TECHNICAL PUBLICATION SJ 82-4

UPPER ST. JOHNS HYDROLOGIC MODEL (USJM) USERS MANUAL

By

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Palatka, Florida

March 1982

Project Number 2030506

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I. INTRODUCTION

The Upper St. Johns River Basin, situated in the east central Florida, covers a drainage area of approximately 2,000 square miles, as shown in Figure 1. The headwaters of the basin originate in the St. Johns River Marsh near the Florida Turnpike. St. Johns River flows northerly with an average gradient of 0.08 feet per mile. The length of the river is about 300 miles.

The Upper St. Johns River Hydrologic Model (USJM) was primarily developed for surface water management study in the Upper St. Johns River Basin. The model will serve as a useful tool for simulating surface runoff response resulting from changes in hydrologic and hydraulic conditions as well as operating schedules. With this information a water management plan can be accomplished. For the purpose of this study, the entire basin south of S.R. 46 was divided into 7 planning units and the main river was divided into 12 river reaches based on natural or artificial drainage characteristics, proposed management plans and other hydrologic features (1). Figure 2 shows the detailed breakdown of the river basin.

II. DESCRIPTION OF COMPUTER PROGRAM

The computer program was developed by C. Charles Tai in 1978. The program was designed such that the hydrologic conditions resulting from any modifications of the management plan can be simulated. The basic input requirements for the program are the daily rainfall, soil and land use data, and hydraulic rating curves.

A. Capabilities and Limitations

The capabilities and limitations of the program can be summarized as follows:

(1) Number of subbasins: 60

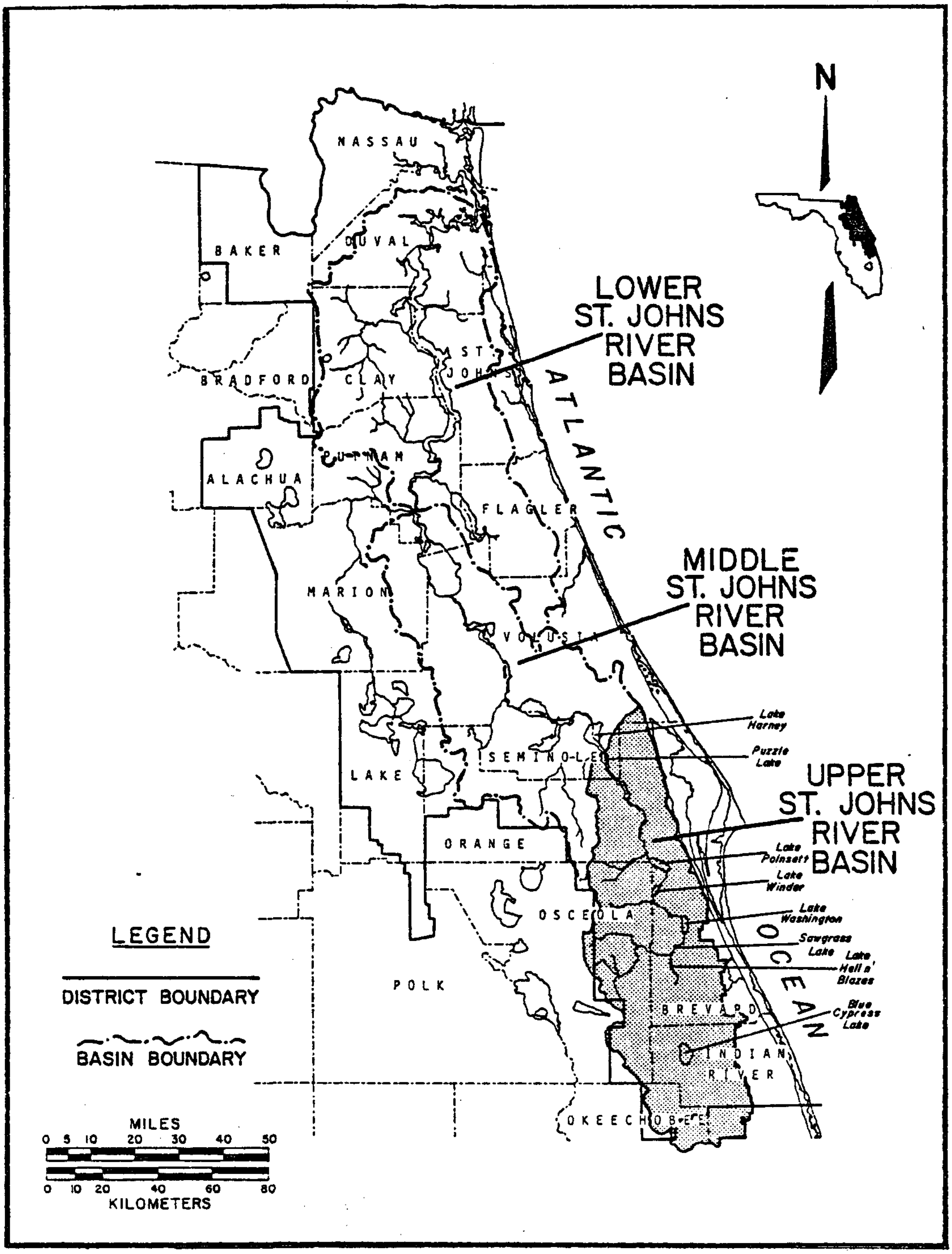

Figure 1. Location of the Upper St. Johns River Basin

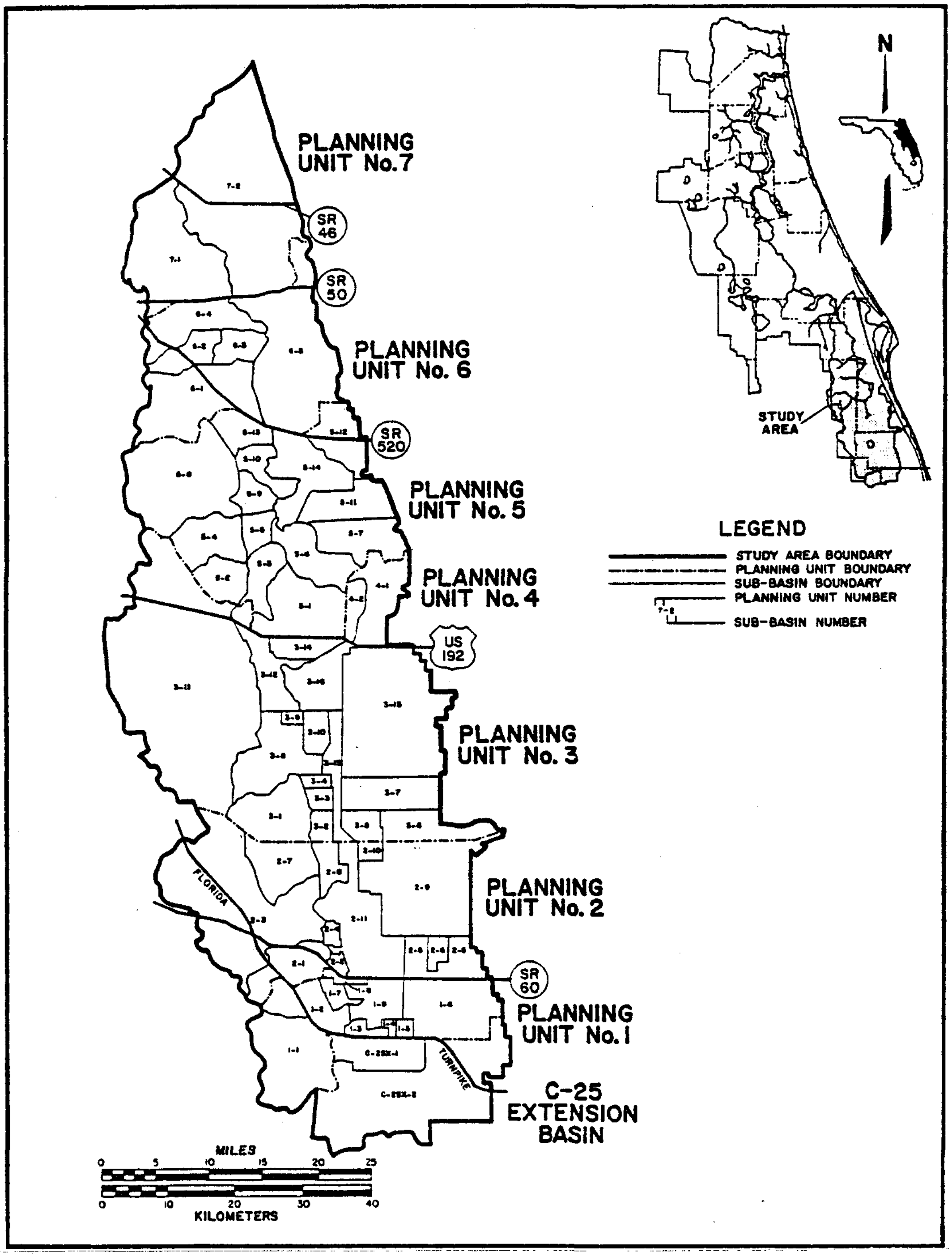

Figure 2. Detailed breakdown of the Upper St. Johns River Basin

(2) Number of land-use classifications: 9

(3) Number of hydrological soil classifications: 4

(4) Number of rainfall stations: 20

(5) Number of main channel reaches: 12

(6) Routing time increment: 24 hours

(7) Number of data points used to define storage-discharge relation for each rating curve: 10

B. Program Organization

The program was written in Fortran IV language for use on a Prime 400 Computer. It consists of a main program and nine subroutines. Each subroutine was structured to handle a specific set of related tasks. Figure 3 shows the schematic diagram of USJM. Description of input data, source program, and a list of symbols are given in Appendices A, B, and C, respectively. A description of each subroutine is as follows:

1. MAIN

The MAIN routine performs executive tasks such as initiating access to subroutines in the proper sequence.

2. Subroutine GDATA

General data such as ISB, JJ, KK, CN, A, SOVL, TK, X and AO are read into this routine. The routine computes open-water area in upland, open-water and marsh areas in valley, and total soil-water storage capacity for each subbasin.

3. Subroutine CLMD

Subroutine CLMD reads NST, NEWTH, NPE, PE, TH, IRF, and RF, then computes potential ET and total monthly rainfall.

4. Subroutine WBGT

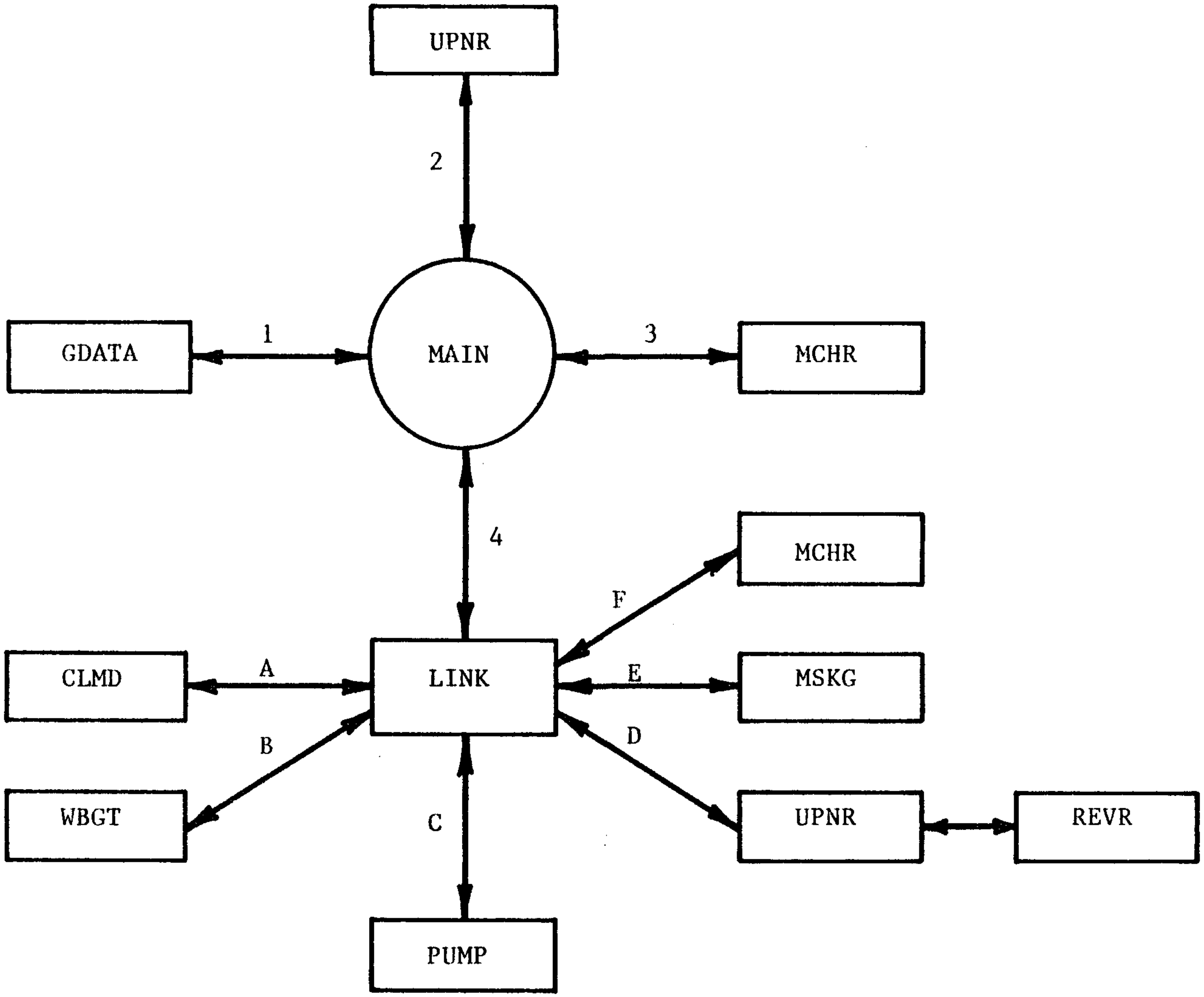

Figure 3. Flow Chart of the Upper St. Johns River Hydrologic Model

The function of this routine is to perform water budget analysis. A bookkeeping procedure was used to provide a continuous update of the soil-water storage capacity of a given soil type. Overland flow is generated when rainfall intensity exceeds infiltration rate and storage capacity. The coefficients A$, B$, C$ and CDET are introduced through data statement.

5. Subroutine REVR

Reservoir routing is handled by this routine.

6. Subroutine UPNR

Subroutine UPNR is used for upland detention routing and reservoir routing for upland retention ponds. The routine reads NAME, AOF, S, AOFRN, SRN, AB, AC, Q1, STO1.

7. Subroutine MSKG

The function of this routine is to handle channel routing using Muskingum method.

8. Subroutine MCHR

Subroutine MCHR performs main river routing. The routine first computes total inflow for a river reach and then routes it to the lower reach by the Puls Method. In addition, the routine can simulate the effect of the operating schedule of existing plan or proposed management plan. This routine reads NH, Q1, STO1, AOFW, S, NRH, NLCH, LCH, NLCF, LCF, SOFLN1, SOLM and AOL.

9. Subroutine PUMP

The function of this routine is to handle pump discharge routing which is performed before reservoir and channel routings. The capacity of each pump is read into the routine via data statement.

10. Subroutine LINK

Subroutines CLMD, WGBT, PUMP, UPNR, MSKG and MCHR are called by this routine to execute specific tasks in the proper sequence. Its function is similar to that of MAIN routine.

C. Input Requirement

Input consists of the following seven data groups:

(1) Output control parameters: IPNT, LANA, IPRNT, IPNR.

(2) Precipitation descriptors: NST, NEWTH, TH, IRF, RF.

(3) Evaporation descriptors: NPE, PE.

(4) Basin descriptors: IBASIN, ISB.

(5) Runoff Curve Number descriptors: JJ, KK, CN, LANA.

(6) Channel routing descriptors: TK, X, AO, NH, Q1, STO1, AOFW, S, NCH, NLCH, LCH, NLCF, LCF.

(7) Reservoir routing descriptors: NAME, AOF, S, AOFRN, SRN, SOFLN1, SOLM, AOL, IRV, IRNG, AB, AC, Q1, STO1.

III. METHODS OF COMPUTATION

The USJM consists of two major components: namely the Runoff Routine and the Routing Routine. The Runoff Routine generates a runoff hydrograph for each discrete land area from a given rainfall input. The Routing Routine modifies the hydrograph by accounting for the effects of impoundment and transient lag time to produce an inflow hydrograph for a channel reach. Finally, the inflow hydrograph is routed through the channel reach to obtain streamflow hydrograph at the lower reach.

A. USJ Runoff Routine

The USJ Runoff Routine shown in Fig. 4 is basically a water balance routine. The primary elements considered in the routine are rainfall, evapotranspiration losses, surface detention storage, overland flow, upper zone

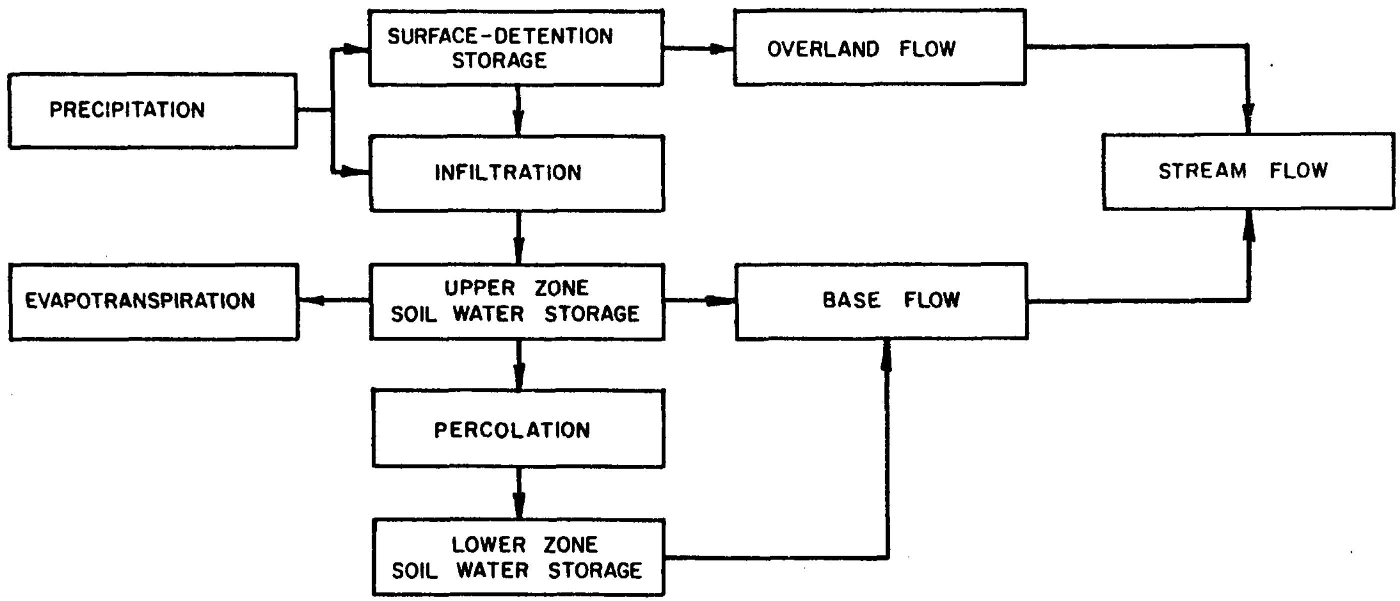

Figure 4. Flow Chart of the Upper St. Johns Runoff Routine

soil water storage, depletion in lower zone soil water storage, and base flow from both upper and lower zones.

Each planning unit is divided into subunits according to land use and soil type. The water balance equation for each subunit can be written as

$$P - ET - OF - BF = \Delta DS + \Delta UST - \Delta LST \quad (1)$$

in which P = rainfall, ET = evapotranspiration, OF = overland flow, BF = base flow, ΔDS = change in surface detention storage, ΔUST = change in upper zone soil water storage, and ΔLST = the depletion in lower zone soil water storage. All terms above are expressed in inches per day.

1. Surface Detention Storage

The simulation cycle starts with the computation of the subunit surface water excess by adding the daily rainfall to the initial (or preceding day) subunit surface detention storage. The subunit surface water excess is firstly allocated to the upper zone soil water storage by infiltration, and then to the surface detention storage according to the following equations (2):

$$FLT = SS - \frac{(SS - 0.2\ (MUST-UST))^2}{SS + 0.8\ (MUST-UST)} \quad (2)$$

and

$$DS = SS - FLT \quad (3)$$

in which FLT = infiltration to upper zone, UST = upper zone soil water storage, SS = unit surface water excess, DS = surface detention storage, and MUST = maximum UST capacity. The surface detention storage so computed is used to generate overland flow.

2. Upper Zone Soil Water Storage

The subsurface water storage above the confined aquifer or hardpan can be divided into upper zone and lower zone soil water storages, as shown in

Fig. 4. Typical soil profiles in Upper St. Johns River Basin have relatively shallow upper zone storages because of existence of high ground water table; therefore, land use is highly related to its depth. However, the actual thickness of the upper zone is difficult to estimate.

For the purpose of runoff simulation, the maximum upper zone soil-water storage is defined as an amount of soil water that will be stored in this zone until it is saturated. Thus, the maximum storage capacity is equal to the amount of soil water required to saturate the entire upper zone. Such capacity depends upon soil type and land use.

The U. S. Soil Conservation Service (SCS) developed a method to estimate the total runoff from the accumulated rainfall by assigning a Runoff Curve Number to a particular land use and soil type (3). The soil water required to fill the upper zone storage, therefore, was related to a particular Runoff Curve Number as follows:

$$SM = \frac{1000}{CN} - 10 \qquad (4)$$

in which SM is retention parameter, and CN is the SCS Runoff Curve Number. The SM computed by Eq. 4 is equivalent to the upper zone soil water storage capacity if the CN value for dry antecedent moisture condition (Condition I) is used. Land uses are classified into 9 general categories based on Level I classification system (4) and soils are classified into 4 hydrologic groups according to the SCS.

The upper zone soil water storage is subject to depletion by evapotranspiration, lateral base flow, and percolation. These three factors are discussed below.

a. Evapotranspiration

Evapotranspiration is generally governed by the following factors: Total energy input, climatological condition, soil type, land use, and soil moisture condition. Normally, the information on total energey input and climatological data may not readily be available in the basin; therefore, pan evaporation data can be used as an index parameter to determine potential evaporation rate. In order to obtain a good estimate of actual evapotranspiration, pan evaporation coefficients have to be adjusted for a particular basin. The acutal evapotranspiration is limitedby the upper zone soil water storage and is computed by the following equation:

$$ET = PE \left(\frac{UST}{USTM}\right)^2 \tag{5}$$

in which ET and PE are the actual and the potential evapotranspirations, respectively.

b. Upper Zone Lateral Base Flow

The upper zone lateral base flow is assumed as a function of the current level of soil water storage. An empirical formula developed based on the data available from similar watershed (5) is as follows:

$$BFU = A \exp (b\ UST^2 + c\ UST + d) \tag{6}$$

in which BFU = base flow in cfs, A = drainage area in acres, and b, c, and d are parameters to be determined.

c. Percolation

The percolation rate is a function of the upper zone soil water storage and can be expressed as follows:

$$PC = \Delta LST\ (UST/USTM)^a \tag{7}$$

in which a is a constant to be determined.

3. Lower Zone Soil Water Storage

The lower zone soil water storage (LST) is depleted only by lateral flow and replenished by percolation from the upper zone soil water storage (UST). Because this storage is generally of great magnitude, the water balance for this zone will be written in terms of the storage deficiency from its capacity.

The lower zone soil water storage is balanced by accounting for the depletion from its capacity as follows:

$$\Delta LST = \Delta LST1 + BFL - PC \quad (8)$$

in which ΔLST = the current storage deficiency, $\Delta LST1$ = the preceding day storage deficiency, BFL = lower zone lateral base flow, and PC = percolation from the upper zone. The base flow is assumed simply as a function of the drainage area and will be calibrated with the base flow data from the area or the neighboring watersheds.

B. USJ Routing Routine

The primary function of the USJ Routing Routine is to determine the time and magnitude of flows in river and to provide a proper flow timing of discharge hydrograph at a point downstream. The routing procedures used in the model are essentially based on the relationship between storage and discharge Two routing methods are considered in this model. The Muskingum method is used for channel routing and the Puls Method for reservoir, upland detention and main channel routings. These two methods are briefly described below. For more detailed discussions, the user should refer to hydrology text books.

The Muskingum Method assumes that outflow is a function of prism and wedge storage, which are functions of inflow and outflow. Outflow can be determined as follows

$$O_2 = O_1 + C_1 (I_1 - O_1) + C_2 (I_2 - I_1) \quad (9)$$

$$C_1 = \frac{t}{K(1-X)+0.5t} \quad (10)$$

$$C_2 = \frac{0.5t - KX}{K(1-X)+0.5t} \quad (11)$$

where O = outflow, I = inflow, t = routing time interval, K = storage constant and X = storage parameter.

The Puls Method assumes that outlow is a function of storage. For a given channel reach and a finite time interval, the continuity equation may be expressed as

$$\frac{1}{2}(I_1 + I_2) - \frac{1}{2}(O_1 + O_2) = \frac{1}{t}(S_2 - S_1) \qquad (12)$$

where I, O, t, and S are inflow, outflow, routing period, and storage, respectively. By arranging the equation such that all the known terms are on the left hand side, the final equation becomes

$$\frac{1}{2}(I_1 + I_2) + \frac{S_1}{t} + \frac{1}{2}O_1 - O_1 = \frac{S_2}{t} + \frac{1}{2}O_2 \qquad (13)$$

Routing is achieved by substituting the known terms in Eq. 13 to find $S_2/t + O_2/2$. Then O_2 is obtained from the relationship between O_2 and $S_2/t + O_2/2$.

The USJ Runoff Routine generates rainfall excess from each subunit area based on soil and land use. The model assumes a certain amount of rainfall excess will remain as surface detention storage and the remaining excess as overland flow. A reduction factor obtained from calibration is used to determine how much rainfall excess is available as surface detention storage for the following day.

A bookkeeping procedure is used to provide a continuous update of rainfall excess so that overland flow hydrograph can be generated. If a flood detention structure exists at the outlet of a subbasin, then the runoff hydrograph is modified by routing through the structure to produce an inflow hydrograph for a channel reach. The hydrograph obtained from reservoir routing is derived basically from the stage-discharge relationship and is a function of water surface elevation and operating method. However, pump discharge routing is performed before reservoir and channel routing when a known discharge is withdrawn from the system by pumping for agricultural, commercial or other uses.

Streamflows are routed through a channel reach using the Muskingum Method to produce an inflow hydrograph for a river reach. Finally, the inflow hydrograph is routed by the Puls Method to obtain a total discharge hydrograph from a river reach. It should be noted that the Puls Method used in river routing was modified and assumed to have a sloping water surface instead of a level water surface.

REFERENCES

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2. William, J. R., and Laseur, N. V., "Water Yield Model Using SCS Curve Numbers", Journal of the Hydraulics Division, ASCE, Vol. 102, No. HY9, September 1976, pp. 1241-1253.
3. National Engineering Handbook, Hydrology, U. S. Department of Agriculture, Soil Conservation Service, Section 4, Chapters 4-10, 1972.
4. "Upper St. Johns River Basin Surface Water Management Plan," Phase I Report, Volume 1, St. Johns River Water Management District, October, 1979, pp. 126-134.
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APPENDIX A

INPUT DATA DESCRIPTION

TT Card: Name of basin

Format: (2X,39A2)

Column Number	Variable	Description
1-2	TT	Card identification
3-80	IBASIN	Name of basin

DI Card: Total number of subbasins, land uses, and hydrologic soil groups

Format:: (2X,3I4)

Column Number	Variable	Description
1-2	DI	Card identification
3-6	ISB	Total number of subbasins
7-10	JJ	Total number of land uses
11-14	KK	Total number of hydrologic soil groups

CN Card: Runoff Curve Number

Format: (2X,9F5.2)

Column Number	Variable	Description
1-2	CN	Card identification
3-7	CN(I,J)	Runoff Curve Number for the i th hydrologic soil group of the j th land use
.		
.		
43-47		

CO Card: Surface runoff coefficient

Format: (2X, 9F5.2)

Column Number	Variable	Description
1-2	CO	Card identification
3-7	COVER(I,J)	Surface runoff coefficient
.		for the i th hydrologic soil
.		group of the j th land use
43-47		

IP Card: Output control for each subbasin

Format: (2X, 10I2)

Column Number	Variable	Description
1-2	IP	Card identification
3-4	IPNT(I)	Index which defines the print
.		status for the i th subbasin
.		IPNT(I) = 0, no output is
.		printed.
.		IPNT(I) = 1, output is
21-22		printed

RT Card: Index control for routing destination

Format: (2X,10I2)

Column Number	Variable	Description
1-2	RT	Card identification
3-4	IRNG(I)	Index which specifies the
.		routing status for the i th
.		subbasin
.		IRNG(I) = 0, no routing is
		performed
.		IRNG(I) = 1-5, reservoir
		routing is performed.
21-22		IRNG(I) = 20, river routing
		is performed

Note: Five detention structures are considered in the current model. Code 01 to 04 refers to the detention structures at Jane Green Creek, Pennywash Creek, Wolf Creek, and Taylor Creek, respectively. Code 05 refers to St. Johns reservoir.

LM Card: Subbasin number

Format: (2X,I4)

Column Number	Variable	Description
1-2	LM	Card identification
3-6	NPU	Subbasin number

A3 Card: Land area matrix

Format: (2X,9F9.0)

Column Number	Variable	Description
1-2	A1,A2,A3,A4	Card identification
3-11	A(I,J,K)	Land area matrix for the i th
.		land use and the j th hydrologic
.		soil group of the k th subbasin
57-65		

Note: A set of five cards is required for each subbasin, i.e., one "LM" card and four "A" cards.

SI Card: Initial depression storage

Format: (2X,10F7.0)

Column Number	Variable	Description
1-2	SI	Card identification
3-8	SOLV(I)	Initial depression storage
.		for the i th subbasin
.		
.		
66-72		

TK Card: Storage constant for Muskingum Routing

Format: (2X,10F7.0)

Column Number	Variable	Description
1-2	TK	Card identification
3-9	TK(I)	Storage constant in days for the i th subbasin
.		
.		
.		
66-72		

XX Card: Storage parameter for Muskingum Routing

Format: (2X,10F7.0)

Column Number	Variable	Description
1-2	XX	Card identification
3-9	X(I)	Storage parameter for the i th subbasin
.		
.		
.		
66-72		

AA Card: Initial outflow data for each subbasin

Format: (2X,10F7.0)

Column Number	Variable	Description
1-2	AA	Card identification
3-9	AO(I)	Initial outflow in cfs for the i th subbasin
.		
.		
.		
66-72		

NA Card: Title of detention structure or reservoir

Format: (2X,20A2)

Column Number	Variable	Description
1-2	NA	Card identification
3-42	NAME	Detention structure or reservoir title

AO Card: Discharge data of detention structure during dry season

Format: (2X,10F7.0)

Column Number	Variable	Description
1-2	AO	Card identificaton
3-9	AOF(I,J)	Discharge data for dry season
.		Subscript I refers to detention
.		structure number. Subscript J
.		refers to rating curve point.
66-72		

SO Card: Storage data of detention structure during dry season

Format: (2X,10F7.0)

Column Number	Variable	Description
1-2	SO	Card identification
3-9	S(I,J)	Storage data for dry season
.		Subscript I refers to detention
.		structure number. Subscript J
.		refers to rating curve point.
66-72		

AR Card: Discharge data of detention structure during rainy season

Format: (2X,10F7.0)

Column Number	Variable	Description
1-2	AR	Card identification
3-9	AOFRN(I,J)	Discharge data for rainy season
.		Subscript I refers to detention
.		structure number. Subscript J
.		refers to rating curve point.
66-72		

SR Card: Storage data of detention structure during rainy season

Format: (2X,10F7.0)

Column Number	Variable	Description
1	SR	Card identification
3-9	SRN(I,J)	Storage data for rainy season
.		Subscript I refers to detention
.		structure number. Subscript J
.		refers to rating curve point.
66-72		

Note: A set of five cards is required to describe the discharge-storage relations of each detention structure, i.e., one "NA" card, and one "AO" card,, one "SO" card, one "AR" card, and one "SR" card, respectively.

RV Card: Initial discharge-storage relation for detention routing

Format: (2X,4F10.2)

Column Number	Variable	Description
1-2	RV	Card identification
3-12	AB(I)	Constant for stage-storage relation
13-22	AC(I)	Constant for stage storage relation
23-32	Q1(I)	Discharge on previous date
33-42	STO1(I)	Storage on previous date

Note: Five "RV" cards are needed to describe the initial discharge-storage relation used in detention routing. Subscript I refers to detention structure number.

MC Card: Total number of river reaches

Format: (2X,I3)

Column Number	Variable	Description
1-2	MC	Card identification
3-5	NH	Total number of river reaches

DI Card: Initial discharge-storage data of river reaches

Format: (2X,2F10.2)

Column Number	Variable	Description
1-2	DI	Card identification
3-12	Q1(I)	Initial discharge of the i th river reach
13-22	STO1(I)	Initial storage of the i th river reach

DS Card: Discharge-storage data for river routing

Format: (2X,4F15.1)

Column Number	Variable	Description
1- 2	DS	Card identification
3-17	AOFW(I,J)	Discharge-storage data for the i th value of the j th river reach
18-32	S(I,J)	
33-47	AOFW(I,J)	
48-62	S(I,J)	

Note: Each card contains two pairs of discharge-storage data. Five "DS" cards are required to describe the discharge-storage relation of each river reach.

CR Card: Local inflow information for river routing

Format: (2X,12I3)

Column Number	Variable	Description
1-2	CR	Card identification
3-5	NRH(I)	River reach number
6-8	NLCH(I)	Number of local inflows that enter at the top of river reach
9-40	LCH(I,J)	Local inflow numbers that enter at the top of river reach ten values are provided for local inflows

Note: Additional "CR" cards are required for other channel reaches.

Subscript I refers to river reach number.

Subscript J refers to local inflow number.

OL Card: Data for off-line reservoir

Format: (2X,3F15.2)

Column Number	Variable	Description
1-2	OL	Card identification
3-17	SOFLN1	Storage of off-line reservoir on previous day
18-32	SOLM	Maximum storage of off-line Reservoir
33-47	AOL	Area of off-line reservoir

SP Card: Simulation period

Format: (2X,4I4)

Column Number	Variable	Description
1-2	SP	Card identification
3-6	IMF	First month of simulation
7-10	IYF	First year of simulation
11-14	IML	Last month of simulation
15-18	IYL	Last year of simulation

RF Card: Information related to rainfall

Format: (2X,I3, A2, I1)

Column Number	Variable	Description
1-2	RF	Card identification
3-5	NST	Total rainfall stations
6	NEWTH	Code which decides which Thiessen weighting factor to be used. NEWTH = YE, new Thiessen weighting factor is used. NEWTH = NO, previous Thiessen weighting factor is used.
8	NPE	Code which decides which pan evaporation data to be used. NPE = 0, previous pan evaporation is used. NPE = 1, new pan evaporation is used.

PE Card: Monthly pan evaporation

Format: (2X,12F5.2)

Column Number	Variable	Description
1-2	PE	Card identification
3-7	PE(I)	Pan evaporation in inches for the i th month
.		
.		
.		
58-62		

Card: Thiessen weighting factors for each subbasin

Format: (16F5.2)

Column Number	Variable	Description
		Card identification
1-5	TH(I,J)	Theissen weighting factors for the i th station of the j th subbasin
.		
.		
.		
68-72		

Note: Additional card is needed for each subbasin.

Card: Rainfall station identification

Format: (I9)

Column Number	Variable	Description
		Card identification
1-9	IRF	Rainfall station identification

Card: Daily rainfall data

Format: (8X,8F8.2)

Column Number	Variable	Description
1-8		Rainfall identification
9-16	RF(I,J,K)	Daily rainfall for the j th day
17-24		of the k th month and of the
.		i th station

Note: For a given rainfall station, daily rainfall is read for the entire year. Additional sets of cards are needed for each rainfall station.

The following variables, which belong to read unit number one, must be defined when the program is being executed.

Variable	Description
IPRNT	Output control code which determines whether or not the simulation output is to be printed. IPRNT = Yes, output is printed. IPRNT = No, no output is printed.
LANA	Code which determines whether or not the table describing land area is to be listed. LANA = Yes, table is generated. LANA = No, no table is generated.
IPNR	Code which specifies whether or not rainfall table is to be printed. IPNR = Yes, table is generated. IPNR = No, no table is generated.
IRV (I)	Code which specifies whether or not reservoir routing is to be considered. IRV (I) = Yes, reservoir routing is considered. IRV (I) = No, no reservoir routing is considered. Subscript I refers to detention structure number.

APPENDIX B

SOURCE PROGRAM

```
C       ***** ST. JOHNS HYDROLOGIC MODEL --- SJM ***
C
C       ***** DEVELOPED BY C. CHARLES TAI, ENGINEERING DIVISION,SJRWMD
C       ***** FOR UPPER ST.JOHNS RIVER BASIN SURFACE WATER MANAGEMENT STUDY
C
C       ***** THIS IS THE MAIN DRIVER PROGRAM *****
C
        COMMON A (9,4,60),ASB(60),JJ,KK,NND(12),PE(12),QRO(31)
        COMMON RF(20,31,12),SM(9,4),SMSB(60),EPX(9,4,60),ST1(9,4,60)
        COMMON STMIN(9,4),TH(20,60),NST,SUR(9,4,60),DLST(9,4,60),SOVL(60)
        COMMON IPNT(60),IRNG(60),TK(60),X(60),AO(60)
        COMMON AWTRM(60),AWTRU(60)
        COMMON QITDV(31)
        COMMON COVER(9,4)
C
        CALL READB
        CALL WRITEB(IO)
        CALL GDATA(IO,ISB)
        CALL UPNR(0,0,0,IO,0,0,0,0,0)
        CALL MCHR(24.,0,0,IO,0,0,0,0,2HNO)
        CALL LINK(IO,ISB)
        CALL CLOSE
        CALL EXIT
        END
```

```
C     ***** GDATA --- GENERAL DATA PREPARATION *****
C
      SUBROUTINE GDATA (IO,ISB)
      COMMON A (9,4,60),ASB(60),JJ,KK,NND(12),PE(12),QRO(31)
      COMMON RF(20,31,12),SM(9,4),SMSB(60),EPX(9,4,60),ST1(9,4,60)
      COMMON STMIN(9,4),TH(20,60),NST,SUR(9,4,60),DLST(9,4,60),SOVL(60)
      COMMON IPNT(60),IRNG(60),TK(60),X(60),AO(60)
      COMMON AWTRM(60),AWTRU(60)
      COMMON QITDV(31)
      COMMON COVER(9,4)
      DIMENSION IBASIN(10), CN(9,4)
C     *****  DATA STATEMENTS *****
      DATA NND/31,28,31,30,31,30,31,31,30,31,30,31/
      DATA CSIN,CDRN/0.35,0.15/
C
      READ(15,522) IBASIN
      READ(15,500) ISB,JJ,KK
      READ(15,540) CN
      READ(15,540) COVER
      READ(15,521) (IPNT(I), I=1,ISB)
      READ(15,520) (IRNG(I), I=1,ISB)
C
      WRITE (IO,522) IBASIN
      WRITE (IO,594) ((CN(J,K),J=1,JJ),K=1,KK)
C
C     ***** LAND AREAS BY LAND USE AND HYDRO-SOIL CLASSIFICATION *****
C
      WRITE (1,538)
      READ (1,523) LANA
      IF(LANA.EQ.2HYE)WRITE (IO,525)
      DO 10 I=1,ISB
      READ (15,500)NPU
      ASB(I)=0.0001
      IF (LANA.EQ.2HYE)WRITE (IO,502)NPU,I
      DO 10K=1,KK
      READ (15,503) (A(J,K,I),J=1,JJ)
      IF (LANA.EQ.2HYE) WRITE(IO,504) (A(J,K,I),J=1,JJ)
      DO 10 J=1,JJ
C     COMPUTE OPEN WATER $ MARSH AREAS IN VALLEY
      IF(IRNG(I).EQ.20.AND.(J.EQ.3.OR.J.EQ.9))AWTRM(I)=AWTRM(I)
     1+A(J,K,I)
C     COMPUTE OPEN WATER AREA FOR RESERVIOR ROUTING
      IF(IRNG(I).GE.10.AND.IRNG(I).LE.15.AND.J.EQ.9)AWTRU(I)=AWTRU(I)
     1+A(J,K,I)
      ASB (I)=ASB(I) + A(J,K,I)
   10 CONTINUE
C
C      ***** SUBBASIN HYDR.CHAR. *****
      READ (15,504) (SOVL(I),I=1,ISB)
      READ (15,504) (TK(I),I=1,ISB), (X(I),I=1,ISB), (AO(I),I=1,ISB)
C
      DO 20 J=1,JJ
      DO 20 K=1,KK
      SM(J,K)=(1000./CN(J,K))-10.
   20 STMIN(J,K)=SM(J,K)*CDRN
```

```
      DO 150 I = 1,ISB
      WRITE (IO,501) I,TK(I),X(I)
      SMSB(I)=0.
      DO  80 J = 1,JJ
      DO  80 K = 1,KK
      DLST (J,K,I)=0.
      ST1(J,K,I)=SM(J,K)*CSIN
      SUR(J,K,I)=0.
C     *** OPEN WATER & MARSH AREA IN VALLEY
C
      IF (IRNG(I).EQ.20.AND.(J.EQ.9.OR.J.EQ.3))ST1(J,K,I)=SM(J,K)
C     **** OPEN WATER AREA IN UPLAND
      IF(J.EQ.9.AND.IRNG(I).GE.10.AND.IRNG(I).LE.15) GO TO 71
      GO TO 70
   71 ST1(J,K,I)=SM(J,K)
      SUR(J,K,I)=SOVL(I)
   70 CONTINUE
      IF(IRNG(I).EQ.20.AND.(J.EQ.9.OR.J.EQ.3)) GO TO 80
C     MAX AVAILABLE SOIL WATER CAPACITY,EXCLUDING OPEN WATER
C     AND MARSH AREAS IN VALLEY
      IF ((ASB(I)-AWTRM(I)).LE.0.) GO TO 80
      SMSB(I)=SMSB(I)+(SM(J,K)*A(J,K,I)/(ASB(I)-AWTRM(I)))
   80 CONTINUE
      IF(SMSB(I).EQ.0.)SMSB(I)=0.001
  150 CONTINUE
      RETURN
  500 FORMAT (2X,5I4)
   501 FORMAT (5X,'SB=',I3,5X,'MSKG RTG CONSTANTS:' 3X,'K=',F10.2,
     13X,'X=',F10.2)
  502 FORMAT (10X,'SB -- ',I4,5X,'GENERATES LOCAL INFLOW--',I3)
  503 FORMAT (2X,9F9.0)
  504 FORMAT (2X,10F7.0)
   520 FORMAT (2X,10I2)
  521 FORMAT (2X,10I1)
  522 FORMAT (2X,39A2)
  523 FORMAT (10A2)
  525 FORMAT (//,10X,'LAND USE - SOIL GROUP AREA MATRIX',//)
  538 FORMAT (2X,'PRINT OUT SUB-BASIN LAND AREAS, YES OR NO')
  540 FORMAT (2X,9F5.2)
  594 FORMAT (10X,'RUNOFF CURVE NO., ACCORDING TO LAND USE AND SOIL'/
     1(10X,9F10.2))
      END
```

```
C      ***** STRC2 ---UPLAND DETENTION ROUTING *****
C
       SUBROUTINE UPNR (IY,IMM,I,IO,DT,NNDC,NDAY,IM1,FI)
       COMMON A (9,4,60),ASB(60),JJ,KK,NND(12),PE(12),QRO(31)
       COMMON RF(20,31,12),SM(9,4),SMSB(60),EPX(9,4,60),ST1(9,4,60)
       COMMON STMIN(9,4),TH(20,60),NST,SUR(9,4,60),DLST(9,4,60),SOVL(60)
       COMMON IPNT(60),IRNG(60),TK(60),X(60),AO(60)
       COMMON AWTRM(60),AWTRU(60)
C
       DIMENSION NAME(6,20), AOF(6,10),S(6,10),A1(10),S1(10)
       DIMENSION AOFRN(6,10),SRN(6,10)
       DIMENSION IRV(6), FI(31)
       DIMENSION AB(6),AC(6),Q1(6),STO1(6)
       IF (KKK.EQ.999) GO TO 30
       DO 25 L=1,5
       READ (15,501) (NAME(L,K),K=1,20)
       READ (15,510) (AOF(L,J),J=1,10),(S(L,J),J=1,10)
C      RAINY SEASON D-S RELATION
   25  READ (15,510) (AOFRN(L,J),J=1,10),(SRN(L,J),J=1,10)
       DO 20 J=1,5
       READ (15,511) AB(J),AC(J),Q1(J),STO1(J)
    20 CONTINUE
       KKK=999
       RETURN
C      ******************************
   30  L=IRNG(I)
       IF (L.EQ.0.OR.L.GE.20) GO TO 310
C          RESERVOIR ROUTING FOR UPPER LAND RETENTION PONDS
       IF (IMM.NE.IM1) GO TO 10
       WRITE (1,500) IY
       WRITE (1,501) (NAME(L,K),K=1,20)
       READ (1,521) IRV(L)
    10 CONTINUE
       PEE=PE(IMM)
       AA=AWTRU(I)
       WRITE (IO,501) (NAME(L,K),K=1,10)
C      ******************************
       IF (IRV(L).NE.2HYE) GO TO 310
       IF(IY.EQ.79.AND.IMM.EQ.9.AND.L.EQ.4) GO TO 310
       IF (IMM.GE.6.AND.IMM.LE.10) GO TO 40
       DO  50 J=1,10
       A1(J)=AOF(L,J)
       S1(J)=S(L,J)
    50  CONTINUE
       GO TO 51
C      RAINY SEASON OPERATION
    40 DO 52 J=1,10
       A1(J)=AOFRN(L,J)
       S1(J)=SRN(L,J)
    52  CONTINUE
    51 CALL REVR (FI,IO,DT,A1,S1,NNDC,AA,AB(L),AC(L),Q1(L),
      1STO1(L),NDAY,PEE,IY,IRNG(I))
        WRITE (IO,531) IMM,IY,FI
   310 CONTINUE
C            ********************
   500 FORMAT (3X,'UPLAND RETENTION AREA ROUTING FOR YEAR --',I5)
   501 FORMAT (2X,20A2)
   510 FORMAT (2X,10F9.0)
   511 FORMAT (2X,5F10.2)
   521 FORMAT (10A2)
   531 FORMAT (2X,2I4/(10F10.0))
       RETURN
       END
```

```
C::::::::::::::::      SUBROUTINE NAME    MCHR      :::::::::::::::
C***********************************************************************
C*          *****  MAIN RIVER CHANNEL ROUTING *****                    *
C*  MAIN CHANNEL ROUTING USING PULS METHOD AND WATER BUDGET FOR        *
C*  EVAPOTRANSPIRATION, ROUTING TIME STEP --24HOURS, ROUTING CYCLE --- *
C*  ONE MONTH.                                                         *
C***********************************************************************
      SUBROUTINE MCHR (DT,NDAY,OL,IO,IY,IM,IM1,IYF,IPRNT)
      COMMON A(9,4,60),ASB(60),JJ,KK
      COMMON NND(12),PE(12),QRO(31),RF(20,31,12),SM(9,4)
      COMMON SMSB(60),EPX(9,4,60)
      COMMON ST1(9,4,60),STMIN(9,4),TH(20,60),NST,SUR(9,4,60)
      COMMON DLST(9,4,60), SOVL(60), IPNT(60)
      COMMON IRNG(60),TK(60),X(60),AO(60)
      COMMON AWTRM(60),AWTRU(60)
      COMMON QITDV(31)
      DIMENSION TINFW1(14),Q(31,14),LCH(14,10),IAA(14,10),IBB(14,2)
      DIMENSION LCF(14,2), STO1(14),Q1(14),OL(31,60)
      DIMENSION SND(10,14), AOFW(10,14), S(10,14)
      DIMENSION AWRH(14),NRH(14), NLCH(14), NLCF(14)
      DIMENSION STO(31,14), Q96(31), QOFLN(31),SOFLN(31),DOFLN(31)
      DIMENSION P(31)
C***********************************************************************
C*  Q           REACH OUTFLOW, CFS                                     *
C*  O           LOCAL INFLOW TO CHANNEL REACH, CFS                     *
C*  RCHQ        REACH INFLOW, CFS                                      *
C*  SND         S/DT+O/2, IN CFS                                       *
C***********************************************************************
      IF (KONT.EQ.99) GO TO 999
      READ (15,530) NH
      WRITE (IO,530) NH
C     *****DATA FROM STAGE-DISC. & STAGE-STORAGE RELATION*****
C         INITIAL REACH DISCHARGE AND STORAGE
      READ (15,580) (Q1(I),STO1(I),I=1,NH)
      WRITE (IO,585)(Q1(I),I=1,NH),(STO1(I),I=1,NH)
C***************
C         DISC-STORAGE RELATION FOR CHANNEL REACHES (10 DATA POINTS)
      READ (15,531) ((AOFW(I,J),S(I,J),I=1,10),J=1,NH)
      DO 21 J=1,NH
      WRITE (IO,532) J
      READ (15,534) NRH(J),NLCH(J),(LCH(J,I),I=1,10),
     1NLCF(J),(LCF(J,I),I=1,2)
C         COMPUTE TINFW1 FOR THE FIRST DAY OF SIMULATION
      IF (NNN.EQ.1) TINFW1(NNN)=0.
      IF (NNN.GT.1) TINFW1(NNN)=Q1(NNN-1)
      DO 22 I=1,10
   22 SND(I,J)=S(I,J)*12.1/DT+AOFW(I,J)/2.
C     COMPUTE WATER AREA IN EACH REACH
      DO 19 I=1,10
      LH=LCH(J,I)
      IAA(J,I)=LCH(J,I)
      IF (IAA(J,I).EQ.0) LCH(J,I)=60
   19 IF (LH.GT.0) AWRH(J)=AWRH(J)+AWTRM(LH)
```

```
      DO 20 I=1,2
      LF=LCF(J,I)
      IBB(J,I)=LCF(J,I)
      IF (IBB(J,I).EQ.0) LCF(J,I)=60
   20 IF (LF.GT.0) AWRH(J)=AWRH(J)+AWTRM(LF)
   21 WRITE (IO,533)(AOFW(I,J),I=1,10),(S(I,J),I=1,10)
      WRITE (IO,510) AWRH
C         ASSIGN OFF-LINE RESERVOIR CAPACITY AND SURFACE AREA
      READ (15,531) SOFLN1,SOLM,AOL
      KONT=99
      RETURN
  999 CONTINUE
C
      AA=0.
      MCC=1.20
C************      INITIALIZE      *****************
      DO 90 NNN=1,NH
      DO 90 J=1,31
   90 Q(J,NNN)=0.
C        ********  BEGIN REACH ROUTING      **********
      DO 1000 J=1,NDAY
C         COMPUTE INDEX RAINFALL
      P(J)=0.
      DO 71 IST=1,NST
      P(J)=P(J)+RF(IST,J,IM)*TH(IST,27)
   71 CONTINUE
      IF (P(J).GE.9.0) KNT=5
      KNT=KNT-1
      DO 1000 NNN=1,NH
C***************
C      FOR BASIC CONCEPT PLAN:
C         BUILT-IN DISC-STORAGE RELATION AT FELLSMERE GRADE REFLECT ---
C         1. FELLSMERE GRADE WEIR CREST=25. FT MSL, LENGTH=400. FT
C         2. DIS-STORAGE RELATION FOR WEIR+CULVERT FLOW ONLY
C         COMPUTE S/DT+Q/2  AT 1ST DAY OF SIMULATION
      SNDNW1=STO1(NNN)*12.1/DT+Q1(NNN)/2.
      TINFW=0.
C     *****ADD UPPER REACH INFLOW TO TOTAL INFLOW*****
      IF (NNN.GT.1) TINFW=Q(J,NNN-1)
C     ADD SUBBASIN INFLOW TO THE HEAD OF REACH TO TOTAL INFLOW
      IF (NLCH(NNN).EQ.0) GO TO 98
      NA=NLCH(NNN)
      DO 99 I=1,NA
      NN=LCH(NNN,I)
   99 TINFW=TINFW+OL(J,NN)
   98 CONTINUE
```

```
C         ADD OFF-LINE RESERVOIR DISCHARGE TO RH-4 REACH INFLOW
      IF (NNN.EQ.4) TINFW=TINFW+DOFLN(J)
C     ET FOR VALLEY SURFACE AND MARSH WILL BE TREATED HERE IN MCHR
C     NOT IN WBGT
C     MCC --- MARSH ET ADJUSTMENT COEFFICIENT
C      COMPUTE TOTAL INFLOW FOR ROUTING
C         REACH INFLOW FROM THE UPSTREAM REACH
      QAV=(TINFW+TINFW1(NNN))/2.
      SNDNW=QAV+SNDNW1-Q1(NNN)
      AA=SND(1,NNN)
      IF (SNDNW.GT.AA) GO TO 174
      Q(J,NNN)=0.
      GO TO 201
  174 DO 175 JR=2,10
      AA=SNDNW-SND(JR,NNN)
      IF(AA) 176,177,175
  177 Q(J,NNN)=AOFW(JR,NNN)
      GO TO 201
  176 Q(J,NNN)=AOFW(JR-1,NNN)+(SNDNW-SND(JR-1,NNN))*
     1(AOFW(JR,NNN)-AOFW(JR-1,NNN))/(SND(JR,NNN)
     2-SND(JR-1,NNN))
      GO TO 201
  175 CONTINUE
      Q(J,NNN)=AOFW(10,NNN)+(SNDNW-SND(10,NNN))*(AOFW(10,NNN)-
     1 AOFW(9,NNN))/(SND(10,NNN)-SND(9,NNN))
  201 CONTINUE
      Q1(NNN)=Q(J,NNN)
C***************
C      BASIC CONCEPT PLAN:
C         ****FELLSMERE REGULATION SCHEDULE****
      IF (NNN.NE.2) GO TO 301
      STORG=STO1(NNN)
C         NORMAL CONDITION DISCHARGE
      Q96(J)=0.
      QOFLN(J)=0.
      IF (SOLM.LE.10.) GO TO 250
C      BLUE CYPRESS LAKE OUTLET STRUCTURE DISCHARGE
C      UNDER NORMAL OPERATING CONDITIONS
      IF(IM.LE.4.AND.STORG.GE.136800.) QOFLN(J)=3000.
      IF(IM.EQ.5.AND.STORG.GE.117100.) QOFLN(J)=3000.
      IF(IM.EQ.6.AND.STORG.GE.87700.)  QOFLN(J)=3000.
      IF(IM.EQ.7.AND.STORG.GE.87700.) QOFLN(J)=3000.
      IF (IM.EQ.8.AND.STORG.GE.117100.) QOFLN(J)=3000.
      IF(IM.GE.9.AND.STORG.GE.136800.) QOFLN(J)=3000.
      IF (SOFLN1.GE.SOLM) QOFLN(J)=0.
C         STORM WATER DISCHARGE
C      (WHEN B.C. LAKE EXCEEDS 25.0, IE STORAGE GREATER THAN 156500)
      XXX=SOFLN1-.6*SOLM
      YYY=.4*SOLM
      IF(STORG.GE.156500.) GO TO 802
      IF (KNT.GE.1) GO TO 802
      GO TO 801
  802 IF (XXX.LE.0.) QOFLN(J)=6000.
      IF(XXX.GT.0..AND.XXX.LE.YYY)QOFLN(J)=6000.*((YYY-XXX)/YYY)**.5
      IF (XXX.GT.YYY) QOFLN(J)=0.
      Q96(J)=6000.-QOFLN(J)
```

```
C      WHEN B.C. LLAKE EXCEEDS 27.0, IE STORAGE GREATER THAN 245000)
      IF(STORG.GE.245000.) GO TO 800
      GO TO 801
  800 Q96(J)=9000.-QOFLN(J)
      IF(Q96(J).GE.6000.) Q96(J)=6000.
  801 CONTINUE
      GO TO 270
C**********
C      EXISTING CONDITION OPTION:
C      S-96 DISCHARGE (WHEN BLUE CYPRESS EXCEEDE 25.2)
  250  AAA=STORG-116090.
      IF (AAA.GT.35500.) AAA=35500.
      IF (AAA.GT.0.) Q96(J)=1500.+(2400.-1500.)*(AAA/35500)
C      TOTAL B.C. LAKE DISC.=WEIR FLOW+CULVVERT+FLOW TO OLR
  270 Q1(NNN)=Q(J,NNN)+Q96(J)+QOFLN(J)
  301 CONTINUE
      IF (NNN.NE.3.OR.SOLM.LE.10.) GO TO 199
C         RAINY SEASON DISC. FROM OFF-LINE RESERVOIR
C         MAY THRU SEPT.
      IF (IM.GT.9.OR.IM.LT.5) GO TO 196
C         RESERVOIR DRAWDOWN DURING NON-FLOODING PERIOD
      IF (Q(J,NNN).GE.5000.) GO TO 197
C         ASSUME MAX. OF-LN DISC=1500. CFS
      IF (XXX.GE.0.) DOFLN(J)=1500.
      IF (XXX.LT.0.) DOFLN(J)=750.*(SOFLN1/(.6*SOLM))**1.0
      GO TO 198
  197 DOFLN(J)=0.
      GO TO 198
C         DRY-SEASON (OCT.THRU APRIL)
  196 DOFLN(J)=100-Q(J,NNN)
      IF (SOFLN1.LE.1000.0.OR.Q(J,NNN).GE.100.)DOFLN(J)=0.
  198 SOFLN(J)=SOFLN1-DOFLN(J)*1.98
C         ADJUST OFF-LINE RESERVOIR STORAGE FOR RAINFALL AND ET
      SOFLN(J)=SOFLN(J)+(P(J)-PE(IM)*MCC)/12.*AOL
      IF (SOFLN(J).LE.0.)SOFLN(J)=0.
      SOFLN(J)=SOFLN(J)+QOFLN(J)*1.98
      SOFLN1=SOFLN(J)
  199 CONTINUE
      STORH=(SNDNW-Q1(NNN)/2.0)*DT/12.1
C      ADJUST STORAGE, DUE TO WITHDRAW FOR IRRIGATION, ET AND DRAINAGE PUMPAGE
C         STORAGE IN AF
C     SURFACE AREA FOR MAIN CHANNEL SUBBASIN(REFLECT CURRENT LAND USE)
C     IN SUCH AREA RAINFALL PRODUCE DIRECT RUNOFF(SEE WBGT)
      WIG=0.
C     WITHDRAW FROM LAKE WASHINGTON (RH #6) FOR MUNICIPAL USE = 18CFS
      IF (NNN.EQ.6) WIG=18.0*1.98
      PMG=0.
      STORH=STORH-WIG+PMG-AWRH(NNN)*PE(IM)/12.*MCC
C         ADD LOCAL INFLOWS AT LOWER END OF THE REACH
      IF (NLCF(NNN).EQ.0) GO TO 203
      NB=NLCF(NNN)
      DO 202 I=1,NB
      NN=LCF(NNN,I)
      Q(J,NNN)=Q(J,NNN)+OL(J,NN)
  202 CONTINUE
  203 CONTINUE
      IF (STORH.LE.0.) STORH=0.
      STO1(NNN)=STORH
      STO(J,NNN)=STORH
      SNDNW1=SNDNW
      TINFW1(NNN)=TINFW
 1000 CONTINUE
```

```
C     WRITE (IO,506) Q96
C     WRITE (IO,507) QOFLN
C     WRITE (IO,508) SOFLN
C     WRITE (IO,509) DOFLN
      DO 2000 NNN=1,NH
      WRITE (IO,500) NNN,IM,IY,(Q(I,NNN),I=1,31)
      WRITE (IO,501) NNN,IM,IY,(STO(I,NNN),I=1,31)
      IF (IPRNT.EQ.2HNO) GO TO 2000
      NRCH=2HNO
      IF (NNN.GE.9) NRCH=2HNO
      IF (NRCH.NE.2HNO)
     1WRITE (IO,548) NRH(NNN),(IAA(NNN,I),I=1,10),(IBB(NNN,I),I=1,2)
      NH1=LCH(NNN,1)
      NH2=LCH(NNN,2)
      NH3=LCH(NNN,3)
      NH4=LCH(NNN,4)
      NH5=LCH(NNN,5)
      NH6=LCH(NNN,6)
      NH7=LCH(NNN,7)
      NH8=LCH(NNN,8)
      NH9=LCH(NNN,9)
      NH10=LCH(NNN,10)
      NF1=LCF(NNN,1)
      NF2=LCF(NNN,2)
      DO 97 J=1,NDAY
      NR=NRH(NNN)
      IF (NRCH.EQ.2HNO) GO TO 97
      WRITE (IO,570) J,OL(J,NH1),OL(J,NH2),OL(J,NH3),OL(J,NH4)
     1,OL(J,NH5),OL(J,NH6),OL(J,NH7),OL(J,NH8),OL(J,NH9),OL(J,NH10),
     2OL(J,NF1),OL(J,NF2),Q(J,NNN),STO(J,NNN)
   97 CONTINUE
 2000  CONTINUE
C          ********************
  500 FORMAT (2X,'RH-',I2,1X,'-DISCHARGE',2I4/(10F10.0))
  501 FORMAT (2X,'RH-',I2,1X,'-STORAGE',2I4/(10F10.0))
  506 FORMAT (3X,'DISCHARGE THRU S-96',/(5X,10F10.0))
  507 FORMAT (3X,'Q(OF-LN)',/(5X,10F10.0))
  508 FORMAT (3X,'S(OF-LN) IN AF',/(5X,10F10.0))
  509 FORMAT (3X,'D(OF-LN)',/(5X,10F10.0))
  510 FORMAT (5X,'WATER SURFACE AREA IN ACRES FOR EACH CHANNEL REACH,
     11 THRU 13, USED FOR COMPUTING CHANNEL REACH ET'/(10F10.0))
  520 FORMAT (2X,10F10.0)
  530 FORMAT (2X,I3)
  531 FORMAT (2X,4F15.2)
  532 FORMAT (10X,'DISCHARGE-STORAGE RELATION FOR REACH --' I5,//)
  533 FORMAT (2X,'D',2X,10F10.1/2X,'S',2X,10F10.1)
  534 FORMAT (2X,15I3,F10.3)
  548 FORMAT (1H1,10X, 'STREAM REACH --',I5/103X,'REACH   REACH'/
     1'DATE',12I8,9X,'OUTFLOW STORAGE'/)
  570 FORMAT (I4,12F8.1,3X,2F10.1)
  580 FORMAT (2X,2F10.2)
  585 FORMAT (5X,'INITIAL REACH DISCHARGE AND REACH STORAGE',/
     1(1X,12F8.0))
      RETURN
      END
```

```
C       ***** LINK *****
C
C       ***** SPECIFIC DATA GENERATION AND PROGRAM LINKAGE ****
        SUBROUTINE LINK (IO,ISB)
        COMMON A(9,4,60),ASB(60),JJ,KK,NND(12),PE(12),QRO(31)
        COMMON RF(20,31,12),SM(9,4),SMSB(60),EPX(9,4,60),ST1(9,4,60)
        COMMON STMIN(9,4),TH(20,60),NST,SUR(9,4,60),DLST(9,4,60),SOVL(60)
        COMMON IPNT(60),IRNG(60),TK(60),X(60),AO(60)
        COMMON AWTRM(60),AWTRU(60)
        COMMON QITDV(31)
        COMMON COVER(9,4)
        DIMENSION O(31),AO1(60),AI1(60),OL(31,60),RCHQ(31)
        DATA DT,DELT /24.,1.0/
C       ***** DEFINE SIMULATION PERIOD *****
        READ(15,500) IMF,IYF,IML,IYL
        WRITE(IO,506)IMF,IYF,IML,IYL
        IM1=IMF
        IY =IYF
   30   NDYR = 365
        NND(2)=28
        IM2 = 12
        IF(IY.NE.IYF) IM1 = 1
        IF(IY.GT.IYL) RETURN
        IF(IY.EQ.ITL) IM2 = IML
        IAA = IY-(IY/4)*4
        IF(IAA.EQ.0) NND(2) = 29
        IF(NND(2).EQ.29)NDYR = 366
        WRITE(1,530)IY
        READ(1,523)IPRNT
        WRITE(IO,501)IY
C       ***** CLIMATOLOGICAL DATA *****
        WRITE(1,577)
        READ(1,523)IPNR
        CALL CLMD(ISB,IPNR,IM1,IM2,IY,IO)
C       ***********************************
C
C       ******** RUNOFF SIMULATION AND ROUTING(SUB-BASIN & MAIN CHANNEL) *****
C
        DO 200 IMM=IM1,IM2
        DO 210 I=1,ISB
        IF ((IPNT(I).EQ.1.AND.IPRNT.EQ.2HYE).OR.(IMM.EQ.IM1.AND.IY.EQ.
       1IYF)) WRITE(IO,519) I, ASB(I)
```

```
C          ******* SUBROUTINE FOR SUB-BASIN RUNOFF *******
      CALL WBGT(I,IM1,IMM,IO,IPRNT)
C         INTERBASIN DIV (SB 2-9,3-6,3-7,3-13)
      IF(I.EQ.18.OR.I.EQ.26.OR.I.EQ.27.OR.I.EQ.33)WRITE(IO,502)I,Q1TDV
C
C         I        PLANNING UNIT NO
C         QRO      R/O AT OUTLET OF THE SUB BASIN
C         IM1      1ST MONTH OF SIMULATION
C         IM2      LAST MONTH OF SIMULATION
C
      NDAY=NND(IMM)
C
C         SUBROUTINE TO COMPUTE PUMP DISCHARGE
C
      CALL PUMP (I,NDAY,QRO)
      CALL UPNR (IY,IMM,I,IO,DT,NNDC,NDAY,IM1,QRO)
C     ***** MSKG ROUTING -- CHANNEL ROUTING *****
      IF (TK(I).EQ.0.) GO TO 350
C      ***********************************************
      TKI=TK(I)
      XI =X(I)
      AOI =AO1(I)
      AII =AI1(I)
      IF (IY.EQ.IYF.AND.IMM.EQ.IM1) AOI=AO(I)
      IF (IY.EQ.IYF.AND.IMM.EQ.IM1) AII=AO(I)
C         ******* PLANNING UNIT CHANNEL ROUTING ********
      CALL MSKG (TKI,XI,DELT,QRO,AII,AOI,NDAY,O,IO,IMM,IM1,IY,IYF)
      DO 160 K=1,NDAY
      OL(K,I)=O(K)
 160  CONTINUE
      AI1(I)= QRO(NDAY)
      AO1(I)= OL(NDAY,I)
      GO TO 210
 350  DO 351 K=1,NDAY
 351  OL(K,I)=QRO(K)
 210  CONTINUE
C
C         ******* MAIN RIVER CHANNEL ROUTING *******
C
      CALL MCHR (DT,NDAY,OL,IO,IY,IMM,IM1,IYF,IPRNT)
 200  CONTINUE
C          ********************
      IY=IY+1
      GO TO 30
 500  FORMAT (2X,5I4)
 501  FORMAT (1H,'***** SIMULATION FOR -- 19',I2,'*****',/)
  502 FORMAT (2X,'Q(INTER-BASIN DIV.)', 'SB-',I3/(5X,10F10.0))
 506  FORMAT (10X,'SIMULATION PERIOD',5X,I4,I5,5X,'TO',14,I5)
 519  FORMAT (5X,'SB--',I4,3X,'D.A. = ',F10.1,'ACRES')
  523 FORMAT (10A2)
 530  FORMAT (2X,'SIMULATION OUTPUT TO BE PRINTED FOR YEAR',I8,3X,'YES
     1OR NO')
 577  FORMAT (2X,'WILL RAINFALL DATA BE PRINTED: YES OR NO')
      END
```

```
C      ***** CLMD *****
C
C      CLAMATOLOGICAL DATA INPUT (RAINFALL & ET DATA)
C
C*****************************************************************************
C*     TO READ PAN EVAP,  THIESSEN WEIGHTING FACTOR AND DAILY RAINFALL AMOUNT   *
C*    FOR EACH RAINFALL STATION UP TO ONE YEAR'S DATA                          *
C*****************************************************************************
       SUBROUTINE CLMD (ISB,IPNR,IM1,IM2,IY,IO)
       COMMON A(9,4,60),ASB(60),JJ,KK
       COMMON NND(12),PE(12),QRO(31),RF(20,31,12),SM(9,4)
       COMMON SMSB(60),EPX(9,4,60)
       COMMON ST1(9,4,60),STMIN(9,4),TH(20,60),NST,SUR(9,4,60)
       COMMON DLST(9,4,60), SOVL(60),IPNT(60)
       COMMON IRNG(60),TK(60),X(60),AO(60)
       COMMON AWTRM(60),AWTRU(60)
       DIMENSION IRF (5)
       DATA PEC/0.79/
C
C*****************************************************************************
C*****************************************************************************
C      ********** RAINFALL DATA MANIPULATION **********
       READ (15,508) NST,NEWTH,NPE
       WRITE (IO,508) NST,NEWTH,NPE
       IF (NPE.EQ.0) GO TO 10
       READ (15,500) PE
       WRITE (IO,501) PE
C      ***** DAILY POTEN. ET, IN INCHES *****
       DO 40 I=1,12
    40 PE(I)=PE(I)/NND(I)*PEC
   10  IF (NEWTH.EQ.2HNO) GO TO 11
       IF (IPNR.EQ.2HYE) WRITE (IO,551)
       DO 12 I=1,ISB
       READ(15,550) (TH(IS,I),IS=1,NST)
        IF (IPNR.EQ.2HYE) WRITE (IO,552) I, (TH(IS,I),IS=1,NST)
   12  CONTINUE
   11  CONTINUE
C          READ R/F DATA (FOR UP TO A YEAR)
       DO 50 I=1,NST
       READ (15,523) (IRF(IR),IR=1,5)
       IF (IPNR.EQ.2HYE) WRITE (IO,510) I, (IRF(IR),IR=1,5)
       DO 50 IM=IM1,IM2
       RFM=0.
       IND=NND(IM)
       READ (15,515) (RF(I,IP,IM),IP=1,IND)
       IF (IPNR.NE.2HYE) GO TO 50
       WRITE (IO,514) IM,(RF(I,IP,IM),IP=1,IND)
       DO 51 IP=1,IND
   51  RFM=RFM + RF(I,IP,IM)
       WRITE (IO,516) RFM
    50 CONTINUE
```

```
C      ******************************
C
C
  500 FORMAT (2X,12F6.2)
  501 FORMAT (10X,'MONTHLY PAN EVAP IN INCHES'/12F6.2)
  508 FORMAT (2X,I3,A2,I1)
  510 FORMAT (/10X,'DAILY R/F AT STATION', 4X,I2,10X,'STA ID. --',5A2)
  514 FORMAT (5X,I4,3X,16F6.2,/(12X,16F6.2))
  515 FORMAT (8X,8F8.2)
  516 FORMAT (15X, 'MONTHLY TOTAL',F10.2,//)
  523 FORMAT (2X,5A2)
  550 FORMAT (16F5.2)
  551 FORMAT (10X,'THIESSEN WEIGHTS',3X,'(RAINFALL STATION X P.U.)')
  552 FORMAT (5X,I3,3X,20F6.2)
      RETURN
      END
```

```
C      ***** WBGT --- RAINFALL/RUNOFF SIMULATION *****
C*******************************************************************************
C*          ***** SJHM  RAINFALL-RUNOFF  MODEL *****                           *
      SUBROUTINE WBGT(I,IM1,IM,IO,IPRNT)
C*                                                                             *
C*          UPPER ST. JOHNS BASIN SUB-BASIN RUNOFF SIMULATION                  *
C*            BASED ON LU AND SOIL                                             *
C*******************************************************************************
      COMMON A(9,4,60),ASB(60),JJ,KK
      COMMON NND(12),PE(12),QRO(31),RF(20,31,12),SM(9,4)
      COMMON SMSB(60),EPX(9,4,60)
      COMMON ST1(9,4,60),STMIN(9,4),TH(20,60),NST,SUR(9,4,60)
      COMMON DLST(9,4,60),SOVL(60),IPNT(60)
      COMMON IRNG (60),TK(60),X(60),AO(60)
      COMMON AWTRM(60),AWTRU(60)
      COMMON QITDV(31)
      COMMON COVER(9,4)
      DIMENSION AWL(9,4),BF(9,4),DEF(31),EV(31)
      DIMENSION P(31), RO(9,4),ST(9,4),BFO(9,4)
      DIMENSION SURPD (9,4),SITDV(2)
      DATA A$,B$,C$/0.,.10,-12./
C
C     DATA CDET/.1,.2,.8,.1,.1,.1,.1,.1,.2,
C    1          .1,.2,.8,.1,.1,.1,.1,.1,.2,
C    2          .1,.2,.8,.1,.1,.1,.1,.1,.2,
C    3          .1,.2,.8,.1,.1,.1,.1,.1,.2/
      DATA FLTRD/0.75/
C*******************************************************************************
C* ST     UPPER ZONE SOIL WATER STORAGE                                        *
C* ST1    INITIAL UPPER ZONE SOIL WATER STORAGE                                *
C* RO     OVERLAND FLOW, INCHES                                                *
C* BF     UPPER ZONE LATERAL BASE FLOW, INCHES                                 *
C* BFO    LOWER ZONE LATERAL BASE FLOW, INCHES                                 *
C* DLST   LOWER ZONE STORAGE DEPLETION, INCHES                                 *
C*******************************************************************************
C       **********      INITIALIZATION      ***********
      IRN=IRNG(I)
      DO 10 J=1,JJ
      DO 10 K=1,KK
      ST(J,K)=ST1(J,K,I)
C     FOR MAIN CHANNEL SURFACE WATER AND MARSH AREAS
      IF (IRN.EQ.20.AND.(J.EQ.9.OR.J.EQ.3)) ST(J,K)=SM(J,K)
C     FOR UPLAND SURFACE WATER AND MARSH AREAS
      IF (IRN.NE.20.AND.(J.EQ.9.OR.J.EQ.3)) ST(J,K)=SM(J,K)
      RO(J,K)=0.
      BF(J,K)=0.
      BFO(J,K)=0.
   10 CONTINUE
      IP=IPNT(I)
      ND=NND(IM)
```

```
C
C
C          BEGIN MONTHLY TIME LOOP OF SUB BASIN R/O SIMULATION
C
C
      QBMO=0.
      QMO=0.
       QROM=0.
      PM=0.
      EVM=0.
C          BEGIN DAILY TIME LOOP
      IF (IP.EQ.1.AND.IPRNT.EQ.2HYE) WRITE (IO,515) I,IM
      DO 30 ID=1,ND
      Q=0.
      QB=0.
      EVTOT=0.
      STSB=0.
      SURSB=0.
      P(ID)=0.
C
C          COMPUTE UPPER ZONE SOIL WATER STORAGE AND OVERLAND
C          DETENTION STORAGE IN SUB BASIN
C          AT BEGINNING OF THE DAY, IN INCHES
C          *********************
C          STSB   UPPER ZONE STORAGE IN SUB BASIN, IN INCHES
C          SURSB  OVERLAND DETENTION STORAGE IN SUB BASIN NOT WITHIN MAIN CHANNEL WAT
C        SURPD  PREVIOUS DAY SUR
C        SUR  DETENTION STORAGE IN AN ELEMENT
      STSB=.0
      SURSB=.0
      AS=ASB(I)
      IF (IRN.EQ.20) AS=ASB(I)-AWTRM(I)
      IF (IRN.GE.10.AND.IRN.LE.15) AS=ASB(I)-AWTRU(I)
      DO 72 J=1,JJ
      DO 72 K=1,KK
      SURPD(J,K)=SUR(J,K,I)
      IF (IRN.EQ.20.AND.(J.EQ.9.OR.J.EQ.3)) GO TO 72
      IF (IRN.GE.10.AND.IRN.LE.15.AND.J.EQ.9) GO TO 72
      STSB=(ST(J,K)*A(J,K,I)/AS)+STSB
      SURSB=(SUR(J,K,I)*A(J,K,I)/AS)+SURSB
   72 CONTINUE
C
C           WATER AVAILABLE FOR BASEFLOWS AT BEGINNING OF THE DAY
C           (UPPER ZONE)
      BFST=STSB
      AA=SMSB(I)
      IF (BFST.GT.AA) BFST=SMSB(I)
      BSNT=BFST-SMSB(I)*CDRN
      IF (BSNT.LT.0.) BSNT=0.001
```

```
C           *********************
C          BFSBO    SUBBASIN BASE FLOW CONTRIBUTION FROM LOWER ZONE.  THE DEPLETION
C                   IN LOWER ZONE STORAGE DUE TO THIS LOSS MUST BE
C                   RECHARGED FROM UPPER ZONE ACCORDING TO A PREDESCRIBED
C                   FUNCTION OF UPPER ZONE STORAGE
C          BFSB     SUBBASIN BASE FLOW CONTRIBUTION FROM UPPER ZONE
C          BFSB & BFSBO IN CFS
      CONST=0.75
      BFSBO=AS*EXP(C$)*CONST
C     NO BASE FLOW FROM LOWER ZONE IN VALLEY SUBBASIN
      BFSB=CONST*(AS*EXP(A$*BSNT**2+B$*BSNT+C$))-BFSBO
      IF (IRN.EQ.20) BFSBO=0.
      IF (IRN.EQ.20) BFSB=0.5*BFSB
C          BFSB & BFSBO  IN ACRE-FT
      IF (BFSB.LE.0.) BFSB=0.
      BFSB=1.98*BFSB
      BFSBO=1.98*BFSBO
C           COMPUTE AVERAGE RAINFALL BASED ON THIESSEN METHOD
       DO 71 IST=1, NST
      P(ID)=P(ID)+RF(IST,ID,IM)*TH(IST,I)
   71 CONTINUE
C          SURFACE STORAGE AND R/O FOR EACH ELEMENT
C          LOOP OVER EACH LU
      DO 80 J=1,JJ
C
C          LOOP OV EACH SOIL
      DO 80 K=1,KK
C          NO INFILTRATION, NO CHANGE BOTH IN UPPER ZONE STORAGE AND
C          LOWER STORAGE, NO BASE FLOW. ET WILL BE CONSIDERED IN MCHR
C          MARSH AND WATER AREAS AND RUNOFF EQUAL TO RAINFALL
      IF (IRN.EQ.20.AND.(J.EQ.9.OR.J.EQ.3)) GO TO 650
      IF (IRN.GE.10.AND.IRN.LE.15.AND.J.EQ.9) GO TO 650
      AA=A(J,K,I)
      IF (AA.EQ.0.) GO TO 80
C
C          BF & BFO IN INCHES
C           *********************
C          BF  UPPER ZONE BASE FLOW FROM SUB-UNIT (OR ELEMENT) PROPORTIONED
C              ACCORDING TO SUB-UNIT UPPER ZONE STORAGE, IN INCHES
C          BFO     BASE FLOW FROM LOWER ZONE EVENLY DISTRIBUTED ON ENTIRE
C                  S.B., INCHES
      BF(J,K)=BFSB*(ST(J,K)/STSB)/A(J,K,I)*12.
      BFO(J,K)=BFSBO/AS*12.
C
C           ***** SUB-UNIT STORAGE, IN INCHES *****
C          ********* SUB-UNIT SURFACE WATER EXCESS **********
   81 SS=P(ID)+SUR(J,K,I)
      IF (ST(J,K).GE.SM(J,K)) GO TO 710
      IF (SS.LE.0.) GO TO 711
      AA=SS-0.2*(SM(J,K)-ST(J,K))
      IF (AA.LE.0.)  AA=0.00001
      FLT=SS-AA**2./(SS+0.8*(SM(J,K)-ST(J,K)))
      FLT=FLTRD*FLT
      IF (FLT.LE.0.) FLT=0.
  712 SUR(J,K,I)=SS-FLT
      ST(J,K)=ST(J,K)+FLT
      GO TO 711
  710 FLT=0.
      GO TO 712
  711 CONTINUE
```

```
C      ***** SUB-UNIT STORAGES AFTER BASE FLOW *****
       AA= ST(J,K)-BF(J,K)
       BB=STMIN(J,K)
       IF (AA.LT.BB) GO TO 700
       ST(J,K)=AA
       GO TO 701
  700 BF(J,K)=ST(J,K)-STMIN(J,K)
       IF (BF(J,K).LE.0.) BF(J,K)=0.
       ST(J,K)=STMIN(J,K)
  701 DLST(J,K,I)=DLST(J,K,I)+BFO(J,K)
C      ********************************************************************
C      ********************************************************************
C          ***** ET BASED ON UPPER ZONE STORAGE *****
       AA=ST(J,K)
       EV(ID)=PE(IM)*(AA/SM(J,K))**.80
C      FOR WATER SURFACE AND MARSH
       IF (J.EQ.3.OR.J.EQ.9) EV(ID)=EV(ID)*1.25
   40  AA=ST(J,K)
       ST(J,K)= ST(J,K)-EV(ID)
       IF (ST(J,K).GT.STMIN(J,K)) GO TO 800
       BB=STMIN(J,K)-ST(J,K)
       DLST(J,K,I)=DLST(J,K,I)+BB
       ST(J,K)=STMIN(J,K)
       SEP=0.
       GO TO 810
C          ***** PERCOLATION FROM UPPER ZONE TO LOWER ZONE *****
 800   SEP=DLST(J,K,I)*((ST(J,K)-STMIN(J,K))/(SM(J,K)-STMIN(J,K)))**1.
C          END OF DAY LOWER ZONE DEPLETION
 810   DA=DLST(J,K,I)-SEP
       IF (DA.GE.0.) GO TO 820
       DA=0.
       SEP=DLST(J,K,I) - DA
  820 DLST(J,K,I)=DA
C          ***** UPPER ZONE  STORAGE AFTER PERCOLATION AND ET *****
       ST(J,K)=ST(J,K)-SEP
       AA=ST(J,K)
       BB=STMIN(J,K)
       IF (AA.LT.BB) ST(J,K)=STMIN(J,K)
C       ******* OVERLAND FLOW SIMULATION *******
C      CDT=CDET(J,K)
       CDT=COVER(J,K)
       IF (IRN.EQ.20) CDT=1.0
C      RO(J,K)=(1.-CDT)*SUR(J,K,I)
       RO(J,K)=CDT*SUR(J,K,I)*0.7
       AA=RO(J,K)
       IF (AA.LE.0.) RO(J,K)=0.
       SUR(J,K,I)=SUR(J,K,I)-RO(J,K)
       AA=SUR(J,K,I)
       IF(AA.LT.0.)SUR(J,K,I)=0.
       GO TO 725
  650 DLST(J,K,I)=0.
       BFO(J,K)=0.
       BF(J,K)=0.
       ST(J,K)=0.
       EV(ID)=0.
       RO(J,K)=P(ID)
C          *****MODIFY ET WITH WATER BALANCE EQUATION *****
C         THIS MODIFICATION WAS DELETED JULY 26,1978
  725 CONTINUE
C          RESET PREVIOUS DAY VALUE
       ST1(J,K,I)=ST(J,K)
```

```
C
C          R/O FOR EACH LU , CFS
      Q=Q+RO(J,K)*A(J,K,I)/12./1.98
      QB=QB+(BF(J,K)+BFO(J,K))*A(J,K,I)/12./1.98
      EVTOT=EVTOT+EV(ID)*A(J,K,I)/ASB(I)
   80 CONTINUE
      QRO(ID)=Q+QB
C
C          MODIFY SUBBASIN RUNOFF INTO ST. JOHNS SYSTEM TO CONSIDER
C          INTERBASIN DIVERSION
C          CDIV = DIVERSION COEFFICIENT, CDIV=0. FOR COMPLETE DIVERSION
C          AND CDIV=1. FOR NO DIVERSION.
C
      CDIV=1.
      IF (I.EQ.5) CDIV=0.
      IF (I.EQ.18) CDIV=.32
      IF (I.EQ.26) CDIV=0.
      IF (I.EQ.27) CDIV=0.0
      IF (I.EQ.33) CDIV=.0
      QITDV(ID)=QRO(ID)*(1.-CDIV)
C          INTER-BASIN DIV. FROM FELLSMERE DRAINAGE DIST.
C     IF (I.NE.18) GO TO 150
C     SITDV(1)=SITDV(1)+QITDV(ID)
C     QITDV(ID)=1097.
C     IF (SITDV(1).LE.QITDV(ID)) QITDV(ID)=0.
C     SITDV(1)=SITDV(1)-QITDV(ID)
C 150 CONTINUE
      QRO(ID)=QRO(ID)*CDIV
C          STSB         SB SOIL MOISTURE STORAGE, IN
C          Q            SURFACE RUNOFF, CFS
C          QB           BASE FLOW, CFS
C          QRO          Q + QB
C          SURSB        SB SURFACE WATER SURPLUS, IN
C          P            RAINFALL, IN
      IF (IPRNT.EQ.2HNO) GO TO 30
      DST=0.
      DO 450 IDJJ=1,JJ
      DO 450 IDKK=1,KK
      DST=DST+DLST(IDJJ,IDKK,I)*A(IDJJ,IDKK,I)/ASB(I)
  450 CONTINUE
      IF (IP.EQ. 1)
     1WRITE (IO,520) ID,STSB,Q,QB,QRO(ID),SURSB,P(ID),EVTOT,DST
      QBMO=QBMO+QB
      QMO=QMO+Q
      QROM=QROM+QRO(ID)
      PM=PM+P(ID)
      EVM=EVM+EVTOT
   30 CONTINUE
      IF (IPRNT.EQ.2HNO) GO TO 20
      IF (IP.EQ.1)
     1WRITE (IO,500) QMO,QBMO,QROM,PM,EVM
   20 CONTINUE
  500 FORMAT (8X,'TOTAL',10X,3F10.2,10X,2F10.2)
  515 FORMAT (5X,'SB--',I3,5X,' MONTH',I3,/10X,'DAY',6X,'STSB',
     16X,'QSUR',5X,'QBASE',7X,'DIS',5X,'SURSB',6X,'RAIN',
     26X,'EVAP'/17X,'IN IN.',4X,'IN CFS',6X,'CFS',6X,'  CFS',
     37X,'IN.',4X,'IN IN.'5X,'IN IN.',5X,'DST'/)
  520 FORMAT (10X,I3,9F10.2)
  530 FORMAT (9F10.2)
      RETURN
      END
```

```
C      *****PUMP --- PUMP DISCHARGE ROUTING *****
       SUBROUTINE PUMP (I,NDAY,FI)
       DIMENSION FI(31), CST(60), CP(60)
C          ROUTING FOR PUMP STATION CONTROL, TO BE PERFORMED BEFORE
C          RESERVOIR AND CHANNEL ROUTING
C          I ------- SUBBASIN SEQUENCE NO.
C          NDAY ---- NO. OF DAY IN THAT MONTH
C          FI ------ DAILY INFLOW TO FEEDER CANNAL
C                    AND RESULTING PUMP DISCHARGE FROM SUBBASIN, CFS.
C          CST ----- STORAGE IN FEEDER CANAL, CFS-DAY.
C          CP ------ DESIGN PUMP CAPACITY, CFS.
C          FLOW REDUCTION DUE TO INTERBASIN DIVERSION WILL BE
C          CONSIDERED IN SUBROUTINE ---WBGT----.
C
       DATA CP/0.,0.,91.,29.,60.,2495.,0.,56.,0.,0.,39.,0.,56.,11.,15.,
     1         0.,326.,593.,0.,0.,
     2         0.,81.,78.,0.,187.,0.,592.,0.,87.,50.,0.,0.,39.,179.,
     3         0.,0.,0.,0.,175.,0.,
     4         43.,0.,0.,0.,177.,0.,0.,27.,192.,42.,0.,0.,0.,0.,0.,0.,
     5         0.,0.,0.,0./
C
C          FLAG TO DETERMINE PUMP CONTROL
C
       IF (CP(I).LE.0.) RETURN
C
C          ASSUMEING FEEDER CANAL INITIAL STORAGE
C
       IF (KCST.EQ.999) GO TO 20
       DO 40 J=1,60
    40 CST(J)=0.
       KCST=999
    20 DO 10 J=1,NDAY
C
C          FI ----- RUNOFF INTO FEEDER CANAL
C
       CST(I)=CST(I) + FI(J)
       IF (I.EQ.45) CST(I)=CST(I)+FI(J)*0.68
       IF (I.EQ.49) CST(I)=CST(I)+FI(J)*0.81
       IF (I.EQ.50) CST(I)=CST(I)+FI(J)*0.07
C
C          GRAVITY FLOW FROM SUB-BASIN PARTIALLY SERVED WITH PUMP STATION
C          (TO BE MODIFIED WITH UPDATED DATA)
       GVT=0.
       IF (I.EQ.45) GVT=FI(I)*0.32
       IF (I.EQ.49) GVT=FI(I)*.19
       IF (I.EQ.50) GVT=FI(I)*.93
C          FI ----- SUBBASIN PUMP DISCHARGE
C
       IF (CST(I).LE.CP(I)) FI(J)=0.
       CSTP=2.*CP(I)
       IF (CST(I).GT.CP(I).AND.CST(I).LE.CSTP) FI(J)=0.5*CP(I)+GVT
       IF (CST(I).GT.CSTP) FI(J)=.9*CP(I)+GVT
       CST(I)=CST(I)-FI(J)
    10 CONTINUE
       RETURN
       END
```

```
      SUBROUTINE REVR (Q,10,DT,AOFW,S,NNDC,A1,A2,A3,Q1,STO1,NDAY,PE,
     1IY,ING)
      DIMENSION FI(31), Q(31),AOFW(10),S(10),SND(10),STO(31),NNDC(12)
C           DISCHARGE(CFS)-STORAGE(AF) RELATION
      DO 10 I=1,NDAY
      FI(I)=Q(I)
      Q(I)=0.
   10 STO(I)=0.
C           TAYLOR CREEK RESERVOIR
      IF (IY.LE.00.AND.ING.EQ.4) GO TO 40
      QAV=0.
      SNDNW=0.
      IF (IY.EQ.49) WRITE (IO,500) AOFW,S
      DO 20 I=1,10
   20 SND(I)=S(I)*12.1/DT+AOFW(I)/2.
C           COMPUTE S/DT+Q/2 AT THE 1ST DAY OF SIMULATON
      SNDNW1=STO1*12.1/DT+Q1/2.
      DO 30 J=1,NDAY
      IF (J.EQ.1) GO TO 190
      QAV=(FI(J)+FI(J-1))/2.
      SNDNW=QAV+SNDNW1-Q(J-1)
      AA=SND(1)
      IF (SNDNW.GT.AA) GO TO 174
      Q(J)=0.
      GO TO 201
  174 DO 175 JR=2,10
      AA=SNDNW-SND(JR)
      IF (AA) 176,177,175
 177  Q(J)=AOFW(JR)
      GO TO 201
  176 Q(J)=AOFW(JR-1)+(SNDNW-SND(JR-1))*(AOFW(JR)-AOFW(JR-1))/
     1(SND(JR)-SND(JR-1))
      GO TO 201
  175 CONTINUE
      Q(J)=AOFW(10)+(SNDNW-SND(10))*(AOFW(10)-AOFW(9))/(SND(10)-SND(9))
      GO TO 201
  190 Q(J)=Q1
      SNDNW=SNDNW1
  201 CONTINUE
C           ADJUST RESERVOIR STORAGE, DUE TO  SEEPAGE, PUMPAGE
C           RAINFALL ALREADY ACCOUNTED IN USPU MODEL
C           STORAGE IN AF
      STO(J)=(SNDNW-Q(J)/2.)*DT/12.1
```

```
C          SURFACE AREA IN AC
C          A1,A2,A3 TO BE DETERMINED
C          ADJUST STORAGE FOR ET
      SPG=0.
      PMP=0.
      AA=A1+A2*STO(J)+A3*STO(J)**2
C     MCC ---- MARSH ET COEF ADJUSTMENT
      MCC=1.20
      STO(J)=STO(J)-SPG+PMP-PE/12.*AA*MCC
      SNDNW1=SNDNW
   30 CONTINUE
      GO TO 1
   40 READ (15,501) (Q(J),J=1,NDAY)
      AA=A1+A2*STO(J)+A3*STO(J)**2
      DO 2 J=1,NDAY
      STO(J)=STO1+(FI(J)-Q(J))*1.98-PE*AA/12*MCC
      STO1=STO(J)
    2 CONTINUE
   1  Q1=Q(NDAY)
      STO1=STO(NDAY)
      WRITE (IO,503) STO(NDAY)
  500 FORMAT (10X,'RESERVOIR ROUTING',/5X,
     1'DISCHARGE', 10F10.2,/7X,'STORAGE',10F10.2)
  501 FORMAT (2X,10F7.1)
  503 FORMAT (10X,'STORAGE AT THE END OF THE MONTH', F10.2)
      RETURN
      END
```

```
C     ***** MSKG -- CHANNEL ROUTING *****
      SUBROUTINE MSKG(TK,X,DELT,I,AI,AO,NDAY,O,IO,IMM,IM1,IY,IYF)
      REAL I
      DIMENSION I(31),O(31)
      DEN=TK*(1.-X)+.5*DELT
      C1=DELT/DEN
      C2=(.5*DELT-TK*X)/DEN
      O(1)=AO +C1*(AI-AO)+ C2*(I(1)-AI)
      ND=NDAY-1
      DO 10 J=1, ND
      O(J+1)=O(J)+C1*(I(J)-O(J)) + C2*(I(J+1)-I(J))
   10 CONTINUE
      RETURN
      END
```

APPENDIX C

LIST OF SYMBOLS

A	Land area matrix
A1	Temporary variable assigned to discharge
A$	Base flow coefficient
AA	Temporary variable assigned to discharge or area
AB	Constant used to adjust storage area due to change in storage
AC	Constant used to adjust storage area due to change in storage
AI1,AII	Temporary variable assigned to surface runoff or outflow
AO	Initial outflow
AOF	Discharge in dry season
AOFRN	Discharge in rainy season
AOFW	Discharge of a channel reach
AOI,AO1	Temporary variable assigned to surface runoff or outflow
AOL	Area of off-line reservoir
AS	Temporary variable assigned to effective area of a subbasin
ASB	Area of subbasin
AWRH	Total open-water and marsh areas of a channel reach
AWTRM	Open-water and marsh areas in valley
AWTRU	Open-water area in upland
BB	Temporary variable assigned to minimum soil-water storage capacity in upper zone
B$	Base flow coefficient
BF	Lateral base flow from upper zone
BFO	Lateral base flow from lower zone
BFSB	Subbasin base flow contributed from upper zone
BFSBO	Subbasin base flow contributed from lower zone

C$	Base flow coefficient
CDET,CDT	Surface runoff coefficient
CDIV	Flow diversion coefficient
CDRN	Constant
CN	SCS Runoff Curve Number
CP	Design pump capacity
CSIN	Constant
CST	Storage in feeder canal
DA	Current storage deficiency
DLST	Storage depletion in lower zone
DOFLN	Discharge from off-line reservoir
FI	Daily inflow to feeder canal
FLTRD	Constant
I	Subbasin Number
IAA	Local inflow number entering at the head of a river reach
IBASIN	Name of drainage basin
IBB	Local inflow number entering at the foot of a river reach
IMF,IM1	First month of simulation
IML,IM2	Last month of simulation
IMM	Month of simulation
IND	Number of days in a given month
IP	Flag to print
IPNR	Flag to print
IPRNT	Flag to print
IRF	Rainfall station identification
IRNG	Flag to routing destination

IRV	Flag to reservoir routing
IS	Number of rainfall stations
ISB	Total number of subbasins
IY	Year of simulation
IYF	First year of simulation
IYL	Last year of simulation
JJ	Total number of land uses
LANA	Flag to print land area matrix
LCF,LF	Local inflow number entering at the foot of a river reach
LCH,LH	Local inflow number entering at the head of a river reach
MCC	ET coefficient for marsh area
NA,NLCH	Number of local inflows entering at the head of a given reach
NAME	Title of reservoir
NB,NLCF	Number of local inflows entering at the foot of a given reach
ND	Number of days in a given month
NDAY	Number of days in a given month
NEWTH	Flag to read new Thiessen weighting factor
NH	Total number of channel reaches
NN	Local inflow number entering at the head of a river reach
NND	Number of days in a given month
NNN	Channel reach number
NPE	Code to read new pan evaporation data
NPU	Subbasin number
NRH	River reach number
NST	Total number of rainfall stations
O	Local inflow to river reach
OL	Temporary variable assigned to surface runoff or inflow

P	Rainfall
PE	Pan evaporation
PEC	Pan evaporation coefficient
Q	Surface runoff or reach outflow
Q1	Initial discharge of a given river reach
QAV	Average total inflow of a given river reach
QB	Base flow
QOFLN	Discharge of off-line reservoir
QRO	Surface runoff at the outlet of the basin
RCHQ	Reach inflow
RF	Daily rainfall
RFM	Total monthly rainfall
RO	Overland flow
S	Storage in dry season or storage of a river reach
S1	Temporary variable assigned to storage
SM	Maximum soil-water storage capacity in upper zone
SMSB	Total soil-water storage capacity in a subbasin excluding open-water and marsh areas in valley
SND	S/DT + 0/2
SNDNN1	(S/DT + 0/2) at the first day of simulation
SOFLN1	Storage of off-line reservoir on the previous day
SOLM	Current storage of off-line reservoir
SOVL	Initial depression storage for each subbasin
SRN	Storage in rainy season
ST	Soil-water storage in the upper zone
ST1	Initial soil-water storage in the upper zone
STMIN	Minimum soil-water storage capacity in the upper zone

STO1	Initial storage of a river reach
STSB	Upper zone storage of a subbasin
SUR	Surface detention storage
SURPD	Surface detention storage on the previous day
SURSB	Surface detention storage of a subbasin
TINFW	Total inflow
TINFW1	Initial total inflow of river reach
TH	Thiessen weighting factor
TK,TKI	Constant used for Muskingum channel routing
X,XI	Constant used for Muskingum channel routing
XXX	Temporary variable assigned to off-line reservoir storage
YYY	Temporary variable assigned to off-line reservoir storage

APPENDIX D

SAMPLE PROBLEM

The input data for the existing condition is given. For the illustration purpose, rainfall data is listed up to one year and one station. The program was calibrated for year 1979. Figures 5, 6, and 7 show the calibrated discharge hydrographs of river reach numbers 5, 8, and 10.

```
TT UPPER ST. JOHNS RIVER BASIN SIMULATION
DI 60,9,4
CN 39.,35.,30.,35.,67.,49.,10.,61.,98.,
CN 61.,60.,55.,60.,76.,70.,10.,75.,98.,
CN 74.,75.,65.,75.,83.,79.,10.,83.,98.,
CN 80.,80.,70.,80.,86.,84.,10.,87.,98.,
CO 1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0
CO 1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0
CO 1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0
CO 1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0
IP00000000000
IP00000000000
IP0000000000
IP0000000000
IP0000000000
IP0000000000
RT00000020000520002000
RT00000000200000002020
RT00000000000000000000
RT01000000202000200002
RT0003002000040000
RT00200000000002000200
LM1        (1-1, FT DRUM CREEK ABOVE FLORIDAS TURNPIKE)
A1 9035.54,3795.64,0.,1142.19,981.34,9024.04
A2 1614.09,92.16,0.,126.29,221.87,2894.95
A3 1923.43,233.81,0.,14.93,162.13,259.84,0.,51.20
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM2        (1-2, JIM GREEN CREEK)
A1 8266.70,4131.01,0.,0.,29.87,1311.16
A2 354.99,37.55,0.,0.,0.,34.13
A3 677.55,110.93,0.,0.,0.,192.85
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM3        (1-3, D.C. SCOTT)
A1 171.95,17.92,0.,0.,0.,1900.81
A2 406.62,15.79,0.,0.,0.,1198.94
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM4        (1-4, D.C. SCOTT)
A1 1.,0.,768.,
A2 0.,0.,256.,
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM5        (1-5)
A1 7.25,0.,0.,0.,1144.76
A2 0.,0.,0.,0.,896.01
A3 0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.
LM6        (1-6, ST. JOHNS D. D.)
A1 507.74,0.,171.,0.,213.33,1762.2,0.,0.,1826.
A2 1762.15,0.,0.,0.,20600.89,2136.3,0.,17.07,17.07
A3 0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.
LM7        (1-7)
A1 0.,34.13,17.07,0.,162.13,640.00
A2 358.40,0.,0.,0.,145.07,1843.21
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
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LM8        (1-8)
A1 0.,0.,0.,0.,89.60,1019.74
A2 0.,0.,0.,0.,290.14,179.20
A3 0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.
LM9        (1-9, ST. JOHNS MARSH)
A1 1.,0.,11648.,
A2 0.,0.,0.,0.,0.,0.,0.,
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM10       (2-1)
A1 10881.,1742.09,0.,0.,0.,1667.,0.,18.35,27.73
A2 282.46,46.93,0.,0.,0.,438.62
A3 42.67,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.,
LM11       (2-2)
A1 25.17,0.,9.39,0.,0.,1160.12
A2 2.99,0.,5.55,0.,0.,588.80
A3 0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.
LM12       (2-3)
A1 47792.0,6073.17,0.,0.,184.32,17780.,0.,139.09,314.03
A2 2885.57,107.52,0.,0.,0.,1060.27
A3 1047.57,124.59,0.,0.,0.,82.77,0.,0.,68.27
A4 53.33,0.,0.,0.,0.,0.,0.
LM13       (2-4)
A1 72.11,106.67,0.,0.,0.,1911.91
A2 0.,0.,0.,0.,0.,0.,0.
A3 0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.
LM14       (2-5)
A1 958.30,148.05,3579.33,0.,98.13,4170.27,0.,5.97
A2 841.82,375.90,143.36,0.,627.63,656.64
A3 0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.
LM15       (2-6)
A1 73.39,1004.81,1012.49
A2 344.75,485.98,833.29
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM16       (2-7)
A1 4526.11,2000.65,0.,0.,243.20,8417.75,0.,0.,1.71
A2 34.13,118.19,0.,0.,0.,61.01
A3 379.74,53.76,0.,0.,68.27,210.77,0.,0.,12.80
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM17       (2-8)
A1 1736.97,30.72,768.01,0.,0.,1673.40,0.,0.,14.93
A2 144.21,35.41,0.,0.,0.,1232.65,0.,0.,38.40
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM18       (2-9 & 2-10)
A1 5326.,247.97,815.,0.,6332.20,17571.,0.,171.95,298.7
A2 8490.29,225.71,60.,0.,5811.24,3432.12,0.,1309.02
A3 789.34,8.53,0.,0.,0.,12.80
A4 0.,0.,0.,0.,0.,0.,0.,0.,
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LM19        (BARNEY GREENE)
A1 1.,0.,2816.,0.,0.,0.,0.
A2 0.,0.,0.,0.,0.,0.,0.
A3 0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM20        (2-11)
A1 498.78,0.,22730.,0.,0.,1624.33,0.,9.81,6326.
A2 0.,0.,128.,0.,0.,42.67
A3 0.,0.,0.,0.,0.,0.,0.,
A4 0.,0.,0.,0.,0.,0.,0.,0.,
LM21        (3-1,WOLF CREEK SOUTH AND SIXMILE CREEK)
A1 7229.48,4222.32,0.,0.,0.,6241.75
A2 646.40,1085.45,3.84,0.,0.,781.66
A3 0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.
LM22        (3-2,TUCKER RANCH)
A1 1.28,16.64,1205.34,0.,0.,1251.42
A2 0.,12.37,13.65,0.,0.,869.98
A3 0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.
LM23        (3-3)
A1 0.,4.27,87.89,0.,0.,2467.86
A2 0.,3.41,0.,0.,0.,295.86
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM24        (3-4)
A1 1788.17,0.,3.84,0.,0.,0.,0.
A2 41.81,0.,.85,0.,0.,0.,0.
A3 0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.
LM25        (3-5)
A1 4213.79,0.,218.03,0.,0.,5.55
A2 1700.28,0.,1.71,0.,0.,4.69
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.
LM26        (3-6)
A1 4695.93,0.,0.,0.,0.,2600.13
A2 1601.29,0.,0.,0.,0.,4969.42
A3 0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.
LM27        (3-7)
A1 5123.88,0.,0.,0.,1191.26,4948.94
A2 98.13,0.,0.,0.,3348.5,1801.40
A3 0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.
LM28        (3-8)
A1 8511.12,3596.82,3.84,0.,0.,6768.68,0.,0.,20.48
A2 925.02,1118.3,0.,0.,0.,218.03
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM29        (3-9)
A1 0.,4.69,0.,0.,426.67,80.64
A2 329.82,74.24,0.,0.,1280.01,321.28
A3 0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.
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LM30        (3-10)
A1 2176.87,104.53,709.55,0.,0.,209.07
A2 2728.55,162.13,6.40,0.,0.,4.27
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM31        (3-11, JANE GREEN CREEK DETENTION AREA)
A1 70577.,21302.,0.,0.,831.15,50320.,105.81,119.47
A2 1159.69,231.25,0.,0.,0.,17.07
A3 1553.08,418.14,0.,0.,0.,204.80
A4 0.,0.,0.,0.,0.,0.,0.
LM32        (3-12)
A1 5010.80,3572.5,0.,0.,111.36,1958.84,60.16,123.73
A2 832.43,878.51,0.,0.,0.,593.07
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 33.71,862.30
LM33        (3-13, MTDD)
A1 9145.23,0.,0.,0.,5.55,6666.29,0.,14305.
A2 9836.43,5.97,2.56,0.,86.19,14665.,0.,9140.54
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM34        (3-14, KEMPFER)
A1 51.20,91.73,0.,0.,0.,708.70,0.,0.,1.71
A2 341.34,99.84,0.,0.,0.,5617.53
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM35        (3-15)
A1 841.82,0.,10449.,0.,0.,15.79
A2 0.,0.,0.,0.,0.,0.,0.,0.
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM36       (3-16)
A1 3648.9,2142.7,2815.59,0.,0.,132.27,0.,0.,817.9
A2 2626.58,527.79,796.17,0.,0.,273.5
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 55.89,2674.5,0.,0.,0.,0.,0.,0.,
LM37        (4-1)
A1 4913.,256.,3925.,0.,0.,1696.,0.,1049.18,21.33
A2 1431.,426.67,682.67,0.,0.,1860.28,0.,548.27
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM38        (4-2)
A1 640.,0.,1390.,0.,0.,0.,0.,0.,2833.1
A2 1024.01,0.,170.67
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.,
LM39        (5-1)
A1 260.27,153.17,0.,0.,0.,1634.57
A2 278.62,1195.10,0.,0.,0.,20286.
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM40        (5-2, PENNEYWASH CREEK DETENTION AREA)
A1 0.,880.65,0.,0.,0.,9445.
A2 0.,0.,0.,0.,0.,0.,0.,0.
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
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LM41        (5-3)
A1 213.33,732.59,208.21,0.,0.,3748.29,0.,0.,4.27
A2 118.61,742.40,102.40,0.,0.,3857.95
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM42        (5-4,  WOLF CREEK DETENTION AREA)
A1 1847.91,1034.67,0.,0.,0.,14526.,42.24
A2 0.,0.,0.,0.,0.,0.,0.,0.
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM43        (5-5)
A1 455.68,518.40,0.,0.,0.,1543.26
A2 1766.84,167.68,0.,0.,0.,1137.5
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM44        (5-6)
A1 5680.3,512.,2975.2,0.,0.,926.30,0.,0.,488.
A2 1330.36,1002.25,71.25,0.,0.,3697.52
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,
LM45        (5-7)
A1 3246.96,2334.31,0.,0.,0.,5721.21,0.,0.,4.27
A2 27.73,2103.05,0.,0.,0.,4180.94,0.,0.,2.99
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM46        (5-8,  TAYLOR CREEK DETENTION AREA)
A1 14189.,4692.,48.,0.,0.,23919.,0.,0.,5493.
A2 0.,0.,0.,0.,0.,0.,0.,0.
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM47        (5-9)
A1 5.12,104.11,0.,0.,0.,1939.79
A2 2131.21,683.10,0.,0.,0.,855.05
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 183.89,411.31,0.,0.,0.,215.47
LM48        (5-10)
A1 535.04,772.27,0.,0.,0.,783.37
A2 1361.08,1611.10,0.,0.,0.,2489.19
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM49        (5-11)
A1 1895.69,996.70,12.80,0.,0.,5922.17,0.,218.03
A2 267.95,83.63,37.12,0.,111.36,5333.80,0.,11.52
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM50        (5-12)
A1 4906.27,0.,157.87,0.,170.67,337.5,0.,3253.36,177.07
A2 1510.41,0.,402.78,0.,206.93,1288.54,0.,406.19,8.53
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM51        (5-13)
A1 3116.4,837.55,10.24,0.,0.,209.07,0.,0.,2.56
A2 160.43,10.24
A3 724.91,759.9,0.,0.,0.,0.,0.,0.,8.53
A4 438.,456.11,0.,0.,0.,0.,0.,0.,2.13
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LM52        (5-14)
A1 7126.65,246.6,8018.,0.,0.,537.02,0.,51.,6385.96
A2 1677.24,866.57,741.98,0.,0.,1101.66,0.,49.07,86.19
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,
LM53        (6-1)
A1 17419.,8683.54,39.25,0.,0.,396.8
A2 2218.26,380.16,120.32,0.,0.,0.,0.,0.,11.95
A3 1988.28,2065.08
A4 2225.93,1784.76
LM54        (6-2)
A1 4911.82,4207.38,0.,0.,0.,51.20
A2 0.,0.,0.,0.,0.,0.,0.,0.
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 0.,0.,0.,0.,0.,0.,0.,0.
LM55        (6-3)
A1 90.88,3732.12,544.43,0.,0.,0.,0.,0.,12.8
A2 3.84,250.88,418.14,0.,0.,0.,0.,0.,9.81
A3 10.24,1139.21,169.39
A4 15.79,1175.05
LM56        (6-4)
A1 7203.88,6535.71,305.92,0.,0.,383.58,0.,418.14,.85
A2 0.,31.57,3411.23,0.,0.,0.,0.,0.,13.23
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 622.94,1384.97,253.44
LM57        (6-5)
A1 24007.,70.40,161.71,0.,0.,852.06,132.37,8599.52,55.04
A2 15184.3,212.91,2962.37,0.,0.,1737.4,0.,1157.98,74.67
A3 2.56,0.,40.11
A4 376.75,0.,5.12,0.,0.,0.,0.,2.13
LM58        (7-1)
A1 10082.,11185.,142.08,0.,128.,7638.65
A2 109.23,1824.01,6502.45,0.,0.,11.95,0.,5.55,122.88
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 1536.18,1772.39,3101.04,0.,0.,477.44,0.,0.,365.66
LM59        (7-2)
A1 21111.,16308.,5439.6,9829.61,629.34,371.2,0.,4313.2,1902.09
A2 881.5,6158.54,17338.,233.82,0.,0.,0.,523.1,1915.75
A3 0.,0.,0.,0.,0.,0.,0.,0.
A4 1913.19,2877.88,266.67,922.46,1.28,38.4,0.,38.83
LM60        (8-1)
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0.,
0.,
0.,
SI 0.,0.,0.,0.,
SI 0.,0.,0.,0.,
SI 0.,0.,0.,0.,
SI 0.,0.,0.,0.,
SI 0.,
SI 0.,
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TK 1.0,4.0,1.2,1.5,0.0,1.6,1.0,2.5,1.0,0.0,
TK 1.6,1.0,1.0,1.0,1.0,1.5,1.0,1.8,1.0,1.0,
TK 6.0,1.6,1.5,1.0,0.0,0.0,1.5,0.0,1.0,2.0,
TK 1.0,2.0,1.1,0.0,1.0,2.5,1.4,1.0,1.0,1.0,
TK 1.0,0.0,2.5,2.0,1.0,2.0,0.0,1.5,0.0,1.0,
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XX .20,.20,.20,.20,.20,.20,.20,.20,.20,.20,
XX .05,.20,.20,.20,.20,.20,.20,.20,.20,.20,
XX .20,.20,.20,.20,.20,.15,.20,.20,.20,.20,
XX .20,.20,.15,.20,.20,.20,.20,.20,.20,.20,
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AA 6.36,5.75,5.88,32.73,4.41,8.17,1.87,5.02,2.45,4.49
AA 9.12,8.75,11.94,2.62,4.24,7.25,12.04,21.88,13.53,9.57,
AA 12.79,32.94,
AA 0.,
AA 0.,
   JANE GREEN CREEK
AO 0.,40.,210.,440.,830.,1280.,1800.,2900.,4100.,6200.,
S1 0.,55.,785.,3015.,7365.,13965.,22625.,46435.,79615.,124775,
AR 0.,40.,210.,440.,830.,1280.,1800.,2900.,4100.,6200.,
S1 0.,55.,785.,3015.,7365.,13965.,22625.,46435.,79615.,124775,
   PENNYWASH CREEK
AO 0.,
S2 0.,
AR 0.,
S2 0.,
   WOLF CREEK
AO 0.,100.,200.,300.,400.,1000.,2000.,4000.,6000.,8000.,
S3 0.,10.,20.,30.,40.,100.,200.,400.,600.,800.,
AR 0.,100.,200.,300.,400.,1000.,2000.,4000.,6000.,8000.,
S3 0.,10.,20.,30.,40.,100.,200.,400.,600.,800.,
   TAYLOR CREEK
AO 0.,600.,1400.,2000.,2600.,3000.,3600.,3600.,3600.,3600.,
S4 28500.,34000.,41500.,53000.,65800.,76000.,96000.,96000.,96000.,96000.,
AR 0.,400.,600.,1000.,1600.,2200.,2600.,3000.,3600.,3600.,
S4 21000.,25600.,28000.,34800.,45200.,56800.,65800.,76000.,96000.,96000.,
   ST. JOHNS RESERVOIR
AO 0.,50.,100.,300.,500.,800.,1000.,1500.,2000.,2500.,
SJ 5000.,6000.,7000.,8000.,9000.,10000.,20000.,30000.,40000.,50000.,
AR 0.,50.,100.,300.,500.,800.,1000.,1500.,2000.,2500.,
SJ 5000.,6000.,7000.,8000.,9000.,10000.,20000.,30000.,40000.,50000.,
RV 0.,
RV 0.,
RV 0.,
RV 0.,0.,0.,26000.,
RV 0.,0.,0.,4000.,
MC 12
DI 0.,16000.,
DI 0.,115000.,
DI 100.,800.,
DI 400.,5000.,
DI 1000.,14500.,
DI 700.,23500.,
DI 1800.,33500.,
DI 1500.,50000.,
DI 1500.,10000.,
DI 1600.,15500.,
DI 1500.,12000.,
DI 1500.,9500.,
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DS 2600.,158390.,4400.,197710.,
DS 6250.,226730.,8250.,268010.,
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DS 0.,194.,100.,292.,
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DS 10000.,79896.,15000.,103513.,
DS 20000.,122526.,35000.,172139.,
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DS 10000.,114467.,15000.,143498.,
DS 20000.,168222.,35000.,228407.,
DS 0.,1000.,100.,1891.,
DS 500.,11195.,1000.,21566.,
DS 2500.,45962.,5000.,73331.,
DS 10000.,111104.,15000.,134852.,
DS 20000.,155791.,35000.,206739.,
DS 0.,500.,100.,957.,
DS 500.,1605.,1000.,2052.,
DS 2500.,13504.,5000.,25001.,
DS 10000.,45655.,15000.,64110.,
DS 20000.,79901.,35000.,122551.,
DS 0.,400.,100.,743.,
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DS 20000.,118268.,35000.,185109.,
DS 0.,1000.,100.,1280.,
DS 500.,3055.,1000.,4989.,
DS 2500.,15758.,5000.,28062.,
DS 10000.,53893.,15000.,80766.,
DS 20000.,96776.,35000.,133683.,
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DS 20000.,90219.,35000.,115710.,
CR 1,10,60,1,2,3,4,5,7,9,8,
CR 2,10,10,11,13,14,15,12,6,17,18,20,0,
CR 3,8,21,22,23,25,26,24,27,16,
CR 4,5,28,29,30,33,35,0,
CR 5,4,31,32,34,36,0,0,
CR 6,2,37,38,0,0,0,0,
CR 7,8,39,40,41,44,45,43,47,48,0,0,0,
CR 8,5,42,46,49,50,51,,
CR 9,4,52,53,54,57,
CR10,2,55,56,0,0,0,
CR11,1,58,
CR12,1,59,
OL 0.,0.,0.,0.,0.,0.,  FOR EXISTING CONDITION
SP 1,76,12,79,
RF  8YE1  THIESSEN WEIGHT
PE 2.97,3.09,5.38,6.42,7.23,6.39,6.18,6.77,5.56,4.67,3.79,3.18,
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.53,.47,
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223238176
1976 1 1    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.44
1976 1 2    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1976 1 3    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1976 1 4    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1976 2 1    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1976 2 2    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1976 2 3    0.00    0.00    0.00    0.00    0.00    0.40    0.00    0.00
1976 2 4    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1976 3 1    0.00    0.92    0.00    0.00    0.00    0.00    0.00    0.00
1976 3 2    0.23    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1976 3 3    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1976 3 4    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1976 4 1    0.00    0.00    0.00    0.00    0.00    0.00    3.40    0.00
1976 4 2    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1976 4 3    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1976 4 4    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1976 5 1    0.00    0.00    0.00    0.00    0.00    0.00    0.00    2.45
1976 5 2    0.00    0.00    0.00    0.00    0.00    4.53    1.63    0.00
1976 5 3    0.00    0.00    0.00    0.00    0.00    0.00    0.77    0.75
1976 5 4    0.00    0.00    0.00    2.00    0.48    0.00    0.00    0.00
1976 6 1    0.00    0.00    1.22    0.36    0.00    0.00    0.00    0.00
1976 6 2    0.53    1.32    0.00    0.00    0.00    0.00    0.00    0.00
1976 6 3    0.00    0.00    0.50    0.30    0.00    2.15    0.00    0.00
1976 6 4    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1976 7 1    1.80    0.00    0.00    0.00    0.00    0.00    0.00    1.38
1976 7 2    0.00    0.42    0.00    0.00    0.00    0.00    0.00    0.00
1976 7 3    2.70    0.00    0.00    0.47    0.00    0.00    0.00    0.00
1976 7 4    0.00    0.00    0.00    0.00    0.77    0.00    0.00    0.00
1976 8 1    0.00    0.00    2.00    1.30    1.57    0.00    0.00    0.00
1976 8 2    0.63    0.00    0.00    0.00    0.97    0.00    0.00    0.00
1976 8 3    0.42    0.00    0.00    0.00    1.30    0.00    0.00    0.00
1976 8 4    0.51    0.00    0.00    0.00    0.00    0.00    0.00    0.00
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1976	9 1	0.00	0.00	0.00	0.00	1.45	0.00	0.00	0.00
1976	9 2	0.26	0.00	0.00	0.00	2.12	0.00	0.00	0.00
1976	9 3	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00
1976	9 4	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.00
1976	10 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1976	10 2	1.50	0.46	0.00	0.00	0.00	0.00	0.00	0.00
1976	10 3	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
1976	10 4	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1976	11 1	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00
1976	11 2	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
1976	11 3	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00
1976	11 4	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00
1976	12 1	0.00	0.00	0.00	0.00	0.00	0.78	0.00	0.00
1976	12 2	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00
1976	12 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1976	12 4	0.00	0.71	0.00	0.00	0.00	0.00	0.36	0.00

FIGURE 5. COMPARISON OF OBSERVED AND SIMULATED HYDROGRAPHS OF 1979
ST JOHNS RIVER NEAR MELBOURNE, AT US HGWY 192

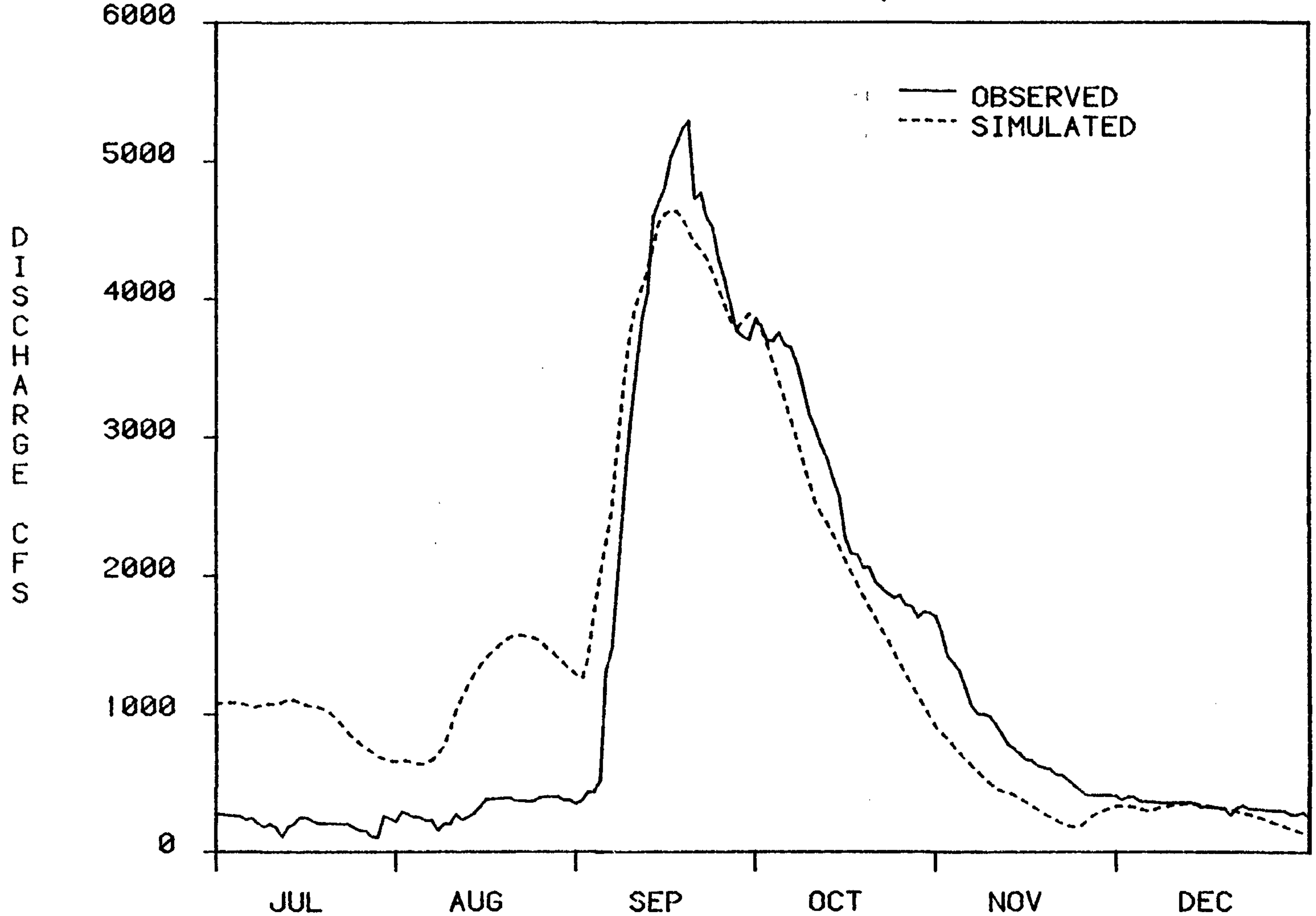

FIGURE 6. COMPARISON OF OBSERVED AND SIMULATED HYDROGRAPHS OF 1979
ST JOHNS RIVER NEAR COCOA, AT SR 520

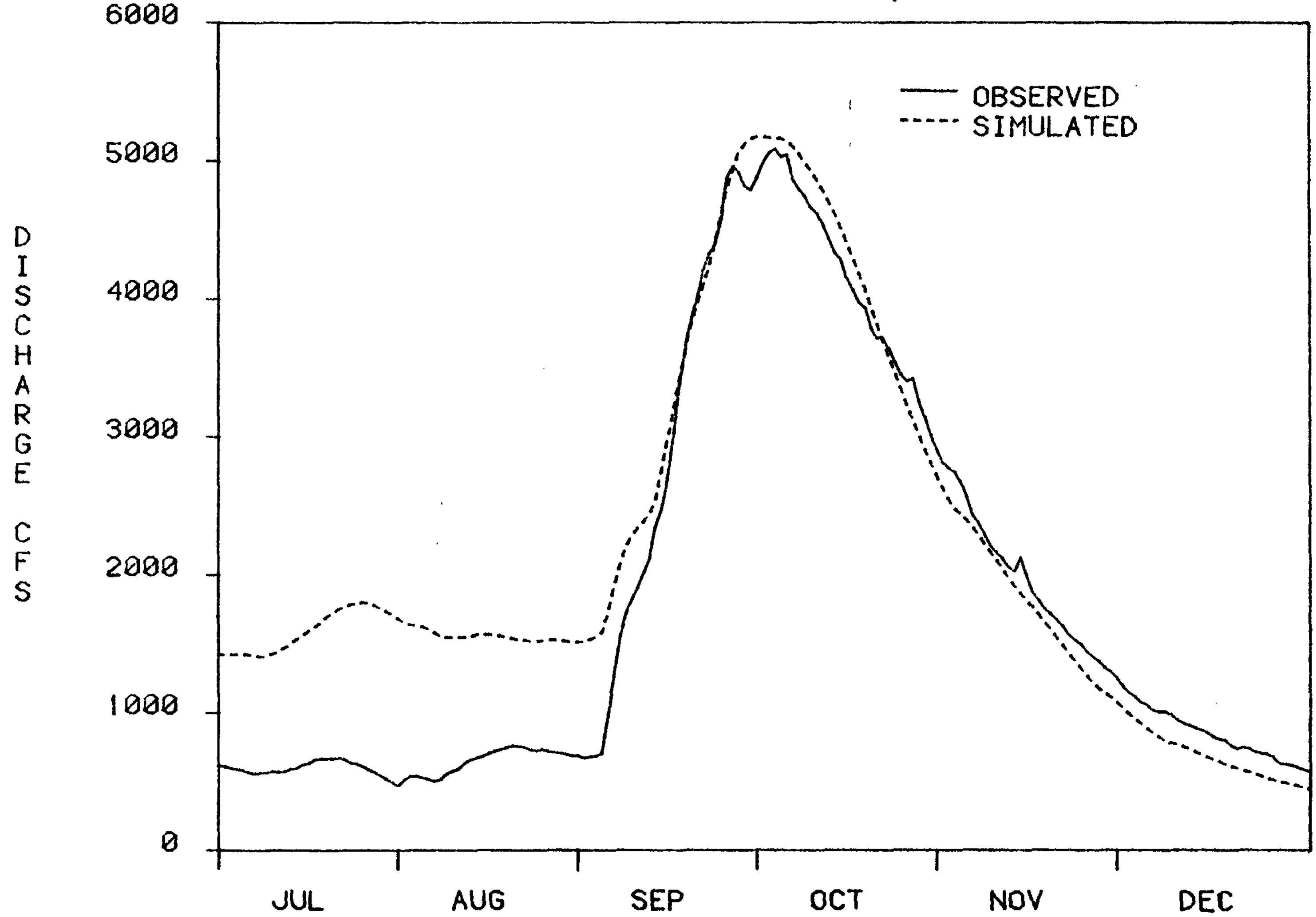

FIGURE 7. COMPARISON OF OBSERVED AND SIMULATED HYDROGRAPHS OF 1979
ST JOHNS RIVER NEAR CHRISTMAS, AT SR 50