissa at the rightmost grid line. (R)

XMIN -- Value of abscissa at the leftmost grid line. (R)

XX -- Dummy variable for infiltration parameters. (R)

YMAX -- Value of ordinate at the uppermost grid line. (R)

YMIN -- Value of ordinate at the lowermost grid line. (R)

YN -- Array containing cumulative number of days counted from
 January 1, 1901 at end of preceding year. (I)

YR -- Year of observed record (last two digits). (I)

C. PROGRAM LISTING

C	*****	A	1
C	*	A	2
C	* JJ47--DISTRIBUTED ROUTING RAINFALL-RUNOFF	A	3
C	* MODEL FOR URBAN PLANNING	A	4
C	*	A	5
C	* OPERATIONAL MODELS PROJECT	A	6
C	* GULF COAST HYDROSCIENCE CENTER	A	7
C	* U. S. GEOLOGICAL SURVEY - WRD	A	8
C	* DATE OF LAST PROGRAM REVISION: AUG 15, 1978	A	9
C	*	A	10
C	*****	A	11
	INTEGER IOUT(2),INDP(50)	A	12
	INTEGER EQ,F0,OPTNO(25),B3,TRYCT,D1,MN(13),E(26),F(26)	A	13
	INTEGER PCCN,DCCN,RODYS,DEL5,DPD,DED,DATERF,DATERL,BTIME,DATE	A	14
	INTEGER STA,STAD,STAD1,STAUP,STAUP1,STAP,STAP1,STAE,STAE1	A	15
	INTEGER YH,MJ,DY,BYH,BMO,BDY,EYH,EMO,EDY,CN,CT,CODE,OPTION,OPT	A	16
	INTEGER NOUD(115),NOUP(115),YN(84),UPD,UDD,IPR(50)	A	17
	INTEGER RITE,W,CHG,FLAG,DEL5P,TESTNO(60)	A	18
	INTEGER FILE	A	19
	REAL IRR	A	20
	DIMENSION TITD(50),TITLUP(50),TITLP(50),TITLE(50),X2(16)	A	21
	DIMENSION PI4P(60,3),IRR(12)	A	22
	DIMENSION K1(60),K2(60)	A	23
C	IF PLOTTING ROUTINE NOT ACCEPTED BY COMPUTER	A	24
C	PULL OUT LOGICAL*1 IMAGE(5200)	A	25
	LOGICAL*1 IMAGE(5200)	A	26
	REAL ISEG,IUP,ILAT	A	27
	COMMON /C1/ NSEG,ISEG(50),IUP(50,3),NPAR,KPSET(50)	A	28
	COMMON /C2/ NL,NPAGE	A	29
	COMMON /C3/ IPRNT,T,AR(50,11),FLGT1(50),KSEG(50),NDX(50),Q1(50),Q2	A	30
	1(50),QSUM(50),QSUM1(50),STO(50)	A	31
	COMMON /C4/ DEL5,MAXL,QCW,QLAT,ILAT(50,4),ITEST(50),ITYPE(50),JLAT	A	32
	1(50,4),JUP(50,3),P(3456,3),PARAM(50,2),RCOE(50,3),UPR(7200)	A	33
	COMMON /C5/ ALPHA(50),EM(50),FRN(50),QMAX(50),SLOPE(50)	A	34
	COMMON /C6/ DT,DTS,QUP,DX(50)	A	35
	COMMON /C7/ ECOMP,I,KINIT,NOUT,NRG,OSI,JOUT(50),JIND,RAT(3,2)	A	36
	COMMON /C8/ I2,I1,IK,TRYCT,KOUT(60),SEG(50)	A	37
	COMMON /C9/ I3,I4,QIH(1728),PTIME,IHYD(60),IJ,IP	A	38
	COMMON /D1/ DP(1000),RODYS	A	39
	REAL IMP,IMPRET,IMPSTT,IMPSTO	A	40
	REAL IN1,IN2	A	41
	COMMON /E1/ IMPRET(1728,3),IMPSTO(3)	A	42
	DIMENSION IWES(30),O2(50,30)	A	43
	COMMON /E2/ SMAX(50),IN2(50),IN1(50),S2O2(50)	A	44
	COMMON /E3/ DELTAT,N08,QS(50,11)	A	45
	COMMON /E4/ WV(50,30),S1(50,30),C1(50,30)	A	46
	COMMON /E5/ S2(50,30),S(50,30),C(50,30)	A	47
	COMMON /F1/ ICT,Q(1728),R(1728),IPL(60)	A	48
	COMMON /PARAM/ NSCALE(1),NHL,NSBH,NVL,NSBV,XMAX,XMIN,YMAX,YMIN,FIL	A	49
	1,E,CH,N3,ND,LABEL(12)	A	50
	INTEGER NF(60),NFE(60),NFS(60),NDATE(60,3),KQ	A	51
	REAL UD(7200),DE(1000)	A	52
	REAL KDRAIN,PS,PSP,PW,Q1,QR,DRAIN,RGF,BMSN,FPK(60),PSUM(120,3),RR	A	53
	REAL COEF,DRN24,ETDEL,ETW,EVC,FR,INC,KSAT,SR,BMS,SMS	A	54
	REAL SFPK(60),PDEL,I2CFSP	A	55
	REAL EPSLN,XX,GOE,OF,B1,B2,X(75),G(75)	A	56
	REAL H(75),U(3),A(76),D(76),DI4P(9,2)	A	57
	REAL UU,SF,BD,GD,HD	A	58
	REAL EVC2,RR2,DRV242,DRAIN2,PW2,ETW2,INC2,KSAT2	A	59
	REAL Q3,SHV,QMX,SMSB(3,2),BMSB(3,2),FVOL(60),SFVOL(60),POBS(60,3)	A	60
	REAL FMTF(9),FMTF1(10),FMTA(6),FMTB(43)	A	61

	DATA FMTA/1H,3H,I3,1H(,1H),3H,3X,3H1H+/	A	62
	DATA FMTP1/3HPSF,4HKSAT,3HGRF,4HBMSEN,3HEVC,2HRR,3HORN,4H,3X,,3H1H+	A	63
	1,14 /	A	64
	DATA FMTP/4H(1H,4H,I3,,443X,F,4H)2,6,4H,3X,,2MA4,1H,1H,1H)/	A	65
	DATA MN/0,31,59,90,120,131,181,212,243,273,304,334,365/,GMX/0,0/	A	66
	DATA H3/0/,FLAG/1/,01/0/,IOUT/4MLIST,4H Y3/,Q3/0,0/,SRV/0,0/	A	67
	DATA OF/1.0E+50/,B1/0,0/,92/0,0/,PCCN/0/,DCCN/0/,UPD/0/,UDD/0/	A	68
C	INITIALIZE DIMP TO ZERO	A	69
	DU 30 J=1,2	A	70
	DU 10 K=1,3	A	71
10	RAT(K,J)=0.0	A	72
	DU 20 I=1,9	A	73
20	DIMP(I,J)=0.0	A	74
30	CONTINUE	A	75
C	JULIAN DATE FOR JAN. 1 OF EACH YEAR	A	76
C	STARTING FROM JAN. 1, 1901	A	77
	YN(1)=0	A	78
	DU 40 I=2,84	A	79
	YN(I)=YN(I-1)+365	A	80
	IF (MOD(I-1,4).EQ.0) YN(I)=YN(I)+1	A	81
40	CONTINUE	A	82
C	INITIALIZE TO ZERO	A	83
	DU 50 I=1,7200	A	84
50	JPH(I)=0.0	A	85
	NKG=0	A	86
	DU 60 I=1,12	A	87
60	IHR(I)=0.0	A	88
	JCW=0.0	A	89
	NUAY=0	A	90
	DU 70 I=1,7200	A	91
70	UD(I)=0.0	A	92
	DU 80 I=1,1000	A	93
	DP(I)=0.0	A	94
80	DE(I)=0.0	A	95
C	OPTION=IOUT(1) LISTS INPUT DATA.	A	96
	READ (5,2020) OPTION,OPT,NOPT1	A	97
	IF (NOPT1.EQ.0) GO TO 100	A	98
	READ (5,2000) (IRR(I),I=1,12)	A	99
	DU 90 I=1,12	A	100
90	IHR(I)=IRR(I)/7.	A	101
	WRITE (6,2010) (IRR(I),I=1,12)	A	102
C	READ-IN STA.NOS. AND NAMES,DA,UNIT TIME, BEGIN AND END	A	103
C	DATES. STATION NUMBERS READ 2A4 FOR IBM WORD SIZE.	A	104
100	READ (5,2040) STAD1,STAD,TITLD,DA	A	105
	READ (5,2040) STAP1,STAP,TITLP	A	106
	READ (5,2040) STAE1,STAE,TITLE	A	107
	READ (5,2060) BYR,BMO,BDY,EYR,EMO,EDY	A	108
C	INITIALIZE VARIABLES	A	109
	NUPD=0	A	110
	DU 110 I=1,115	A	111
	NUJD(I)=0	A	112
110	NUUP(I)=0	A	113
120	UPD=0	A	114
	PCCN=0	A	115
	NKG=NRG+1	A	116
	IF (NRG.GT.1) WRITE (6,2510)	A	117
	NUDD=0	A	118
	READ (5,2050) STAUP1,STAJP,TITLUP,PTIME	A	119
C	DETERMINE JULIAN DATE FOR BEGIN AND END OF RECORD.	A	120
C	DATE=1 FOR JAN. 1, 1901	A	121
	IF (MOD(BYR,4).NE.0) GO TO 130	A	122

	IF (BMO-2) 130,130,140	A 123
130	LEAP=0	A 124
	GO TO 150	A 125
140	LEAP=1	A 126
150	JATERF=YN(BYR)+MN(BMO)+BDY*LEAP	A 127
	IF (MOD(EYR,4).NE.0) GO TO 160	A 128
	IF (EMO-2) 160,160,170	A 129
160	LEAP=0	A 130
	GO TO 180	A 131
170	LEAP=1	A 132
180	JATERL=YN(EYR)+MN(EMO)+EDY*LEAP	A 133
C	CALCULATE NUMBER OF DAYS OF RECORD	A 134
	NODYS=DATERL-DATERF+1	A 135
	WRITE (6,2070) STAD1,STAD,TITLD,STAUP1,STAJP,TITLUP,STAP1,STAP,TIT	A 136
	LP,STAE1,STAE,TITLE,DA,PTIME,BMO,BDY,BYR,DATERF,EMO,EDY,EYR,DATERL	A 137
C	COMPUTE TIME PARAMETERS	A 138
C	NDAY IS SET TO STARTING TIME ELEMENT FOR A RAIN GAGE	A 139
	PUEL=PTIME/1440.0	A 140
	NUELS=1440/PTIME	A 141
	NDAY=NUPD*NUELS*(NRG-1)	A 142
	NUPD=0	A 143
	DTIME=PTIME	A 144
	DPD=DATERF-1	A 145
	DEL5=DPD	A 146
	DEL5=DTIME/5	A 147
	DEL5P=DEL5+1	A 148
C	READ IN DATA FROM A CARD	A 149
C	PERFORM EDIT CHECK ON STATION NO., UNIT TIME, AND	A 150
C	CHRONOLOGICAL SEQUENCE OF CARD	A 151
C	ENTER DATA INTO ARRAYS ACCORDING TO CODING	A 152
C	CHECK LAST FOUR CHARACTERS OF STATION NOS. ONLY	A 153
C	DATES FOR CODES 1 AND 2	A 154
	IF (OPTION.EQ.IDJT(1)) WRITE (6,2510)	A 155
	KP=0	A 156
190	READ (5,2080) STA1,STA,YR,MO,DY,CT,CN,(X2(I),I=1,12),CODE	A 157
	IF (CODE.EQ.8) GO TO 120	A 158
	IF (CODE.EQ.9) GO TO 320	A 159
	IF (MOD(YR,4).NE.0) GO TO 200	A 160
	IF (MO-2) 200,200,210	A 161
200	LEAP=0	A 162
	GO TO 220	A 163
210	LEAP=1	A 164
220	DATE=YN(YR)+MN(MO)+DY*LEAP	A 165
	IF (CODE.EQ.2) GO TO 270	A 166
C	DATA ENTRIES FOR CODE 1	A 167
	IF (STA.NE.STAUP) GO TO 430	A 168
	IF (CT.NE.BTIME) GO TO 430	A 169
	IF (DATE=UPD) 430,240,230	A 170
230	NUPD=NUPD+1	A 171
	NDATE(NUPD,1)=DY	A 172
	NDATE(NUPD,2)=MO	A 173
	NDATE(NUPD,3)=YR	A 174
	NUP(NUPD)=DATE	A 175
	UPD=DATE	A 176
	PCCN=CN	A 177
	GO TO 250	A 178
240	IF (CN.LE.PCCN) GO TO 430	A 179
	PCCN=CN	A 180
C	NDAY IS NUPD*NUELS*(NRG-1) WITH NRG UPDATED EACH GAGE READ	A 181
250	K4DAY=NUELS*(NUPD-1)+12*CN*NDAY	A 182
	KK=K4DAY-11	A 183

I=0	A 184
DO 260 K=KK,K4DAY	A 185
I=I+1	A 186
X2(I)=X2(I)/100.0	A 187
260 JPR(K)=X2(I)	A 188
IF (OPTION.NE.IUJT(1)) GO TO 190	A 189
WRITE (6,2090) STAU1,STA,YR,MO,DY,CT,CN,(X2(I),I=1,12),CODE	A 190
GO TO 190	A 191
C DATA ENTRIES FOR CODE 2	A 192
270 IF (STA.NE.STAD) GO TO 430	A 193
IF (CT.NE.BTIME) GO TO 430	A 194
IF (DATE-JDD) 430,290,280	A 195
280 NUDD=NUDD+1	A 196
NUDD(NUDD)=DATE	A 197
JDD=DATE	A 198
DCCN=CN	A 199
GO TO 300	A 200
290 IF (CN.LE.DCCN) GO TO 430	A 201
DCCN=CN	A 202
300 K4DAY=NDELS*(NUDD-1)+12*CN	A 203
C ENTER DATA INTO ARRAYS ACCORDING TO CODE TYPE	A 204
KK=K4DAY-1	A 205
I=0	A 206
DO 310 K=KK,K4DAY	A 207
I=I+1	A 208
310 JU(K)=X2(I)	A 209
IF (OPTION.NE.IUJT(1)) GO TO 190	A 210
WRITE (6,2090) STAD1,STA,YR,MO,DY,CT,CN,(X2(I),I=1,12),CODE	A 211
GO TO 190	A 212
C DATES FOR CODES 3-4	A 213
320 READ (5,2100) STAD1,STA,YR,MO,CN,(X2(I),I=1,16),CODE	A 214
IF (CODE.EQ.9) GO TO 440	A 215
IF (CODE.EQ.4) GO TO 340	A 216
DO 330 I=1,16	A 217
IF (X2(I).GE.IRR(MO).OR.X2(I).LT.0.0) GO TO 330	A 218
X2(I)=IRR(MO)	A 219
330 CONTINUE	A 220
340 CONTINUE	A 221
IF (OPTION.NE.IUJT(1)) GO TO 350	A 222
WRITE (6,2110) STAD1,STA,YR,MO,CN,(X2(I),I=1,16),CODE	A 223
350 CONTINUE	A 224
LEAP=0	A 225
IF (MOD(YR,4).EQ.0) LEAP=1	A 226
IF (CN.LT.2) GO TO 370	A 227
DATE=YN(YR)+MN(MO)+17	A 228
IF (MO.LE.2) GO TO 360	A 229
DATE=DATE+LEAP	A 230
360 I1=YN(YR)+MN(MO+1)-DATE+1	A 231
IF (MO.LE.1) GO TO 390	A 232
I1=I1+LEAP	A 233
GO TO 390	A 234
370 DATE=YN(YR)+MN(MO)+1	A 235
IF (MO.LE.2) GO TO 380	A 236
DATE=DATE+LEAP	A 237
380 I1=16	A 238
390 IF (CODE.EQ.4) GO TO 410	A 239
C DATA ENTRIES FOR CODE 3	A 240
IF (STA.NE.STAP) GO TO 430	A 241
IF (DATE.LE.DPD) GO TO 430	A 242
DPD=DATE	A 243
I1=I1+DPD-DATERF	A 244

KK=DPD-DATERF+1	A 245
I=0	A 246
DO 400 K=KK,II	A 247
I=I+1	A 248
C CHECK FOR GAP IN DAILY RECORD	A 249
IF (X2(I).NE.99.99) GO TO 400	A 250
C IF THERE IS A GAP SET UP INDICATORS FOR THIS	A 251
KP=KP+1	A 252
INDP(KP)=K	A 253
X2(I)=0.0	A 254
400 DP(K)=X2(I)	A 255
GO TO 320	A 256
C DATA ENTRIES FOR CODE 4	A 257
410 IF (STA.NE.STAE) GO TO 430	A 258
IF (DATE.LE.DED) GO TO 430	A 259
DED=DATE	A 260
II=II+DED-DATERF	A 261
KK=DED-DATERF+1	A 262
I=0	A 263
DO 420 K=KK,II	A 264
I=I+1	A 265
420 DE(K)=X2(I)	A 266
GO TO 320	A 267
C PRINT CARD WITH INCONSISTENT DATA	A 268
430 WRITE (6,2120) STA,STAP,DATE,DPD,CODE	A 269
STOP	A 270
440 CONTINUE	A 271
INDP(KP+1)=II+1	A 272
I=0	A 273
J=1	A 274
C CHECK FOR INPUT DATA ERRORS	A 275
L=NOUD(1)	A 276
M=NOUP(1)	A 277
K=0	A 278
IF (OPT.EQ.1) GO TO 480	A 279
IF (L.EQ.M) GO TO 460	A 280
450 WRITE (6,2130) K,L,M	A 281
STOP	A 282
460 DO 470 K=DATEF,DATERL	A 283
I=I+1	A 284
IF (DP(I).GE.0.0) GO TO 470	A 285
IF (K.NE.L) GO TO 450	A 286
IF (K.NE.M) GO TO 450	A 287
J=J+1	A 288
L=NOUD(J)	A 289
M=NOUP(J)	A 290
470 CONTINUE	A 291
C * INITIAL OPTIMIZATION ROUTINE *	A 292
480 DO 490 I=1,3	A 293
490 U(I)=0.0	A 294
READ (5,2140) EU,F0,K,EPN	A 295
NN=2	A 296
NPAR=1	A 297
IF (EO.GT.7) NPAR=2	A 298
DO 500 I=1,EO	A 299
500 READ (5,2150) X(I),G(I),4(I)	A 300
READ (5,2360) (OPTNO(I),I=1,F0)	A 301
IFOP1=F0+1	A 302
DO 510 I=IFOP1,EO	A 303
510 OPTNO(I)=0	A 304
C SET MAXIMUM TRYCT	A 305

NK=K*FO	A 306
IF (NK.EQ.0) H3=1	A 307
DO 520 I=1,76	A 308
A(I)=0.0	A 309
520 U(I)=0.0	A 310
DO 530 I=1,26	A 311
C(I)=0	A 312
530 F(I)=0	A 313
TRYCT=0	A 314
C CHECK IF INITIAL PARAMETER VALUE WITHIN OUTER BOUNDARY	A 315
C VALUES	A 316
DO 550 I=1,E0	A 317
XX=X(I)	A 318
IF (XX.LE.G(I)) GO TO 540	A 319
IF (XX.GE.H(I)) GO TO 540	A 320
C STORE INITIAL PARAMETER VALUES	A 321
X(E0+I)=XX	A 322
GO TO 550	A 323
C IF PARAMETER VALUES NOT WITHIN BOUNDARY VALUES	A 324
C PRINT ERROR MESSAGE	A 325
540 WRITE (6,2160) I,G(I),X(I),H(I)	A 326
STOP	A 327
550 CONTINUE	A 328
DO 560 I=1,E0	A 329
L=2*E0+I	A 330
G(L)=0.0	A 331
H(L)=0.0	A 332
K=E0+I	A 333
C COMPUTE INNER BOUNDARY VALUES	A 334
GUE=(H(I)-G(I))*0.0001	A 335
G(K)=G(I)+GUE	A 336
560 H(K)=H(I)-GUE	A 337
C ENTER A(I) = 0.0 INTO ARRAY	A 338
L=FO+1	A 339
DO 570 I=1,FO	A 340
LJ=L+I	A 341
A(LJ)=1.0	A 342
C COMPUTE INITIAL STEP SIZE	A 343
J=OPTNO(I)	A 344
A(I)=X(J)*EPSLN	A 345
570 CONTINUE	A 346
C DESCRIBE INFILTRATION PARAMETERS	A 347
WRITE (6,2170)	A 348
J=1	A 349
DO 580 I=1,E0	A 350
FMTP(7)=FMTP1(10)	A 351
FMTP(8)=FMTP1(10)	A 352
K=I	A 353
IF (I.GT.7) K=I-7	A 354
IF (I.NE.OPTNO(J)) GO TO 580	A 355
FMTP(7)=FMTP1(9)	A 356
FMTP(8)=FMTP1(9)	A 357
J=J+1	A 358
580 WRITE (6,FMTP) I,X(I),FMTP1(K)	A 359
NO=0	A 360
IF (NK.EQ.0) GO TO 940	A 361
WRITE (6,2180)	A 362
WRITE (6,2190) (A(I),I=1,FO)	A 363
WRITE (6,2200) NK,EPSLN	A 364
GO TO 940	A 365
C * MODIFIED ROSENBERG OPTIMIZATION *	A 366

590	UU=U(NN)	A 367
C	CHECK FOR IMPROVEMENT IN OBJECTIVE FUNCTION	A 368
	IF (UU.GT.OF) GO TO 650	A 369
C	NEW OBJECTIVE FUNCTION LESS THAN OLD OBJ. FUNCTION	A 370
	DU 620 I=1,F0	A 371
	M=OPTNO(I)	A 372
	XX=X(M)	A 373
	K=E0*M	A 374
	L=2*E0*M	A 375
C	CHECK ON INNER LOWER BOUNDARY	A 376
	IF (XX.GE.G(K)) GO TO 600	A 377
	GU=(G(K)-XX)/(G(K)-G(M))	A 378
	HU=UU-G(L)	A 379
	GU TO 610	A 380
C	CHECK ON INNER UPPER BOUNDARY	A 381
600	IF (XX.LE.H(K)) GO TO 620	A 382
	GU=(XX-H(K))/(H(M)-H(K))	A 383
	HU=UU-H(L)	A 384
610	JU=UU+((-2.0*GU+4.0)*GU-3.0)*GU*HD	A 385
	IF (UU.GT.OF) GO TO 650	A 386
620	CONTINUE	A 387
C	SET OF TO NEW OBJ. FCT.	A 388
	OF=UU	A 389
	DU 630 I=1,F0	A 390
C	STORE OLD PARAMETER VALUE IN LAST THIRD OF MATRIX	A 391
	M=OPTNO(I)	A 392
	XX=X(M)	A 393
	K=E0*M	A 394
	L=2*E0*M	A 395
	X(L)=XX	A 396
C	CHECK ON INNER BOUNDARIES	A 397
	IF (XX.GT.H(K)) GO TO 630	A 398
	IF (XX.LT.G(K)) GO TO 630	A 399
C	ENTER CURRENT OBJ. FCT. IN G + H ARRAYS	A 400
	G(L)=UU	A 401
	H(L)=UU	A 402
630	CONTINUE	A 403
	IF (NO.EQ.0) GO TO 640	A 404
C	F(I)=1 IF NEW PARAMETER VALUE IMPROVES OBJ. FCT.	A 405
	F(NO)=1	A 406
	E(NO)=0	A 407
C	COMPUTE CUMULATIVE STEP SIZE	A 408
	D(NO)=D(NO)+A(NO)	A 409
C	COMPUTE NEXT FORWARD STEP SIZE	A 410
	A(NO)=3.0*A(NO)	A 411
640	WRITE (6,2210) TRYCT,U(2)	A 412
	WRITE (6,2220)	A 413
	WRITE (6,2230) (X(I),I=1,E0)	A 414
	IF (TRYCT.NE.NK) GO TO 690	A 415
	93=1	A 416
	RITE=1	A 417
	GO TO 1360	A 418
C	IF NEW OBJ. FCT. EXCEEDS OLD OBJ. FCT.	A 419
C	SET PARAMETER TO PREVIOUS VALUE	A 420
650	M=2*E0	A 421
	DU 660 I=1,F0	A 422
	K=OPTNO(I)	A 423
	LK=K*M	A 424
660	X(K)=X(LK)	A 425
	GO TO 740	A 426
C	ROUTINE TO COMPUTE NEW PARAMETER VALUE	A 427

670 IF (TRYCT.NE.NK) GO TO 680	A 428
GO TO 640	A 429
680 TRYCT=TRYCT+1	A 430
OPTION=IOUT(2)	A 431
IF (NO.EQ.FO) GO TO 690	A 432
NO=NO+1	A 433
GO TO 700	A 434
690 NO=1	A 435
700 DO 730 I=1,FO	A 436
K=OPTNO(I)	A 437
IFO=FO+I+NO	A 438
XX=X(K)+A(IFO)*A(NO)	A 439
IF (XX.LE.G(K).OR.XX.GE.G(K)) GO TO 710	A 440
X(K)=XX	A 441
GO TO 730	A 442
710 L=2*EO	A 443
IF (I.EQ.1) GO TO 740	A 444
II=I-1	A 445
DO 720 IJ=1,II	A 446
I2=II+1-IJ	A 447
K=OPTNO(I2)	A 448
LK=L+K	A 449
720 X(K)=X(LK)	A 450
GO TO 740	A 451
730 CONTINUE	A 452
GO TO 1360	A 453
C COMPUTES BACK STEP LENGTH(WHEN NEW OBJ. FCT. > OLD)	A 454
740 IF (TRYCT.NE.NK) GO TO 750	A 455
B3=1	A 456
RITE=1	A 457
GO TO 1360	A 458
C COMPUTE NEXT BACKWARD STEP SIZE	A 459
750 A(NO)=-0.5*A(NO)	A 460
C E(I)=1 INDICATES PARAMETER VALUE CHANGED BY BACKWARD	A 461
C STEP SIZE	A 462
E(NO)=E(NO)+1	A 463
C DETERMINE IF BOTH BACKWARD AND FORWARD STEP SIZE	A 464
C ADJUSTMENTS FAILED TO IMPROVE OBJ. FCT.	A 465
DO 760 I=1,FO	A 466
LJ=E(I)*F(I)	A 467
IF (LJ.LE.0) GO TO 670	A 468
760 CONTINUE	A 469
C VECTOR ORTHONORMALIZED WHEN IPEF.GT.0 FOR ALL I	A 470
DO 770 I=1,FO	A 471
L=FO*(I+1)	A 472
A(L)=D(FO)*A(L)	A 473
K=FO+I	A 474
IF (FO.EQ.1) GO TO 780	A 475
LJ=FO-1	A 476
DO 770 LK=1,LJ	A 477
J2=FO-LK	A 478
L=K+J2	A 479
770 A(L)=D(J2)*A(L)+A(L+1)	A 480
C NORMALIZE VECTOR LENGTHS TO 1.0	A 481
780 BD=0.0	A 482
DO 790 I=1,FO	A 483
LJ=FO+I+1	A 484
790 BU=A(LJ)**2+BD	A 485
B1=SQRT(BD)	A 486
DO 800 I=1,FO	A 487
L=FO+I+1	A 488

800	A(L)=A(L)/B1	A 489
C	RECOMPUTE STEP SIZE INCREMENT	A 490
	SF=0.0	A 491
	DU 810 I=1,FO	A 492
	K=OPTNO(I)	A 493
	L=FO*I+1	A 494
810	SF=SF+ABS(A(L))*X(K)	A 495
	A(1)=SF*EPSLN	A 496
	BU=0.0	A 497
	DU 820 I=1,FO	A 498
	IK=FO*I+2	A 499
820	BU=A(IK)**2+BD	A 500
	BC=SQRT(BD)/B1	A 501
	WRITE (6,2240) B1,BC	A 502
	J=2	A 503
830	IF (FO.LT.J) GO TO 910	A 504
	K=1	A 505
	BU=0.0	A 506
840	IF (K.GE.J) GO TO 870	A 507
	DU 850 I=1,FO	A 508
	L=FO*I	A 509
	LJ=L+J	A 510
	LK=L+K	A 511
850	BU=BU+A(LJ)*A(LK)	A 512
	DU 860 I=1,FO	A 513
	L=FO*I+J	A 514
	LJ=L-J+K	A 515
860	A(L)=A(L)-A(LJ)*BD	A 516
	K=K+1	A 517
	BU=0.0	A 518
	GO TO 840	A 519
870	DU 880 I=1,FO	A 520
	LJ=FO*I+J	A 521
880	BU=A(LJ)**2+BD	A 522
	BU=SQRT(BD)	A 523
	DU 890 I=1,FO	A 524
	L=FO*I+J	A 525
890	A(L)=A(L)/BD	A 526
	SF=0.0	A 527
	DU 900 I=1,FO	A 528
	K=OPTNO(I)	A 529
	L=FO*I+J	A 530
900	SF=SF+ABS(A(L))*X(K)	A 531
	A(J)=SF*EPSLN	A 532
	J=J+1	A 533
	GO TO 830	A 534
910	WRITE (6,2250)	A 535
	DU 920 I=1,FO	A 536
	LJ=I*FO+1	A 537
	LK=I*FO+FO	A 538
920	WRITE (6,2260) (A(IJ),IJ=LJ,LK)	A 539
	NU=0	A 540
	WRITE (6,2270) (A(I),I=1,FO)	A 541
	DU 930 I=1,FO	A 542
	D(I)=0.0	A 543
	F(I)=0	A 544
	K=OPTNO(I)	A 545
	LJ=EO+K	A 546
930	X(LJ)=X(K)	A 547
	RITE=1	A 548
	GO TO 1360	A 549

940	CONTINUE	A 550
	NPAGE=0	A 551
	MAXL=55	A 552
C	HEAD CATCHMENT DATA	A 553
	HEAD (5,2280) NSEG,DT,OSI,VRG,IMP	A 554
	DT=DT*60.	A 555
	WRITE (6,2290) NSEG,DT,OSI,VRG,NPAR,IMP	A 556
	CALL PAGE	A 557
	WRITE (6,2300)	A 558
	NL=NL+4	A 559
	N08=0	A 560
	N09=10	A 561
	DO 1000 I=1,NSEG	A 562
	HEAD (5,2340) ISEG(I),(IUP(I,J),J=1,3),(ILAT(I,J),J=1,4),ITYPE(I),	A 563
	1,IPR(I),NDX(I),FLGTH(I),SLOPE(I),FRN(I),(PARAM(I,J),J=1,2),KPSET(I)	A 564
	2),(RCOE(I,J),J=1,VRG)	A 565
	IF (ITYPE(I).EQ.8) N08=N08+1	A 566
	IF (ITYPE(I).EQ.8) IRES(N08)=I	A 567
	IF (ITYPE(I).EQ.9) N09=N09+1	A 568
	IF (ITYPE(I).EQ.9) IRES(N09)=I	A 569
	IF (NDX(I)) 950,950,960	A 570
950	NDX(I)=10	A 571
960	NL=NL+1	A 572
	DX(I)=FLGTH(I)/NDX(I)	A 573
	IF (NL-MAXL) 990,980,980	A 574
970	WRITE (6,1990)	A 575
	STOP	A 576
980	CALL PAGE	A 577
	NL=NL+5	A 578
	WRITE (6,2300)	A 579
990	WRITE (6,2350) ISEG(I),(IUP(I,J),J=1,3),(ILAT(I,J),J=1,4),ITYPE(I)	A 580
	1,IPR(I),NDX(I),FLGTH(I),SLOPE(I),FRN(I),(PARAM(I,J),J=1,2),KPSET(I)	A 581
	2),(RCOE(I,J),J=1,VRG)	A 582
	IF (ITYPE(I).NE.15.AND.ITYPE(I).NE.16) GO TO 1000	A 583
	IF (I.EQ.1) GO TO 970	A 584
	ITYPE(I)=ITYPE(I)-10	A 585
	IF (PARAM(I-1,2).NE.PARAM(I,2)) GO TO 970	A 586
	PARAM(I-1,2)=-PARAM(I-1,2)	A 587
	IF (PARAM(I-1,1).NE.PARAM(I,1)) GO TO 970	A 588
	PARAM(I,1)=-PARAM(I,1)	A 589
1000	CONTINUE	A 590
	DELTAT=DT/60.	A 591
	IF (N08.EQ.0) GO TO 1060	A 592
	DO 1050 I2=1,N08	A 593
	K=IRES(I2)	A 594
	DDMIN=DELTAT	A 595
	J=NDX(K)	A 596
	DO 1010 II=1,J	A 597
	READ (5,2150) O2(K,II),S2(K,II)	A 598
	WV(K,II)=S2(K,II)/DELTAT+O2(K,II)/2.	A 599
	TEST=WV(K,II)-O2(K,II)	A 600
	IF (TEST.GE.0.0) GO TO 1010	A 601
	DDT=S2(K,II)/(O2(K,II)/2.0)	A 602
	IF (DDT.LT.DDMIN) DDMIN=DDT	A 603
	WRITE (6,2310) K,DDMIN	A 604
1010	CONTINUE	A 605
	DO 1020 II=2,J	A 606
	S1(K,II)=(O2(K,II)-O2(K,II-1))/(WV(K,II)-WV(K,II-1))	A 607
	CL(K,II)=O2(K,II)-S1(K,II)*WV(K,II)	A 608
	S(K,II)=(O2(K,II)-O2(K,II-1))/(S2(K,II)-S2(K,II-1))	A 609
	C(K,II)=O2(K,II)-S(K,II)*S2(K,II)	A 610

1020	CONTINUE	A 611
	VL=NL+5+NDX(K)	A 612
	IF (NL-MAXL) 1040,1030,1030	A 613
1030	CALL PAGE	A 614
	VL=5+NDX(K)	A 615
1040	WRITE (6,2320) ISEG(K)	A 616
	WRITE (6,2330) (J2(K,II),S2(K,II),NV(K,II),II=1,J)	A 617
1050	CONTINUE	A 618
1060	IF (NRG.EQ.3) GO TO 1090	A 619
C	SET THEISSEN COEFFICIENTS FOR UNUSED RAIN GAGES TO ZERO	A 620
	NRG1=NRG+1	A 621
	DO 1080 J=NRG1,J	A 622
	DO 1070 K=1,NSEG	A 623
1070	RCDEF(K,J)=0.0	A 624
1080	CONTINUE	A 625
1090	CONTINUE	A 626
	IF (NL-MAXL+10) 1110,1110,1100	A 627
1100	CALL PAGE	A 628
1110	VL=NL+4	A 629
C	SET-UP KINEMATIC MODEL PARAMETERS	A 630
	CALL AM	A 631
C	SET-UP COMPUTATION SEQUENCE	A 632
	CALL SEQ (DA,DIMP)	A 633
C	SET-UP OUTPUT SEQUENCE	A 634
	NOJT=0	A 635
	DO 1130 I=1,NSEG	A 636
	IF (IPR(I)) 1130,1130,1120	A 637
C	SET-UP INDICATORS FOR SEGMENTS WITH PRINTED OUTFLOW	A 638
1120	NOJT=NOUT+1	A 639
	JOJT(NOUT)=I	A 640
	SEG(NOUT)=ISEG(I)	A 641
1130	CONTINUE	A 642
C	INITIALIZE VARIABLES	A 643
	DO 1140 III=1,NRG	A 644
1140	IMPSTO(III)=0.0	A 645
	NOFE=1	A 646
	II=1	A 647
	DO 1150 I=1,60	A 648
	FPK(I)=0.0	A 649
1150	FVOL(I)=0.0	A 650
C	* STORM ANALYSIS * (PEAK, BASEFLOW, VOLUME)	A 651
C	NDAY IS SET TO NUMBER OF TIME INTERVALS FOR A RAIN GAGE	A 652
	NDAY=NUPD*NDELS	A 653
C	5280**2/12*60*60*24=26.888: CONVERTS INCHES TO CFS	A 654
	12CFSP=26.8888889*DA*NDELS	A 655
C	FOR EACH SET OF EVENTS, THE NO. OF EVENTS IN THE SET	A 656
C	IS ENTERED FOR AS MANY TIMES AS THERE ARE EVENTS IN THE	A 657
C	SET. A SET OF EVENTS CONSISTS OF A FRACTION OF A DAY OR	A 658
C	A SERIES OF CONTINUOUS DAYS.	A 659
	HEAD (5,2360) I,(NF(K),K=1,I)	A 660
	WRITE (6,2480) I,(NF(K),K=1,I)	A 661
C	BEGIN ANALYSIS OF A SET OF EVENTS	A 662
1160	DO 1170 I=1,NUPD	A 663
	KIT=(II-1)*NDELS	A 664
	IF (NOUP(I+1).NE.(NOUP(I)+1)) GO TO 1180	A 665
1170	CONTINUE	A 666
1180	NFII=NF(NOFE)	A 667
	I4=II	A 668
	II=I+1	A 669
C	BEGIN ANALYSIS OF A STORM	A 67
1190	READ (5,2030) KS,KE,IPL(NOFE),VOLI	A 671

WRITE (6,2490) NOFE,KS,KE	A 672
FVOL(NOFE)=VOL I	A 673
K1(NOFE)=KIT+KS	A 674
K2(NOFE)=KIT+KE	A 675
KS=(KS-1)*DELS+1	A 676
KE=KE*DELS	A 677
NFS(NOFE)=KS	A 678
NFE(NOFE)=KE	A 679
NFI1=NFI1-1	A 680
DO 1200 LJ=1,NRG	A 681
1200 PUBS(NOFE,LJ)=0.0	A 682
C FIND PEAK DISCHARGE	A 683
LJ=K1(NOFE)	A 684
LM=K2(NOFE)	A 685
JM=0.0	A 686
IF (OPT.EQ.1) GO TO 1240	A 687
DO 1230 K=LJ,LM	A 688
JJ=UD(K)	A 689
IF (Q3.LE.QMX) GO TO 1220	A 690
JMX=Q3	A 691
IJ=I4+(K-KIT)/NDELS	A 692
C NDATE IS USED FOR PRINTING OUT THE DATE OF STORM	A 693
DO 1210 K3=1,3	A 694
1210 NDATE(NOFE,K3)=NDATE(IJ,K3)	A 695
C IF FIRST TIME PERIOD OF STORM, SET UD(K)= BASEFLOW	A 696
1220 IF (O1.NE.0) GO TO 1230	A 697
JM=Q3	A 698
J1=1	A 699
1230 CONTINUE	A 700
C FIND RUNOFF VOLUME ABOVE BASEFLOW	A 701
C AND RAINFALL VOLUME	A 702
GO TO 1260	A 703
1240 DO 1250 K3=1,3	A 704
IJ=I4+(LJ-KIT)/NDELS	A 705
1250 NDATE(NOFE,K3)=NDATE(IJ,K3)	A 706
1260 DO 1290 L=LJ,LM	A 707
DO 1270 I=1,NRG	A 708
IC=NDAY*(I-1)+L	A 709
1270 PUBS(NOFE,I)=PUBS(NOFE,I)+UPR(I2)	A 710
IF (OPT.EQ.1) GO TO 1290	A 711
C CHECK UNIT DISCHARGE FOR VALUES LESS THAN BASEFLOW	A 712
C IF FOUND SET BASEFLOW TO MINIMUM UNIT DISCHARGE	A 713
IF (UD(L).GE.QR) GO TO 1280	A 714
JR=UD(L)	A 715
1280 SRV=SRV+UD(L)	A 716
1290 CONTINUE	A 717
C IF STORM VOLUMES FURNISHED GO TO 1300	A 718
IF (OPT.EQ.1) GO TO 1300	A 719
SRV=SRV-QR*(LM-LJ+1)	A 720
FVOL(NOFE)=SRV/I2CFSP	A 721
C FIND PEAK DISCHARGE ABOVE BASEFLOW	A 722
1300 FPK(NOFE)=QMX-QR	A 723
SFPK(NOFE)=0.0	A 724
IF (IPL(NOFE).EQ.0.OR.QR.EQ.0.0) GO TO 1320	A 725
DO 1310 K=LJ,LM	A 726
1310 UD(K)=UD(K)-JR	A 727
1320 NOFE=NOFE+1	A 728
JMX=0.0	A 729
SRV=0.0	A 730
O1=0	A 731
C CHECK FOR MORE STORMS IN SET OF EVENTS	A 732

IF (NFIL.GT.0) GO TO 1190	A 733
C CHECK TO SEE IF ALL EVENTS HAVE BEEN ANALYZED	A 734
IF (NUPD.GE.1) GO TO 1190	A 735
NOFE=NOFE-1	A 736
HEAD (5,2360) (KOUT(I),I=1,NOFE)	A 737
WHITE (6,2500) (KOUT(I),I=1,NOFE)	A 738
HEAD (5,2360) (TESTNO(I),I=1,NOFE)	A 739
HEAD (5,2360) (IHVD(I),I=1,NOFE)	A 740
WHITE (6,2380) (IHVD(I),I=1,NOFE)	A 741
IF (NK.EQ.0) GO TO 1340	A 742
WHITE (6,2370)	A 743
FMTB(1)=FMTA(3)	A 744
FMTB(2)=FMTA(1)	A 745
DO 1330 I=3,42	A 746
1330 FMTB(I)=FMTA(5)	A 747
FMTB(43)=FMTA(4)	A 748
1340 KNN=0	A 749
C OUTPUT FLOOD EVENTS TO BE USED IN OPTIMIZATION	A 750
DO 1350 I=1,NOFE	A 751
IF (TESTNO(I).NE.1) GO TO 1350	A 752
KNN=KNN+1	A 753
LJ=I+2	A 754
FMTB(LJ)=FMTA(2)	A 755
WHITE (6,FMTB) I	A 756
FMTB(LJ)=FMTA(5)	A 757
FMTB(2)=FMTA(6)	A 758
1350 CONTINUE	A 759
RITE=1	A 760
C END OF INITIAL PROGRAM SET-UP	A 761
1360 CONTINUE	A 762
C INITIALIZE	A 763
J1=0.0	A 764
J2=0.0	A 765
NU2=NOFE+NOFE	A 766
DO 1390 NRG1=1,NRG	A 767
DO 1370 I=1,NOFE	A 768
PIMP(I,NRG1)=0.0	A 769
1370 SFVOL(I)=0.0	A 770
DO 1380 I=1,NO2	A 771
1380 PSUM(I,NRG1)=0.0	A 772
1390 CONTINUE	A 773
I1=1	A 774
SMS=0.0	A 775
BMS=0.0	A 776
CHG=1	A 777
C ESTABLISH CURRENT INFILTRATION PARAMETER VALUES	A 778
PSP=X(1)	A 779
KSAT=X(2)/12.0	A 780
RGF=X(3)	A 781
BMSN=X(4)	A 782
EVC=X(5)	A 783
RH=X(6)	A 784
DMN24=X(7)*X(2)*24.0	A 785
IF (NPAR.EQ.1) GO TO 1400	A 786
PSP2=X(8)	A 787
KSAT2=X(9)/12.0	A 788
RGF2=X(10)	A 789
BMSN2=X(11)	A 790
EVC2=X(12)	A 791
RH2=X(13)	A 792
DMN242=X(14)*X(9)*24.0	A 793

	DRAIN2=DRN242/NDELS	A 794
	COEF2=(RGF2-1.0)/BMSN2	A 795
1400	KURAIN=DRN24/NDELS	A 796
	COEF=(RGF-1.0)/BMSN	A 797
C	INITIALIZE VARIABLES	A 798
	DO 1420 NP=1,NPAR	A 799
	DO 1410 I=1,VRG	A 800
	SMSB(I,NP)=0.0	A 801
1410	BMSB(I,NP)=0.0	A 802
1420	CONTINUE	A 803
	KP=1	A 804
	K=1	A 805
C	BEGIN SIMULATION	A 806
	KINIT=0	A 807
	IK=1	A 808
	NFD=0	A 809
	M=0	A 810
	DO 1920 IW=1,RUDYS	A 811
	M=M+1	A 812
	IF (M.GT.RUDYS) GO TO 1920	A 812A
C	FOR GAP IN RECORD, INITIALIZE SOIL MOISTURE TO ZERO	A 813
	IF (M.NE.INDP(KP)) GO TO 1450	A 814
	LJ=KP+1	A 815
	M=INDP(LJ)+1	A 816
	KP=KP+2	A 817
	BMS=0.0	A 818
	DO 1440 NP=1,NPAR	A 820
	DO 1430 LJ=1,NMG	A 821
	BMSB(LJ,NP)=0.0	A 822
1430	SMSB(LJ,NP)=0.0	A 823
1440	CONTINUE	A 824
1450	CONTINUE	A 825
	PW=RR*UP(M)	A 826
	IF (NPAR.EQ.2) PW2=RR2*UP(M)	A 827
	ETW=EVC*DE(M)	A 828
	IF (NPAR.EQ.2) ETW2=EVC2*DE(M)	A 829
	IF (PW.LT.0.0) GO TO 1720	A 830
C	IF FLAG=0, COMPUTE SIMULATED VOL. AND PEAK FLOW	A 831
C	IF FLAG=1, DO DAILY MOISTURE ACCOUNTING	A 832
	IF (FLAG.NE.0) GO TO 1700	A 833
C	SET-UP FOR ROUTING THE GENERATED EXCESS PRECIPITATION	A 834
	NFD1=0	A 835
	NFD=NFD+1	A 836
	KINIT=1	A 837
1460	IJ=1	A 838
	NL=100	A 839
	IF (I1.GT.NOFE) GO TO 1680	A 840
	ICT=0	A 841
	IF (IHYP(I1).EQ.0.OR.H3.EQ.0) GO TO 1500	A 842
	I4=0	A 843
	JJ=NF(I1)*(288/DELS)	A 844
	DO 1470 I=1,JJ	A 845
1470	WH(I)=0.0	A 846
1480	READ (5,2390) ICODE+JJJ,(X2(I),I=1,10)	A 847
	DO 1490 I=1,10	A 848
	WH(JJJ)=X2(I)	A 849
1490	JJJ=JJJ+1	A 850
	IF (ICODE.EQ.0) GO TO 1480	A 851
	I3=JJJ	A 852
1500	CONTINUE	A 853
	WMA=0.0	A 854

IF (B3.EQ.0.OR.KOUT(I1).EQ.0) KINIT=0	A 855
KH=0	A 856
IJKS=NFS(I1)	A 857
IJK=NFE(I1)	A 858
I12=I1+NOFE	A 859
C ROUTE EXCESS PPT. FOR A STORM	A 860
DO 1560 I=IJKS,IJK	A 861
IF (I.NE.IJKS.OR.NFD1.NE.0) GO TO 1510	A 862
IK=IK+IJKS/DELS	A 863
IF (DELS.EQ.1) IK=IK-1	A 864
1510 CONTINUE	A 865
KDY=I+1726	A 866
DO 1520 NRG1=1,NRG	A 867
PSUM(I1,NRG1)=PSUM(I1,NRG1)+P(I1,NRG1)	A 868
I2=NDAY*(NRG1-1)+IK	A 869
PIMP(I1,NRG1)=PIMP(I1,NRG1)+(UPR(I2)/DELS-IMPRT(I1,NRG1))	A 870
IF (NPAH.NE.1) PSUM(I12,NRG1)=PSUM(I12,NRG1)+P(KDY,NRG1)	A 871
C INDICATOR TO BEGIN ROUTING ONCE EXCESS PPT. OCCURS	A 872
1520 IF (P(I1,NRG1).NE.0.0) KH=1	A 873
C DO NOT ROUTE IF PAHAMETER ADJUSTMENT HAS NOT TERMINATED	A 874
C OR DETAILED OUTPUT NOT PRINTED FOR STORM	A 875
IF (B3.EQ.0) GO TO 1550	A 876
IF (KOUT(I1).EQ.0) GO TO 1550	A 877
IF (KH.EQ.0) GO TO 1550	A 878
C P(I1,I11)=EXCESS PPT. DURING 1 5-MIN. TIME PERIOD	A 879
C FROM I11 GAGE	A 880
DO 1530 NRG1=1,NRG	A 881
C ROUTE IF DISCHARGE FOR MOST DOWNSTREAM SEGMENT IS NOT 0	A 882
C OR IF EXCESS PPT. > 0	A 883
IF (QIND.NE.0.0.OR.P(I1,NRG1).NE.0.0) GO TO 1540	A 884
1530 CONTINUE	A 885
KH=0	A 886
ECOMP=ECOMP+5.0	A 887
T=T+5.0	A 888
GO TO 1650	A 889
1540 CONTINUE	A 890
IF (ICT.EQ.0.AND.IPL(I1).EQ.1) ADZ=(I-IJKS)/DELS	A 891
CALL ROUTE (23)	A 892
IF (QIND.GT.QMX) QMX=QIND	A 893
ECOMP=ECOMP+5.0	A 894
C DETERMINE WHETHER UN NOT AT END OF UNIT-TIME INTERVAL	A 895
1550 IJ=IJ+1	A 896
IF (IJ.EQ.DELESP) IK=IK+1	A 897
IF (IJ.EQ.DELESP) I4=0	A 898
IF (IJ.EQ.DELESP) IJ=1	A 899
1560 CONTINUE	A 900
IF (KOUT(I1).EQ.0.OR.B3.EQ.0) GO TO 1600	A 901
IF (NO8.EQ.0) GO TO 1580	A 902
DO 1570 JJ=1,NO8	A 903
K5=IRES(JJ)	A 904
1570 WRITE (6,2470) ISEG1(K5),SMAX(K5)	A 905
1580 IF (NO9.EQ.10) GO TO 1600	A 906
DO 1590 JJJ=1,NO9	A 907
K5=IRES(JJJ)	A 908
1590 WRITE (6,2470) ISEG1(K5),SMAX(K5)	A 909
1600 CONTINUE	A 910
IF (B3.EQ.0.OR.IPL(I1).EQ.0) GO TO 1630	A 911
WRITE (6,2510)	A 912
IX=Q(1)	A 913
IY=Q(ICT)	A 914
XMIN=IX	A 915

	AMAX=1Y+1.	A 916
	YMAX=QMX	A 917
	IF (QMX.LT.FPK(11)) YMAX=FPK(11)	A 918
	JJJ=YMAX/10	A 919
	YMAX=(JJJ+1.)*10.	A 920
C	IF PLOTTING ROUTINE NOT ACCEPTED BY COMPUTER	A 921
C	PULL OUT NEXT 11 STATEMENTS (A 923 THROUGH A 933)	A 922
	CALL PLOT2 (IMAGE,XMAX,XMIN,YMAX,0.0,6)	A 923
	CALL PLOT3 (IMC,Q,R,ICT)	A 924
	IF (OPT.EQ.1) GO TO 1620	A 925
	JJ=0	A 926
	LK=K1(11)+ADZ	A 927
	LJ=K2(11)	A 928
	DO 1610 KW=LK,LJ	A 929
	JJ=JJ+1	A 930
1610	K(JJ)=UB(KQ)	A 931
	CALL PLOT3 (IMD,Q,R,ICT)	A 932
1620	CALL PLOT4 (11,11MFLOW IN CFS)	A 933
1630	CONTINUE	A 934
C	INITIALIZE VARIABLES	A 935
C	COPY SIMULATED FLOOD VOLUME AND PEAK	A 936
C	FOR I-TH EVENT INTO STORAGE ARRAYS SFVOL AND SFPK.	A 937
	DO 1640 LK=1,NMG	A 938
	LJ=LK+3	A 939
1640	QCM=QCM+DIMP(LJ,1)*PSUM(11,LK)+DIMP(LK,1)*DIMP(11,LK)+DIMP(LJ,2)*P	A 940
	PSUM(112,LK)	A 941
	SFVOL(11)=QCM/(5280.0*5280.0*DA)	A 942
	QCM=0.0	A 943
	SFPK(11)=QMX	A 944
	IF (TESTNO(11).NE.1) GO TO 1660	A 945
	IF (SFVOL(11).EQ.0) GO TO 1650	A 946
	IF (FVOL(11).EQ.0.0) GO TO 1650	A 947
	J2=U2+ALOG(SFVOL(11)/FVOL(11))*2	A 948
1650	IF (QMX.EQ.0.) GO TO 1660	A 949
	IF (FPK(11).EQ.0.0) GO TO 1660	A 950
	J1=U1+ALOG(QMX/FPK(11))*2	A 951
1660	11=11+1	A 952
	NFD1=NFD1+1	A 953
C	IF HAVE ANALYZED ALL EVENTS OF SET OF EVENTS, GO TO 1680	A 954
	IF (NF(NFD).NE.NFD1) GO TO 1670	A 955
	IF (MOD(IK-1,NDELS).EQ.0) GO TO 1680	A 956
	KQ=(IK-1)/NDELS	A 957
	IK=(KQ+1)*NDELS+1	A 958
	GO TO 1680	A 959
1670	IJK=IJK+1	A 960
	IJKS=NFS(11)	A 961
C	IF NEXT STORM DOES NOT BEGIN IMMEDIATELY AFTER LAST	A 962
C	STORM, SET KINIT=1 SO SUBROUTINE INIT WILL BE CALLED	A 963
	IF (IJK.NE.IJKS) KINIT=1	A 964
	IK=IK+(IJKS-IJK)/DELS	A 965
	GO TO 1660	A 966
1680	NFD=NFD+NFD1-1	A 967
	IF (W.GT.MODYS) GO TO 1920	A 968
	FLAG=1	A 969
	CMG=1	A 970
	DO 1690 III=1,NRG	A 971
1690	IMPSTU(III)=0.0	A 972
C	DAILY MOISTURE ACCOUNTING	A 973
C	DETERMINE IF MOISTURE EXCESS OR DEFICIENCY OCCURS	A 974
1700	INC=PW-ETW	A 975
	IF (NPAW.EQ.2) INC2=PW2-ETW2	A 976

DU 1710 III=1,NMG	A 977
CALL DSM (SMSB(III,1),BMSB(III,1),INC,DWN24,BMSN)	A 978
IF (NPAR.EQ.2) CALL DSM (SMSB(III,2),BMSB(III,2),INC2,DWN242,BMSN2	A 979
1)	A 980
1710 CONTINUE	A 981
C FINISHED WITH DAY	A 982
GO TO 1920	A 983
C BEGIN UNIT-TIME SIMULATION	A 984
1720 FLAG=0	A 985
KTEMP=K	A 986
DU 1910 NP=1,NPAR	A 987
DRAIN=KBRAIN	A 988
IF (NP.EQ.2) DRAIN=BRAIN2	A 989
BMS=BMSN	A 990
IF (NP.EQ.2) BMS=BMSN2	A 991
K=KTEMP	A 992
IF (W.GT.MODY5) GO TO 1910	A 993
ETDEL=PEL*ETW	A 994
IF (NP.EQ.2) ETDEL=MDEL*ETW2	A 995
IF (NP.EQ.1) KINIT=KINIT+1	A 996
DU 1900 III=1,NMG	A 997
CMG=1	A 998
KDAY=200*(KINIT-1)+1	A 999
C COMPUTE SMS,BMS FOR AREAS FOR EACH RAIN GAGE, SOIL TYPE	A1000
SMS=SMSB(III,NP)	A1001
BMS=BMSB(III,NP)	A1002
KKK=K+(III-1)*NUPD*NDLS	A1003
K*DAY=KKK*NDLS-1	A1004
DU 1800 KK=KKK,K*DAY	A1005
IF (UPR(KK).LE.0.0) GO TO 1810	A1006
SRP=UPR(KK)/DEL5	A1007
SR=SRP*RAT(III,NP)	A1008
IF (CMG.NE.1) GO TO 1730	A1009
C BEGIN COMPUTATION OF INFILTRATION	A1010
C REDETERMINE PS AFTER BREAK IN RAINFALL	A1011
PS=PSP*(RGF-COEF*BMS)	A1012
IF (NP.EQ.2) PS=PSP2*(RGF2-COEF2*BMS)	A1013
CMG=0	A1014
1730 CONTINUE	A1015
C DEFINE 5-MIN. RAINFALL SUPPLY RATE	A1016
IF (SMS.LE.0.0) GO TO 1740	A1017
C IF SATURATED ZONE EXISTS	A1018
FR=KSAT*(1.0+PS/SMS)	A1019
IF (NP.EQ.2) FR=KSAT2*(1.0+PS/SMS)	A1020
GO TO 1750	A1021
C IF NO SATURATED ZONE EXISTS	A1022
1740 FR=KSAT*(1.0+PS/SR)	A1023
IF (NP.EQ.2) FR=KSAT2*(1.0+PS/SR)	A1024
C DETERMINE EXCESS PPT. IN UNIT TIME	A1025
1750 DU 1800 NKL=1,DEL5	A1026
IF (SR.GE.FR) GO TO 1760	A1027
QH=SR**2/(2.0*FR)	A1028
GO TO 1770	A1029
C PONDED CONDITION	A1030
1760 QH=SR-FR/2.0	A1031
1770 SMS=SMS+SH-QH	A1032
C KDAY IS 5-MIN. INTERVAL IN A DETAILED STORM	A1033
KDY=KDAY	A1034
IF (NP.EQ.2) KDY=KDY+1720	A1035
P(KDY,III)=QH	A1036
IF (NP.EQ.2) GO TO 1790	A1037

C	CALCULATE 5-MIN ADDITIONS TO IMPERVIOUS RETENTION	A1038
	IF (IMPSTU(III).EQ.IMP) GO TO 1780	A1039
	IMPSTT=IMPSTU(III)+SRP	A1040
	IF (IMPSTT.GT.IMP) IMPSTT=IMP	A1041
	IMPRET(KDY,III)=IMPSTT-IMPSTU(III)	A1042
	IMPSTU(III)=IMPSTT	A1043
	GO TO 1790	A1044
1780	IMPRET(KDY,III)=0.0	A1045
1790	CONTINUE	A1046
	KDAY=KDAY+1	A1047
C	SMS= NEW MOISTURE CONTENT OF SATURATED ZONE	A1048
	FM=KSAT*(1.0+PS/SMS)	A1049
1800	IF (NP.EQ.2) FM=KSAT2*(1.0+PS/SMS)	A1050
	GO TO 1880	A1051
C	DEPLETION OF SOIL MOISTURE BY ET DURING UNIT-TIME	A1052
C	INTERVALS OF NO PPT.	A1053
1810	CONTINUE	A1054
	IF (SMS.LE.ETDEL) GO TO 1820	A1055
	SMS=SMS-ETDEL	A1056
	GO TO 1830	A1057
1820	BMS=BMS+SMS-ETDEL	A1058
	SMS=0.0	A1059
C	CHECK FOR COMPLETE SOIL DRYING	A1060
	IF (BMS.LE.0.0) BMS=0.0	A1061
C	REDISTRIBUTION OF SOIL MOISTURE WITH FLOW FROM	A1062
C	SATURATED TO UNSATURATED ZONE	A1063
1830	IF (SMS.LE.DRAIN) GO TO 1840	A1064
	SMS=SMS-DRAIN	A1065
	BMS=BMS+DRAIN	A1066
C	BMS= NEW SOIL MOISTURE CONTENT OF UNSATURATED ZONE	A1067
	GO TO 1850	A1068
1840	BMS=BMS+SMS	A1069
	SMS=0.0	A1070
C	DRAINAGE TO LOWER LYING ZONE	A1071
1850	IF (BMS.GT.BMST) BMS=BMST	A1072
C	BREAK IN UNIT RAINFALL	A1073
	CHG=1	A1074
C	NO EXCESS PRECIPITATION	A1075
C	REMEMBER KDAY IS 5-MIN. INTERVAL IN A DETAILED STORM	A1076
	DO 1870 NKL=1,DELS	A1077
	KDY=KDAY	A1078
	IF (NP.EQ.2) KDY=KDY+1728	A1079
	P(KDY,III)=0.0	A1080
	IF (NP.EQ.2) GO TO 1860	A1081
C	CALCULATE 5-MIN EVAPORATION FROM IMPERVIOUS RETENTION	A1082
	IMPSTU(III)=IMPSTU(III)-ETDEL/DELS	A1083
	IF (IMPSTU(III).LT.0.0) IMPSTU(III)=0.0	A1084
	IMPRET(KDY,III)=0.0	A1085
1860	CONTINUE	A1086
1870	KDAY=KDAY+1	A1087
C	1880 ENDS RAIN GAGE III FOR UNIT-RAINFALL DAY	A1088
1880	CONTINUE	A1089
	IF (III.NE.NMG) GO TO 1890	A1090
	K=N+NDELS	A1091
C	COMPUTE SMS AND BMS FOR AREAS COVERED BY EACH RAIN GAGE	A1092
1890	SMSB(III,NP)=SMS	A1093
	BMSB(III,NP)=BMS	A1094
C	1910 ENDS UNIT-RAINFALL DAY	A1095
1900	CONTINUE	A1096
1910	CONTINUE	A1097
C	1920 ENDS ALL DAYS, W=1, MODYS	A1098

1920	CONTINUE	A1099
	U(1)=U1	A1100
	U(2)=U2	A1101
	U(3)=U1+0.5*U2	A1102
C	* WRITE ROUTINE *	A1103
C		A1104
	IF (RITE.NE.1) GO TO 1980	A1105
	IF (KNN.EQ.0) GO TO 1950	A1106
	UNN1=EXP(SQRT(U(NN)/KNN))	A1107
	UNN2=1.0/UNN1	A1108
	IF (B3.NE.1) GO TO 1930	A1109
	WRITE (6,2400)	A1110
	GO TO 1940	A1111
1930	WRITE (6,2410)	A1112
1940	WRITE (6,2420) U(NN),UNN1,UNN2,(X(I),I=1,EO)	A1113
1950	WRITE (6,2510)	A1114
	DO 1970 I=1,NOFE	A1115
	WRITE (6,2430) I,FPK(I),SFPK(I)	A1116
	WRITE (6,2440) (III,POBS(I,III),III=1,NNG)	A1117
	VR=999.0	A1118
	IF (FVOL(I).EQ.0.0.OR.SFVOL(I).EQ.0.0) GO TO 1960	A1119
	VR=ALOG(FVOL(I)/SFVOL(I))*2	A1120
1960	CONTINUE	A1121
	WRITE (6,2450) FVOL(I),SFVOL(I)	A1122
	IF (TESTNO(I).EQ.0) GO TO 1970	A1123
	WRITE (6,2460) VR	A1124
1970	CONTINUE	A1125
	RITE=0	A1126
1980	IF (B3.EQ.0) GO TO 590	A1127
	STOP	A1128
C		A1129
1990	FORMAT (1H ,39HEHRROR IN SEGMENT DATA FOR TYPE 15 OR 16)	A1130
2000	FORMAT (12F5.3)	A1131
2010	FORMAT (1H ,1X,36HDAILY IRRIGATION LOADS IN INCHES ARE/1H ,2X,4HJA	A1132
	1N.,2X,4HFEB.,1X,5HMARCH,1X,5HAPRIL,3X,3HMay,2X,4HJUNE,2X,4HJULY,2X	A1133
	2,4HAUG.,1X,5HSEPT.,2X,4HOCT.,2X,4HNOV.,2X,4HDEC./1H ,12(1X,F5.3))	A1134
2020	FORMAT (A4,2I1)	A1135
2030	FORMAT (2I4,1I,F6.2)	A1136
2040	FORMAT (2A4,50A1,F6.2)	A1137
2050	FORMAT (2A4,50A1,F6.0)	A1138
2060	FORMAT (20X,3I3,3X,3I3)	A1139
2070	FORMAT (1M0,22MDISCHARGE STATION ,2A4,50A1/1H ,20HUNIT PRECIP.	A1140
	1 STATION,2X,2A4,50A1/1H ,22HDAILY PRECIP. STATION ,2A4,50A1/1H ,18	A1141
	2HPAN-EVAPU. STATION,4X,2A4,50A1/1H ,14HDRAINAGE AREA=F6.2,8H SQ.	A1142
	9M1./1H ,16HUNIT DATA ARE IN,F9.3,18H MINUTE INCREMENTS/1H ,29HTHE	A1143
	PERIOD OF RECORD IS FROM ,12,1M-,12,1M-,12,6H (DAY=,17,5H) TO ,12,	A1144
	51M-,12,1M-,12,6H (DAY=,17,1H))	A1145
2080	FORMAT (2A4,5I2,12F5.0,12)	A1146
2090	FORMAT (1H ,2A4,5I3,12F6.2,13)	A1147
2100	FORMAT (2A4,2I2,1I,16F4.2,2X,1I)	A1148
2110	FORMAT (1H ,2A4,2I3,12,16(1X,F4.2),13)	A1149
2120	FORMAT (10X,A8,5X,A8,5X,18,5X,18,5X,1I)	A1150
2130	FORMAT (2X,20HEHRROR IN UNIT DATA--,3I6)	A1151
2140	FORMAT (3I4,F8.0)	A1152
2150	FORMAT (3F10.0)	A1153
2160	FORMAT (1H ,27HBOUNDARY CHECK OF PARAMETER,13,3F10.3)	A1154
2170	FORMAT (1H1,24HINITIAL PARAMETER VALUES/)	A1155
2180	FORMAT (///1H ,20HINITIAL STEP SIZE INCREMENTS/)	A1156
2190	FORMAT (1X,10F12.6)	A1157
2200	FORMAT (1H //1H ,31HTHE MAX. NUMBER OF ITERATIONS= ,14//1H ,58HINI	A1158
	TIALLY AND AFTER EACH VECTOR MATRIX ORTHONORMALIZATION,/1H ,40HTHE	A1159

2	PARAMETRIC VECTOR (INCREMENT SIZE IS,F7.3,19H OF THE VECTOR SIZE/)	A1160
2210	FORMAT (1H0,16HAT ITEHATION NO.,I3,20H OBJECTIVE FUNCTION=,F11.6)	A1161
2220	FORMAT (1H ,20HPARAMETER VALUES ARE)	A1162
2230	FORMAT (1H ,7F12.6/1H ,7F12.6)	A1163
2240	FORMAT (1H ,4HB1 =,F9.6,3X,4HB2 =,F9.6)	A1164
2250	FORMAT (1H ,24HNEW ORTHONORMAL BASIS)	A1165
2260	FORMAT (1H ,16F8.5)	A1166
2270	FORMAT (1H ,35HSTART OF STAGE STEP SIZE INCREMENTS/1H ,13F10.6)	A1167
2280	FORMAT (15,2F5.0,15,F5.0)	A1168
2290	FORMAT (17,47X,20HNUMBER OF SEGMENTS =,15/50X,4HUT =,F7.3,8H MINUTE	A1169
	15/40X,20HOUTPUT SAMPLING INTERVAL =,F6.2,8H MINUTES/40X,22HNUMBER	A1170
	20H MAIN GAGES =,12/46X,26HNUMBER OF PARAMETER SETS =,12/43X,22HIMP	A1171
	3EHVIOUS RETENTION =,F4.2,7H INCHES)	A1172
2300	FORMAT (17,60X,6HLENGTH,9X,9HROUGHNESS,19X,21HTHIESSEN COEFFICIENTS	A1173
	1/8H SEGMENT,1X,17HUPSTREAM SEGMENTS,3X,17HADJACENT SEGMENTS,1X,4H	A1174
	2TYPE,1X,3H1PR,1X,3HNDX,1X,6H(FEET),3X,6HSLUPE,1X,9HPARAMETER,1X,16H	A1175
	3UTHER PARAMETERS,14,4(1X,14))	A1176
2310	FORMAT (1H ,40HROUTING INTERVAL FOR DETENTION RESERVOIR,I3,42H IS	A1177
	1100 LARGE, REDUCE TO A VALUE LESS THAN,F6.3)	A1178
2320	FORMAT (1H0,9X,18HRESERVOIR SEGMENT ,A4)	A1179
2330	FORMAT (1H0,5X,7HOUTFLOW,5X,7HSTORAGE,5X,10HS2/UT+U2/2,/(1X,3(F9.	A1180
	12,4X)))	A1181
2340	FORMAT (8A4,3I2,5F5.0,I2,3F5.0)	A1182
2350	FORMAT (2X,A4,3X,3(1X,A4),3X,4(1X,A4),I3,2I4,F8.0,F8.4,F8.3,2F9.3,	A1183
	1I2,5F5.0)	A1184
2360	FORMAT (40I2)	A1185
2370	FORMAT (1H ,47HTHE FLOOD EVENTS IN THE OBJECTIVE FUNCTION ARE)	A1186
2380	FORMAT (1H ,29HINPUT HYDROGRAPHS FOR STORMS ,30I3)	A1187
2390	FORMAT (12,I3,10F5.3)	A1188
2400	FORMAT (1H0,11X,44HEND OF RUN--RESULTS OF LAST SUCCESSFUL TRIAL)	A1189
2410	FORMAT (1H1,50X,18HBEGINNING OF STAGE)	A1190
2420	FORMAT (1H ,20HOBJECTIVE FUNCTION =,E14.7,34H WHICH IS A ROOT MEAN	A1191
	1 SQUARE ERROR,E9.3,4H TO,F9.3/1H ,20HPARAMETER VALUES ARE/1H ,7F1	A1192
	22.6/1H ,7F12.6)	A1193
2430	FORMAT (1H0,36HDETAILED DISCHARGE FOR FLOOD NUMBER ,12/1H ,25HOBSE	A1194
	1HVED PEAK DISCHARGE =,F9.2,4H CFS/1H ,26HSIMULATED PEAK DISCHARGE	A1195
	2=,F9.2,4H CFS)	A1196
2440	FORMAT (1H ,31HOBSEVED RAINFALL GAGE NUMBER,3(I3,3H = ,F9.3,7H	A1197
	1INCHES))	A1198
2450	FORMAT (1H ,24HOBSEVED DIRECT RUNOFF =,F9.3,7H INCHES/1H ,25HSIMU	A1199
	1LATED DIRECT RUNOFF =,F9.3,7H INCHES)	A1200
2460	FORMAT (1H ,35HCONTRIBUTION TO OBJECTIVE FUNCTION=,E10.3)	A1201
2470	FORMAT (1H0,40HMAXIMUM STORAGE IN DETENTION RESERVOIR ,A4,4H WAS,	A1202
	1F8.3,10H CFS-HOURS)	A1203
2480	FORMAT (1H ,9HTHERE ARE,14,31H FLOOD PEAKS GROUPEO AS FOLLOWS,10I6	A1204
	1/3(44X,10I6/))	A1205
2490	FORMAT (1H ,9HSTORM NO.,I3,22H STARTS AT TIME PERIOD,I5,12H AND EN	A1206
	1DS AT,I6)	A1207
2500	FORMAT (1H0,27HDETAILED OUTPUT FOR STORMS ,30I3)	A1208
2510	FORMAT (1H1)	A1209
	END	A1210-
	SUBROUTINE ROUTE (B3)	B 1
C	ROUTING ROUTINE BASED ON SCHAAKE KINEMATIC WAVE MODEL	B 2
	INTEGER B3,DELS,MOUT	B 3
	DIMENSION QOUT(50)	B 4
	COMMON /C1/ NSEG,ISEG(50),JUP(50,3),NPAH,KPSET(50)	B 5
	COMMON /C2/ NL,NPAGE	B 6
	COMMON /C3/ IPRNT,T,AN(50,11),FLGTH(50),KSEG(50),NDX(50),Q1(50),Q2	B 7
	1(50),QSUM(50),QSUML(50),STU(50)	B 8
	COMMON /C4/ DELS,MAXL,QCW,QLAT,ILAT(50,4),ITEST(50),ITYPE(50),JLAT	B 9
	1(50,4),JUP(50,3),P(3456,3),PAHAM(50,2),RCUEF(50,3),UPH(1200)	B 10

	COMMON /C6/ DT,DT5,QUP,DX(50)	B	11
	COMMON /C7/ ECOMP,I,KINIT,NOUT,NHG,OSI,JOUT(50),QIND,NAT(J,2)	B	12
	COMMON /C8/ I2,I1,IK,THYCT,KOUT(60),SEG(50)	B	13
	COMMON /F1/ ICT,I(172B),H(172B),IPL(60)	B	14
C	IF AT BEGINNING OF STORM, INITIALIZE CATCHMENT	B	15
	IF (KINIT.NE.1) GO TO 10	B	16
	MAXL=55	B	17
	CALL INIT	B	18
	NL=100	B	19
C	COMPUTE OUTFLOW HYDROGRAPHS FOR EACH SEGMENT	B	20
	10 CALL FLOW	B	21
	20 IF (IPRNT*OSI-T) 40,40,30	B	22
	30 IF (T-ECOMP) 10,90,90	B	23
	40 TOUT=IPRNT*OSI	B	24
	B=(TOUT-(T-DT))/DT	B	25
	DO 50 J=1,NOUT	B	26
	K=JOUT(J)	B	27
	QUOUT(J)=Q1(K)+(Q2(K)-Q1(K))*B	B	28
	50 IF (K.EQ.KSEG(NSEG)) QIND=QUOUT(J)	B	29
	IF (NL-MAXL+3) 70,70,60	B	30
	60 CALL PAGE	B	31
	WRITE (6,100) 11,(SEG(J),J=1,NOUT)	B	32
	70 NL=NL+(NOUT-1)/10+1	B	33
	MOUT=1/288	B	34
	MOUT=MOUT*288	B	35
	TOUT=((1-MOUT)*5.)/60.	B	36
	WRITE (6,110) TOUT,I,(QUOUT(J),J=1,NOUT)	B	37
	IF (IPL(11).NE.1) GO TO 80	B	38
	ICT=ICT+1	B	39
	IRV=1/288	B	40
	Q(ICT)=TOUT+IRV*24.0	B	41
	R(ICT)=QIND	B	42
	80 CONTINUE	B	43
	IPRNT=IPRNT+1	B	44
	GO TO 20	B	45
	90 CONTINUE	B	46
	RETURN	B	47
C		B	48
	100 FORMAT (8X,12HFLOOD NUMBER,13//7X,4HTIME,9X,1H1,6X,32HOUTFLOW HYDR	B	49
	8UGRAPHS (IN CFS) /7X,5H ,10X,10(6X,A4)/(19X,A4,9(6X,A4))	B	50
	110 FORMAT (6X,F7.2,2X,I5,2X,10F10.3/(22X,10F10.3))	B	51
	END	B	52-
	SUBROUTINE DSM (SMS,BMS,INC,DRN24,BMSN)	C	1
C	THIS SUBROUTINE DOES SOIL MOISTURE ACCOUNTING	C	2
C	ON DAYS OF DAILY RAINFALL. IT ADDS DAILY RAINFALL TO SMS,	C	3
C	SUBTRACTS ET FROM SMS ON (IF SMS=0) FROM BMS, AND	C	4
C	DRAINS SMS DOWNWARD TO BMS	C	5
	REAL SMS,BMS,DRN24,INC,BMSN	C	6
	IF (INC.LE.0.0) GO TO 10	C	7
C	ADD EXCESS MOISTURE TO SATURATED ZONE	C	8
	SMS=SMS+INC	C	9
	GO TO 30	C	10
C	DEDUCT MOISTURE DEFICIENCY FROM SATURATED ZONE	C	11
	10 IF ((SMS+INC).GE.0.0) GO TO 20	C	12
C	EVAPOTRANSPIRATION FROM UNSATURATED ZONE	C	13
	BMS=BMS+SMS+INC	C	14
	SMS=0.0	C	15
C	CHECK FOR COMPLETE SOIL DRYING	C	16
	IF (BMS.LT.0.0) BMS=0.0	C	17
	GO TO 30	C	18
C	EVAPOTRANSPIRATION FROM SATURATED ZONE	C	19

20 SMS=SMS+INC	C 20
C REDISTRIBUTION OF SOIL MOISTURE WITH FLOW FROM	C 21
C SATURATED TO UNSATURATED ZONE	C 22
30 IF (SMS.LE.DMN24) GO TO 40	C 23
C MOISTURE IN SATURATED ZONE ABOVE FIELD CAPACITY	C 24
SMS=SMS-DMN24	C 25
BMS=BMS-DMN24	C 26
GO TO 50	C 27
C SATURATED ZONE COMPLETELY DEPLETED	C 28
40 BMS=BMS+SMS	C 29
C BMS= NEW MOISTURE CONTENT OF UNSATURATED ZONE	C 30
SMS=0.0	C 31
C DRAINAGE TO DEEPER LYING ZONE	C 32
50 IF (BMS.GT.BMSN) BMS=BMSN	C 33
RETURN	C 34
END	C 35-
SUBROUTINE FLOW	D 1
C THIS SUBROUTINE COMPUTES SEGMENT OUTFLOWS AT T+DT	D 2
REAL ISEG,IUP,ILAT	D 3
REAL IN1,IN2	D 4
INTEGER DELS	D 5
DIMENSION XA(11), XQ(11)	D 6
COMMON /C1/ NSEG,ISEG(50),IUP(50,3),NPAR,KPSET(50)	D 7
COMMON /C3/ IPRT,T,AR(50,11),FLGTH(50),KSEG(50),NDX(50),Q1(50),Q2	D 8
(50),QSUM(50),QSUML(50),STU(50)	D 9
COMMON /C4/ DELS,MAXL,QCW,JLAT,ILAT(50,4),ITEST(50),ITYPE(50),JLAT	D 10
(50,4),JUP(50,3),P(1755,3),PAHAM(50,2),RCOEF(50,3),UPR(4000)	D 11
COMMON /C5/ ALPHA(50),EM(50),FRN(50),QMAX(50),SLOPE(50)	D 12
COMMON /C6/ DT,UTS,QUP,DX(50)	D 13
COMMON /C7/ ECOMP,I,KINIT,NOUT,NRG,OSI,JOUT(50),QIND,NAT(3,2)	D 14
COMMON /C8/ I2,I1,IK,TRYCT,KOUT(60),SEG(50)	D 15
COMMON /C9/ I3,I4,QIH(400),PTIME,IMYD(60),IJ,IP	D 16
COMMON /E2/ SMAX(50),IN2(50),IN1(50),S202(50)	D 17
COMMON /E3/ DELTAT,NOB,US(50,11)	D 18
T=T+DT	D 19
DO 140 NSG=1,NSG	D 20
K=KSEG(NSG)	D 21
IF (ITYPE(K).GE.7) GO TO 40	D 22
N=NDX(K)+1	D 23
ALP=ALPHA(K)	D 24
UTSX=UTS/UX(K)	D 25
YEM=EM(K)-1.	D 26
YEM=EM(K)	D 27
CALL UP (K)	D 28
CALL LAT (K)	D 29
J1(K)=Q2(K)	D 30
ALAT=QLAT*UTS	D 31
XQ(1)=QUP	D 32
XA(1)=(QUP/ALP)**(1./YEM)	D 33
DO 20 J=2,N	D 34
IF (AR(K,J).LE.0.) GO TO 10	D 35
THETA=UTSX*YEM*US(K,J)/AR(K,J)	D 36
IF (THETA.LT.1) GO TO 10	D 37
XQ(J)=XQ(J-1)+(ALAT+AR(K,J-1)-XA(J-1))/UTSX	D 38
XA(J)=(XQ(J)/ALP)	D 39
IF (XA(J).LT.0.) XA(J)=0.0	D 40
IF (YEM.NE.1.) XA(J)=XA(J)**(1./YEM)	D 41
GO TO 20	D 42
10 XA(J)=AR(K,J)+ALAT+UTSX*(QS(K,J-1)-QS(K,J))	D 43
IF (XA(J).LT.0.0) XA(J)=0.0	D 44
XQ(J)=ALP*XA(J)	D 45

	IF (YEM.NE.1.) XQ(J)=ALP*(XA(J)**YEM)	D	46
20	CONTINUE	D	47
	DO 30 J=1,N	D	48
	AM(K,J)=XA(J)	D	49
	US(K,J)=XQ(J)	D	50
30	CONTINUE	D	51
	Q2(K)=XQ(N)	D	52
	GO TO 140	D	53
40	CALL UP (K)	D	54
	Q1(K)=Q2(K)	D	55
	IF (ITYPE(K)-8) 60,50,60	D	56
50	CALL PULS (K)	D	57
	GO TO 140	D	58
60	IF (ITYPE(K)-9) 90,70,90	D	59
70	IN1(K)=IN2(K)	D	60
	IN2(K)=QUP	D	61
	AVIN=(IN1(K)+IN2(K))/2.	D	62
	STO(K)=STU(K)+AVIN*DELTAT	D	63
	Q2(K)=STO(K)/PARAM(K,1)	D	64
	STO(K)=STO(K)-Q2(K)*DELTAT	D	65
	IF (STO(K).LT.SMAX(K)) GO TO 80	D	66
	SMAX(K)=STO(K)	D	67
80	GO TO 140	D	68
90	IF (ITYPE(K)-10) 130,100,130	D	69
100	IF (IMYD(I1).EQ.0.OR.IP.GT.I3) GO TO 120	D	70
	I4=I4+1	D	71
	IP=(I+DELS-IJ)/DELS	D	72
	IF (IP.NE.1) GO TO 110	D	73
	Q2(K)=(DT/P TIME)*I4*(QIH(IP)-0.0)	D	74
	GO TO 140	D	75
110	Q2(K)=(DT/P TIME)*I4*(QIH(IP)-QIH(IP-1))*QI4(IP-1)	D	76
	GO TO 140	D	77
120	Q2(K)=0.0	D	78
	GO TO 140	D	79
130	Q2(K)=QUP	D	80
140	CONTINUE	D	81
	RETURN	D	82
	END	D	83-
	SUBROUTINE LAT (K)	E	1
C	THIS SUBROUTINE COMPUTES LATERAL INFLOW FROM OVERLAND	E	2
C	FLOW SEGMENTS OR FROM RAINFALL	E	3
	INTEGER DELS	E	4
	REAL ISEG,IUP,ILAT	E	5
	COMMON /C1/ NSEG,ISEG(50),IUP(50,3),NPAR,K=SET(50)	E	6
	COMMON /C3/ IPHNT,T,AM(50,11),FLGTH(50),KSEG(50),NDX(50),Q1(50),Q2	E	7
	1(50),QSUM(50),QSUM1(50),STU(50)	E	8
	COMMON /C4/ DELS,MAXL,QCN,QLAT,ILAT(50,4),ITEST(50),ITYPE(50),JLAT	E	9
	1(50,4),JUP(50,3),P(3456,3),PARAM(50,2),RCOE(50,3),UPR(7200)	E	10
	COMMON /C6/ DT,DTS,QUP,DX(50)	E	11
	COMMON /C7/ ECUMP,I,KINIT,NOUT,NRG,OSI,JOUT(50),QIND,RAT(3,2)	E	12
	COMMON /C8/ I2,I1,IK,TRYCT,KOUT(60),SEG(50)	E	13
	REAL IMPRET,IMPSTO	E	14
	COMMON /E1/ IMPHET(1728,3),IMPSTO(3)	E	15
C	COMPUTE LAT. INFLOW RATE FROM OVERLAND FLOW TO SEGMENT K	E	16
	QLAT=0.	E	17
	IF (ITYPE(K)-5) 10,50,10	E	18
10	IF (ITYPE(K)-6) 20,50,20	E	19
20	QPR=QSUM1(K)	E	20
	DO 40 J=1,4	E	21
	IF (JLAT(K,J)) 40,40,30	E	22
30	JJ=JLAT(K,J)	E	

	JLAT=QLAT+Q2(JJ)	E 24
40	CONTINUE	E 25
	WSJML(K)=QLAT	E 26
	QLAT=(QLAT+QPR)/2.	E 27
	RETURN	E 28
C	COMPUTE LATERAL INFLOW RATE FROM RAIN	E 29
50	EP=0.0	E 30
	AP=0.0	E 31
	TPAR1=PARAM(K,1)	E 32
	TPAR2=PARAM(K,2)	E 33
	IF (TPAR1.LT.0.0) TPAR1=0.0	E 34
	IF (TPAR2.LT.0.0) TPAR2=0.0	E 35
	IPAR=1	E 36
	IF (KPSET(K).EQ.2) IPAR=IPAR+1728	E 37
	DO 60 III=1,NRG	E 38
	EP=EP+(RCOEF(K,III)*P(IPAR,III))/5.0	E 39
60	AP=AP+(RCOEF(K,III)*(UPR(I2)/DELS-IMPRET(I,III)))/5.0	E 40
	QLAT=(TPAR2*AP+TPAR1*EP)/720.0	E 41
C	THE CONSTANT 720 CONVERTS SQFT-IN/MINUTE TO CFS	E 42
	WSJML(K)=QLAT	E 43
	RETURN	E 44
	END	E 45-
	SUBROUTINE UP (K)	F 1
C	THIS SUBROUTINE COMPUTES UPSTREAM INFLOW TO SEGMENT K	F 2
	INTEGER DELS	F 3
	REAL ILAT	F 4
	COMMON /C3/ IPRNT,T,AN(50,11),FLGTH(50),KSEG(50),NDX(50),Q1(50),Q2	F 5
	1(50),WSUM(50),WSJML(50),STO(50)	F 6
	COMMON /C4/ DELS,MAXL,QC#,QLAT,ILAT(50,4),ITEST(50),ITYPE(50),JLAT	F 7
	1(50,4),JUP(50,3),P(3456,3),PARAM(50,2),RCOEF(50,3),UPR(7200)	F 8
	COMMON /C5/ ALPHA(50),EM(50),FRN(50),QMAX(50),SLOPE(50)	F 9
	COMMON /C6/ DT,DTS,QUP,DX(50)	F 10
	QUP=0.	F 11
	QPR=QSUM(K)	F 12
	DO 20 J=1,3	F 13
	IF (JUP(K,J)) 20,20,10	F 14
10	JJ=JUP(K,J)	F 15
	QUP=QUP+Q2(JJ)	F 16
20	CONTINUE	F 17
	WSUM(K)=QUP	F 18
	IF (ITYPE(K).EQ.8.OR.ITYPE(K).EQ.9) GO TO 130	F 19
	IF (QUP-QMAX(K)) 80,80,30	F 20
30	IF (QPR-QMAX(K)) 40,70,70	F 21
40	PDT=(QUP-QMAX(K))/(QUP-QPR)	F 22
	STO(K)=STO(K)-(DTS*(QMAX(K)-QPR)/2.0)*(1.0-PDT)	F 23
	IF (STO(K)) 50,60,60	F 24
50	STO(K)=0.	F 25
60	STO(K)=STO(K)+(DTS*(QUP-QMAX(K))/2.0)*PDT	F 26
	QUP=QMAX(K)	F 27
	RETURN	F 28
70	STO(K)=STO(K)+(((QPR+QUP)/2.0)-QMAX(K))*DTS	F 29
	QUP=QMAX(K)	F 30
	RETURN	F 31
80	IF (QPR-QMAX(K)) 90,90,110	F 32
90	IF (STO(K)) 120,120,100	F 33
100	STO(K)=STO(K)-(QMAX(K)-((QPR+QUP)/2.0))*DTS	F 34
	IF (STO(K)) 120,140,140	F 35
110	PDT=(QPR-QMAX(K))/(QPR-QJP)	F 36
	STO(K)=STO(K)+((QPR-QMAX(K))*PDT*DTS/2.0)-((QMAX(K)-QJP)*(1.0-PDT)	F 37
	1*DTS/2.0)	F 38
	IF (STO(K)) 120,140,140	F 39

120	SFO(K)=0.	F	40
130	CONTINUE	F	41
	RETURN	F	42
140	JUP=QMAX(K)	F	43
	RETURN	F	44
	END	F	45-
	SUBROUTINE SEQ (DA,DIMP)	G	1
C	THIS SUBROUTINE SETS UP COMPUTATIONAL SEQUENCE	G	2
	REAL ISEG,IUP,ILAT	G	3
	REAL DIMP(9,2)	G	4
	INTEGER DEL5	G	5
	COMMON /C1/ NSEG,ISEG(50),IUP(50,3),NPAR,KPSET(50)	G	6
	COMMON /C2/ NL,NPAGE	G	7
	COMMON /C3/ IPHNT,T,AR(50,11),FLGT4(50),KSEG(50),NDX(50),Q1(50),Q2	G	8
	1(50),QSUM(50),QSUML(50),STU(50)	G	9
	COMMON /C4/ DEL5,MAXL,QCH,QLAT,ILAT(50,4),ITEST(50),ITYPE(50),JLAT	G	10
	1(50,4),JUP(50,3),P(3456,3),PAHAM(50,2),HCOEF(50,3),UPR(7200)	G	11
	COMMON /C5/ ALPHA(50),EM(50),FRN(50),QMAX(50),SLOPE(50)	G	12
C	NUMBER CONTRIBUTING SEGMENTS (IUP,ILAT) USING SUBROUTINE	G	13
C	ITRAN WHICH GIVES THE CONTRIBUTING SEGMENTS THE SAME	G	14
C	NUMBER AS THE ORDER OF THE SEGMENTS (I.E., I)	G	15
	DO 20 I=1,NSEG	G	16
	ITEST(I)=0	G	17
	DO 10 J=1,3	G	18
	X=IUP(I,J)	G	19
	JUP(I,J)=ITRAN(X)	G	20
10	CONTINUE	G	21
	DO 20 J=1,4	G	22
	X=ILAT(I,J)	G	23
	JLAT(I,J)=ITRAN(X)	G	24
20	CONTINUE	G	25
	II=0	G	26
C	ORDER OVERLAND FLOW SEGMENTS FIRST	G	27
	DO 80 I=1,NSEG	G	28
	IF (ITYPE(I).EQ.10) GO TO 40	G	29
	IF (ITYPE(I)-5) 30,40,30	G	30
30	IF (ITYPE(I)-6) 80,40,80	G	31
40	N=0	G	32
	DO 60 J=1,3	G	33
	IF (JUP(I,J)) 60,60,50	G	34
50	N=1	G	35
60	CONTINUE	G	36
	IF (N) 70,70,80	G	37
70	II=II+1	G	38
	KSEG(II)=I	G	39
	ITEST(I)=1	G	40
80	CONTINUE	G	41
	VONCH=II	G	42
C	CHECK EACH SEGMENT TO SEE IF IT HAS BEEN SEQUENCED	G	43
	I=1	G	44
	NIT=0	G	45
90	IF (ITEST(I)) 130,130,100	G	46
100	I=I+1	G	47
C	CHECK IF SEGMENT SEQUENCING IS COMPLETED AND FOR ERRORS	G	48
	IF (I-NSEG) 90,90,110	G	49
110	I=1	G	50
	NIT=NIT+1	G	51
	IF (NIT-3*NSEG) 120,120,350	G	52
120	IF (II-NSEG) 90,210,210	G	53
130	N=0	G	54
C	CHECK SEGMENT FOR UPSTREAM SEGMENTS WHICH HAVE NOT	G	55

C	BEEN SEQUENCED YET	G	56
	DO 160 J=1,3	G	57
	IF (JUP(I,J)) 160,160,140	G	58
140	K=JUP(I,J)	G	59
	IF (ITEST(K)) 150,150,160	G	60
150	N=1	G	61
160	CONTINUE	G	62
C	CHECK SEGMENT FOR ANY LATERAL INFLOW SEGMENTS WHICH	G	63
C	HAVE NOT BEEN SEQUENCED YET	G	64
	DO 190 J=1,4	G	65
	IF (JLAT(I,J)) 190,190,170	G	66
170	K=JLAT(I,J)	G	67
	IF (ITEST(K)) 180,180,190	G	68
180	N=1	G	69
190	CONTINUE	G	70
C	IF SEGMENT HAS NO UNSEQUENCED UPSTREAM OR LATERAL INFLOW	G	71
C	SEGMENTS,SEQUENCE IT NEXT	G	72
	IF (N) 200,200,100	G	73
200	II=II+1	G	74
	KSEG(II)=I	G	75
	ITEST(I)=1	G	76
	IF (II-NSEG) 100,210,210	G	77
210	IF (NL-MAXL+10) 230,230,220	G	78
220	CALL PAGE	G	79
C	OUTPUT COMPUTATION SEQUENCE	G	80
230	N=0	G	81
	WRITE (6,370)	G	82
	NL=NL+5	G	83
	DO 340 I=1,NSEG	G	84
	K=KSEG(I)	G	85
	IF (ITYPE(K).EQ.8) GO TO 240	G	86
	IF (ITYPE(K)-4) 240,240,310	G	87
C	CHECK FOR CHANNELS WITH MISSING INFLOW SEGMENT	G	88
240	NN=0	G	89
	DO 270 J=1,3	G	90
	IF (JLAT(K,J)) 250,250,260	G	91
250	IF (JUP(K,J)) 270,270,260	G	92
260	NN=1	G	93
270	CONTINUE	G	94
	IF (NN) 280,280,310	G	95
280	N=1	G	96
	IF (NL-MAXL+1) 300,300,290	G	97
290	CALL PAGE	G	98
300	NL=NL+1	G	99
	WRITE (6,380) K,ISEG(K)	G	100
	GO TO 340	G	101
310	IF (NL-MAXL+1) 330,330,320	G	102
320	CALL PAGE	G	103
330	NL=NL+1	G	104
	WRITE (6,390) K,ISEG(K),ALPHA(K),EM(K)	G	105
C	CHECK FOR INPUT DATA ERROR	G	106
340	CONTINUE	G	107
	IF (N) 360,360,350	G	108
350	WRITE (6,400) II,(ITEST(I),I=1,NSEG)	G	109
	WRITE (6,410) (I,(JUP(I,J),J=1,3),(JLAT(I,J),J=1,4),I=1,NSEG)	G	110
	STOP	G	111
360	CONTINUE	G	112
	CALL AREA (DA,DIMP,NONCH)	G	113
	RETURN	G	114
C		G	115
370	FORMAT (//10X,20HCOMPUTATION SEQUENCE,16X,28HKINEMATIC CHANNEL PAR	G	116

	1AMETERS//12X,5MINDEX,3X,7HSEGMENT,19X,5X,54ALPHA,6X,14M)	G 117
	380 FORMAT (52X,13.6X,A4.6X,22HMISSING INFLOW SEGMENT)	G 118
	390 FORMAT (13X,13.5X,A4,F31.2,F10.3)	G 119
	400 FORMAT (42X,35HINPUT DATA ERROR, EXECUTION STOPPED/5X,15/(5X,1015)	G 120
	1)	G 121
	410 FORMAT (5X,1015)	G 122
	END	G 123-
	SUBROUTINE INIT	H 1
C	THIS SUBROUTINE INITIALIZES CATCHMENT FOR BEGINNING OF	H 2
C	NEW STORM	H 3
	REAL IN2,ISEG,IUP,ILAT,INV1	H 4
	COMMON /C1/ VSEG,ISEG(50),IUP(50,3),NPAR,KPSET(50)	H 5
	COMMON /C3/ IPRNT,T,AR(50,11),FLGTH(50),KSEG(50),NDX(50),Q1(50),Q2	H 6
	1(50),QSUM(50),QSUML(50),STO(50)	H 7
	COMMON /C4/ DELS,MAXL,QCW,ULAT,ILAT(50,4),ITEST(50),ITYPE(50),JLAT	H 8
	1(50,4),JUP(50,3),P(3456,3),PARAM(50,2),RCOE(50,3),UPR(7200)	H 9
	COMMON /C7/ ECUMP,I,KINIT,YOUT,NRG,OSI,JOUT(50),QIND,RAT(3,2)	H 10
	COMMON /E2/ SMAX(50),IN2(50),IN1(50),S2O2(50)	H 11
	COMMON /E3/ DELTAT,NOR,QS(50,11)	H 12
	COMMON /E5/ S2(50,30),S(50,30),C(50,30)	H 13
	T=0.	H 14
	KINIT=0	H 15
	ECOMP=5.0	H 16
	QIND=0.0	H 17
	IPRNT=1	H 18
	DO 30 L=1,NSEG	H 19
	QSUM(L)=0.	H 20
	QSUML(L)=0.	H 21
	K=KSEG(L)	H 22
	SMAX(K)=0.0	H 23
	IN2(K)=0.0	H 24
	STO(K)=0.	H 25
	IF (ITYPE(K).EQ.9) STO(K)=PARAM(K,2)	H 26
	N=NDX(K)+1	H 27
	IF (ITYPE(K).GT.7) GO TO 20	H 28
	DO 10 J=1,N	H 29
	QS(K,J)=0.0	H 29A
10	AR(K,J)=0.0	H 30
20	Q2(K)=0.	H 31
	Q1(K)=0.	H 32
	IF (ITYPE(K).NE.8) GO TO 30	H 33
	CALL TABLE (K,PARAM(K,2),S2,S,C,Q2(K),NDX(K))	H 34
	S2Q2(K)=PARAM(K,2)/DELTAT*Q2(K)/2.	H 35
	STO(K)=PARAM(K,2)	H 36
30	CONTINUE	H 37
	RETURN	H 38
	END	H 39-
	SUBROUTINE AREA (DA,DIMP,NONCH)	I 1
	THIS SUBROUTINE 1. ADJUSTS RAIN GAGE TO BASIN	I 2
C	2. CHECKS COMPUTED DRAINAGE AREA VERSUS FURNISHED	I 3
C	DRAINAGE AREA. 3. DETERMINES PERVIOUS AND IMPERVIOUS	I 4
C	AREAS COVERED BY EACH RAIN GAGE FOR EACH SOIL TYPE	I 5
	INTEGER DELS	I 6
	REAL DIMP(9,2),DT(150,6,2)	I 7
	DIMENSION KS(50)	I 8
	COMMON /C1/ VSEG,ISEG(50),IUP(50,3),NPAR,KPSET(50)	I 9
	COMMON /C3/ IPRNT,T,AR(50,11),FLGTH(50),KSEG(50),NDX(50),Q1(50),Q2	I 10
	1(50),QSUM(50),QSUML(50),STO(50)	I 11
	COMMON /C4/ DELS,MAXL,QCW,ULAT,ILAT(50,4),ITEST(50),ITYPE(50),JLAT	I 12
	1(50,4),JUP(50,3),P(3456,3),PARAM(50,2),RCOE(50,3),UPR(7200)	I 13
	COMMON /C7/ ECUMP,I,KINIT,NOUT,NRG,OSI,JOUT(50),QIND,RAT(3,2)	I 14

COMMON /CB/ I2,I1,IK,TRYCT,KOUT(60),SEG(50)	I 15
KLL=NSEG+100	I 16
DO 30 L=1,NPAR	I 17
DO 20 I=1,KLL	I 18
DO 10 J=1,6	I 19
10 DT(I,J,L)=0.0	I 20
20 CONTINUE	I 21
30 CONTINUE	I 22
JAT=0.0	I 23
C CALCULATE PERVIOUS AND IMPERVIOUS DRAINAGE AREA FROM	I 24
C OVERLAND FLOW SEGMENTS INTO EACH CHANNEL FOR EACH RAIN	I 25
C GAGE AND SOIL TYPE	I 26
DO 120 I=1,NSEG	I 27
IF (ITYPE(I).NE.5.AND.ITYPE(I).NE.6) GO TO 120	I 28
DO 110 KL=1,NSEG	I 29
DO 100 KM=1,4	I 30
KL1=KL+NSEG	I 31
KL2=KL+2*NSEG	I 32
IF (I.NE.JLAT(KL,KM)) GO TO 100	I 33
KK=0.0	I 34
ANEI=1.-PARAM(I,1)-PARAM(I,2)	I 35
IF (PARAM(I,2).LT.0.) ANEI=ANEI+2.*PARAM(I,2)	I 36
DO 40 KMM=1,NMG	I 37
40 KK=RK*RCOEF(1,KMM)	I 38
DO 90 KK=1,NPAR	I 39
PK=0.0	I 40
IF (KPSET(I).EQ.KK) PK=1.0	I 41
DO 80 KMM=1,3	I 42
KMM1=KMM+3	I 43
DTEMP=FLGTH(KL)*FLGTH(I)*RCOEF(I,KMM)*PK	I 44
IF (PARAM(I,2).LT.0.) GO TO 50	I 45
DT(KL,KMM1,KK)=DT(KL,KMM1,KK)+DTEMP*PARAM(I,2)	I 46
IF (PARAM(I,1).LT.0.) GO TO 60	I 47
50 DT(KL1,KMM1,KK)=DT(KL1,KMM1,KK)+DTEMP*PARAM(I,1)	I 48
DT(KL2,KMM1,KK)=DT(KL2,KMM1,KK)+DTEMP*ANEI	I 49
60 DTEMP=DTEMP/RK	I 50
IF (PARAM(I,2).LT.0.) GO TO 70	I 51
DT(KL,KMM,KK)=DT(KL,KMM,KK)+DTEMP*PARAM(I,2)	I 52
IF (PARAM(I,1).LT.0.) GO TO 80	I 53
70 DT(KL1,KMM,KK)=DT(KL1,KMM,KK)+DTEMP*PARAM(I,1)	I 54
DT(KL2,KMM,KK)=DT(KL2,KMM,KK)+DTEMP*ANEI	I 55
80 CONTINUE	I 56
90 CONTINUE	I 57
100 CONTINUE	I 58
110 CONTINUE	I 59
120 CONTINUE	I 60
C AGGREGATE DRAINAGE AREA FOR EACH CHANNEL SEGMENT FOR	I 61
C EACH RAIN GAGE FOR EACH SOIL TYPE	I 62
KM1=NSEG-NONCH	I 63
DO 130 I=1,KM1	I 64
NONCH=NONCH+1	I 65
KS(I)=KSEG(NONCH)	I 66
130 CONTINUE	I 67
KM1=KM1-1	I 68
DO 180 KI=1,KM1	I 69
KJ=KS(KI)	I 70
KJJ=KJ+NSEG	I 71
KJK=KJ+2*NSEG	I 72
KP1=KI+1	I 73
K=KM1+1	I 74
DO 170 I=KP1,K	I 75

JK=KS(I)	I 76
JKK=JK+NSEG	I 77
JKL=JK+2*NSEG	I 78
DO 160 KMK=1,3	I 79
IF (JUP(JK,KMK).NE.KJ) GO TO 160	I 80
DO 150 KMM=1,NRG	I 81
KMM=KMM+3	I 82
DO 140 KK=1,VPAR	I 83
DT(JK,KMM,KK)=DT(JK,KMM,KK)+DT(KJ,KMM,KK)	I 84
DT(JK,KMM,KK)=DT(JK,KMM,KK)+DT(KJ,KMM,KK)	I 85
DT(JKK,KMM,KK)=DT(JKK,KMK,KK)+DT(KJJ,KMM,KK)	I 86
DT(JKK,KMM,KK)=DT(JKK,KMK,KK)+DT(KJJ,KMM,KK)	I 87
DT(JKL,KMM,KK)=DT(JKL,KMK,KK)+DT(KJK,KMM,KK)	I 88
DT(JKL,KMM,KK)=DT(JKL,KMK,KK)+DT(KJK,KMM,KK)	I 89
140 CONTINUE	I 90
150 CONTINUE	I 91
160 CONTINUE	I 92
170 CONTINUE	I 93
180 CONTINUE	I 94
C CALCULATE TOTAL DRAINAGE AREA AND TOTAL PERVIOUS AND	I 95
C IMPERVIOUS AREA FOR EACH RAIN GAGE AND SOIL TYPE	I 96
K=KSEG(NSEG)	I 97
KP=K+NSEG	I 98
KQ=K+2*NSEG	I 99
DTEMP1=0.0	I 100
DO 220 KMM=1,3	I 101
KMP=KMM+3	I 102
KMQ=KMM+6	I 103
DO 190 KK=1,VPAR	I 104
DAT=DAT+DT(K,KMM,KK)+DT(KP,KMM,KK)+DT(KQ,KMM,KK)	I 105
DTEMP1=DTEMP1+DT(K,KMP,KK)+DT(KP,KMP,KK)+DT(KQ,KMP,KK)	I 106
DIMP(KMM,KK)=DT(K,KMM,KK)	I 107
DIMP(KMP,KK)=DT(KP,KMM,KK)	I 108
DIMP(KMQ,KK)=DT(KQ,KMM,KK)	I 109
190 CONTINUE	I 110
IF (DIMP(KMP,1).EQ.0.0) GO TO 200	I 111
RAT(KMM,1)=(DIMP(KMP,1)+DIMP(KMQ,1))/DIMP(KMP,1)	I 112
200 IF (DIMP(KMP,2).EQ.0.0) GO TO 210	I 113
RAT(KMM,2)=(DIMP(KMP,2)+DIMP(KMQ,2))/DIMP(KMP,2)	I 114
210 DIMP(KMM,1)=DIMP(KMM,1)+DIMP(KMM,2)	I 115
220 CONTINUE	I 116
C ADJUST RAIN GAGE TO BASIN, IF NECESSARY	I 117
DTEMP1=DTEMP1/DAT	I 118
IF (DTEMP1.LT.0.995.OR.DTEMP1.GT.1.005) CALL RFADJ (DTEMP1,NRG)	I 119
C CHECK COMPUTED DRAINAGE AREA WITH FURNISHED DRAINAGE AREA	I 120
JAT=DAT/5280.0**2	I 121
DAT1=DAT/OA	I 122
DAT2=OA/DAT	I 123
RATIO=1.01	I 124
IF (DAT1.LT.RATIO.AND.DAT2.LT.RATIO) GO TO 230	I 125
WRITE (6,240) DA,DAT	I 126
230 CONTINUE	I 127
DA =DAT	I 128
RETURN	I 129
C	I 130
240 FORMAT (1H ,25HFURNISHED DRAINAGE AREA =,F8.3,2X,12HSQUARE MILES/1	I 131
1H ,25HCOMPUTED DRAINAGE AREA =,F8.3,38H THESE DIFFER BY MORE THAN	I 132
2 ONE PERCENT)	I 133
END	I 134
SUBROUTINE RFADJ (DTEMP1,NRG)	J 1
C THIS SUBROUTINE ADJUSTS RAIN GAGE TO BASIN	J 2

INTEGER RUDYS,DELS	J	3
COMMON /C1/ NSEG,ISEG(50),IUP(50,3),NPAR,KPSET(50)	J	4
COMMON /C4/ DELS,MAXL,QC#,QLAT,ILAT(50,4),ITEST(50),ITYPE(50),JLAT	J	5
1(50,4),JUP(50,3),P(3456,3),PARAM(50,2),RCOEF(50,3),UPR(7200)	J	6
COMMON /D1/ DP(1000),RUDYS	J	7
WRITE (6,50) DTEMP1	J	8
JU 10 KP=1,7200	J	9
10 UPR(KP)=UPR(KP)*DTEMP1	J	10
JU 30 KP=1,NSEG	J	11
IF (ITYPE(KP).NE.5.AND.ITYPE(KP).NE.6) GO TO 30	J	12
JU 20 KMM=1,3	J	13
20 RCOEF(KP,KMM)=RCOEF(KP,KMM)/DTEMP1	J	14
WRITE (6,60) KP,(RCOEF(KP,KMM),KMM=1,VRG)	J	15
30 CONTINUE	J	16
JU 40 KP=1,RUDYS	J	17
40 DP(KP)=DP(KP)*DTEMP1	J	18
RETURN	J	19
C	J	20
50 FORMAT (1H ,49HALL RAINFALLS HAVE BEEN MULTIPLIED BY A FACTOR OF,F	J	21
19.4/67H TO ADJUST RAIN GAGE TO BASIN. SIMILARLY, ALL THEISEN COEF	J	22
2FICIENTS/61H HAVE BEEN ADJUSTED TO APPLY TO THE REVISED AVERAGE RA	J	23
3INFALL.)	J	24
60 FORMAT (1H ,15,JF15.6)	J	25
END	J	26-
FUNCTION ITRAN (X)	K	1
C THIS FUNCTION NUMBERS LATERAL AND JPSTREAM INFLOW	K	2
C SEGMENTS TO CORRESPOND TO THE ISEG'S	K	3
REAL ISEG,IUP	K	4
COMMON /C1/ NSEG,ISEG(50),IUP(50,3),NPAR,KPSET(50)	K	5
I=1	K	6
10 IF (X-ISEG(I)) 30,20,30	K	7
20 ITRAN=I	K	8
RETURN	K	9
30 I=I+1	K	10
IF (I-NSEG) 10,10,40	K	11
40 ITRAN=0	K	12
RETURN	K	13
END	K	14-
SUBROUTINE AM	L	1
C THIS SUBROUTINE COMPUTES THE PARAMETERS ALPHA AND EM	L	2
C AND THE FULL-SEGMENT FLOW FOR EACH SEGMENT	L	3
INTEGER DELS	L	4
COMMON /C1/ NSEG,ISEG(50),IUP(50,3),NPAR,KPSET(50)	L	5
COMMON /C4/ DELS,MAXL,QC#,QLAT,ILAT(50,4),ITEST(50),ITYPE(50),JLAT	L	6
1(50,4),JUP(50,3),P(3456,3),PARAM(50,2),RCOEF(50,3),UPR(7200)	L	7
COMMON /C5/ ALPHA(50),EM(50),FRN(50),QMAX(50),SLOPE(50)	L	8
JU 80 I=1,NSEG	L	9
N=ITYPE(I)	L	10
IF (N.GE.8) N=7	L	11
GO TO (10,20,30,40,50,70,60), N	L	12
10 ALPHA(I)=1.49/FRN(I)*SQRT(SLOPE(I)/PARAM(I,1)**(2./3.))	L	13
AMAX=PARAM(I,1)*PARAM(I,2)	L	14
EM(I)=1.67	L	15
JMAX(I)=ALPHA(I)*AMAX*EM(I)	L	16
GO TO 80	L	17
20 AMAX=3.14*PARAM(I,1)**2/4.	L	18
QFULL=1.49/FRN(I)*AMAX*(PARAM(I,1)/4.)*(2./3.)*SQRT(SLOPE(I))	L	19
ALPHA(I)=QFULL/AMAX	L	20
EM(I)=1.	L	21
JMAX(I)=QFULL	L	22
GO TO 80	L	23

30	ALPHA(I)=1.41/FRN(I)*SQRT(SLOPE(I))/PARAM(I,1)**(1./3.)	L	24
	JMAX(I)=10.**10	L	25
	EM(I)=1.33	L	26
	GO TO 80	L	27
40	ALPHA(I)=PARAM(I,1)	L	28
	EM(I)=PARAM(I,2)	L	29
	JMAX(I)=10.**10	L	30
	GO TO 80	L	31
50	ALPHA(I)=1.49/FRN(I)*SQRT(SLOPE(I))	L	32
	JMAX(I)=10.**10	L	33
	EM(I)=1.67	L	34
	GO TO 80	L	35
60	JMAX(I)=10.**10	L	36
	ALPHA(I)=0.	L	37
	EM(I)=0.	L	38
	GO TO 80	L	39
70	JMAX(I)=10.**10	L	40
	ALPHA(I)=64.4*SLOPE(I)/(FRN(I)*.0000141)	L	41
	EM(I)=3.	L	42
80	CONTINUE	L	43
	RETURN	L	44
	END	L	45-
	SUBROUTINE PAGE	M	1
C	THIS SUBROUTINE SETS UP A NEW PAGE	M	2
	COMMON /C2/ NL,NPAGE	M	3
	NPAGE=NPAGE+1	M	4
	WRITE (6,10) NPAGE	M	5
	NL=3	M	6
	RETURN	M	7
		M	8
C		M	9
10	FORMAT (1H1,110X,4HPAGE,I4//20X,2044)	M	10-
	END	N	1
	SUBROUTINE PULS (K)	N	2
C	THIS SUBROUTINE PERFORMS MODIFIED PULS ROUTING	N	3
	REAL IN1,IN2	N	4
	COMMON /C3/ IPRNT,T,AK(50,11),FLGTH(50),KSEG(50),NDX(50),Q1(50),Q2	N	5
	1(50),QSUM(50),QSUML(50),STO(50)	N	6
	COMMON /E2/ SMAX(50),IN2(50),IN1(50),S202(50)	N	7
	COMMON /E3/ DELTAT,NOB,Q5(50,11)	N	8
	COMMON /E4/ WV(50,30),S1(50,30),C1(50,30)	N	9
	IN1(K)=IN2(K)	N	10
	IN2(K)=QSUM(K)	N	11
	AVIN=(IN1(K)+IN2(K))/2.	N	12
	S202(K)=S202(K)+AVIN-Q1(K)	N	13
	IF (IN2(K).LT.0.005) GO TO 10	N	14
	CALL TABLE (K,S202(K),WV,S1,C1,Q2(K),NDX(K))	N	15
10	IF (IN2(K).LT.0.005) Q2(K)=IN2(K)	N	16
	STO(K)=(S202(K)-Q2(K)/2.)*DELTAT	N	17
	IF (STO(K).LT.SMAX(K)) GO TO 20	N	18
	SMAX(K)=STO(K)	N	19
20	CONTINUE	N	20
	RETURN	N	21-
	END		

	SUBROUTINE P4PLOT	0	1
	16 MARCH 73	0	2
C	IMPLICIT LOGICAL*1(W), LOGICAL*1(K)	0	3
	DIMENSION NSCALE(5), ABNDS(26), X(1), Y(1)	0	4
	LOGICAL*1 NOS(10)/'0','1','2','3','4','5','6','7','8','9'/	0	5
	LOGICAL*1 IMAGE(1), CH, LABEL(1), ERR1, ERR3, ERR5	0	6
	LOGICAL*1 VC, HC, FOR1(19), FOR2(15), FOR3(19), NC, BL, HF, HF1	0	7
	REAL*8 FOX1(3), FOX2(2), FOX3(3)	0	8
	INTEGER*2 VCH	0	9
	EQUIVALENCE (FOX1, FOX1), (FOR2, FOX2), (FOR3, FOX3), (VC, VCH)	0	10
	INTEGER FILE	0	11
	DATA HC/'-'/, NC/'+'/, BL/' '/, HF/'F'/, HF1/'.'/	0	12
	DATA FOX1/'(1XA1,F9','.2, 121', 'A1) '/	0	13
	DATA FOX2/'(1XA1, 9', 'X121A1) '/	0	14
	DATA FOX3/'(1HOF .', ' , F ', ' ,) '/	0	15
	DATA VCH/24F00/	0	16
	DATA KPL0T1/, FALSE./, KPL0T2/, FALSE./	0	17
	DATA KABSC, KJND, KBTGL/3/, FALSE./	0	18
C	ENTRY PL0T1(NSCALE, NML, NSB1, NVL, NSBV)	0	19
	IFL=FILE	0	20
	ERR1=.FALSE.	0	21
	ERR3=.FALSE.	0	22
	ERR5=.FALSE.	0	23
	KPL0T1=.TRUE.	0	24
	KPL0T2=.FALSE.	0	25
	NH=IABS(NML)	0	26
	NS1=IABS(NSB1)	0	27
	NV=IABS(NVL)	0	28
	NSV=IABS(NSBV)	0	29
	NSCL=NSCALE(1)	0	30
	IF (NH*NSH*NV*NSV.NE.0) GO TO 1	0	31
	KPL0T=.FALSE.	0	32
	ERR1=.TRUE.	0	33
	RETURN	0	34
1	KPL0T=.TRUE.	0	35
	IF (NV.LE.25) GO TO 2	0	36
	KPL0T=.FALSE.	0	37
	ERR3=.TRUE.	0	38
	RETURN	0	39
2	CONTINUE	0	40
	NVM=NV-1	0	41
	NVP=NV+1	0	42
	NHM=NH*NSH	0	43
	NHMP=NDH+1	0	44
	NVV=NV*NSV	0	45
	NVVP=NDV+1	0	46
	NIMG=(NDHP*NDVP)	0	47
	IF (NDV.LE.120) GO TO 3	0	48
	KPL0T=.FALSE.	0	49
	ERR5=.TRUE.	0	50
	RETURN	0	51
3	CONTINUE	0	52
	IF (NSCL.EQ.0) GO TO 4	0	53
	FSY=10.*NSCALE(2)	0	54
	FSX=10.*NSCALE(4)	0	55
	IY=MIN0(IABS(NSCALE(3)), 7)+1	0	56
	IX=MIN0(IABS(NSCALE(5)), 9)+1	0	57
	GO TO 5	0	58
4	FSY=1.	0	59
	FSX=1.	0	60
		0	61

1Y=4	0	62
1X=4	0	63
5 FOR1(10)=NOS(1Y)	0	64
VA=MINO(1X,NSV)-1	0	65
VS=NA-MINU(NA,120-NDV)	0	66
VB=11-NS+NA	0	67
11=NB/10	0	68
12=NB-11*10	0	69
FOR3(6)=NOS(11+1)	0	70
FOR3(7)=NOS(12+1)	0	71
FOR3(9)=NOS(VA+1)	0	72
IF (NV.GT.0) GO TO 7	0	73
DO 6 J=11,18	0	74
6 FOR3(J)=BL	0	75
GO TO 8	0	76
7 11=NV/10	0	77
12=NV-11*10	0	78
FOR3(11)=NOS(11+1)	0	79
FOR3(12)=NOS(12+1)	0	80
FOR3(13)=HF	0	81
11=NSV/100	0	82
13=NSV-11*100	0	83
12=13/10	0	84
13=13-12*10	0	85
FOR3(14)=NOS(11+1)	0	86
FOR3(15)=NOS(12+1)	0	87
FOR3(16)=NOS(13+1)	0	88
FOR3(17)=HF1	0	89
FOR3(18)=FOR3(9)	0	90
4 IF (KPLOT1) RETURN	0	91
KPLOT1=.TRUE.	0	92
C	0	93
ENTRY PLOT2(IMAGE,XMAX,XMIN,YMAX,YMIN,FILE)	0	94
IFL=FILE	0	95
KPLOT2=.TRUE.	0	96
IF (KPLOT1) GO TO 9	0	97
NSCL=0	0	98
NH=5	0	99
NSH=10	0	100
NV=10	0	101
NSV=10	0	102
GO TO 1	0	103
9 CONTINUE	0	104
IF (KPLOT) GO TO 10	0	105
IF (ERR1) WRITE (IFL,30)	0	106
IF (ERR3) WRITE (IFL,31)	0	107
IF (ERR5) WRITE (IFL,32)	0	108
RETURN	0	109
10 YMX=YMAX	0	110
DM=(YMAX-YMIN)/FLOAT(NDH)	0	111
DV=(XMAX-XMIN)/FLOAT(NDV)	0	112
DO 11 I=1,NVP	0	113
11 ABNOS(I)=(XMIN+FLOAT((I-1)*NSV)*DV)*FSX	0	114
DO 12 I=1,NIMG	0	115
12 IMAGE(I)=BL	0	116
DO 16 I=1,NDHP	0	117
I2=I*NDVP	0	118
I1=I2-NDV	0	119
KNHOR=MOD(I-1,NSH).NE.0	0	120
IF (KNHOR) GO TO 14	0	121
DO 13 J=11,12	0	122

13	IMAGE(J)=MC	0 123
14	CONTINUE	0 124
	DO 16 J=I1,I2,NSV	0 125
	IF (KNHON) GO TO 15	0 126
	IMAGE(J)=NC	0 127
	GO TO 16	0 128
15	IMAGE(J)=VC	0 129
16	CONTINUE	0 130
	XMIN1=XMIN-DV/2.	0 131
	YMIN1=YMIN-DH/2.	0 132
	RETURN	0 133
C		0 134
	ENTRY PLOT3(CH,X,Y,N3)	0 135
	IF (KPLT2) GO TO 18	0 136
17	WRITE (IFL,33)	0 137
18	CONTINUE	0 138
	IF (.NOT.KPLT) RETURN	0 139
	IF (N3.GT.0) GO TO 19	0 140
	KPLT=.FALSE.	0 141
	WRITE (IFL,34)	0 142
	RETURN	0 143
19	DO 26 I=1,N3	0 144
	IF (DV) 21,20,21	0 145
20	DUM1=0	0 146
	GO TO 22	0 147
21	CONTINUE	0 148
	DUM1=(X(I)-XMIN1)/DV	0 149
22	IF (DH) 24,23,24	0 150
23	DUM2=0	0 151
	GO TO 25	0 152
24	CONTINUE	0 153
	DUM2=(Y(I)-YMIN1)/DH	0 154
25	CONTINUE	0 155
	IF (DUM1.LT.0..OR.DUM2.LT.0.) GO TO 26	0 156
	IF (DUM1.GE.NDVP..OR.DUM2.GE.NDHP) GO TO 26	0 157
	NX=1+INT(DUM1)	0 158
	NY=1+INT(DUM2)	0 159
	J=(NDHP-NY)*NDVP+NX	0 160
	IMAGE(J)=CH	0 161
26	CONTINUE	0 162
	RETURN	0 163
C		0 164
	ENTRY PLOT4(NL,LABEL)	0 165
	ENTRY FPLOT4(NL,LABEL)	0 166
	IF (.NOT.KPLT) RETURN	0 167
	IF (.NOT.KPLT2) GO TO 17	0 168
	DO 28 I=1,NDHP	0 169
	IF (I.EQ.NDHP.AND.KHOTGL) GO TO 28	0 170
	WL=BL	0 171
	IF (I.LE.NL) WL=LABEL(I)	0 172
	I2=I*NOVP	0 173
	I1=I2-NDV	0 174
	IF (MOD(I-1,NSH).EQ.0.AND..NOT.KORJ) GO TO 27	0 175
	WRITE (IFL,FOR2) WL,(IMAGE(J),J=I1,I2)	0 176
	GO TO 28	0 177
27	CONTINUE	0 178
	ORDNO=(YMX-FLOAT(I-1)*DH)*FSY	0 179
	IF (I.EQ.NDHP) ORDNO=YMIN	0 180
	WRITE (IFL,FOR1) WL,ORDNO,(IMAGE(J),J=I1,I2)	0 181
28	CONTINUE	0 182
	IF (KABSC) GO TO 29	0 183

7	WRITE (IFL,FOR3) (ABNOS(J),J=1,NVP)	O 184
29	RETURN	O 185
C		O 186
	ENTRY OMIT(LSW)	O 187
	KASC=MOD(LSW,2).EQ.1	O 188
	KORD=MOD(LSW,4).GE.2	O 189
	KBTGL=LSW.GE.4	O 190
	RETURN	O 191
C		O 192
C		O 193
C		O 194
	30 FORMAT (TS,'SOME PLOT1 ARG. ILLEGALLY 0')	O 195
	31 FORMAT (TS,'NO. OF VERTICAL LINES >25')	O 196
	32 FORMAT (TS,'WIDTH OF GRAPH >121')	O 197
	33 FORMAT (TS,'PLOT2 MUST BE CALLED')	O 198
	34 FORMAT (TS,'PLOT3, ARG2) 0')	O 199
	END	O 200-
	SUBROUTINE TABLE (K,F1,F3,S3,C3,F2,J)	P 1
C	THIS SUBROUTINE PERFORMS LINEAR INTERPOLATION FOR	P 2
C	MODIFIED PULS ROUTING	P 3
	DIMENSION F3(50,30), S3(50,30), C3(50,30)	P 4
	DO 10 I=2,J	P 5
	IF (F1.LT.F3(K,I)) GO TO 20	P 6
10	CONTINUE	P 7
	I=J	P 8
20	F2=S3(K,I)*F1+C3(K,I)	P 9
	RETURN	P 10
	END	P 11-

D. SCHEMATIC OF PROGRAM DECK SETUP

D. SCHEMATIC OF PROGRAM DECK SETUP

13	Initial values and bounds of parameters
12	Details for optimization round
11	Daily-evaporation data
10	Daily-rainfall data
9	Unit-discharge data (optional)
8	Unit-rainfall data for station no. 3 (optional)
7	Unit-rainfall station no. 3 and unit-time interval (optional)
8	Unit-rainfall data for station no. 2 (optional)
7	Unit-rainfall station no. 2 and unit-time interval (optional)
8	Unit-rainfall data
7	Unit-rainfall station and unit-time interval
6	Period of record
5	Daily-evaporation station
4	Daily-rainfall station
3	Streamflow station & drainage area
2	Irrigation rates (optional)
1 1/	Option card

1/ Number refers to card group in data input specifications.

SCHEMATIC OF PROGRAM DECK SETUP--continued

23	Input-hydrograph cards (optional)
22	Input-hydrograph-indicator card
21	Optimization card
20	Routing card
19	Storm-separation cards
18	Storm-sequencing card
17	Outflow-storage relationships (optional)
16	Segment characteristics
15	Model-control card
14	<u>1</u> Parameter-adjustment card

1 Number refers to card group in data input specifications.

E. SAMPLE RUNS

It remains largely an art to characterize a basin in terms of a number of segments which account for the essential basin properties. In order to provide the "artist" with some help; an example, Sand Creek Tributary at Denver, Colorado, will be discussed. The approach illustrated by this example is not meant to provide hard and fast rules but rather to serve as a guide for applying the model. Different objectives and study limitations will require deviations from this guide.

The Sand Creek Tributary at Denver drainage basin is a 183-acre area of predominantly single-family residential land use with some multifamily land use, a church, a recreational center, a fire station, and two small parks. The basin has some storm sewers in its upper end but relies mostly on street gutters and concrete-lined open ditches for flow conveyance. Detailed records of rainfall and stream stage are collected at the station by the operation of dual-digital recorders which code the data on 16-channel paper tape at 5-minute intervals. Use of a single timer provides for simultaneous actuation of both recorders. A stage-discharge relation was developed on the basis of step-backwater analysis of a reach of concrete-lined stream channel and discharge measurements made during storm runoff. The rainfall-runoff data used in this example have been published (Ducret and Hodges, 1975).

Two sample runs will be discussed for the Sand Creek Tributary at Denver basin. The first run was an optimization run without any routing. In the second run, the soil-moisture-accounting and infiltration parameters were set at their final values from the first run and routing was performed for ten storm events. These two runs could have been accomplished with a single computer run; however, experience with the model has shown the two-stage approach to be preferred. The following is a discussion by card group of the input data for the first computer run.

Card Group 1

It was desired to list the input rainfall and evaporation data; therefore, $\emptyset PTI \emptyset N = LIST$. Storm-runoff volumes were included in the model-input data; therefore, $\emptyset PT = 1$.

Card Group 2

No card was included because daily rainfalls were not to be modified for irrigation ($N \emptyset PT1 = 0$).

Card Groups 3, 4, and 5

The streamflow, daily-rainfall and daily-evaporation station identifiers were input to the model using these three cards. Card Group 3 also included the drainage area of the basin (0.286 square miles).

Card Group 6

The first runoff period to be simulated occurred on July 12, 1973. In order to establish initial soil-moisture conditions for this date, the beginning day of record was set at May 1, 1973. The last runoff period to be simulated occurred on July 30, 1974; therefore, the last day of record was set at July 31, 1974 (1 day after last unit-rainfall day).

Card Group 7

The unit-rainfall station number and name were input along with the time increment of unit data (5 minutes for this example).

Card Group 8

Card Group 8 was used to input the unit-rainfall data. Ducret and Hodges (1975) reported data for 14 runoff periods during 1973 and 1974 (table 4). Four of these runoff periods were not selected for simulation for the reasons given in table 4. Because no unit-discharge data were read-in (ØPT = 1), a card with a CØDE of 9 punched in column 80 was placed at the end of Card Group 8.

Card Group 9

Card Group 9 was skipped because no unit-discharge data were input for this run.

Card Group 10

Card Group 10 was used to read in the daily-rainfall data. Because a large gap in time existed between runoff-period numbers 8 (September 11, 1973) and 9 (July 22, 1974), 9999's were punched as the daily rainfall for September 15, 1973 and May 1, 1974. Daily-rainfall cards were not included for the intervening period. Continuation of the daily moisture accounting on May 1, 1974 should have allowed sufficient time for the model to establish initial soil-moisture conditions for the runoff of July 22, 1974.

Card Group 11

Card Group 11 was used to read in the daily-evaporation data. Note that daily-evaporation cards were not included for the period between September 15, 1973, and May 1, 1974, as this period was to be skipped by the model. A card with a CØDE of 9 punched in column 80 was placed at the end of Card Group 11.

Card Group 12

There were seven parameters in the soil-moisture and infiltration components because a single soil type was assumed throughout the basin.

Table 4.--Summary of runoff periods at Sand Creek Tributary Basin at Denver, Colorado, 1973 and 1974.

Runoff- period number ¹	Date	Rainfall, in inches	Runoff volume, in inches	Percent runoff	Peak flow, in cubic feet per second	Comments
--	May 5-6, 1973	4.38	1.2	27	31	Poor temporal correlation of rainfall and runoff
1	July 12, 1973	.33	.080	24	32	
2	July 19, 1973	.63	.16	25	68	
--	July 20, 1973	.11	.054	49	20	Anomalously high percentage of runoff
3	July 22, 1973	.23	.055	24	22	
4	July 24, 1973	.95	.33	35	104	
5	July 30, 1973	.34	.063	19	32	
6	Aug. 7, 1973	1.94	.70	36	236	
--	Sept. 9, 1973	.24	.030	12	21	Very poor temporal correlation of rainfall and runoff
7	Sept. 11, 1973	.51	.073	14	48	
8	Sept. 11, 1973	.56	.23	41	143	
--	June 8, 1974	1.04	---	--	17	Too much estimated flow to accurately determine runoff volume ¹
9	July 22, 1974	1.06	.20	19	98	
10	July 30, 1974	1.38	.53	38	251	

¹/Number refers to flood-event number used in model output. Runoff periods without a number were not simulated for reasons explained in comments.

The model is primarily sensitive to only four of the seven parameters; therefore, only four parameters were adjusted by the model. Based on experience with the model, the number of trial adjustments per parameter was set at 10 and the initial step size for parameter adjustment at 0.060.

Card Group 13

The soils in the drainage basin are highly pervious sands which would be expected to result in higher values for PSP, KSAT, and BMSN than those suggested as initial values in table 3. However, for this run the initial magnitudes and lower and upper limits of the soil-moisture and infiltration parameters were set at the values suggested in table 3.

Card Group 14

The parameters to be optimized were PSP, KSAT, RGF, and BMSN; therefore, the subscripts for card 14 are 1, 2, 3, and 4.

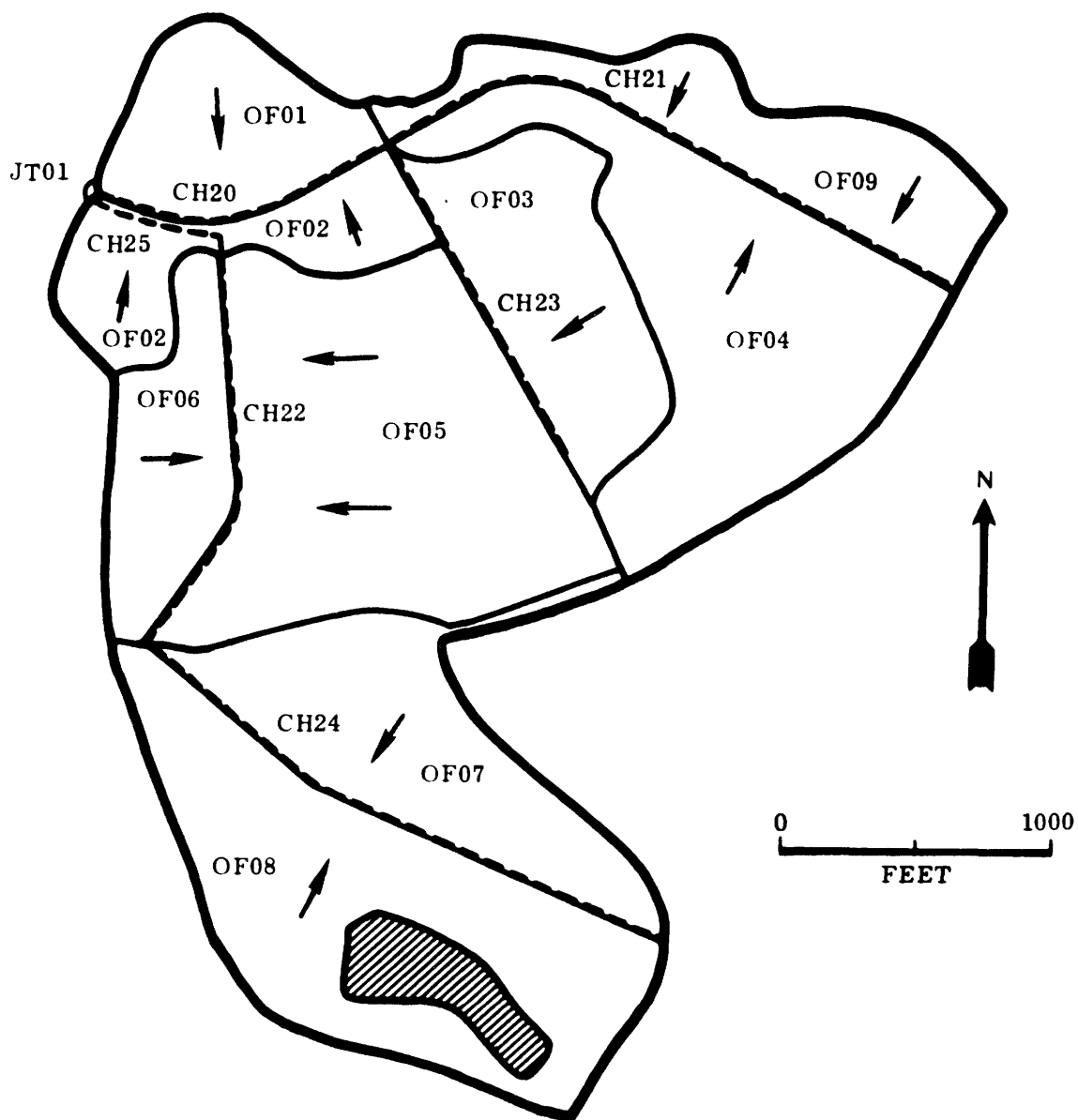
Card Groups 15 and 16

An aerial photo of the drainage basin is shown in figure 13. The first step in subdividing this drainage basin into segments was to obtain available information on the physical characteristics of the catchment. This consisted of an aerial photograph from a local engineering firm, drainage maps which also showed street-corner elevations from the City of Denver, and the U.S. Geological Survey topographic map for the area. Using the above information, the drainage-basin boundary was approximated in the office and then field checked. The drainage network; inlets to the drainage network; all flow directions on streets, particularly at street intersections; and effective impervious surfaces from roofs, parking lots, etc., were delineated on copies of the aerial photos. This information was obtained and (or) verified by on-site inspection.

It was then the "artist's" turn. Using the marked-up photos from the above exercise, the basin was delineated into sub-basins (overland-flow segments) and a drainage network (channel segments). An attempt was made to balance number of segments (5 to 15 overland-flow segments was selected as an "optimum" range based on difficult to rationalize "engineering judgment"), maximum "uniformity" within segments, segmentation into overland-flow segments with balanced lengths of overland flow to their designated channel segments, and compatibility between overland-flow segments and their designated channel segments (that is, an optimum segmentation for overland-flow segments may result in a poor arrangement of channel segments). Ideally, perhaps, major changes within the drainage network such as in geometry, size, roughness, and (or) slope would result in separate channel segments. However, in many cases the channel segmentation will be governed by the overland-flow segmentation. Likewise, channel intersections often exert a controlling influence on overland-flow segmentation. A schematic of the basin segmentation is illustrated in figure 14.



Figure 13.--Aerial photograph of Sand Creek Tributary Basin at Denver, Colorado.



EXPLANATION



- Drainage Basin Boundary
- OF02 Overland-Flow-Segment Boundary and Number
- CH23 Channel Segment and Number
- JT01 ° Junction Segment and Number
-  Non-Contributing Area within Drainage Basin
-  General Direction of Overland Flow

Figure 14.--Schematic of Sand Creek Tributary Basin at Denver, Colorado, showing segmentation for rainfall-runoff modeling.

The rationale behind the basin segmentation of figure 14 is as follows: It is often easiest to start at the downstream end of a basin and that approach was used when segmenting this basin. It was first noted that the major drainage system of the basin consisted of concrete-lined ditches which were located in the positions marked by channel segments CH20, CH21, and CH22. In analyzing the reach of concrete-lined ditch comprised of CH20 and CH21, it was noted that a street, which drained 14 acres of land, ØF03, intersected this reach. Therefore, this reach of concrete-lined ditch was subdivided into channel segments CH20 and CH21, and the intersecting street was designated as channel segment CH23. Overland-flow segments ØF01, ØF02, ØF03, ØF04, and ØF09 were then delineated based on this channel segmentation. It should be noted that overland-flow segment ØF04 does not have balanced lengths of overland flow to CH21. To further subdivide this overland-flow segment would also require that segments CH21 and ØF09 be further subdivided.

The unallocated concrete-lined ditch was then assigned as channel segment CH22. Overland-flow segments ØF06 and ØF05 were then delineated. To avoid the need to subdivide channel segment CH20 which would require subdividing overland-flow segments ØF01 and ØF02, channel segment CH25 was used to bypass channel segment CH20. A junction segment, JT01, was required to sum the flow from the two channel segments at the outlet of the basin. Finally, the remaining part of the basin was drained by a street which was assigned as channel segment CH24.

Once the basin was segmented, the sub-basin boundaries were field checked and representative channel cross sections were determined. Channel slopes were determined from the drainage maps, and overland-flow slopes were estimated from the U.S. Geological Survey topographic map for the area and the street-corner elevations shown on the City of Denver drainage maps. Sub-basin areas were planimetered and lengths of overland flow were computed by dividing the area of each sub-basin, in square feet, by the length, in feet, of the channel segment into which it contributes lateral inflow. The segment characteristics are shown in tables 5 and 6. Note in figure 14 that overland-flow segment ØF08 has a noncontributing area within its boundary. This results from internal drainage to a flood-control lake.

Roughness coefficients for the channel segments were estimated at 0.016 for the concrete-lined channels and 0.013 for the street-gutter channels. Two options are available for roughness coefficients for overland-flow segments. A single roughness coefficient can be assigned to an overland-flow segment or else the segment can be assigned two roughness coefficients, one for pervious surfaces and one for impervious surfaces. For this basin, two roughness coefficients were specified for overland-flow segment numbers ØF01, ØF07, and ØF08; 0.20 for pervious surfaces (ØP01, ØP07, ØP08) and 0.013 for impervious surfaces (ØI01, ØI07, ØI08). Only one roughness was specified for the other overland-flow segments because distances of pervious-surface overland flow were generally short over lawns and onto streets with the streets dominating the flow conveyance. Roughness coefficients for these segments were set at 0.016.

Table 5.--Overland-flow segment characteristics for Sand Creek Tributary
Basin at Denver, Colorado

Segment number	Channel segment for drainage	Area (acre)	Length (feet)	Slope (feet/feet)	Perviousness	Effective imperviousness
ØF01	CH20	12.6	454	0.005	0.80	0.15
ØF02	CH20	10.6	382	.022	.47	.36
ØF03	CH23	14.0	480	.024	.48	.31
ØF04	CH21	30.5	593	.018	.54	.32
ØF05	CH22	36.5	1,006	.022	.57	.27
ØF06	CH22	10.7	295	.004	.44	.42
ØF07	CH24	19.0	372	.012	.80	.16
ØF08	CH24	31.5	617	.007	.58	.33
ØF09	CH21	17.5	340	.010	.70	.22

Table 6.--Channel-segment characteristics for Sand Creek Tributary Basin
at Denver, Colorado

Segment number	Upstream segment(s)	Length (feet)	Slope (feet/feet)	Manning <i>n</i>	Width (feet) at 1-foot depth
CH20	CH23,CH21	1,210	0.005	0.016	11
CH21	---	2,240	.007	.016	11
CH22	CH24	1,580	.008	.016	4.3
CH23	---	1,270	.029	.013	31
CH24	---	2,225	.005	.013	50
CH25	CH22	460	.005	.016	11

It remained to determine the time interval (Δt) and segment intervals (NDX) for the finite-difference calculations. Detailed output from the basin outlet was all that was required. Therefore, Δt was computed based on the entire channel length through the basin and the average overland-flow length to that channel. Three distinct channel networks drained the basin--a network comprised of channels CH20 and CH21, a network comprised of channels CH20 and CH23, and a network comprised of channels CH22, CH24, and CH25. Equations 12, 13, and 14 were used to calculate Δt for each of these three channel networks. The following illustrates application of these equations to the channel network comprised of channels CH20 and CH21.

The average slope (weighted by sub-basin area) of the sub-basins draining to the channel network (segments ØF01, ØF02, ØF04, and ØF09) is 0.014. Assuming this value for slope and 0.020 for FRN(I) and using the equations for turbulent overland-flow segments from table 2:

$$\alpha_o \approx \frac{(1.49) \sqrt{0.014}}{0.020} = 8.8$$

and

$$m_o = 1.67$$

Letting FRN(I) = 0.016, PARAM (I, 1) = 11 feet and SLOPE(I) = 0.006 in the equations for triangular cross sections from table 2:

$$\alpha_c \approx \frac{1.41 \sqrt{0.006}}{(0.016) (11)^{1/3}} = 3.1$$

and

$$m_c = 1.33$$

The average length of overland-flow (weighted by sub-basin area) to the channel network is 475 feet. The length of channels CH20 plus CH21 is 3,450 feet. For the storms simulated, the maximum 5-minute rainfall intensity was 5.64 inches per hour, and the maximum 15-minute rainfall intensity was 4.64 inches per hour. Therefore, the maximum rainfall intensity for equations 13 and 14 was set at 5 inches per hour. Substituting the above values into equation 13 results in

$$t_o = \left[\frac{475}{8.8 (5/43200)^{0.67}} \right]^{1/1.67} = 413 \text{ seconds}$$

and into equation 14 results in

$$t_c = \left[\frac{3,450}{3.1 ([2 * 5 * 475]/43200)^{0.33}} \right]^{1/1.33} = 338 \text{ seconds}$$

Therefore $\Delta t \approx 0.1 (413 + 338) = 75$ seconds. Similar calculations for the network comprised of channels CH20 and CH23 and the network comprised of channels CH22, CH24, and CH25 resulted in a Δt of 57 seconds and 95 seconds, respectively. Based on these results, Δt for the model was set at 1.0 minute.

Calculation of NDX for segments ØP01, ØI01, CH24 and CH22 is discussed below.

For segment ØP01, $L_o = 454$ feet, $\alpha_o = 0.53$, $i_e = 5$ minutes, and $m_o = 1.67$. Therefore, from equation 13

$$t_o = \left[\frac{454}{(0.53) (5/43200)^{0.67}} \right]^{1/1.67} = 2,165 \text{ seconds.}$$

Then, from equation 21

$$NDX = \frac{2,165}{60} = 36.1$$

However, the maximum NDX allowed by the model is 10. Therefore, NDX for segment ØP01 was set at 10. This should not present any significant problems as the flow from this segment which is entirely pervious is minor compared to that from the segments with impervious surfaces which were used in the calculation of Δt .

For segment ØI01, $L_o = 454$ feet, $\alpha_o = 8.10$, $i_e = 5$ minutes, and $m_o = 1.67$. Therefore, from equation 13

$$t_o = \left[\frac{454}{(8.10) (5/43200)^{0.67}} \right]^{1/1.67} = 423 \text{ seconds.}$$

Then, from equation 21

$$NDX = \frac{423}{60} = 7.05, \text{ say } 7.$$

For segment CH24, $L_c = 2,225$ feet, $L_o \approx 500$ feet, $\alpha_o = 2.08$, $i_e = 5$ minutes, and $m_c = 1.33$. Therefore, from equation 14,

$$t_c = \left[\frac{2,225}{(2.08) ([2 * 5 * 500]/43200)^{0.33}} \right]^{1/1.33} = 324 \text{ seconds.}$$

Then, from equation 22

$$NDX = \frac{324}{60} = 5.4, \text{ say } 6.$$

Channel segment CH22 not only has lateral inflow from overland-flow segments but also has upstream inflow from CH24. Therefore, equation 14 does not apply. Assuming the upstream inflow to dominate, the time of concentration of a wave (not a particle) through CH24 could be approximated by

$$t_c \approx \frac{L_c}{\alpha_c m_c A_c^{m_c-1}} \quad (30)$$

where A_c is an average cross-sectional area of flow in square feet. Letting $L_c = 1,580$ feet, $\alpha_c = 4.85$, $m_c = 1.33$, and $A_c = 2.5$ square feet in equation 30

$$t_c \approx \frac{1,580}{(4.85)(1.33)(2.5^{0.33})} = 181$$

Then, from equation 22

$$NDX = \frac{181}{60} = 3.0, \text{ say } 3.$$

Card Group 17

Card Group 17 was skipped because there were no modified-Puls detention reservoirs (segments of ITYPE(I) = 8).

Card Group 18

Ten storms were simulated by the model. Of these storms all but two were separated by at least one day without unit-rainfall data. The exceptions were the two storms which occurred on September 11, 1973 (runoff-period numbers 7 and 8). Therefore, NF(I) = 1; I = 1-6, 9, 10 and NF(I) = 2; I = 7, 8.

Card Group 19

The starting and ending time increments for each storm and the observed volumes of runoff, in inches, are input to the model using Card Group 19.

Card Group 20

No runoff was routed for this run; therefore, KOUT(I) = 0, I = 1, NØFE.

Card Group 21

Runoff periods 1-6 and 10 were used in computing the value of the objective function.

Card Group 22

No input hydrographs were necessary; therefore, $IHYD(I) = 0$, $I = 1$, $NØFE$.

Card Group 23

Card Group 23 was skipped, because there were no input-hydrograph segments ($ITYPE(I) = 10$ on Card Group 16).

The first run resulted in "optimal" values of the infiltration and soil-moisture-accounting parameters. In the second run, these parameters were set at their final values from the first run and routing was performed for all unit-rainfall runoff periods. The results are shown in table 7. The optimization option was not used during the second run. The following changes in input data were made.

Card Group 12

The number of parameters to be adjusted, the number of trial adjustments per parameters, and the initial step size for parameter adjustment were specified as zero.

Card Group 13

The initial values of PSP, KSAT, RGF, and BMSN were changed to 6.03, 0.121, 13.82, and 11.0, respectively, based on the results of the optimization run.

Card Group 14

Card 14 was changed to a blank card.

Card Group 19

It was not necessary to input storm-runoff volumes as no optimization was to be performed for this run. The ending time increment for storm number 7 was changed to 95 to demonstrate that changes in the starting and (or) ending time increments for a storm will only affect simulated storm-runoff volumes if a different rainfall occurred (that is, storm-runoff volumes are independent of routing).

Card Group 20

All unit-rainfall runoff periods were routed for this run; therefore, $KØUT(I) = 1$, $I = 1$, $NØFE$.

Table 7.--Comparison of measured and simulated runoff volumes and peak flows for Sand Creek Tributary Basin at Denver, Colorado.

Runoff- period number	Date	Runoff volume, in inches		Peak flow, in cubic feet per second	
		Measured	Simulated	Measured	Simulated
1	July 12, 1973	0.080	0.080	32	23
2	July 19, 1973	.16	.19	68	74
3	July 22, 1973	.055	.052	22	14
4	July 24, 1973	.33	.28	104	97
5	July 30, 1973	.063	.082	32	28
6	Aug. 7, 1973	.70	.76	236	280
7	Sept. 11, 1973	.073	.14	48	58
8	Sept. 11, 1973	.23	.16	143	68
9	July 22, 1974	.20	.32	98	117
10	July 30, 1974	.53	.47	251	216

Card Group 21

No optimization was performed; therefore, $\text{TESTNØ}(I) = 0$, $I = 1$,
NØFE.

Input for Run Number 1

LIST	73 05 01	74 07 31	75 08 01	76 09 01	77 10 01	78 11 01	79 12 01	80 13 01	81 14 01	82 15 01	83 16 01	84 17 01	85 18 01	86 19 01	87 20 01	88 21 01	89 22 01	90 23 01	91 24 01	92 25 01	93 26 01	94 27 01	95 28 01	96 29 01	97 30 01	98 31 01	99 32 01	100 33 01	101 34 01	102 35 01	103 36 01	104 37 01	105 38 01	106 39 01	107 40 01	108 41 01	109 42 01	110 43 01	111 44 01	112 45 01	113 46 01	114 47 01	115 48 01	116 49 01	117 50 01	118 51 01	119 52 01	120 53 01	121 54 01	122 55 01	123 56 01	124 57 01	125 58 01	126 59 01	127 60 01	128 61 01	129 62 01	130 63 01	131 64 01	132 65 01	133 66 01	134 67 01	135 68 01	136 69 01	137 70 01	138 71 01	139 72 01	140 73 01	141 74 01	142 75 01	143 76 01	144 77 01	145 78 01	146 79 01	147 80 01	148 81 01	149 82 01	150 83 01	151 84 01	152 85 01	153 86 01	154 87 01	155 88 01	156 89 01	157 90 01	158 91 01	159 92 01	160 93 01	161 94 01	162 95 01	163 96 01	164 97 01	165 98 01	166 99 01	167 100 01	168 101 01	169 102 01	170 103 01	171 104 01	172 105 01	173 106 01	174 107 01	175 108 01	176 109 01	177 110 01	178 111 01	179 112 01	180 113 01	181 114 01	182 115 01	183 116 01	184 117 01	185 118 01	186 119 01	187 120 01	188 121 01	189 122 01	190 123 01	191 124 01	192 125 01	193 126 01	194 127 01	195 128 01	196 129 01	197 130 01	198 131 01	199 132 01	200 133 01	201 134 01	202 135 01	203 136 01	204 137 01	205 138 01	206 139 01	207 140 01	208 141 01	209 142 01	210 143 01	211 144 01	212 145 01	213 146 01	214 147 01	215 148 01	216 149 01	217 150 01	218 151 01	219 152 01	220 153 01	221 154 01	222 155 01	223 156 01	224 157 01	225 158 01	226 159 01	227 160 01	228 161 01	229 162 01	230 163 01	231 164 01	232 165 01	233 166 01	234 167 01	235 168 01	236 169 01	237 170 01	238 171 01	239 172 01	240 173 01	241 174 01	242 175 01	243 176 01	244 177 01	245 178 01	246 179 01	247 180 01	248 181 01	249 182 01	250 183 01	251 184 01	252 185 01	253 186 01	254 187 01	255 188 01	256 189 01	257 190 01	258 191 01	259 192 01	260 193 01	261 194 01	262 195 01	263 196 01	264 197 01	265 198 01	266 199 01	267 200 01	268 201 01	269 202 01	270 203 01	271 204 01	272 205 01	273 206 01	274 207 01	275 208 01	276 209 01	277 210 01	278 211 01	279 212 01	280 213 01	281 214 01	282 215 01	283 216 01	284 217 01	285 218 01	286 219 01	287 220 01	288 221 01	289 222 01	290 223 01	291 224 01	292 225 01	293 226 01	294 227 01	295 228 01	296 229 01	297 230 01	298 231 01	299 232 01	300 233 01	301 234 01	302 235 01	303 236 01	304 237 01	305 238 01	306 239 01	307 240 01	308 241 01	309 242 01	310 243 01	311 244 01	312 245 01	313 246 01	314 247 01	315 248 01	316 249 01	317 250 01	318 251 01	319 252 01	320 253 01	321 254 01	322 255 01	323 256 01	324 257 01	325 258 01	326 259 01	327 260 01	328 261 01	329 262 01	330 263 01	331 264 01	332 265 01	333 266 01	334 267 01	335 268 01	336 269 01	337 270 01	338 271 01	339 272 01	340 273 01	341 274 01	342 275 01	343 276 01	344 277 01	345 278 01	346 279 01	347 280 01	348 281 01	349 282 01	350 283 01	351 284 01	352 285 01	353 286 01	354 287 01	355 288 01	356 289 01	357 290 01	358 291 01	359 292 01	360 293 01	361 294 01	362 295 01	363 296 01	364 297 01	365 298 01	366 299 01	367 300 01	368 301 01	369 302 01	370 303 01	371 304 01	372 305 01	373 306 01	374 307 01	375 308 01	376 309 01	377 310 01	378 311 01	379 312 01	380 313 01	381 314 01	382 315 01	383 316 01	384 317 01	385 318 01	386 319 01	387 320 01	388 321 01	389 322 01	390 323 01	391 324 01	392 325 01	393 326 01	394 327 01	395 328 01	396 329 01	397 330 01	398 331 01	399 332 01	400 333 01	401 334 01	402 335 01	403 336 01	404 337 01	405 338 01	406 339 01	407 340 01	408 341 01	409 342 01	410 343 01	411 344 01	412 345 01	413 346 01	414 347 01	415 348 01	416 349 01	417 350 01	418 351 01	419 352 01	420 353 01	421 354 01	422 355 01	423 356 01	424 357 01	425 358 01	426 359 01	427 360 01	428 361 01	429 362 01	430 363 01	431 364 01	432 365 01	433 366 01	434 367 01	435 368 01	436 369 01	437 370 01	438 371 01	439 372 01	440 373 01	441 374 01	442 375 01	443 376 01	444 377 01	445 378 01	446 379 01	447 380 01	448 381 01	449 382 01	450 383 01	451 384 01	452 385 01	453 386 01	454 387 01	455 388 01	456 389 01	457 390 01	458 391 01	459 392 01	460 393 01	461 394 01	462 395 01	463 396 01	464 397 01	465 398 01	466 399 01	467 400 01	468 401 01	469 402 01	470 403 01	471 404 01	472 405 01	473 406 01	474 407 01	475 408 01	476 409 01	477 410 01	478 411 01	479 412 01	480 413 01	481 414 01	482 415 01	483 416 01	484 417 01	485 418 01	486 419 01	487 420 01	488 421 01	489 422 01	490 423 01	491 424 01	492 425 01	493 426 01	494 427 01	495 428 01	496 429 01	497 430 01	498 431 01	499 432 01	500 433 01	501 434 01	502 435 01	503 436 01	504 437 01	505 438 01	506 439 01	507 440 01	508 441 01	509 442 01	510 443 01	511 444 01	512 445 01	513 446 01	514 447 01	515 448 01	516 449 01	517 450 01	518 451 01	519 452 01	520 453 01	521 454 01	522 455 01	523 456 01	524 457 01	525 458 01	526 459 01	527 460 01	528 461 01	529 462 01	530 463 01	531 464 01	532 465 01	533 466 01	534 467 01	535 468 01	536 469 01	537 470 01	538 471 01	539 472 01	540 473 01	541 474 01	542 475 01	543 476 01	544 477 01	545 478 01	546 479 01	547 480 01	548 481 01	549 482 01	550 483 01	551 484 01	552 485 01	553 486 01	554 487 01	555 488 01	556 489 01	557 490 01	558 491 01	559 492 01	560 493 01	561 494 01	562 495 01	563 496 01	564 497 01	565 498 01	566 499 01	567 500 01	568 501 01	569 502 01	570 503 01	571 504 01	572 505 01	573 506 01	574 507 01	575 508 01	576 509 01	577 510 01	578 511 01	579 512 01	580 513 01	581 514 01	582 515 01	583 516 01	584 517 01	585 518 01	586 519 01	587 520 01	588 521 01	589 522 01	590 523 01	591 524 01	592 525 01	593 526 01	594 527 01	595 528 01	596 529 01	597 530 01	598 531 01	599 532 01	600 533 01	601 534 01	602 535 01	603 536 01	604 537 01	605 538 01	606 539 01	607 540 01	608 541 01	609 542 01	610 543 01	611 544 01	612 545 01	613 546 01	614 547 01	615 548 01	616 549 01	617 550 01	618 551 01	619 552 01	620 553 01	621 554 01	622 555 01	623 556 01	624 557 01	625 558 01	626 559 01	627 560 01	628 561 01	629 562 01	630 563 01	631 564 01	632 565 01	633 566 01	634 567 01	635 568 01	636 569 01	637 570 01	638 571 01	639 572 01	640 573 01	641 574 01	642 575 01	643 576 01	644 577 01	645 578 01	646 579 01	647 580 01	648 581 01	649 582 01	650 583 01	651 584 01	652 585 01	653 586 01	654 587 01	655 588 01	656 589 01	657 590 01	658 591 01	659 592 01	660 593 01	661 594 01	662 595 01	663 596 01	664 597 01	665 598 01	666 599 01	667 600 01	668 601 01	669 602 01	670 603 01	671 604 01	672 605 01	673 606 01	674 607 01	675 608 01	676 609 01	677 610 01	678 611 01	679 612 01	680 613 01	681 614 01	682 615 01	683 616 01	684 617 01	685 618 01	686 619 01	687 620 01	688 621 01	689 622 01	690 623 01	691 624 01	692 625 01	693 626 01	694 627 01	695 628 01	696 629 01	697 630 01	698 631 01	699 632 01	700 633 01	701 634 01	702 635 01	703 636 01	704 637 01	705 638 01	706 639 01	707 640 01	708 641 01	709 642 01	710 643 01	711 644 01	712 645 01	713 646 01	714 647 01	715 648 01	716 649 01	717 650 01	718 651 01	719 652 01	720 653 01	721 654 01	722 655 01	723 656 01	724 657 01	725 658 01	726 659 01	727 660 01	728 661 01	729 662 01	730 663 01	731 664 01	732 665 01	733 666 01	734 667 01	735 668 01	736 669 01	737 670 01	738 671 01	739 672 01	740 673 01	741 674 01	742 675 01	743 676 01	744 677 01	745 678 01	746 679 01	747 680 01	748 681 01	749 682 01	750 683 01	751 684 01	752 685 01	753 686 01	754 687 01	755 688 01	756 689 01	757 690 01	758 691 01	759 692 01	760 693 01	761 694 01	762 695 01	763 696 01	764 697 01	765 698 01	766 699 01	767 700 01	768 701 01	769 702 01	770 703 01	771 704 01	772 705 01	773 706 01	774 707 01	775 708 01	776 709 01	777 710 01	778 711 01	779 712 01	780 713 01	781 714 01	782 715 01	783 716 01	784 717 01	785 718 01	786 719 01	787 720 01	788 721 01	789 722 01	790 723 01	791 724 01	792 725 01	793 726 01	794 727 01	795 728 01	796 729 01	797 730 01	798 731 01	799 732 01	800 733 01	801 734 01	802 735 01	803 736 01	804 737 01	805 738 01	806 739 01	807 740 01	808 741 01	809 742 01	810 743 01	811 744 01	812 745 01	813 746 01	814 747 01	815 748 01	816 749 01	817 750 01	818 751 01	819 752 01	820 753 01	821 754 01	822 755 01	823 756 01	824 757 01	825 758 01	826 759 01	827 760 01	828 761 01	829 762 01	830 763 01	831 764 01	832 765 01	833 766 01	834 767 01	835 768 01	836 769 01	837 770 01	838 771 01	839 772 01	840 773 01	841 774 01	842 775 01	843 776 01	844 777 01	845 778 01	846 779 01	847 780 01	848 781 01	849 782 01	850 783 01	851 784 01	852 785 01	853 786 01	854 787 01	855 788 01	856 789 01	857 790 01	858 791 01	859 792 01	860 793 01	861 794 01	862 795 01	863 796 01	864 797 01	865 798 01	866 799 01	867 800 01	868 801 01	869 802 01	870 803 01	871 804 01	872 805 01	873 806 01	874 807 01	875 808 01	876 809 01	877 810 01	878 811 01	879 812 01	880 813 01	881 814 01	882 815 01	883 816 01	884 817 01	885 818 01	886 819 01	887 820 01	888 821 01	889 822 01	890 823 01	891 824 01	892 825 01	893 826 01	894 827 01	895 828 01	896 829 01	897 830 01	898 831 01	899 832 01	900 833 01	90
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Output for Run Number 1

DISCHARGE STATION 06714310 SAND CREEK TRIBUTARY AT DENVER, COLORADO
 UNIT PRECIP. STATION 06714310 SAND CREEK TRIBUTARY AT DENVER, COLORADO
 DAILY PRECIP. STATION 06714310 SAND CREEK TRIBUTARY AT DENVER, COLORADO
 PAN-EVAP. STATION 40350010 FORT COLLINS
 DRAINAGE AREA= 0.24 SQ. MI.
 UNIT DATA ARE IN 5.000 MINUTE INCREMENTS
 THE PERIOD OF RECORD IS FROM 5- 1-73 (DAY= 26413) TO 7-31-74 (DAY= 26875)

[illegible]

INITIAL PARAMETER VALUES

1	5.000000	PSP	.
2	0.050000	KSAT	.
3	10.000000	KSF	.
4	5.000000	BMSN	.
5	0.700000	EVC	
6	0.900000	K2	
7	0.800000	URN	

INITIAL STEP SIZE INCREMENTS

0.300000	0.003000	0.600000	0.300000
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THE MAX. NUMBER OF ITERATIONS= 40

INITIALLY AND AFTER EACH VECTOR MATRIX ORTHONORMALIZATION.
THE PARAMETRIC VECTOR INCREMENT SIZE IS, 0.060 OF THE VECTOR SIZE

NUMBER OF SEGMENTS = 19
DT = 1.000 MINUTES
OUTPUT SAMPLING INTERVAL = 5.00 MINUTES
NUMBER OF RAIN GAGES = 1
NUMBER OF PARAMETER SETS = 1
IMPERVIOUS RETENTION = 0.05 INCHES

THIENSEN COEFFICIENTS

SEGMENT	UPSTREAM SEGMENTS	ADJACENT SEGMENTS	TYPE	IPR	NDX	LENGTH (FEET)	SLOPE	ROUGHNESS PARAMETER	OTHER PARAMETERS	THIENSEN COEFFICIENTS
UP01			5	0	10	454.	0.0050	0.200	0.800	0.150 1 1.00
0101			15	0	7	454.	0.0050	0.013	0.800	0.150 1 1.00
OF02			5	0	5	382.	0.0220	0.016	0.470	0.360 1 1.00
OF03			5	0	6	480.	0.0240	0.016	0.480	0.310 1 1.00
JF04			5	0	7	593.	0.0180	0.016	0.540	0.320 1 1.00
OF05			5	0	9	1006.	0.0220	0.016	0.570	0.270 1 1.00
OF06			5	0	7	295.	0.0040	0.016	0.440	0.420 1 1.00
OP07			5	0	10	372.	0.0120	0.200	0.800	0.160 1 1.00
J107			15	0	5	372.	0.0120	0.013	0.800	0.160 1 1.00
OP08			5	0	10	617.	0.0070	0.200	0.580	0.330 1 1.00
0108			15	0	8	617.	0.0070	0.013	0.580	0.330 1 1.00
OF09			5	0	6	340.	0.0100	0.016	0.700	0.220 1 1.00
CH20	UP01 J101 UF02		3	0	3	1210.	0.0050	0.016	11.000	0.0 0 0.0
CH21	OF04 JF09		3	0	4	2240.	0.0070	0.016	11.000	0.0 0 0.0
CH22	UF05 JF06		3	0	3	1580.	0.0080	0.016	4.300	0.0 0 0.0
CH23	OF03		3	0	2	1270.	0.0290	0.013	31.000	0.0 0 0.0
CH24	UP07 J107 UP08 0108		3	0	6	2225.	0.0050	0.013	50.000	0.0 0 0.0
CH25			3	0	2	460.	0.0050	0.016	11.000	0.0 0 0.0
JT01	CH20 CH25		7	1	10	0.	0.0	0.0	0.0	0.0 0 0.0

KINEMATIC CHANNEL PARAMETERS

COMPUTATION SEQUENCE

INDEX	SEGMENT	ALPHA	M
1	OP01	0.53	1.670
2	0101	8.10	1.670
3	OF02	13.81	1.670
4	OF03	14.43	1.670
5	OF04	12.49	1.670
6	OF05	13.81	1.670
7	OF06	5.89	1.670
8	OP07	0.82	1.670
9	0107	12.56	1.670
10	OP08	0.62	1.670
11	0108	9.59	1.670
12	OF09	9.31	1.670
14	CH21	3.32	1.330
16	CH23	5.88	1.330
17	CH24	2.88	1.330
13	CH20	2.80	1.330
15	CH22	4.85	1.330
18	CH25	2.80	1.330
19	JT01	0.0	0.0
THERE ARE 10 FLOOD PEAKS GROUPED AS FOLLOWS			
		1	1

STORM NO.	1	STARTS AT TIME PERIOD	226	AND ENDS AT	250
STORM NO.	2	STARTS AT TIME PERIOD	247	AND ENDS AT	275
STORM NO.	3	STARTS AT TIME PERIOD	168	AND ENDS AT	190
STORM NO.	4	STARTS AT TIME PERIOD	217	AND ENDS AT	260
STORM NO.	5	STARTS AT TIME PERIOD	220	AND ENDS AT	250
STORM NO.	6	STARTS AT TIME PERIOD	195	AND ENDS AT	225
STORM NO.	7	STARTS AT TIME PERIOD	73	AND ENDS AT	85
STORM NO.	8	STARTS AT TIME PERIOD	173	AND ENDS AT	190
STORM NO.	9	STARTS AT TIME PERIOD	5	AND ENDS AT	35

DETAILED OUTPUT FOR STORMS 0 0 0 0 0 0 0 0 0 0 0 0
 INPUT HYDROGRAPHS FOR STORMS 0 0 0 0 0 0 0 0 0 0 0 0
 THE FLOOD EVENTS IN THE OBJECTIVE FUNCTION ARE
 1 2 3 4 5 6
 10

OBJECTIVE FUNCTION = 0.6309789E U0 WHICH IS A ROOT MEAN SQUARE ERROR 0.135E 01 TO 0.741
 BEGINNING OF STAGE
 PARAMETER VALUES ARE
 5.000000 0.050000 10.000000 5.000000 0.700000 0.900000 0.800000

DETAILED DISCHARGE FOR FLOOD NUMBER 1
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.330 INCHES
 OBSERVED DIRECT RUNOFF = 0.080 INCHES
 SIMULATED DIRECT RUNOFF = 0.085 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION= 0.450E-02

DETAILED DISCHARGE FOR FLOOD NUMBER 2
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.630 INCHES
 OBSERVED DIRECT RUNOFF = 0.140 INCHES
 SIMULATED DIRECT RUNOFF = 0.247 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION= 0.169E 00

DETAILED DISCHARGE FOR FLOOD NUMBER 3
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.230 INCHES
 OBSERVED DIRECT RUNOFF = 0.055 INCHES
 SIMULATED DIRECT RUNOFF = 0.057 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION= 0.899E-03

DETAILED DISCHARGE FOR FLOOD NUMBER 4
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.950 INCHES
 OBSERVED DIRECT RUNOFF = 0.325 INCHES
 SIMULATED DIRECT RUNOFF = 0.348 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION= 0.463E-02

DETAILED DISCHARGE FOR FLOOD NUMBER 5
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.340 INCHES
 OBSERVED DIRECT RUNOFF = 0.063 INCHES
 SIMULATED DIRECT RUNOFF = 0.089 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION= 0.115E 00

DETAILED DISCHARGE FOR FLOOD NUMBER 6
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 1.140 INCHES
 OBSERVED DIRECT RUNOFF = 0.704 INCHES
 SIMULATED DIRECT RUNOFF = 1.154 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION= 0.244E 00

DETAILED DISCHARGE FOR FLOOD NUMBER 7
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.510 INCHES
 OBSERVED DIRECT RUNOFF = 0.073 INCHES
 SIMULATED DIRECT RUNOFF = 0.169 INCHES

DETAILED DISCHARGE FOR FLOOD NUMBER 8
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.560 INCHES
 OBSERVED DIRECT RUNOFF = 0.231 INCHES
 SIMULATED DIRECT RUNOFF = 0.224 INCHES

UNOBSERVED PEAK DISCHARGE = 0.0 CFS
SIMULATED PEAK DISCHARGE = 0.0 CFS
OBSERVED RAINFALL GAGE NUMBER 1 = 1.060 INCHES
OBSERVED DIRECT RUNOFF = 0.198 INCHES
SIMULATED DIRECT RUNOFF = 0.411 INCHES

DETAILED DISCHARGE FOR FLOOD NUMBER 10
OBSERVED PEAK DISCHARGE = 0.0 CFS
SIMULATED PEAK DISCHARGE = 0.0 CFS
OBSERVED RAINFALL GAGE NUMBER 1 = 1.390 INCHES
OBSERVED DIRECT RUNOFF = 0.534 INCHES
SIMULATED DIRECT RUNOFF = 0.549 INCHES
CONTRIBUTION TO OBJECTIVE FUNCTION= 0.729E-01

AT ITERATION NO. 0 OBJECTIVE FUNCTION= 0.630979
PARAMETER VALUES ARE
5.000000 0.050000 10.000000 5.000000 0.700000 0.900000 0.800000

AT ITERATION NO. 1 OBJECTIVE FUNCTION= 0.597197
PARAMETER VALUES ARE
5.299999 0.050000 10.000000 5.000000 0.700000 0.900000 0.800000

AT ITERATION NO. 2 OBJECTIVE FUNCTION= 0.544178
PARAMETER VALUES ARE
5.249999 0.053000 10.000000 5.000000 0.700000 0.900000 0.800000

AT ITERATION NO. 3 OBJECTIVE FUNCTION= 0.504645
PARAMETER VALUES ARE
5.299999 0.053000 10.599999 5.000000 0.700000 0.900000 0.800000

AT ITERATION NO. 4 OBJECTIVE FUNCTION= 0.503906
PARAMETER VALUES ARE
5.249999 0.053000 10.599999 5.299999 0.700000 0.900000 0.800000

AT ITERATION NO. 5 OBJECTIVE FUNCTION= 0.408993
PARAMETER VALUES ARE
6.199999 0.053000 10.599999 5.299999 0.700000 0.900000 0.800000

AT ITERATION NO. 6 OBJECTIVE FUNCTION= 0.328132
PARAMETER VALUES ARE
6.199999 0.062000 10.599999 5.299999 0.700000 0.900000 0.800000

AT ITERATION NO. 7 OBJECTIVE FUNCTION= 0.265055
PARAMETER VALUES ARE
6.199999 0.062000 12.399999 5.299999 0.700000 0.900000 0.800000

AT ITERATION NO. 8 OBJECTIVE FUNCTION= 0.263532
PARAMETER VALUES ARE
6.199999 0.062000 12.399999 6.199999 0.700000 0.900000 0.800000

AT ITERATION NO. 9 OBJECTIVE FUNCTION= 0.174056
PARAMETER VALUES ARE
6.199999 0.062000 12.399999 6.199999 0.700000 0.900000 0.800000

8.55555M 0.00000 12.39999 5.15555 0.70000 0.90000

AT ITERATION NO. 12 OBJECTIVE FUNCTION= 0.143732
 PARAMETER VALUES ARE
 8.55555 0.00000 12.39999 5.15555 0.70000 0.90000

B1 = 6.015103 B2 = 0.741328
 NEW ORTHONORMAL BASIS
 0.64837-0.76133-0.00002 0.00000
 0.00648 0.00552-0.99996-0.00001
 0.39900 0.33980 0.00450-0.85156
 0.64837 0.55217 0.00729 0.52410
 START OF STAGE STEP SIZE INCREMENTS
 0.985343 0.554243 0.012542 0.913502

OBJECTIVE FUNCTION = 0.1437320E 00 WHICH IS A ROOT MEAN SQUARE ERROR 0.115E 01 TO 0.866
 PARAMETER VALUES ARE
 8.899998 0.089000 12.399999 8.899998 0.700000 0.900000 0.800000

OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.330 INCHES
 OBSERVED DIRECT RUNOFF = 0.040 INCHES
 SIMULATED DIRECT RUNOFF = 0.080 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION = 0.851E-04

DETAILED DISCHARGE FOR FLOOD NUMBER 2
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.530 INCHES
 OBSERVED DIRECT RUNOFF = 0.140 INCHES
 SIMULATED DIRECT RUNOFF = 0.187 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION = 0.235E-01

DETAILED DISCHARGE FOR FLOOD NUMBER 3
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.230 INCHES
 OBSERVED DIRECT RUNOFF = 0.055 INCHES
 SIMULATED DIRECT RUNOFF = 0.052 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION = 0.281E-02

DETAILED DISCHARGE FOR FLOOD NUMBER 4
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.950 INCHES
 OBSERVED DIRECT RUNOFF = 0.325 INCHES
 SIMULATED DIRECT RUNOFF = 0.218 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION = 0.245E-01

DETAILED DISCHARGE FOR FLOOD NUMBER 5
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.340 INCHES
 OBSERVED DIRECT RUNOFF = 0.063 INCHES
 SIMULATED DIRECT RUNOFF = 0.083 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION = 0.720E-01

DETAILED DISCHARGE FOR FLOOD NUMBER 6
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 1.940 INCHES
 OBSERVED DIRECT RUNOFF = 0.704 INCHES
 SIMULATED DIRECT RUNOFF = 0.763 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION = 0.638E-02

DETAILED DISCHARGE FOR FLOOD NUMBER 7
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.510 INCHES
 OBSERVED DIRECT RUNOFF = 0.074 INCHES
 SIMULATED DIRECT RUNOFF = 0.140 INCHES

DETAILED DISCHARGE FOR FLOOD NUMBER 8
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.560 INCHES
 OBSERVED DIRECT RUNOFF = 0.231 INCHES
 SIMULATED DIRECT RUNOFF = 0.158 INCHES

OBSERVED PEAK DISCHARGE = 0.0 CFS
SIMULATED PEAK DISCHARGE = 0.0 CFS
OBSERVED RAINFALL GAGE NUMBER 1 = 1.060 INCHES
OBSERVED DIRECT RUNOFF = 0.199 INCHES
SIMULATED DIRECT RUNOFF = 0.320 INCHES

DETAILED DISCHARGE FOR FLOOD NUMBER 10
OBSERVED PEAK DISCHARGE = 0.0 CFS
SIMULATED PEAK DISCHARGE = 0.0 CFS
OBSERVED RAINFALL GAGE NUMBER 1 = 1.390 INCHES
OBSERVED DIRECT RUNOFF = 0.534 INCHES
SIMULATED DIRECT RUNOFF = 0.474 INCHES
CONTRIBUTION TO OBJECTIVE FUNCTION = 0.144E-01

AT ITERATION NO. 16 OBJECTIVE FUNCTION = 0.143732
PARAMETER VALUES ARE
0.009998 0.009000 12.399999 0.899998 0.700000 0.300000 0.800000

AT ITERATION NO. 17 OBJECTIVE FUNCTION = 0.143324
PARAMETER VALUES ARE
8.173506 0.094269 12.724245 9.426899 0.700000 0.900000 0.900000

AT ITERATION NO. 23 OBJECTIVE FUNCTION = 0.142805
PARAMETER VALUES ARE
8.173506 0.100565 12.724216 9.426852 0.700000 0.900000 0.800000

AT ITERATION NO. 28 OBJECTIVE FUNCTION = 0.142750
PARAMETER VALUES ARE
8.173506 0.100562 12.529718 9.546543 0.700000 0.900000 0.800000

AT ITERATION NO. 30 OBJECTIVE FUNCTION = 0.142502
PARAMETER VALUES ARE
7.628636 0.104513 12.772903 9.941719 0.700000 0.900000 0.800000

AT ITERATION NO. 33 OBJECTIVE FUNCTION = 0.142432
PARAMETER VALUES ARE
7.608727 0.104914 12.797574 9.991810 0.700000 0.900000 0.800000

AT ITERATION NO. 34 OBJECTIVE FUNCTION = 0.142275
PARAMETER VALUES ARE
6.034122 0.116770 13.527129 11.167338 0.700000 0.900000 0.800000

AT ITERATION NO. 35 OBJECTIVE FUNCTION = 0.141546
PARAMETER VALUES ARE
6.034122 0.121491 13.527107 11.167303 0.700000 0.900000 0.800000

AT ITERATION NO. 36 OBJECTIVE FUNCTION = 0.141498
PARAMETER VALUES ARE
6.034121 0.121496 13.818453 10.987766 0.700000 0.900000 0.800000

END OF RUN--RESULTS OF LAST SUCCESSFUL TRIAL
OBJECTIVE FUNCTION = 0.1414879E 00 WHICH IS A ROOT MEAN SQUARE ERROR 0.115E 01 TO 0.867
PARAMETER VALUES ARE

DETAILED DISCHARGE FOR FLOOD NUMBER 1
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.330 INCHES
 OBSERVED DIRECT RUNOFF = 0.040 INCHES
 SIMULATED DIRECT RUNOFF = 0.050 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION= 0.735E-04

DETAILED DISCHARGE FOR FLOOD NUMBER 2
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.530 INCHES
 OBSERVED DIRECT RUNOFF = 0.140 INCHES
 SIMULATED DIRECT RUNOFF = 0.186 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION= 0.224E-01

DETAILED DISCHARGE FOR FLOOD NUMBER 3
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.230 INCHES
 OBSERVED DIRECT RUNOFF = 0.055 INCHES
 SIMULATED DIRECT RUNOFF = 0.052 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION= 0.294E-02

DETAILED DISCHARGE FOR FLOOD NUMBER 4
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.950 INCHES
 OBSERVED DIRECT RUNOFF = 0.325 INCHES
 SIMULATED DIRECT RUNOFF = 0.277 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION= 0.257E-01

DETAILED DISCHARGE FOR FLOOD NUMBER 5
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.340 INCHES
 OBSERVED DIRECT RUNOFF = 0.063 INCHES
 SIMULATED DIRECT RUNOFF = 0.092 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION= 0.695E-01

DETAILED DISCHARGE FOR FLOOD NUMBER 6
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 1.940 INCHES
 OBSERVED DIRECT RUNOFF = 0.704 INCHES
 SIMULATED DIRECT RUNOFF = 0.754 INCHES
 CONTRIBUTION TO OBJECTIVE FUNCTION= 0.479E-02

DETAILED DISCHARGE FOR FLOOD NUMBER 7
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.510 INCHES
 OBSERVED DIRECT RUNOFF = 0.073 INCHES
 SIMULATED DIRECT RUNOFF = 0.139 INCHES

DETAILED DISCHARGE FOR FLOOD NUMBER 8
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 0.0 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.560 INCHES
 OBSERVED DIRECT RUNOFF = 0.231 INCHES
 SIMULATED DIRECT RUNOFF = 0.157 INCHES

OBSERVED PEAK DISCHARGE = 0.0 CFS
SIMULATED PEAK DISCHARGE = 0.0 CFS
OBSERVED RAINFALL GAGE NUMBER 1 = 1.060 INCHES
OBSERVED DIRECT RUNOFF = 0.198 INCHES
SIMULATED DIRECT RUNOFF = 0.318 INCHES

DETAILED DISCHARGE FOR FLOOD NUMBER 10
OBSERVED PEAK DISCHARGE = 0.0 CFS
SIMULATED PEAK DISCHARGE = 0.0 CFS
OBSERVED RAINFALL GAGE NUMBER 1 = 1.390 INCHES
OBSERVED DIRECT RUNOFF = 0.534 INCHES
SIMULATED DIRECT RUNOFF = 0.471 INCHES
CONTRIBUTION TO OBJECTIVE FUNCTION = 0.160E-01

Input for Run Number 2

LIST	73 05 01	74 07 31	75 01 01	76 01 01	77 01 01	78 01 01	79 01 01	80 01 01	81 01 01	82 01 01	83 01 01	84 01 01	85 01 01	86 01 01	87 01 01	88 01 01	89 01 01	90 01 01	91 01 01	92 01 01	93 01 01	94 01 01	95 01 01	96 01 01	97 01 01	98 01 01	99 01 01	100 01 01	101 01 01	102 01 01	103 01 01	104 01 01	105 01 01	106 01 01	107 01 01	108 01 01	109 01 01	110 01 01	111 01 01	112 01 01	113 01 01	114 01 01	115 01 01	116 01 01	117 01 01	118 01 01	119 01 01	120 01 01	121 01 01	122 01 01	123 01 01	124 01 01	125 01 01	126 01 01	127 01 01	128 01 01	129 01 01	130 01 01	131 01 01	132 01 01	133 01 01	134 01 01	135 01 01	136 01 01	137 01 01	138 01 01	139 01 01	140 01 01	141 01 01	142 01 01	143 01 01	144 01 01	145 01 01	146 01 01	147 01 01	148 01 01	149 01 01	150 01 01	151 01 01	152 01 01	153 01 01	154 01 01	155 01 01	156 01 01	157 01 01	158 01 01	159 01 01	160 01 01	161 01 01	162 01 01	163 01 01	164 01 01	165 01 01	166 01 01	167 01 01	168 01 01	169 01 01	170 01 01	171 01 01	172 01 01	173 01 01	174 01 01	175 01 01	176 01 01	177 01 01	178 01 01	179 01 01	180 01 01	181 01 01	182 01 01	183 01 01	184 01 01	185 01 01	186 01 01	187 01 01	188 01 01	189 01 01	190 01 01	191 01 01	192 01 01	193 01 01	194 01 01	195 01 01	196 01 01	197 01 01	198 01 01	199 01 01	200 01 01	201 01 01	202 01 01	203 01 01	204 01 01	205 01 01	206 01 01	207 01 01	208 01 01	209 01 01	210 01 01	211 01 01	212 01 01	213 01 01	214 01 01	215 01 01	216 01 01	217 01 01	218 01 01	219 01 01	220 01 01	221 01 01	222 01 01	223 01 01	224 01 01	225 01 01	226 01 01	227 01 01	228 01 01	229 01 01	230 01 01	231 01 01	232 01 01	233 01 01	234 01 01	235 01 01	236 01 01	237 01 01	238 01 01	239 01 01	240 01 01	241 01 01	242 01 01	243 01 01	244 01 01	245 01 01	246 01 01	247 01 01	248 01 01	249 01 01	250 01 01	251 01 01	252 01 01	253 01 01	254 01 01	255 01 01	256 01 01	257 01 01	258 01 01	259 01 01	260 01 01	261 01 01	262 01 01	263 01 01	264 01 01	265 01 01	266 01 01	267 01 01	268 01 01	269 01 01	270 01 01	271 01 01	272 01 01	273 01 01	274 01 01	275 01 01	276 01 01	277 01 01	278 01 01	279 01 01	280 01 01	281 01 01	282 01 01	283 01 01	284 01 01	285 01 01	286 01 01	287 01 01	288 01 01	289 01 01	290 01 01	291 01 01	292 01 01	293 01 01	294 01 01	295 01 01	296 01 01	297 01 01	298 01 01	299 01 01	300 01 01	301 01 01	302 01 01	303 01 01	304 01 01	305 01 01	306 01 01	307 01 01	308 01 01	309 01 01	310 01 01	311 01 01	312 01 01	313 01 01	314 01 01	315 01 01	316 01 01	317 01 01	318 01 01	319 01 01	320 01 01	321 01 01	322 01 01	323 01 01	324 01 01	325 01 01	326 01 01	327 01 01	328 01 01	329 01 01	330 01 01	331 01 01	332 01 01	333 01 01	334 01 01	335 01 01	336 01 01	337 01 01	338 01 01	339 01 01	340 01 01	341 01 01	342 01 01	343 01 01	344 01 01	345 01 01	346 01
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[illegible]

DISCHARGE STATION 06714310 SAND CREEK TRIBUTARY AT DENVER, COLORADO
UNIT PRECIP. STATION 06714310 SAND CREEK TRIBUTARY AT DENVER, COLORADO
DAILY PRECIP. STATION 06714310 SAND CREEK TRIBUTARY AT DENVER, COLORADO
PAV-EVAPO. STATION 40350010 FORT COLLINS
DRAINAGE AREA= 0.29 SQ. MI.
UNIT DATA ARE IN 5.000 MINUTE INCREMENTS
THE PERIOD OF RECORD IS FROM 5- 1-73 (JAY= 25419) TO 7-31-74 (JAY= 26875)

[illegible]

INITIAL PARAMETER VALUES

1	6.030000	PSP
2	0.121000	KSAT
3	13.820000	KGF
4	11.000000	HMSN
5	0.700000	EVC
6	0.900000	RZ
7	0.800000	DRN

NUMBER OF SEGMENTS = 19
 DT = 1.000 MINUTES
 OUTPUT SAMPLING INTERVAL = 5.00 MINUTES
 NUMBER OF MAIN GASES = 1
 NUMBER OF PARAMETER SETS = 1
 IMPERVIOUS RETENTION = 0.05 INCHES

THIESSEN COEFFICIENTS

SEGMENT	UPSTREAM SEGMENTS	ADJACENT SEGMENTS	TYPE	IPR	NDX	LENGTH (FEET)	SLOPE	ROUGHNESS PARAMETER	OTHER PARAMETERS	THIESSEN COEFFICIENTS
OP01			5	0	10	454.	0.0050	0.200	0.500	0.150 1 1.00
OP01			15	0	7	454.	0.0050	0.013	0.500	0.150 1 1.00
OF02			5	0	5	382.	0.0220	0.016	0.470	0.360 1 1.00
OF03			5	0	6	480.	0.0240	0.016	0.480	0.310 1 1.00
OF04			5	0	7	593.	0.0180	0.016	0.540	0.320 1 1.00
OF05			5	0	9	1006.	0.0220	0.016	0.570	0.270 1 1.00
OF06			5	0	7	295.	0.0040	0.016	0.440	0.420 1 1.00
OP07			5	0	10	372.	0.0120	0.000	0.300	0.160 1 1.00
OP07			15	0	5	372.	0.0120	0.013	0.400	0.160 1 1.00
OP08			5	0	10	617.	0.0070	0.020	0.580	0.330 1 1.00
OP08			15	0	8	617.	0.0070	0.013	0.580	0.330 1 1.00
OP09			-	-	6	340.	0.0100	0.015	0.700	0.220 1 1.00
CH20		OP01 J101 UF02	3	0	3	1210.	0.0050	0.016	11.000	0.0 0 0.0
CH21		UF04 JF04	3	0	4	2240.	0.0070	0.016	11.000	0.0 0 0.0
CH22		OF05 JF06	3	0	3	1580.	0.0080	0.016	4.300	0.0 0 0.0
CH23		JF03	3	0	2	1270.	0.0290	0.013	31.000	0.0 0 0.0
CH24		UP07 J107 JP09 O109	3	0	6	2225.	0.0050	0.013	50.000	0.0 0 0.0
CH25			3	0	2	460.	0.0050	0.016	11.000	0.0 0 0.0
J101			7	1	10	0.	0.0	0.0	0.0	0.0 0 0.0

KINEMATIC CHANNEL PARAMETERS

INDEX	SEGMENT	ALPHA	M
1	OP01	0.53	1.670
2	J101	8.10	1.670
3	OF02	13.81	1.670
4	UF03	14.43	1.670
5	JF04	12.49	1.670
6	UF05	13.81	1.670
7	JF06	5.89	1.670
8	OP07	0.62	1.670
9	J107	12.56	1.670
10	JP08	0.62	1.670
11	O108	9.59	1.670
12	OF09	9.31	1.670
14	CH21	3.32	1.330
16	CH23	5.88	1.330
17	CH24	2.08	1.330
13	CH20	2.80	1.330
15	CH22	4.85	1.330
18	CH25	2.80	1.330
19	J101	0.0	0.0

THERE ARE 10 FLOOD PEAKS GROUPED AS FOLLOWS

STORM NO.	1	2	3	4	5	6	7	8	9	10
STARTS AT TIME PERIOD	226	247	168	217	220	195	73	173	5	68
ENDS AT TIME PERIOD	250	275	190	260	250	225	95	190	35	90

FLOOD NUMBER	I	OUTFLOW HYDROGRAPHS (IN CFS)
TIME		JT01
19.83	226	0.004
19.92	227	0.122
19.00	228	0.905
19.08	229	2.778
19.17	230	6.977
19.25	231	15.739
19.33	232	21.932
19.41	233	22.840
19.50	234	20.075
19.58	235	16.025
19.67	236	12.347
19.75	237	9.462
19.83	238	7.312
19.92	239	5.728
20.00	240	4.552
20.08	241	3.673
20.17	242	3.004
20.25	243	2.489
20.33	244	2.085
20.42	245	1.765
20.50	246	1.508
20.58	247	1.300
20.67	248	1.129
20.75	249	0.987
20.83	250	0.865

FLOOD NUMBER	TIME	I	OUTFLOW HYDROGRAPHS (IN CFS)
			JT01
20.58	247		1.255
20.67	248		29.921
20.75	249		73.915
20.83	250		70.151
20.92	251		50.567
21.00	252		34.802
21.08	253		25.039
21.17	254		18.895
21.25	255		14.897
21.33	256		12.054
21.42	257		9.692
21.50	258		7.744
21.58	259		6.279
21.67	260		5.105
21.75	261		4.190
21.83	262		3.479
21.92	263		2.919
22.00	264		2.475
22.08	265		2.119
22.17	266		1.830
22.25	267		1.595
22.33	268		1.401
22.42	269		1.241
22.50	270		1.105
22.58	271		0.999
22.67	272		0.897
22.75	273		0.815
22.83	274		0.744
22.92	275		0.684

FLOOD NUMBER	I	OUTFLOW HYDROGRAPHS (IN CFS)
TIME		UT01
14.00	165	0.071
14.08	167	1.070
14.17	170	6.603
14.25	171	11.862
14.33	172	13.768
14.42	173	13.027
14.50	174	11.093
14.58	175	9.005
14.67	175	7.184
14.75	177	5.727
14.83	175	4.596
14.91	177	3.725
15.00	180	3.054
15.08	181	2.532
15.17	182	2.122
15.25	183	1.795
15.33	184	1.535
15.42	185	1.320
15.50	185	1.145
15.58	187	1.001
15.67	185	0.881
15.75	187	0.777
15.83	191	0.593

FLOOD NUMBER	4	TIME	T	OUTFLOW HYDROGRAPHS (IN CFS)
				J101
18.08	217			0.004
18.17	218			1.717
18.25	219			37.444
18.33	220			96.521
18.42	221			88.985
18.51	222			62.524
18.58	223			47.040
18.67	224			35.824
18.75	225			26.701
18.83	226			19.571
18.92	227			14.404
19.00	228			10.894
19.08	229			8.754
19.17	230			7.627
19.25	231			7.264
19.33	232			6.441
19.42	233			6.325
19.50	234			5.575
19.58	235			4.894
19.67	236			4.624
19.75	237			4.955
19.83	238			5.637
19.92	239			6.331
20.00	240			7.134
20.08	241			7.745
20.17	242			8.206
20.25	243			7.840
20.33	244			7.021
20.42	245			6.067
20.50	246			5.150
20.58	247			4.345
20.67	248			3.67
20.75	249			3.11
20.83	250			2.655
20.92	251			2.275
21.00	252			1.975
21.08	253			1.715
21.17	254			1.505
21.25	255			1.330
21.33	256			1.184
21.42	257			1.060
21.50	258			0.955
21.58	259			0.865
21.67	260			0.785

FLOOD NUMBER	TIME	I	OUTFLOW HYDROGRAPHS (IN CFS)
18.33	220		JUL
18.42	221		0.000
18.50	222		0.000
18.58	223		0.000
18.67	224		0.000
18.75	225		0.000
18.83	226		0.000
18.92	227		0.000
19.00	228		0.000
19.08	229		0.419
19.17	230		7.065
19.25	231		21.472
19.33	232		28.345
19.42	233		25.992
19.50	234		20.405
19.58	235		15.142
19.67	236		11.247
19.75	237		8.444
19.83	238		6.451
19.92	239		5.041
20.00	240		4.034
20.08	241		3.235
20.17	242		2.655
20.25	243		2.207
20.33	244		1.855
20.42	245		1.577
20.50	246		1.353
20.58	247		1.170
20.67	248		1.020
20.75	249		0.895
20.83	250		0.790

FLOOD NUMBER	6	I	OUTF-OW HYDROGRAPHS (IN CFS)
TIME			J101
16.25	195		0.034
16.33	196		9.688
16.42	197		128.050
16.50	198		252.314
16.58	199		279.563
16.67	200		248.413
16.75	201		187.771
16.83	202		109.460
16.92	203		69.989
17.00	204		54.925
17.08	205		44.053
17.17	206		34.390
17.25	207		26.520
17.33	208		20.765
17.42	209		16.685
17.50	210		13.770
17.58	211		11.640
17.67	212		10.041
17.75	213		8.809
17.83	214		7.835
17.92	215		7.047
18.00	216		6.396
18.08	217		5.849
18.17	218		5.383
18.25	219		4.975
18.33	220		4.624
18.42	221		4.310
18.50	222		4.029
18.58	223		3.775
18.67	224		3.545
18.75	225		3.335

FLOOD NUMBER

DATE

14.42 172
 14.50 173
 14.58 174
 14.67 175
 14.75 176
 14.83 177
 14.92 178
 14.92 179
 15.00 180
 15.08 181
 15.17 182
 15.25 183
 15.33 184
 15.42 185
 15.50 186
 15.58 187
 15.67 188
 15.75 189
 15.83 190

OUTSTANDING
 6.004
 1.293
 25.111
 68.083
 67.690
 48.084
 31.972
 21.424
 14.894
 10.720
 7.967
 6.089
 4.762
 3.803
 3.094
 2.555
 2.134
 1.810

FLOOD NUMBER	TIME	OUTFLOW HYDROGRAPHS (IN CFS)
1	0.42	J101
2	0.50	0.000
3	0.58	0.000
4	0.67	0.000
5	0.75	0.001
6	0.83	0.011
7	0.92	0.143
8	1.00	3.957
9	1.08	38.155
10	1.17	91.031
11	1.25	116.772
12	1.33	99.689
13	1.42	74.000
14	1.50	52.869
15	1.58	39.792
16	1.67	30.772
17	1.75	23.755
18	1.83	18.529
19	1.92	14.997
20	2.00	12.271
21	2.08	9.925
22	2.17	8.000
23	2.25	6.470
24	2.33	5.277
25	2.42	4.350
26	2.50	3.629
27	2.58	3.064
28	2.67	2.616
29	2.75	2.257
30	2.83	1.969
31	2.92	1.731
32		1.537

FLOOD NUMBER 10		OUTFLOW HYDROGRAPHS (IN CFS)	
TIME	I	JT01	
5.67	69	0.000	
5.75	69	1.215	
5.83	70	37.229	
5.92	71	151.200	
6.00	72	215.654	
6.08	73	175.276	
6.17	74	116.856	
6.25	75	77.343	
6.33	76	51.940	
6.42	77	35.443	
6.50	79	24.579	
6.58	79	17.642	
6.67	80	13.150	
6.75	81	10.139	
6.83	82	8.073	
6.92	83	6.615	
7.00	84	5.559	
7.08	85	4.771	
7.17	86	4.171	
7.25	87	3.703	
7.33	88	3.329	
7.42	89	3.024	
7.50	90	2.771	

DETAILED DISCHARGE FOR FLOOD NUMBER 1
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 22.84 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.330 INCHES
 OBSERVED DIRECT RUNOFF = 0.0 INCHES
 SIMULATED DIRECT RUNOFF = 0.040 INCHES

DETAILED DISCHARGE FOR FLOOD NUMBER 2
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 73.92 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.530 INCHES
 OBSERVED DIRECT RUNOFF = 0.0 INCHES
 SIMULATED DIRECT RUNOFF = 0.176 INCHES

DETAILED DISCHARGE FOR FLOOD NUMBER 3
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 13.77 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.230 INCHES
 OBSERVED DIRECT RUNOFF = 0.0 INCHES
 SIMULATED DIRECT RUNOFF = 0.022 INCHES

DETAILED DISCHARGE FOR FLOOD NUMBER 4
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 46.52 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.950 INCHES
 OBSERVED DIRECT RUNOFF = 0.0 INCHES
 SIMULATED DIRECT RUNOFF = 0.277 INCHES

DETAILED DISCHARGE FOR FLOOD NUMBER 5
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 28.35 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.340 INCHES
 OBSERVED DIRECT RUNOFF = 0.0 INCHES
 SIMULATED DIRECT RUNOFF = 0.092 INCHES

DETAILED DISCHARGE FOR FLOOD NUMBER 6
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 279.56 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 1.940 INCHES
 OBSERVED DIRECT RUNOFF = 0.0 INCHES
 SIMULATED DIRECT RUNOFF = 0.755 INCHES

DETAILED DISCHARGE FOR FLOOD NUMBER 7
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 57.87 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.510 INCHES
 OBSERVED DIRECT RUNOFF = 0.0 INCHES
 SIMULATED DIRECT RUNOFF = 0.140 INCHES

DETAILED DISCHARGE FOR FLOOD NUMBER 8
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 58.06 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 0.560 INCHES
 OBSERVED DIRECT RUNOFF = 0.0 INCHES
 SIMULATED DIRECT RUNOFF = 0.127 INCHES

DETAILED DISCHARGE FOR FLOOD NUMBER 9
 OBSERVED PEAK DISCHARGE = 0.0 CFS
 SIMULATED PEAK DISCHARGE = 116.77 CFS
 OBSERVED RAINFALL GAGE NUMBER 1 = 1.060 INCHES
 OBSERVED DIRECT RUNOFF = 0.0 INCHES

MULATED DIRECT RUNOFF = 0.314 INCHES
TAILED DISCHARGE FOR FLOOD NUMBER 10
SERVED PEAK DISCHARGE = 0.0 CFS
MULATED PEAK DISCHARGE = 215.65 CFS
SERVED RAINFALL GAGE NUMBER 1 = 1.330 INCHES
SERVED DIRECT RUNOFF = 0.0 INCHES
MULATED DIRECT RUNOFF = 0.471 INCHES



WATER RESOURCES DIVISION

**Gulf Coast Hydroscience Center
NSTL Station, Mississippi**