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A COMPUTER ROUTINE FOR DATA REDUCTIO
OF A STORM EVENT RECORD
PROGRAM DOCUMENTATION
(IN CDC 3170 LANGUAGE)

by
H.Y.F. Ng

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A COMPUTER ROUTINE FOR DATA REDUCTION OF A STORM EVENT RECORD

PROGRAM DOCUMENTATION
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H.Y.F. Ng

Hydraulics Section
Hydraulics Research Division
Canada Centre for Inland Waters
Burlington, Ontario
December 1977

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1. PURPOSE

To handle data reduction and produce suitable data format for urban runoff studies.

2. DESCRIPTION

This routine is written primarily for data reduction of storm events recorded in 1976 and 1977 on the Malvern Test Catchment in Burlington, Ontario.

This routine reads magnetic tape containing records of a tipping bucket raingauge and the height of water level over a measuring weir. The routine converts the number of raingauge tips into rainfall intensity, and the height of water level to runoff flow rate by using an experimental rating curve. The output is a plot of hyetograph and hydrograph on the same time axis. Associated values can also be punched on IBM computer cards or written on magnetic tape. The tipping bucket and the measuring weir head records from a strip chart recorder are required to be digitized by a digitizer and stored on a magnetic tape. The digitizer is a HP Model 9107A Digitization system.

The routine automatically discretized precipitation data into one minute intervals. The discretization of runoff flow records depends on the user's choice.

Values of rating curve for conversion of the weir head into the flow rate are stored in the routine's main program.

3. ROUTINE FUNCTION

Precipitation and runoff data are recorded on the same strip chart recorder. These data are digitized using CCIW HP Model 9107A Digitization System. A program is written to use the system. The procedures for the use of the program are given under the INSTRUCTION section. The system stores the digitized values onto a magnetic tape.

Upon entering the computer routine, the main program HYGRAP will generate 100 water level values of the weir rating curve. The 100 water level values correspond to the 100 discharge values of a weir rating curve calibrated from laboratory.

These weir rating curve values along with the water level values return from Subroutine RUNOFF are used by the main program yo determine the runoff flow rate.

The Subroutine PRECIP is called to process digitized rainfall data. The process includes sorting and arranging at time when tipping bucket occurred. Results are converted into precipitation intensity and written on a temporary disc file for a plot routine to plot out.

The Subroutine RUNOFF is called to process digitized runoff data. The process is to decode the coordinates of water level and time digitized from the strip chart record. The decoded ordinate of water level is the actual weir head, and the decoded abscissa is the length unit of time. This length unit is then converted into clock hour time. Results are written onto a temporary disc file, and control is returned to the main program to determine flow rate.

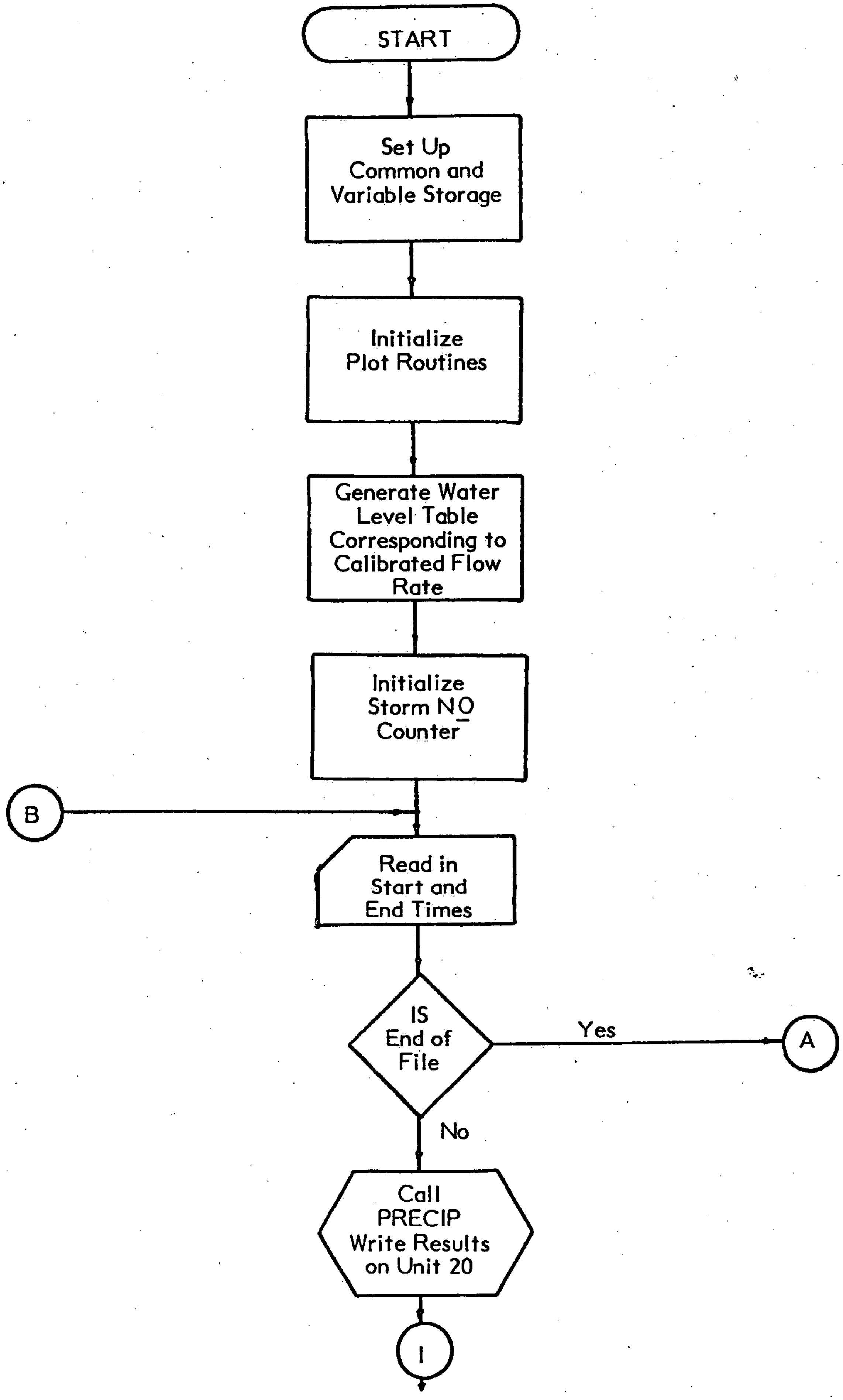
The Subroutine TPLOT is called to plot out the determined flow rate on a X-Y graph. Where Y is the ordinate of flow rate and X is the abscissa of time.

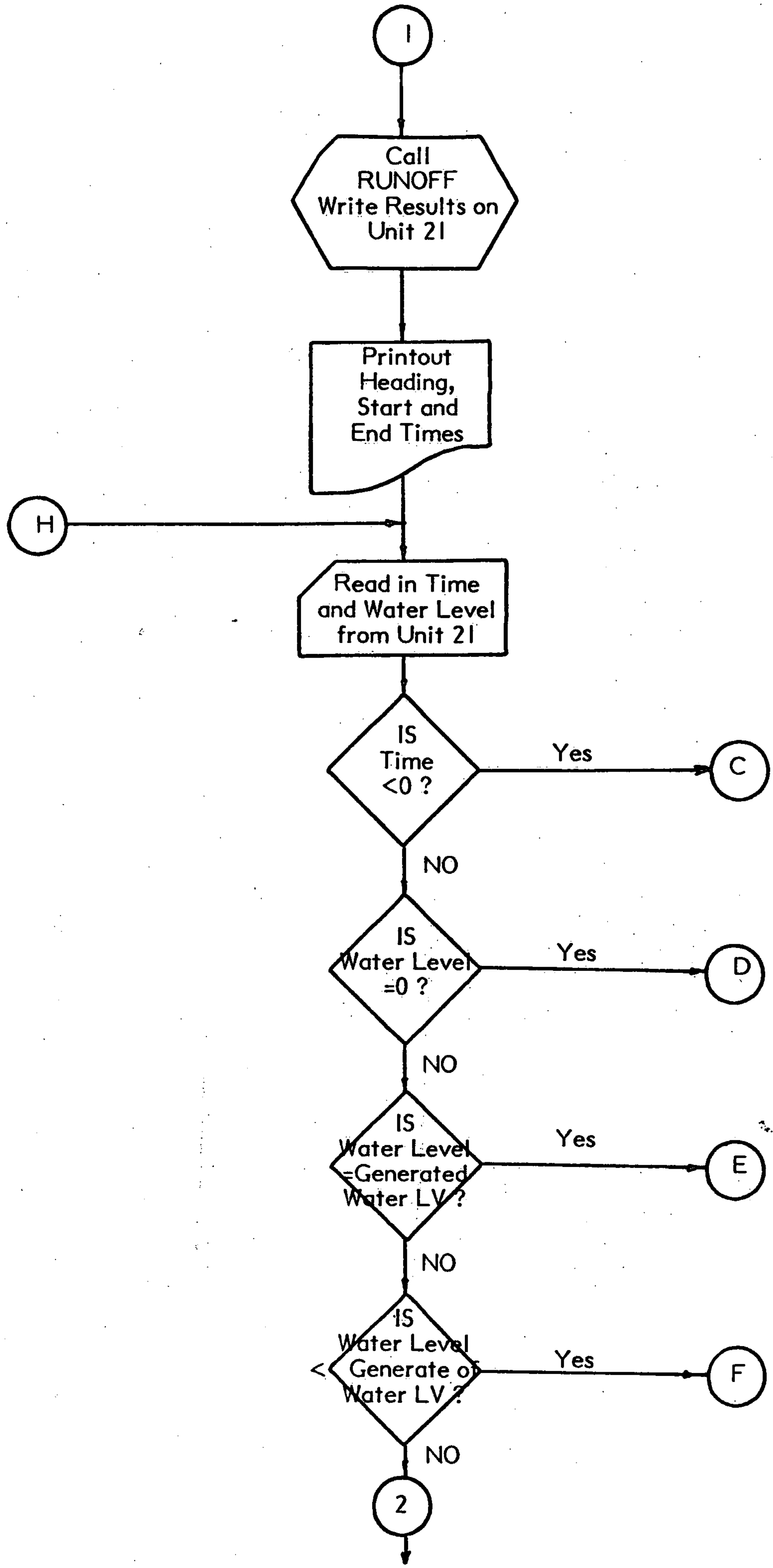
The HOURAXIS is called to draw the timescale on X axis.

The Subroutine RPLOT is called to plot out the determined rainfall intensity on the same time axis as the runoff flow rate.

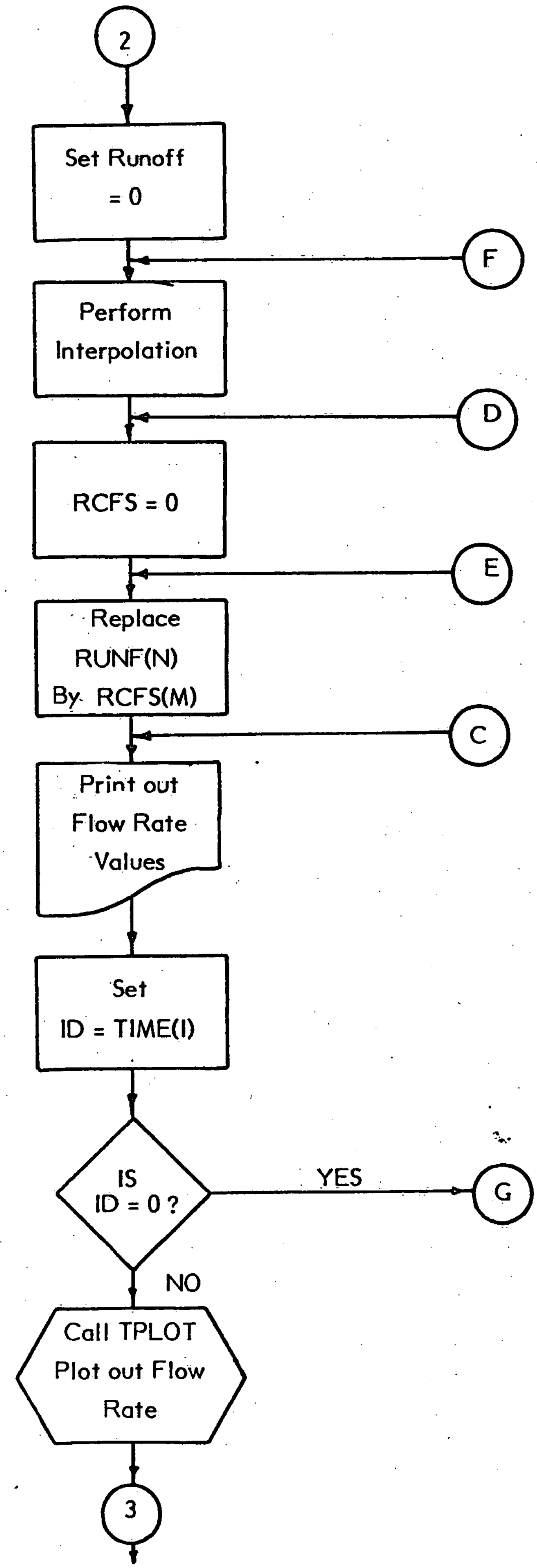
The main program checks the end of the file to see whether to terminate the program or continue to process the next storm event data.

FLOW CHART OF MAIN PROGRAM

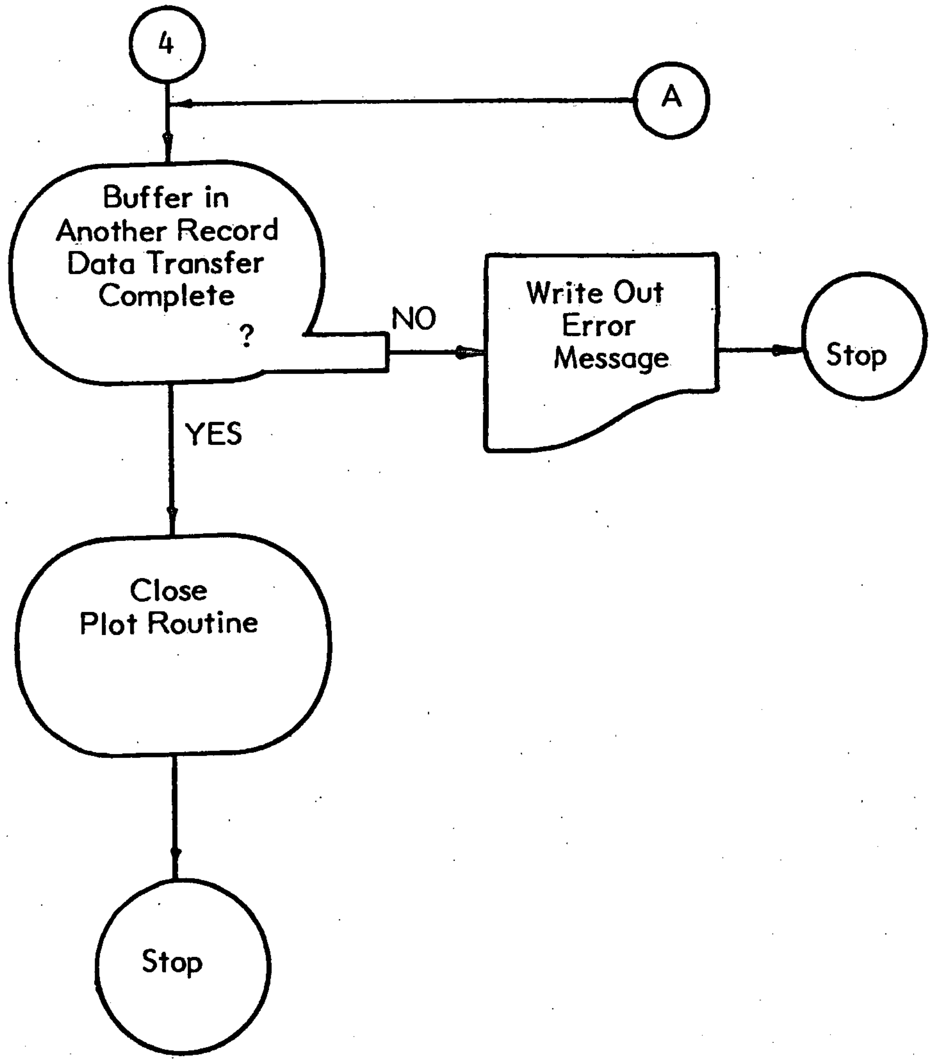




1
Call RUNOFF Write Results on Unit 21
Printout Heading, Start and End Times
H
Read in Time and Water Level from Unit 21
IS Time <0 ?
Yes
C
NO
IS Water Level =0 ?
Yes
D
NO
IS Water Level =Generated Water LV ?
Yes
E
NO
IS Water Level < Generate of Water LV ?
Yes
F
NO
2



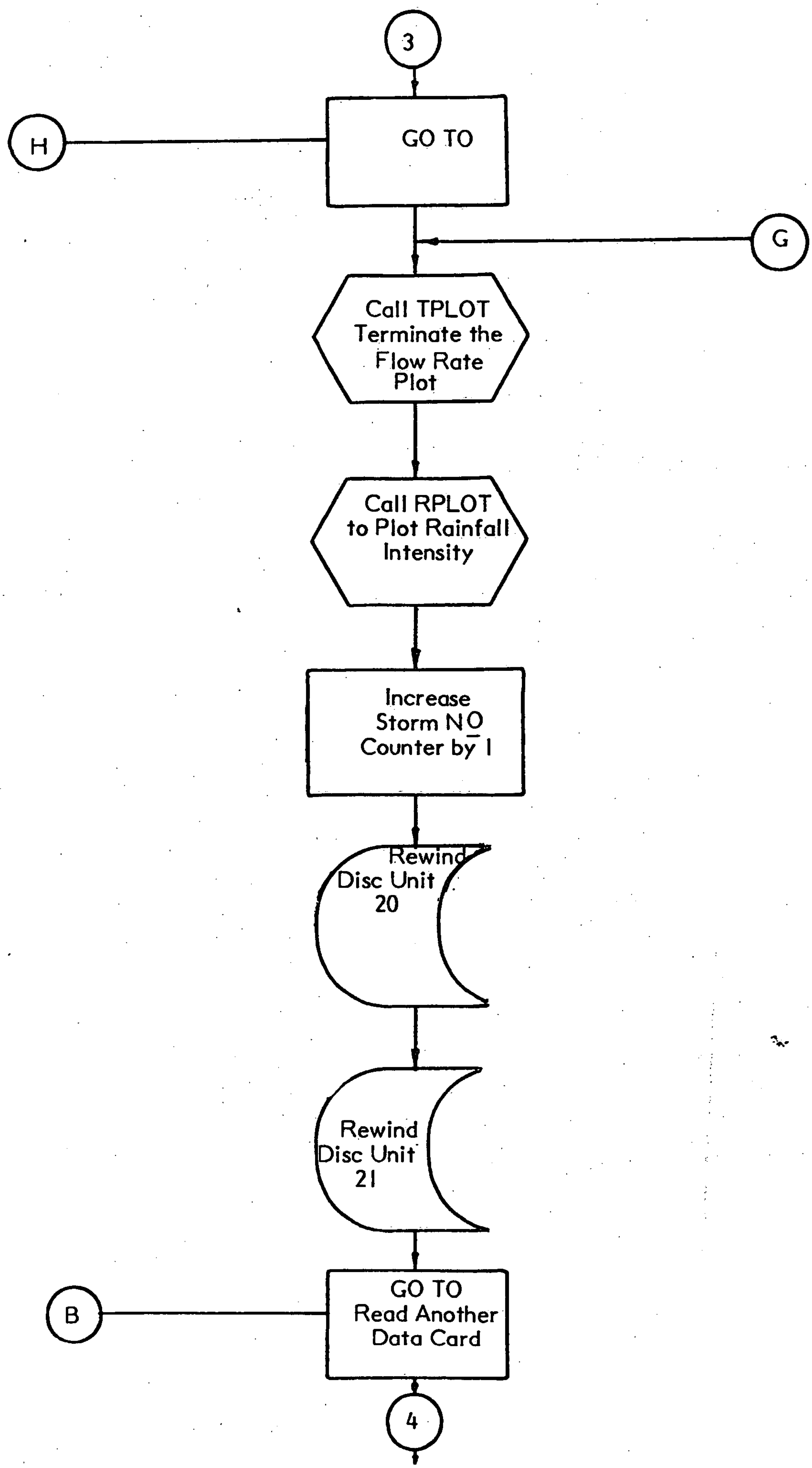
2
Set Runoff
= 0
F
Perform
Interpolation
D
RCFS = 0
E
Replace
RUNF(N)
By RCFS(M)
C
Print out
Flow Rate
Values
Set
ID = TIME(I)
IS
ID = 0 ?
YES
G
NO
Call TPLOT
Plot out Flow
Rate
3


4
A
Buffer in Another Record Data Transfer Complete ?
NO
Write Out Error Message
Stop
YES
Close Plot Routine
Stop

5. DECK SET-UP ORDER FOR HYET

```
$JOB, acc. no., Job id., 5, 3000.
$SCHED, TIME=4, CORE=100, 607=1, SLR=50
$*DEF(Ø,, PLIB, 005/072, p. LIB.AUX.LIB.)
$*DEF(Ø,, PDIR, 005/072, p.LIB.AUX.DIR.)
$*DEF(T,,1,607,Tape NO,Ø,,,,,,M,,I)
$FTNU(X,S,L)
     FØRTRAN DECK

$AUX,PLIB,PDIR
     DATA CARDS
77 EØF
88
```


3
GO TO
H
G
Call TPLOT Terminate the Flow Rate Plot
Call RPLOT to Plot Rainfall Intensity
Increase Storm NO Counter by 1
Rewind Disc Unit 20
Rewind Disc Unit 21
GO TO Read Another Data Card
B
4

6. INPUT (DATA CARDS)

Each time the program is run, the input data card must be set up as follows:

CARD	DESCRIPTION	FORMAT	COLUMNS
1	Station No.	A8	1-8
		BLANK	9-10
	Year	I2	11-12
	Start Hour	I3	13-15
	Start Day	I3	16-18
	Start Month	I3	19-21
	End Hour	I3	22-24
	End Day	I3	25-27
	End Month	I3	28-30

2 If more storm events are to be processed simultaneously, repeat format as Card 1 and punch required Start hour, day and month, and end of hour, day and month for subsequent storm events.

7. INSTRUCTIONS FOR DIGITIZATION

A. Equipment Needed

HP Calculator

HP Digitzer

Extended Memory

Coupler

Tape Drive

B. Switches to be Set on Calculator

Rad

Fixed

On

Run

Printer On

Decimal Wheel Set at 2

C. Mount the Magnetic Tape

After winding the tape, turn the tape drive "ON" and press LOAD FORWARD on the tape drive. When the "READY" light comes on press

STOP
RESET
STOP

on the Coupler. This should leave STOP in the out (not depressed) position.

D. To enter the programs

press:	CLEAR, FMT, SET FLAG, END on the calculator
enter:	Program P_o
press:	O, FMT, FMT, END
enter:	program P_9
press:	9, FMT, FMT, END
press:	0, FMT, GØ TO ( )( ), CONTINUE

E. Start steps

(i) (a) enter start day and month (DD.MM) of point Ø (hour on strip chart).

(b) press ↑

(c) enter stop day and month (DD.MM)

(d) press CONTINUE

(ii) (a) digitize start point Ø with red button

(b) digitize end point p(hour on strip chart) with WHITE BUTTON

(iii) (a) enter YDMAX (maximum unit on Y axis)

(b) press CONTINUE

(iv) digitize point at YDMAX with WHITE BUTTON

(v) digitize designated points on curve with WHITE BUTTON and take one point beyond point p at which point the program will automatically return to step (i) for next data set entry.

Note: Start hour and stop hour of a storm event must be determined prior to digitization. These hours are to be used in the INPUT DATA CARDS of the FORTRAN program. The hour to be recognized is 00 to 24.

8-a. VARIABLES DESCRIPTION --- MAIN PROGRAM HYGRAH

VARIABLES	DESCRIPTION
IBUF	An array which contains integer words buffer in from magnetic tape
METRIC	An array which contains 100 water level values of the weir rating curve
NSTORM	A counter
RUNF	An array which contains 100 discharges values of the weir rating curve
CUMS	An array which contains the discharge values in S.I. Unit
YR	Storm year
SHR	Storm start hour
SDAY	Storm start day
SMO	Storm start month
EHR	Storm end hour
EDAY	Storm end day
EMO	Storm end month
NAME	Name of the catchment
JTIME	An array which contains the time in hours and minute
XWL	An array which contains the water level height
RCFS	An arrary which contains the discharge values in CFS unit
IC	An indicator to signify the termination of plot routines

8-b. VARIABLES DESCRIPTION --- SUBROUTINE TPLOT

VARIABLES	DESCRIPTION
IDS	Put start year, month,and day into one name
IDE	Put end year, month, and day into one name
IHT	Storm start hour
LHT	Storm end hour
TEM	Runoff variable
TS	Start hour
TIME	Value converted from time unit to X-axis scale
Y	Value converted from runoff unit to Y-axis scale

8-c. VARIABLES DESCRIPTION --- SUBROUTINE RPLOT

VARIABLES	DESCRIPTION
STN	Name of catchment
IQ	A roll number
SDAY	Day of the storm
SMO	Month of the storm
YR	Year of the storm
IBAS	The time which contains hour and minute
RAIN	An array which contains 15 rainfall intensity values
HT	A value converted from rainfall intensity for plotting
X	A value calculated from hour and minute plotting on X-axis
IRAIN	An array which contains 15 rainfall intensity values in integer form

8-d. VARIABLES DESCRIPTION --- SUBROUTINE HOURAXIS

VARIABLES	DESCRIPTION
MONTH	An array which contains the 12 calendar months
MON	An array which contains the last day of the 12 calendar months
MNN	An array which contains the last day of the 12 calendar months in the DATA STATEMENT
IYS	Storm start year
IMS	Storm start month
IDS	Storm start day
IYE	Storm end year
IME	Storm end month
IDE	Storm end day
XT	Distance used to locate the plot of day, month and year below the X-axis
D	The clock hour used for plotting on X-axis

8-e. VARIABLES DESCRIPTION --- SUBROUTINE LEAP

VARIABLES	DESCRIPTION
IYR	A value contains the year which uses to calculate leap year month of February

8-f. VARIABLES DESCRIPTION --- SUBROUTINE PRECIP

VARIABLES	DESCRIPTION
NO	A counter
IBUF	An array which contains integer word of rainfall values buffer in from magnetic tape
STN	See main program
SHR	"
SDAY	"
SMO	"
EHR	"
EDAY	"
EMO	"
IWL	An array which contains depth of rainfall
L	The record length
IUM	An array which contains sums of depth of rainfall in one minute
RAIN	An array which contains rainfall intensity in real form
IRAIN	An array which contains rainfall intensity in integer form
TIME	An array which contains hour and minute
IBAS	Time base for specifying 15 values of rainfall intensity in a roll

8-g. VARIABLES DESCRIPTION --- SUBROUTINE RUNOFF

VARIABLES	DESCRIPTION
NO	A counter
J	An array counter
L	The record length
IBUF	An array which contains integer words of weir height
THOURS	A value converted from year, month, day and hours
TSCALE	A time scale for conversion of DECODE value TAIM
WL	An array which contains hour and minute
IDAY1	Start day of storm
IMO1	Start month of storm
IDAY2	End day of storm
IMO2	End month of storm
XMAX	Maximum length of storm duration on strip chart in inches

APPENDIX

I. PROGRAMMES LISTING

II. EXAMPLE OF DATA INPUT AND OUTPUT

APPENDIX I

```
C
C     THIS PROGRAM DESIGNED TO PLOT RUNOFF HYDROGRAPH AND THE PRECIPITAT
C     INTENSITY AT THE SAME TIME AXIS BASE.
      PROGRAM HYGRAP
      INTEGER YR,SHR,SDAY,SMO,EHR,EDAY,EMO
      REAL METRIC
      COMMON /STORM/ NSTORM
      COMMON /1/ IBUF(5000)
      COMMON /DATE/ STN,YR,SHR,SDAY,SMO,EHR,EDAY,EMO
      COMMON /TIME/ IDS,IDE
      COMMON /2/ XWL(1000),JTIME(1000)
      COMMON /3/ RCFS(1000),NAME(10),CMS(1000)
      DIMENSION METRIC(100), NCFS(100), CUMS(100), RUNF(100)
C
C     METRIC IS THE WATER LEVEL READING IN TENTH OF METRE
C
C     NCFS IS THE DISCHARGE IN HUNDREDTH OF CUBIC FOOT PER SEC
      DATA NCFS/0002,0005,0013,0020,0028,0037,0047,0058,0070,0082,0095,
     $0109,0123,0139,0154,0171,0188,0206,0225,0244,0264,0285,0306,0329,
     $0351,0375,0399,0424,0449,0475,0502,0530,0558,0587,0617,0647,0670,
     $0710,0743,0776,0810,0845,0881,0917,0954,0992,1031,1070,1111,1152,
     $1194,1237,1280,1325,1370,1416,1463,1511,1560,1610,1661,1712,1765,
     $1818,1873,1926,1985,2042,2101,2160,2220,2282,2344,2408,2473,2539,
     $2605,2673,2743,2813,2884,2957,3031,3106,3182,3260,3338,3418,3500,
     $3582,3666,3751,3838,3926,4016,4106,4199,4292,4387,4484/
C
C     GENERATE WATER LEVEL TABLE CORRESPONDS TO DISCHARGE NCFS
C
      IB = 5000
      CALL PLOT (0.0,1.8,-3)
      HZ = 0.0
      CM = 0.005
      DO 20 I=1,100
      HZ = HZ+CM
      METRIC(I) = HZ
      RUNF(I) = FLOAT(NCFS(I))/100.0
      CUMS(I) = RUNF(I)/35.31
   20 CONTINUE
C
C
      NSTORM = 1
   30 CONTINUE
      CALL ZEROV (RCFS,1000)
      CALL ZEROV (CMS,1000)
      READ (60,190) YR,SHR,SDAY,SMO,EHR,EDAY,EMO,NAME
      IF (IFEOF(60).EQ.-1) GO TO 150
      WRITE (61,200) NAME,NSTORM
      WRITE (61,210) SDAY,SMO,YR
      CALL PRECIP
      REWIND 20
      CALL RUNOFF (JX)
      REWIND 21
      WRITE (61,220) NSTORM
      WRITE (61,210) SDAY,SMO,YR
      WRITE (61,230)
      IHOUR = 0
      ID2 = 0
      ID = -1
      READ (21) (JTIME(I),XWL(I),I=1,JX)
      IF (IFEOF(21).EQ.-1) GO TO 140
C
C     CONVERT WL. TO FLOW RATE
      DO 90 M=1,JX
      IF (JTIME(M).LE.0) GO TO 100
      WZ = XWL(M)
      IF (WZ.EQ.0.0) GO TO 60
      DO 40 N=1,100
      IF (WZ.EQ.METRIC(N)) GO TO 80
      IF (WZ.LE.METRIC(N)) GO TO 50
   40 CONTINUE
   50 CONTINUE
      IF (N.GT.1) GO TO 70
   60 CONTINUE
      RCFS(M) = 0.0
      GO TO 90
   70 CONTINUE
      RCFS(M) = RUNF(N-1)+(WZ-METRIC(N-1))*(RUNF(N)-RUNF(N-1))/(METRIC(N
     $)-METRIC(N-1))
      GO TO 90
   80 CONTINUE
```

APPENDIX I

```
      RCFS(M) = IBUF(N)
 90   CONTINUE
 100  CONTINUE
      IM = M-1
      DO 110 N=1,IM
      CMS(N) = RCFS(N)/35.31
 110  CONTINUE
      DO 120 JK=1,IM,10
      JK2 = JK+9
      IF(JK2.GT.IM)JK2 = IM
      WRITE (61,240) (JTIME(K),K=JK,JK2)
      WRITE (61,250) (RCFS(K),K=JK,JK2)
      WRITE (61,260) (CMS(K),K=JK,JK2)
 120  CONTINUE
      DO 130 I=1,IM
      ID = JTIME(I)
      IF(ID.LT.ID2)IHOUR = IHOUR+2400
      ID2 = ID
      ID = ID+IHOUR
      IF (ID.EQ.0) GO TO 140
      VEL = RCFS(I)
      CALL TPLOT (VEL,IC,ID)
      JD = ID
 130  CONTINUE
 140  CONTINUE
      IC = -2
      CALL TPLOT (VEL,IC,ID)
      CALL RPLOT (VEL)
      NSTORM = NSTORM+1
      REWIND 20
      REWIND 21
      GO TO 30
 150  CONTINUE
      WRITE (61,270)
      BUFFER IN (1,0) (IBUF(1),IBUF(IB))
      IF (IFUNIT(1)) 160,160,170
 160  STOP 100
 170  CONTINUE
      CALL PLOT (0.0,0.0,999)
      STOP
 180  WRITE (61,280)
      CALL PLOT (0.0,0.0,999)
      STOP 777
C
C
 190  FORMAT (10X,I2,6I3,10A4)
 200  FORMAT (1H1,////30X,10A4,/11X,*STORMNO.*,I3)
 210  FORMAT (/11X,*STORMDATE*,I2,1H/,I2,1H/,I2)
 220  FORMAT (//11X,*STORMNO.*,I3)
 230  FORMAT (/45X,*FLOWRATE*,/37X,*(SELECTEDTIMEINTERVAL)*)
 240  FORMAT (/06X,*TIME(HR,MIN)>*,10(I5,1X))
 250  FORMAT (11X,*(CFS)*,7X,10(F5.2,1X))
 260  FORMAT (11X,≠(M**3/S)≠,5X,10(F5.3,1X))
 270  FORMAT (//////1X,*RECORDISCOMPLETE*)
 280  FORMAT (///10X,*MORETAPERECORDSTHANCARDINPUTRECORDS*//)
      END
```

```
C     THIS SUBROUTINE PLOTS THE RUNOFF HYDROGRAPH
      SUBROUTINE TPLOT (TEM,IC,ID)
      INTEGER YR,SHR,SDAY,SMO,EHR,EDAY,EMO
      DIMENSION ITLE(6), ICM(7), ITP(3)
      COMMON /TIME/ IDS,IDE
      COMMON /DATE/ STM,YR,SHR,SDAY,SMO,EHR,EDAY,EMO
      COMMON /SCALE/ XSCALE
      COMMON /STORM/ NSTORM
      COMMON /3/ RCFS(1000),NAME(10),CMS(1000)
      DATA ITLE/4HRUNO,4HFF F,4HLOW ,4H RAT,4HE (C,4HFS) /
      DATA ICM/4HRUNO,4HFF F,4HLOW ,4HRATE,4H (M*,4H*3/S,4HEC  /
      DATA ITP/4HTIME,4H (HO,4HURS) /
      DATA YSCALE/05.0/
      DATA XSCALE/1.0/
      IDS = YR*10000+SMO*100+SDAY
      IDE = YR*10000+EMO*100+EDAY
      IHT = SHR*100
      LHT = EHR*100
      IC = IC+1
      IF (IC) 10,20,30
10    CONTINUE
      FN = NSTORM
      CALL HOURAXIS (0.0,0.0,100.0,IHT,IDS,LHT,IDE,PL)
      Y = PL/2.0-2.0
      CALL AXIS (PL,0.0,1H ,-1,6.0,90.0,00.0,0.142)
      CALL SYMBOL (PL+0.50,1.5,0.14,23HRUNOFF FLOW RATE (M /S),90.0,23)
      CALL SYMBOL (PL+0.36,4.19,0.08,1H3,90.0,1)
      CALL SYMBOL (X+1.00,-0.90,0.12,ITP,0.0,12)
      CALL SYMBOL (X,-1.3,0.14,29HMALVERN CATCHMENT - STORM NO.,0.0,29)
      CALL NUMBER (X+4.4,-1.3,0.14,FN,0.0,-1)
      TEM = PL
      RETURN
20    CONTINUE
      CALL AXIS (0.0,0.0,ITLE,24,6.0,90.0,00.0,05.0)
      TS = IHT/100.0+MOD(IHT,100)/60.0
      TIME = ID/100.0+MOD(ID,100)/60.0
      TIME = (TIME-TS)/XSCALE
      IPEN = 2
      Y = TEM/YSCALE
      CALL PLOT (TIME,Y,3)
30    CONTINUE
      TIME = ID/100+MOD(ID,100)/60.0
      TIME = (TIME-TS)/XSCALE
      IF(TEM.LT.0.0) IPEN = 3
      IF (TEM.LT.0.0) RETURN
      Y = TEM/YSCALE
      IF (IPEN.EQ.3) CALL PLOT (TIME,Y,3)
      CALL PLOT (TIME,Y,2)
      IPEN = 2
      RETURN
      END
```

```
C     THIS SUBROUTINE PLOTS TIME AXIS IN HOURS/INCH
      SUBROUTINE HOURAXIS (XP,YP,DI,HS,DS,HE,DE,PLEN)
C     ARGUMENTS:
C     XP,YP - CO-ORDINATES OF START OF AXIS
C     DI    - SCALE OF X-AXIS IN DAYS/INCH
C     DS    - START DATE IN YYMMDD
C     DE    - END DATE IN YYMMDD
C     PLEN  - MAXIMUM PEN MOVEMENT RELATIVE TO XP IN X DIRECTION
C             IS RETURNED TO CALLING PROGRAM
      INTEGER DS,DE,HS,HE
      DIMENSION MONTH(12), MON(12), MNN(12)
      DIMENSION IDT(3)
      DATA MONTH/4?HJAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC/
      DATA MNN/31,28,31,30,31,30,31,31,30,31,30,31/
      CALL MOVE (MNN,MON,12)
      ENCODE (6,60,IDT) DS
      DECODE (6,70,IDT) IYS,IMS,IDS
      ENCODE (6,60,IDT) DE
      DECODE (6,70,IDT) IYE,IME,IDE
      IDE = IDE+IFIX(DI/2400.0+0.99)-1
      IF (IDE.LE.MON(IME)) GO TO 10
      IDE = IDE-MON(IME)
      IME = IME+1
      IF (IME.LE.12) GO TO 10
      IME = 1
      IYE = IYE+1
   10 CONTINUE
      MTH = IMS
      D = HS
      ID = IDS
      IY = IYS
      X = XP-1.0
      Y = YP
      CALL LEAP (IYS,MON(2))
      CALL PLOT (XP,YP,3)
      IF(IY.EQ.IYE)MON(IME) = IDE
      XT = X+(MON(IMS)-IDS)/DI/2.0+0.6
   20 CONTINUE
      X = X+1.0
      CALL PLOT (X,Y,2)
      CALL PLOT (X,Y-.10,2)
      IF (D-FLOAT(IFIX(D)).LT..01) CALL NUMBER (X-.05,Y-.3,.1,D,0.,-1)
      IF (XT.GT.X) GO TO 30
      ENCODE (9,80,IDT) ID,MONTH(MTH),IY
      CALL SYMBOL (XT+0.5,Y-0.48,0.12,IDT,0.0,9)
      XT = 1.0E6
   30 CONTINUE
      CALL PLOT (X,Y,3)
      D = D+DI
      IF (IY.EQ.IYE.AND.MTH.EQ.IME.AND.ID.EQ.IDE.AND.IFIX(D).GT.HE)
     * GO TO 50
      IF (IFIX(D).LE.2400) GO TO 20
      D = 100.0
      ID = ID+1
      IF (ID.LE.MON(MTH)) GO TO 40
      MTH = MTH+1
      IF (MTH.LE.12) GO TO 40
      MTH = 1
      IY = IY+1
      MON(2) = 28
      CALL LEAP (IY,MON(2))
      IF(IY.EQ.IYE)MON(IME) = IDE
   40 CONTINUE
      IF (IY.GT.IYE) GO TO 50
      IF (IY.EQ.IYE.AND.MTH.GT.IME) GO TO 50
      XT = X+(MON(MTH)-1)/DI/2.0-0.4
      GO TO 20
   50 CONTINUE
      PLEN = X-XP
      RETURN
C
C
   60 FORMAT (I6)
   70 FORMAT (3I2)
   80 FORMAT (I2,1X,A4,I2)
      END
```

SUBROUTINE LEAP (IYR,I)

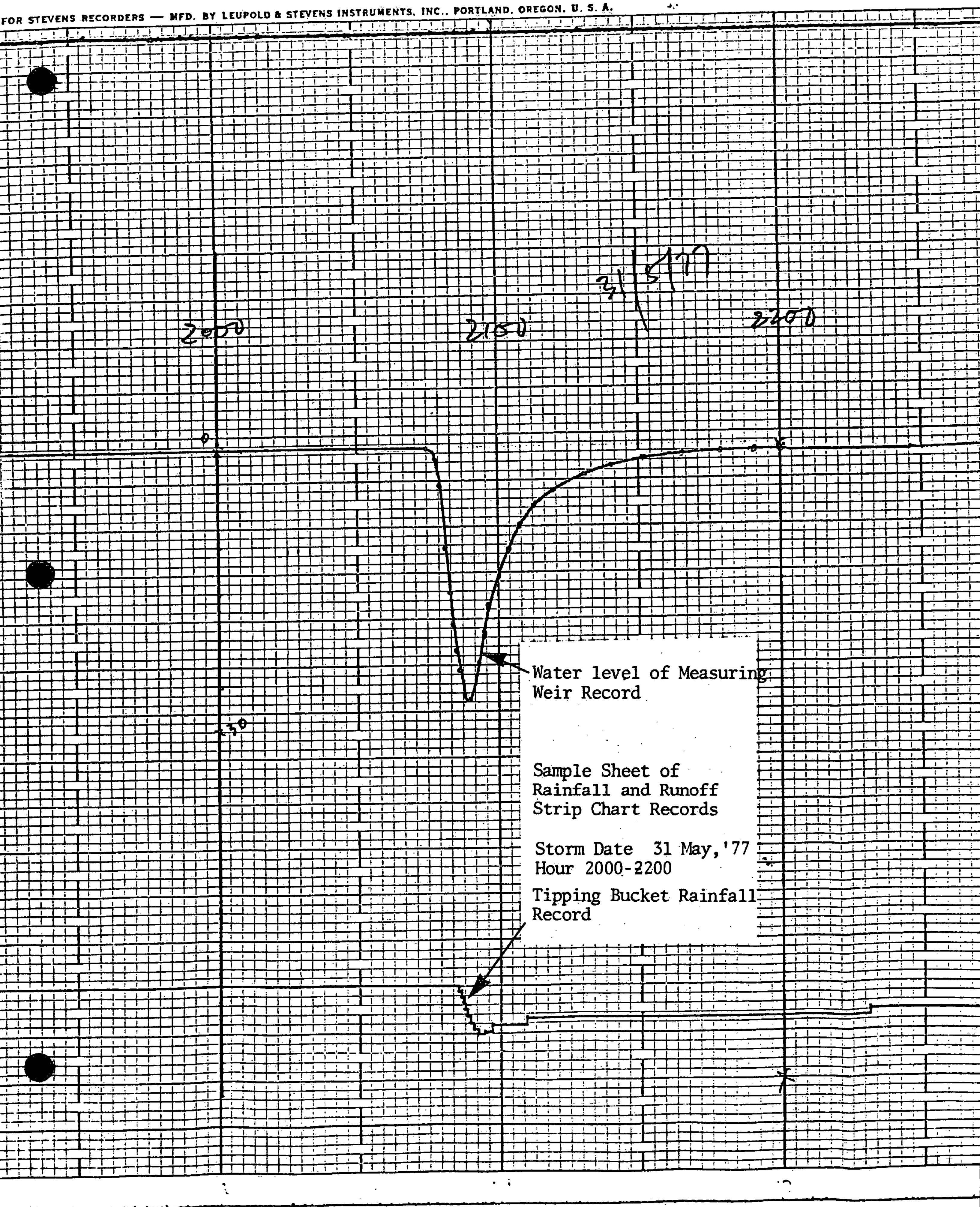
```
      SUBROUTINE LEAP (IYR,I)
C     IF IYR IS A LEAP YEAR.INCREMENT I
      IF(IYR/4*4.EQ.IYR)I = I+1
      IF (IYR.LT.1752) RETURN
      IF(IYR/100*100.EQ.IYR)I = I-1
      IF(IYR/400*400.EQ.IYR)I = I+1
      RETURN
      END
```

```
C     THIS SUBROUTINE PLOTS PRECIPITATION INTENSITY IN IN/HOUR
      SUBROUTINE PPLOT (PL)
      INTEGER YR,SHR,SDAY,SMO,EHR,EDAY,EMO
      COMMON /DATE/ STN,YR,SHR,SDAY,SMO,EHR,EDAY,EMO
      COMMON /STORM/ NSTORM
      COMMON /TIME/ IDS,IDE
      COMMON /SCALE/ XSCALE
      COMMON /3/ RCFS(1000),NAME(10),CMS(1000)
      DIMENSION RAIN(15), IRAIN(15)
      DATA RAIN(15)/1.0/
      DATA XSCALE/1.0/
      DATA YSCALE/2.0/
      YP = 0.0
      XSC = 1.0/(60.0*XSCALE)
      CALL PLOT (0.0,8.5,-3)
      READ (20) STN,IQ,SDAY,SMO,YR,IBAS,(RAIN(I1),I1=1,15)
      ENCODE (6,70,MIN) IBAS
      DECODE (6,80,MIN) IHR,IMIN
      IHS = SHR*100
      HI = IHS/100.0+MOD(IHS,100)/60.0
      HS1 = FLOAT(IHR)
      XS = (HS1-HI)/XSCALE
      X = XS-XSC+IMIN/60.0/XSCALE
      GO TO 20
   10 CONTINUE
      READ (20) STN,IQ,SDAY,SMO,YR,IBAS,(RAIN(I1),I1=1,15)
      ENCODE (6,70,MIN) IBAS
      DECODE (6,80,MIN) IHR,IMIN
      IF (IFEOF(20).EQ.-1) GO TO 60
      IF (RAIN(1).EQ.0.0) CALL PLOT (X+XSC,0.0,2)
   20 CONTINUE
      DO 50 I=1,15
      X = X+XSC
      CALL PLOT (X,0.0,3)
      IF (RAIN(I)) 30,30,40
   30 CONTINUE
      YP = 0.0
      GO TO 50
   40 CONTINUE
      HT = -RAIN(I)/YSCALE
      IF (YP.LT.0.0) CALL PLOT (X,YP,3)
      CALL PLOT (X,HT,2)
      CALL PLOT (X+XSC,HT,2)
      IF (RAIN(I+1).EQ.0.0) CALL PLOT (X+XSC,0.0,2)
      YP = HT
   50 CONTINUE
      GO TO 10
   60 CONTINUE
      X = X+XSC
      CALL PLOT (X,0.0,3)
      CALL PLOT (XS-1.0,0.0,2)
      CALL AXIS (XS-1.0,-2.0,1H ,1,2.0,90.0,4.0,-YSCALE)
      CALL SYMBOL (XS-1.35,-1.9,0.06,31HPRECIPITATION INTENSITY (IN/HR),
     $90.0,31)
      IF(X.GT.PL)PL = X
      CALL PLOT (PL+8.0,-8.5,-3)
      RETURN
C
C
   70 FORMAT (I4)
   80 FORMAT (2I2)
      END
```

```
      SUBROUTINE PRECIP
      INTEGER YR,SHR,SDAY,SMO,EHR,EDAY,EMO
      INTEGER TIME
      COMMON /DATE/ STN,YR,SHR,SDAY,SMO,EHR,EDAY,EMO
      COMMON /1/ IBUF(5000)
      DIMENSION IWL(1000), IUM(1000), ITIME(1000)
      DIMENSION MON(12), MNN(12), RAIN(1000)
      DIMENSION TIME(1000), WL(1000), IRAIN(1000)
      IB = 5000
C
      NO = 1
      IZ = 0
      IYR = YR+1900
      IHR = SHR*100
      LHR = EHR*100
10    BUFFER IN (1,0) (IBUF(1),IBUF(IB))
      IF (IFUNIT(1)) 20,40,30
20    STOP 001
30    STOP 002
40    L = LENGTH(1)
      I = L-2
      DECODE (12,180,IBUF(I) )CHECK
      IF (CHECK.EQ.99.99) GO TO 10
      DECODE (36,190,IBUF(1) )IDAY1,IMO1,IDAY2,IMO2,XMAX
      IF (IDAY1.NE.SDAY.OR.IMO1.NE.SMO) GO TO 150
      IF (IDAY2.NE.EDAY.OR.IMO2.NE.EMO) GO TO 150
C
C     CONVERT THE X-VALUES TO TIME VALUES
C
      CALL JULIAN (JU1,IYR,IMO1,IDAY1)
      CALL JULIAN (JU2,IYR,IMO2,IDAY2)
      THOURS = (JU2-JU1)*24.0+EHR-SHR
      TSCALE = THOURS/XMAX
      J = 0
      ADDHRS = (SDAY-1)*24.0
      DO 50 I=10,L,5
      J = J+1
      DECODE (24,200,IBUF(I) )TAIM,WL(J)
      IWL(J) = WL(J)*10.00+SIGN(0.5,WL(J))
      IF(IWL(J).LT.0)IWL(J) = 0
      IF(IWL(J).GT.0)IWL(J) = 1
      T = TAIM*TSCALE
      IT = T
      T = T-IT
      JT = T*60.0+0.5
      IF(JT.GE.60)JT = JT+40
      IT = IT*100.0+JT+SHR*100
      TIME(J) = MOD(IT-1,2400)+1
50    CONTINUE
      J = J+1
      TIME(J) = -1
      IWL(J) = 0
      WRITE (61,160)
      M = 0
      DO 70 K=1,J
      KK = K+1
      IF (TIME(KK).NE.TIME(K)) GO TO 60
      IWL(KK) = IWL(K)+IWL(KK)
      GO TO 70
60    M = M+1
      IUM(M) = IWL(K)
      ITIME(M) = TIME(K)
70    CONTINUE
      CALL ZEROV (RAIN,15)
      CALL ZEROV (IRAIN,15)
      IQ = 1
      IBAS = SHR*100
      NHR = EHR*100
      MN = 0
      DO 130 IR=1,M
      IF(ITIME(IR).GE.2400)ITIME(IR) = ITIME(IR)-2400
80    J = ITIME(IR)-IBAS+1
      IF (ITIME(IR).LT.0) GO TO 140
      IF (J.LE.0) GO TO 90
      IF (J.LE.15) GO TO 120
90    WRITE (61,170) SDAY,SMO,YR,IBAS,(RAIN(I1),I1=1,15)
      WRITE (20) STN,IQ,SDAY,SMO,YR,IBAS,(RAIN(I1),I1=1,15)
      IQ = IQ+1
      CALL ZEROV (IRAIN,15)
      CALL ZEROV (RAIN,15)
```

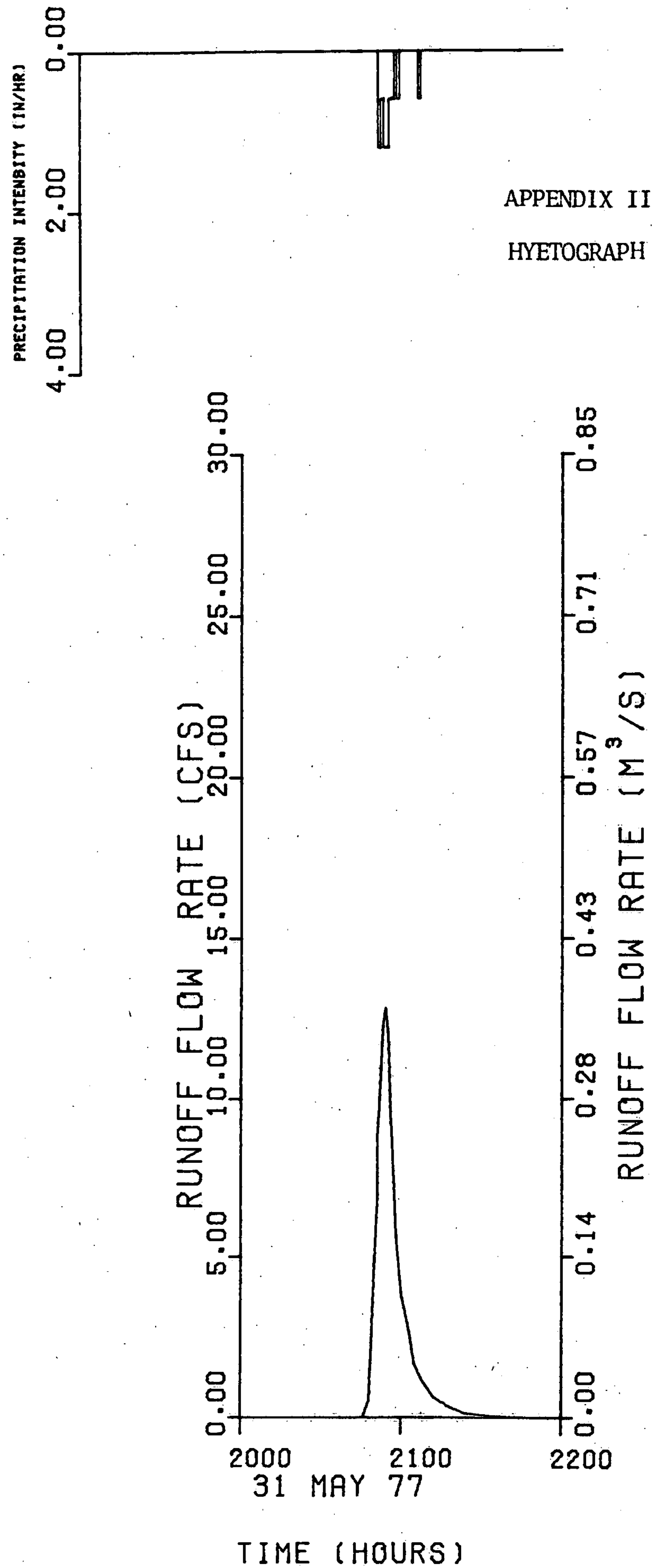
```
      IBAS = IBAS+15
      MN = MN+15
      IF (MN.NE.60) GO TO 100
      MN = 0
      IBAS = IBAS+40
  100 IF (IBAS.LT.2400) GO TO 80
      IBAS = IBAS-2400
      SDAY = SDAY+1
      IF (SDAY.LE.MNN(SMO)) GO TO 110
      SDAY = SDAY-MNN(SMO)
      SMO = SMO+1
  110 CONTINUE
      GO TO 80
  120 IRAIN(J) = IUM(IR)*60
      RAIN(J) = FLOAT(IRAIN(J))/100.0
  130 CONTINUE
  140 CONTINUE
      END FILE 20
      NO = NO+1
      RETURN
  150 WRITE (61,210) IDAY1,IMO1,IDAY2,IMO2,XMAX
      RETURN
C
C
  160 FORMAT (/09X,*DATEHOUR*,20X,*RAINFALLINTENSITY(IN/HR.)*,/37X,*(1-
     $MINUTEINTERVAL,15-VALUESACROSS)*,/)
  170 FORMAT (8X,I2,1H/,I2,1H/,I2,1X,I4,2X,15(F3.1,1X))
  180 FORMAT (F10.2)
  190 FORMAT (5X,I2,1X,I2,7X,I2,1X,I2,2X,F10.2)
  200 FORMAT (F10.2,2X,F10.2)
  210 FORMAT (///10X,*DATEONTAPEDOESNOTMATCHDATEONINPUTCARD*//10X,4(I4,
     $1X),F7.2)
      END
```

```
      SUBROUTINE RUNOFF (J)
      INTEGER YR,SHR,SDAY,SMO,EHR,EDAY,EMO,TIME
      DIMENSION IWL(1000), MNN(12)
      COMMON /2/ XWL(1000),JTIME(1000)
      DIMENSION TIME(1000), WL(1000)
      COMMON /DATE/ STN,YR,SHR,SDAY,SMO,EHR,EDAY,EMO
      COMMON /1/ IBUF(5000)
      CALL ZEROV (JTIME,1000)
      IB = 5000
C
      NO = 1
      IYR = YR+1900
      IZ = 0
      IHR = SHR*100
      LHR = EHR*100
 20   BUFFER IN (1,0) (IBUF(1),IBUF(IB))
      IF (IFUNIT(1)) 30,50,40
 30   STOP 001
 40   STOP 002
 50   L = LENGTH(1)
      I = L-2
      DECODE (12,80,IBUF(I) )CHECK
      IF (CHECK.EQ.99.39) GO TO 20
      DECODE (36,90,IBUF(1) )IDAY1,IMO1,IDAY2,IMO2,XMAX
      IF (IDAY1.NE.SDAY.OR.IMO1.NE.SMO) GO TO 70
      IF (IDAY2.NE.EDAY.OR.IMO2.NE.EMO) GO TO 70
C
      CALL JULIAN (JU1,IYR,IMO1,IDAY1)
      CALL JULIAN (JU2,IYR,IMO2,IDAY2)
C     CONVERT THE X-VALUES TO TIME VALUES
C
      THOURS = (JU2-JU1)*24.0+EHR-SHR
      TSCALE = THOURS/XMAX
      J = 0
      ADDHRS = (SDAY-1)*24.0
      DO 60 I=10,L,6
      J = J+1
      DECODE (24,100,IBUF(I) )TAIM,WL(J)
      IF(WL(J).LT.0.0)WL(J) = 0.0
      IWL(J) = WL(J)
      XWL(J) = WL(J)/100.0
      T = TAIM*TSCALE
      IT = T
      T = T-IT
      IT = IT*100.0+T*60.0+0.5+SHR*100
      TIME(J) = MOD(IT-1,2400)+1
      JTIME(J) = TIME(J)
 60   CONTINUE
      J = J+1
      TIME(J) = -1
      JTIME(J) = TIME(J)
      IWL(J) = 0
      XWL(J) = 0.0
      WRITE (21) (JTIME(I),XWL(I),I=1,J)
      END FILE 21
      NO = NO+1
      RETURN
 70   WRITE (61,110) IDAY1,IMO1,IDAY2,IMO2,XMAX
      RETURN
C
C
 80   FORMAT (F10.2)
 90   FORMAT (5X,I2,1X,I2,7X,I2,1X,I2,2X,F10.2)
 100  FORMAT (F10.2,2X,F10.2)
 110  FORMAT (///10X,*DATEONTAPEDOESNOTMATCHDATEONINPUTCARD*//10X,4(I4,
     $1X),F7.2)
      END
```


FOR STEVENS RECORDERS — MFD. BY LEUPOLD & STEVENS INSTRUMENTS, INC., PORTLAND, OREGON, U. S. A.
31/5/77
2000
2150
2200
Water level of Measuring Weir Record
Sample Sheet of Rainfall and Runoff Strip Chart Records
Storm Date 31 May,'77
Hour 2000-2200
Tipping Bucket Rainfall Record

APPENDIX II OUTPUT

HYETOGRAPH & HYDROGRAPH PLOTS



MALVERN CATCHMENT - STORM NO. 2

MALVERN TEST CATCHMENT (BURLINGTON)

STORM NO. 2

STORM DATE 31/ 5/77

RAINFALL INTENSITY (IN/HR.)
(1-MINUTE INTERVAL. 15-VALUES ACROSS

DATE	HOUR															
31/ 5/77	2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31/ 5/77	2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31/ 5/77	2030	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31/ 5/77	2045	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.6	1.2	1.2	0.6	0.6	0.0	0.6	0.0
31/ 5/77	2100	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31/ 5/77	2115	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31/ 5/77	2130	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31/ 5/77	2145	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

STORM NO. 2

STORM DATE 31/ 5/77

FLOW RATE
(SELECTED TIME INTERVAL)

TIME(HR.MIN)>	2045	2046	2048	2049	2050	2051	2051	2052	2053	2054
(CFS)	0.00	0.08	0.54	2.56	4.91	6.84	8.75	10.14	12.28	12.63
(M**3/S)	0.000	0.002	0.015	0.073	0.139	0.194	0.248	0.287	0.348	0.363
TIME(HR.MIN)>	2055	2056	2057	2058	2100	2103	2105	2108	2112	2118
(CFS)	11.97	9.58	7.48	5.64	3.81	2.60	1.65	1.12	0.64	0.31
(M**3/S)	0.339	0.271	0.212	0.160	0.108	0.074	0.047	0.032	0.016	0.009
TIME(HR.MIN)>	2124	2131	2139	2147	2154	2202				
(CFS)	0.13	0.07	0.03	0.00	0.00	0.00				
(M**3/S)	0.004	0.002	0.001	0.000	0.000	0.000				

RECORD IS COMPLETE

PLOT TAPE SUCCESSFULLY WRITTEN

STOP

1 54 38
Environment Canada Library, Burlington
3 9055 1017 8383 4