Hydrologic Analysis Programs for Programmable Calculators and Digital Computers for use in Hydropower Studies

by
L.F. Heitz

Idaho Water and Energy Resources Research Institute
University of Idaho
Moscow, Idaho
March 1982

Technical Report

A-068-IDA

HYDROLOGIC ANALYSIS PROGRAMS FOR PROGRAMMABLE CALCULATORS AND DIGITAL COMPUTERS FOR USE IN HYDROPOWER STUDIES

by

Leroy F. Heitz

Submitted to

Office of Water Research and Technology
United States Department of the Interior
Washington, D.C. 20242

The work on which this report is based was supported in part by funds provided by the United States Department of the Interior as authorized under the Water Research and Development Act of 1978.

The work is taken from the Appendices of a Ph.D. dissertation, "Hydrologic Evaluation Methods for Hydropower Studies" by Leroy F. Heitz.

Idaho Water and Energy Resources Research Institute
University of Idaho
Moscow, Idaho 83843

March 1982

The following appendices, Appendix A and Appendix B, are taken from a Ph.D. dissertation titled, "Hydrologic Evaluation Methods for Hydropower Studies", by L. F. Heitz dated May 1981. These appendices contain many programs for programmable calculators and computers that are very useful for making the hydrologic analysis phases of a hydropower study. The programs were developed in conjunction with this and other projects dealing with the evaluation of the hydrologic parameters required for hydropower planning studies. The appendices include programs to make calculations for and to plot flow duration curves, programs for determining power and energy production from a hydro site and programs for determining flows in a highly regulated stream system. Each program write up contains a complete listing of the program and samples of using the program on a real problem.

The analyses techniques used in each of the programs are discussed in detail in the dissertation referenced above. Other sources of information on the analysis techniques used include "Low Head Hydro", (Gladwell and Warnick, 1978), "A Resource Survey of Hydroelectric Potential - Pacific Northwest Region", (Gladwell et al, 1979), "Methodologies for the Determination of Flow Duration Curves at Specific Sites on Ungaged Reaches of Streams", (Emmert, 1979), "Idaho Hydroelectric Potential Theoretical Potential in Streams and Potential at Existing Dams and Proposed Sites, (Heitz et al, 1980), and User Guide for Idaho Hydrologic Maps" (Warnick et al, 1981).

REFERENCES

Emmert, R.L., "Methodologies for the Determination of Flow Duration Curves at Specific Sites on Ungaged Reaches of Streams," a Master of Science Thesis in the Graduate School of the University of Idaho, Moscow, Idaho, May 1979.

Gladwell, J.S. and C.C. Warnick, "Low Head Hydro, An Examination of an Alternative Energy Source," Idaho Water Resources Research Institute, Moscow, Idaho, September 1978, 205 pp.

Gladwell, J.S., C.C. Warnick, et al, "Phase I, A Resource Survey of Low-Head Hydroelectric Potential-Pacific Northwest Region," a ten volume completion report to the U.S. Department of Energy, Idaho Water Resources Research Institute, University of Idaho, Moscow, Idaho, March 1979.

Heitz, L.F., C.C. Warnick, J.S. Gladwell, "Idaho Hydroelectric Potential Theoretical Potential in Streams and Potential at Existing Dams and Proposed Sites," Idaho Water and Energy Resources Research Institute, University of Idaho, Moscow, Idaho, August 1980.

Heitz, L.F., "Hydrologic Evaluation Methods for Hydropower Studies," a Ph.D. dissertation in the Graduate School of the University of Idaho, Moscow, Idaho, May, 1981.

Warnick, C.C., L.F. Heitz, L.A. Kirkland and G.G. Burke, "User Guide for Idaho Hydroelectric Maps," Idaho Water and Energy Resources Institute, University of Idaho, Moscow, Idaho, June 1981.

APPENDIX A

COMPUTER AND CALCULATOR PROGRAMS
FOR USE IN HYDROLOGIC ANALYSES OF HYDROPOWER POTENTIAL

APPENDIX A
TABLE OF CONTENTS

APPENDIX A
LIST OF FIGURES

FIGURE — Page

APPENDIX A
LIST OF FIGURES CONTINUED

FIGURE PAGE

PROGRAM 1
FLOW DURATION CURVE COMPUTATION AND PLOTTING PROGRAM
FORTRAN VERSION

This program is designed to compute duration curves using user supplied flow data. In order to keep the program flexible, the user must supply certain statements in the main program to read the format of a particular flow data set. These statements need to be in Fortran language to be compatible with the rest of the main program. The simplified flow schematic in Figure 1 shows how the program is structured and what variables are passed between subroutines.

The main program is used to initialized plotter routines and to input flow data. The user must supply adequate read statements so that a flow data file is input to the program. The flow variable is Q and is dimensioned for 1200 values. These statements should be inserted between lines 80 and 90 in the main program. In addition a station number, (NSTA) number of flow values to be processed (NUM) and starting and ending year of data (NYRST, NYREN) must also be provided. These variables can be read in as input data or generated within the main program prior to the call to the duration subroutine.

Subroutine Dura is used to compute the exceedance percents for the various classes. Subroutine Pltdur generates the data for the flow duration curve plots. Listings of the main program and the two subroutines are shown in Figure 2. Flow classes from 0 to 200,000 cfs are contained in data statements lines 140 to 180 of Subroutine Dura. These can be changed if they are not acceptable. Line 100 contains the assignment of

FIGURE 1
SIMPLIFIED FLOW DIAGRAM
FOR DURATION CURVE PROGRAM

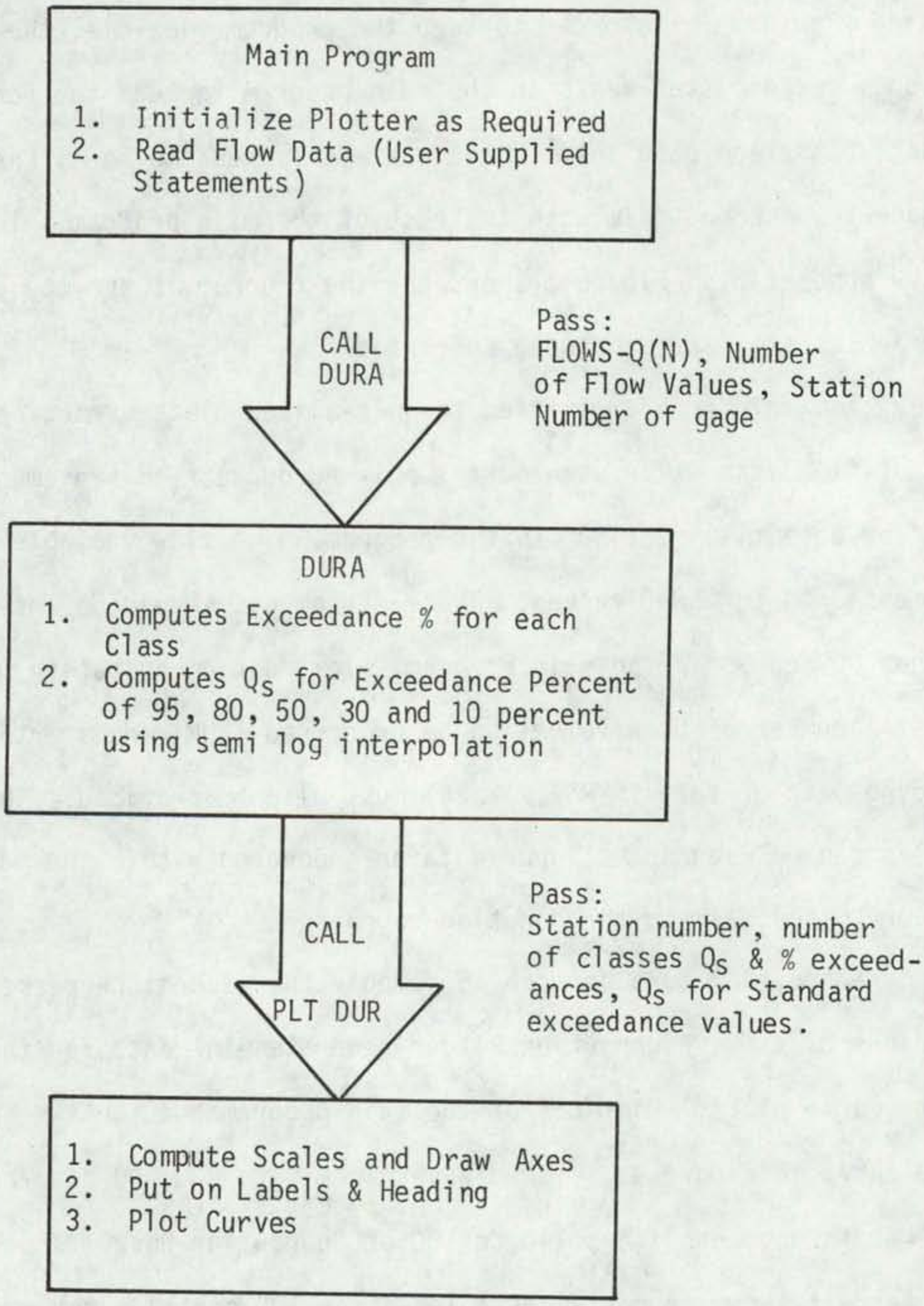


FIGURE 2
FLOW DURATION CURVE
COMPUTATION AND PLOTTING PROGRAM

MAIN PROGRAM

```
C   MAIN PROGRAM TO READ FLOW DATA
       DIMENSION Q(1200)
       CALL PLOTS (0,0,13)
       CALL PLOT (2.0,-15.0,-3)
       CALL PLOT (0.0,2.0,-3)
       CALL SYMBOL (0.0,-.5,.07,'I',0.0,1)
       CALL SYMBOL (0.0,10.15, .07,'I',0.0,1)
C   INSERT FLOW DATA READ STATEMENTS BETWEEN THIS AND NEXT COMMENT CARD
C   INSERT FLOW DATA READ STATEMENTS BETWEEN THIS AND PREVIOUS COMMENT
C   VALUES FOR NSTA=STATION NUMBER (3 DIGIT MAX),NUM=NUMBER OF FLOW
C   VALUES,Q(N)=FLOW ARRAY,NYRST=STARTING YEAR OF RECORD,NYREN=
C   ENDING YEAR OF RECORD  MUST BE PROVIDED.  THESE VALUES MUST BE
C   GENERATED BY THE INSERTED DATA READ STATEMENTS.
       CALL DURA (NSTA,NUM,Q,NYRST,NYREN)
       CALL PLOT(6.0,0,0,999)
       STOP
       END
```

SUBROUTINE DURA

```
      SUBROUTINE DURA (NSTA,NUM,Q,NYRST,NYREN)
      DIMENSION CLASS(46),NCOUNT(47),NTOTGT(47),PERCEN(47),B(47)
C   THIS SUBROUTINE COMPUTES DURATION VALUES FOR FLOW RECORD 'Q'
C   SUBROUTINE USES FLOW CLASS SCHEME OF COMPUTATION
      DIMENSION Q(1200),MONTHS(12)
      DIMENSION QPER(7),CPER(7)
      DATA CPER/95.,80.,50.,30.,10./
      DATA NCLASS/46/
C   THE FOLLOWING STATEMENT CONTAINS THE CLASS INTERVAL BOUNDARIES
C   THESE VALUES CAN BE CHANGED BY CHANGING THE NUMBERS IN THE
C   DATA STATEMENT
      DATA CLASS /0.,5.,10.,30.,50.,70.,100.,150.,200.,300.,400.,500.,
     1600.,700.,800.,900.,1000.,1200.,1500.,1800.,2000.,2500.,3000.,
     13500.,4000.,4500.,5000.,5500.,6000.,6500.,7000.,7500.,8000.,8500.,
     19000.,9500.,10000.,15000.,20000.,25000.,30000.,35000.,40000.,
     145000.,50000.,200000./
      QSUM=0
C     COMPUTE CLASS FOR EACH FLOW AND TOTAL COUNTS IN EACH CLASS
      DO 30 N=1,NCLASS
   30 NCOUNT(N)=0
      N = NCLASS/2
      DO 40 I=1,NUM
      IF(Q(I).GE.CLASS(NCLASS))  GO TO 40
      IF (Q(I).LT.CLASS(1))  GO TO 40
   26 CONTINUE
      IF (Q(I).GE.CLASS(N).AND.Q(I).LT.CLASS(N+1)) GO TO 32
      IF(Q(I).LT.CLASS(N))  GO TO 27
      N = N+ 1
      GO TO 26
   27 N = N- 1
      GO TO 26
   32 NCOUNT(N+1)=NCOUNT(N+1)+1
   40 CONTINUE
C     COMPUTE TOTAL COUNTS ANDCHECK AGAINST TOTAL # OF FLOWS
      NTOT=0
      DO 45 I=1,NCLASS
```

```
   45 NTOT=NTOT+NCOUNT(I)
      IF(NTOT.EQ.NUM) GO TO 48
      WRITE (6,46) NTOT,NUM
   46 FORMAT (//,' TOTAL COUNTS =',I6,' TOTAL FLOWS =',I6,
     1' CHECK INTERVALS',/)
C     COMPUTE PERCENTAGES
   48 NTOTGT(NCLASS +1)=0
      NCOUNT(NCLASS+1)=0
      DO 52 M=1,NCLASS
      N=NCLASS+1-M
      NTOTGT(N)= (NTOTGT(N+1)-NCOUNT(N+1)   )
      B(N)=-NTOTGT(N)
      C=NTOT
   52 PERCEN(N)=B(N)/C * 100.
C     OUTPUT DURATION TABLE
      WRITE (6,47) NSTA,NYRST,NYREN
   47 FORMAT('1',22X,'STATION',I3,/,23X,'WATER YEAR',/,22X,
     1I3,' THRU',I3,/)
      WRITE(6,60)
   60 FORMAT(' CLASS',5X,'LOWER',5X,'UPPER  INTERVAL    NUMBER   PERCENT
     1',/,10X,  ' LIMIT     LIMIT     COUNT     GREATER    GREATER',/,
     210X,'  CFS        CFS')
      DO 62  N= 2,NCLASS
      M=N-1
      WRITE(6,65) M,CLASS(N-1),CLASS(N),NCOUNT(N),     B(N),PERCEN (N)
   65 FORMAT(I5,2F10.2,I10,F10.0,F10.0)
   62 CONTINUE
   70 CONTINUE
      N= 2
C COMPUTE SEMI-LOG INTERPOLATED 95,80,50,30,AND 10 PERCENT
C  EXCEEDANCE FLOWS
      DO 560 I = 1,5
      DO 550 K = N,NCLASS
      IF (PERCEN(K).LT.CPER(I))GO TO 500
      IF (PERCEN(K+1).GT.CPER(I)) GO TO 550
      QPER(I)=10**(((ALOG10(CLASS(K+1))-ALOG10(CLASS(K)))
     1/(PERCEN(K)-PERCEN(K+1))*(PERCEN(K)-CPER(I)))+ALOG10(CLASS(K)))
      GO TO 560
  550 CONTINUE
  500 QPER (I) = CLASS(K-1)
      WRITE (6,502) CPER(I)
  502 FORMAT (/,' ALL EXCEEDANCE % LESS THAN',F6.0,' PERCENT',/)
  560 CONTINUE
C  WRITE OUT INTERPOLATED FLOWS
      WRITE (6,504) NSTA
  504 FORMAT(/,'      STATION ',I3 ,/,' EXCEEDANCE       FLOW')
      WRITE (6,506)  (CPER(I),QPER(I),I=1,5)
  506 FORMAT(F8.0,3X,F12.2)
C  CALL PLOTTING SUBROUTINE
      CALL PLTDUR(NSTA  ,NCLASS,CLASS,PERCEN,CPER,QPER,NYRST,NYREN)
      RETURN
      END
```

FIGURE 2 CONTINUED

SUBROUTINE PLTDUR

```
      SUBROUTINE PLTDUR (NSTA,NCLASS,CLASS,PERCEN,CPER,QPER,NYRST,NYREN)
C     SUBROUTINE PLTDUR USED TO MAKE PLOTS OF DURATION DATA
      DIMENSION  CLASS (46),PERCEN(47),X(50),Y(50),CPER(7),QPER(7)
      STA = FLOAT (NSTA)
C  ROUTINE TO ELIMINATE ALL BUT ONE ZERO VALUE AND ALL
C  BUT ONE 100 PERCENT VALUE
      N = 0
      DO 20 I = 2,NCLASS
      IF (PERCEN(I).GT.99.999)  GO TO 20
      IF (PERCEN(I).LT..0001) GO TO 15
      N = N + 1
      IF (I.EQ.2)  GO TO 17
      IF (N.GT.1)  GO TO 17
      X(N) = PERCEN(I-1)
      Y(N) = CLASS (I-1)
      N = N + 1
       GO TO 17
   15 N = N+ 1
       X(N) = PERCEN (I)
      Y(N) = CLASS (I)
      GO TO 21
   17 X(N) = PERCEN(I)
      Y(N) = CLASS(I)
   20 CONTINUE
   21 NMPTS = N
      CALL PLOT (1.5,0.0,-3)
C  THE FOLLOWING STATEMENT CONTROLS WHETHER A LOG OR ARITHMETIC
C  PLOT IS MADE. 'LOG =1' = LOG PLOT, 'LOG=0' = ARITHMETIC PLOT
      CALL PLOT (1.5,0.0,-3)
      LOG = 1
      IF(LOG.EQ.1) GO TO 65
      CALL SCALE(Y,9.0,NMPTS,1)
      CALL AXIS (0.0,0.0,'FLOW IN CFS',11,9.0,90.,
     1Y(NMPTS+1),Y(NMPTS+2))
      GO TO 67
   65 CALL SCALG (Y,9.0,NMPTS,1)
      CALL LBAXS (0.0,0.0,'FLOW IN CFS', 11,9.0,90.,Y(NMPTS+1),Y(NMPTS
     1+ 2))
   67 CONTINUE
      X(NMPTS+1) = 0.0
      X(NMPTS+2) = 20.0
      CPER(6) = X(NMPTS + 1)
      CPER(7) = X(NMPTS + 2)
      QPER(6) = Y(NMPTS+ 1)
      QPER(7) = Y(NMPTS + 2)
      CALL AXIS (0.0,0.0,'EXCEEDANCE PERCENTAGE',-21,5.0,0.0,X(NMPTS+1),
     1X(NMPTS+2))
      IF(LOG.EQ.1)  GO TO 69
      CALL LINE (X,Y,NMPTS,1,-1,4)
      CALL GRID (0.0,0.0,1.0,1.0,5,9)
      GO TO 72
   69 CALL LGLIN (X,Y,NMPTS,1,-1,4,+1)
   72 CONTINUE
      CALL SYMBOL(.75,9.75,.14,        'DURATION CURVE FOR STATION',0.0,
     126)
```

FIGURE 2 CONTINUED

```
      YRST = FLOAT (NYRST )
      YREN = FLOAT (NYREN)
      CALL NUMBER (2.3,9.55,.14,STA,0.0,-1)
      CALL SYMBOL (1.8,9.35,.14,'WATER YEAR',0.0,10)
      IF ((NYRST+1).NE.NYREN) GO TC 61
      CALL NUMBER (2.4,9.15,.14,YRST,0.0,4)
      GO TO 63
   61 CONTINUE
      CALL NUMBER (1.82,9.15,.14,YRST,0.0,-1)
      CALL SYMBOL (2.2,9.15,.14,'THRU',0.0,4)
      CALL NUMBER (2.9,9.15,.14,YREN,0.0,-1)
   63 CONTINUE
      IF (LOG.NE.1)  GO TO 25
C PLOT LOG GRIDS
      NMGRD = 9.1 * Y(NMPTS + 2)
      DO 25 I = 1,NMGRD
      X1 = 0.0
      Y1 = I/Y(NMPTS + 2)
      CALL PLOT (X1,Y1,3)
      X2 = 5
      CALL PLOT (X2,Y1,2)
   25 CONTINUE
C   PLOT 10,30,50,80,95 LINES AND LABEL
      DO 40 I = 1,6
      Y1 =0.02
      IF (I.GT.3) GO TO 28
      X1 = .5 + (I-1) -.14
      PER = 10.+ (I-1) * 20.
      GO TO 35
   28 CONTINUE
      IF ( I.GT.4) GO TO 30
      X1 = 3.86
      PER = 80
      GO TO 35
   30 CONTINUE
      IF ( I.GT.5) GO TO 32
      X1 = 4.61
      PER = 95.
      GO TO 35
   32 X1 = 5.0
      Y1 = 0.0
   35 CONTINUE
      IF (Y1.LT.0.0001)  GO TC 37
      CALL NUMBER (X1,Y1,.14,PER,0.0,-1)
      Y1 = .27
      X1 = X1 + .14
   37 CONTINUE
      CALL PLOT (X1,Y1,3)
      Y2 = 9.0
      CALL PLOT (X1,Y2,2)
   40 CONTINUE
      CALL SYMBOL(5.3,8.6,.14,'%       Q',0.0,7)
      DO 50  I=1,5
      YPOS = 8.4-I*.2
      CPES = CPER(I)
```

FIGURE 2 CONTINUED

```
      QPES = QPER(I)
      CALL NUMBER(6.2,YPOS,.10,QPES     ,0,2)
      CALL NUMBER(5.3,YPOS,.10,CPES     ,0,0)
   50 CONTINUE
      CALL PLOT (7.0,0.0,-3)
      CALL SYMBOL (0.0,-.5,.07,'I',0.0,1)
      CALL SYMBOL (0.0,10.15,0.07,'I',0.0,1)
      RETURN
      END
```

INPUT DATA

80 FLOW DATA FOR STATION 8 GAGE 2070 FOLLOWS

29	45.	39.	36.	35.	33.	37.	66.	293.	387.	98.	38.	35.
30	42.	37.	57.	47.	43.	49.	381.	500.	316.	81.	43.	37.
31	44.	31.	22.	21.	24.	39.	164.	476.	127.	35.	19.	27.
32	32.	39.	37.	36.	40.	48.	131.	516.	577.	162.	59.	38.
33	41.	43.	28.	29.	27.	28.	49.	155.	628.	129.	56.	39.
34	37.	34.	32.	31.	37.	76.	316.	365.	131.	54.	31.	28.
35	40.	51.	40.	35.	35.	41.	121.	457.	418.	86.	39.	31.
36	32.	34.	30.	32.	35.	38.	252.	698.	348.	77.	40.	36.
37	28.	26.	26.	24.	27.	30.	60.	383.	280.	81.	38.	31.
38	32.	38.	95.	50.	45.	57.	210.	650.	772.	185.	65.	47.
39	53.	50.	40.	35.	30.	47.	204.	429.	147.	63.	33.	30.
40	33.	30.	40.	40.	41.	73.	252.	582.	310.	71.	37.	45.
41	57.	57.	46.	42.	40.	63.	154.	524.	378.	99.	58.	49.
42	50.	88.	147.	70.	54.	55.	246.	393.	516.	143.	55.	39.
43	38.	63.	48.	45.	51.	60.	436.	564.	751.	363.	87.	51.
44	50.	52.	44.	36.	36.	36.	84.	287.	284.	83.	44.	37.
45	33.	46.	34.	37.	32.	38.	77.	427.	492.	131.	52.	41.
46	40.	46.	46.	60.	50.	56.	294.	713.	504.	127.	53.	48.
47	58.	65.	75.	51.	51.	85.	211.	825.	505.	126.	53.	46.
48	67.	50.	46.	65.	48.	45.	126.	624.	691.	128.	56.	43.
49	45.	48.	38.	35.	35.	45.	229.	805.	408.	90.	46.	37.
50	44.	49.	45.	45.	47.	61.	150.	445.	795.	282.	73.	52.
51	79.	87.	72.	56.	73.	69.	311.	667.	513.	168.	66.	47.
52	87.	60.	57.	51.	48.	47.	272.	825.	604.	148.	59.	42.
53	35.	34.	38.	53.	48.	51.	174.	372.	759.	276.	72.	44.
54	41.	47.	43.	39.	44.	60.	248.	703.	507.	192.	69.	47.
55	41.	41.	34.	33.	33.	37.	58.	298.	599.	148.	49.	41.
56	44.	59.	112.	84.	61.	74.	338.	899.	710.	142.	59.	42.
57	47.	48.	44.	39.	48.	54.	140.	804.	716.	136.	52.	42.
58	52.	42.	39.	33.	45.	38.	117.	844.	589.	128.	59.	42.
59	40.	60.	63.	51.	46.	44.	175.	399.	551.	116.	56.	69.
60	88.	61.	43.	40.	43.	68.	182.	398.	498.	96.	55.	37.

FIGURE 2 CONTINUED

DURATION TABLE

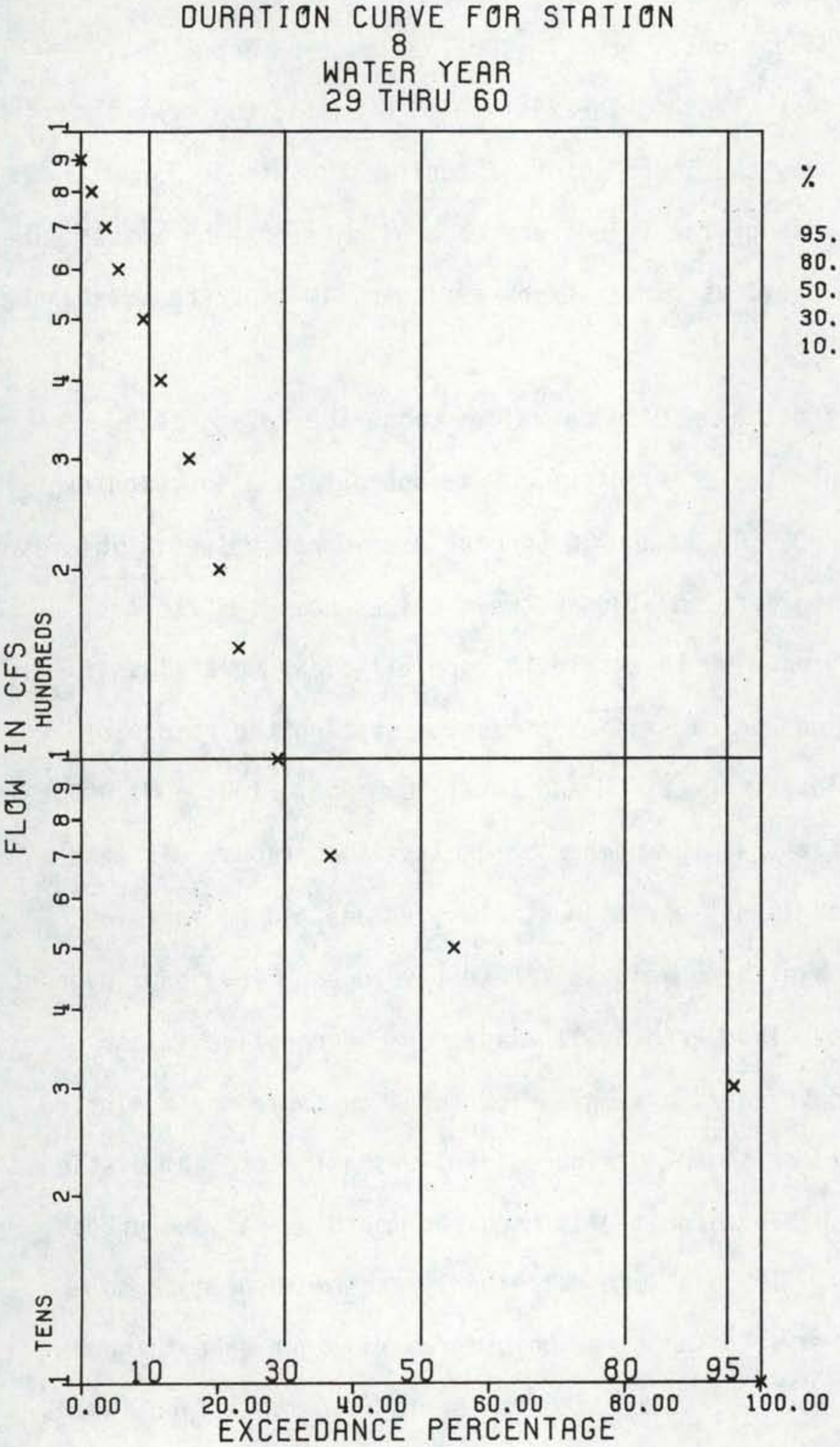
STATION 8
WATER YEAR
29 THRU 60

CLASS	LOWER LIMIT CFS	UPPER LIMIT CFS	INTERVAL COUNT	NUMBER GREATER	PERCENT GREATER
1	0.0	5.00	0	384.	100.
2	5.00	10.00	0	384.	100.
3	10.00	30.00	15	369.	96.
4	30.00	50.00	158	211.	55.
5	50.00	70.00	70	141.	37.
6	70.00	100.00	30	111.	29.
7	100.00	150.00	22	89.	23.
8	150.00	200.00	11	78.	20.
9	200.00	300.00	17	61.	16.
10	300.00	400.00	16	45.	12.
11	400.00	500.00	10	35.	9.
12	500.00	600.00	14	21.	5.
13	600.00	700.00	7	14.	4.
14	700.00	800.00	8	6.	2.
15	800.00	900.00	6	0.	0.
16	900.00	1000.00	0	0.	0.
17	1000.00	1200.00	0	0.	0.
18	1200.00	1500.00	0	0.	0.
19	1500.00	1800.00	0	0.	0.
20	1800.00	2000.00	0	0.	0.
21	2000.00	2500.00	0	0.	0.
22	2500.00	3000.00	0	0.	0.
23	3000.00	3500.00	0	0.	0.
24	3500.00	4000.00	0	0.	0.
25	4000.00	4500.00	0	0.	0.
26	4500.00	5000.00	0	0.	0.
27	5000.00	5500.00	0	0.	0.
28	5500.00	6000.00	0	0.	0.
29	6000.00	6500.00	0	0.	0.
30	6500.00	7000.00	0	0.	0.
31	7000.00	7500.00	0	0.	0.
32	7500.00	8000.00	0	0.	0.
33	8000.00	8500.00	0	0.	0.
34	8500.00	9000.00	0	0.	0.
35	9000.00	9500.00	0	0.	0.
36	9500.00	10000.00	0	0.	0.
37	10000.00	15000.00	0	0.	0.
38	15000.00	20000.00	0	0.	0.
39	20000.00	25000.00	0	0.	0.
40	25000.00	30000.00	0	0.	0.
41	30000.00	35000.00	0	0.	0.
42	35000.00	40000.00	0	0.	0.
43	40000.00	45000.00	0	0.	0.
44	45000.00	50000.00	0	0.	0.
45	50000.00	200000.00	0	0.	0.

STATION 8

EXCEEDANCE	FLOW
95.	30.41
80.	36.63
50.	54.78
30.	95.13
10.	463.47

FIGURE 2 CONTINUED



%	Q
95.	30.41
80.	36.63
50.	54.78
30.	95.13
10.	463.47

number of classes to be used. The maximum value that can be used is 46, with existing dimensions. New class values must be input in ascending order. The first class in the listing is 0-5 cfs, the next class is 5-10. Notice how only the lower limit of the first class is input as the first value. The rest of the values are upper limits of each class. The upper limit to the previous class serves as lower limit of the existing class.

After computing the exceedance values using the categorizing method, an exceedance table is output. Dura subroutine also computes Q values for the 95, 80, 50, 30 and 10 percent exceedance values. This is done using a semi log interpolation between values computed for the classes. This program also checks to be sure all flows were classified. If any flows could not be classified a message stating the number of flows classified (Total counts = N and Total Number of Flows = M). Total Count minus total flows is the number of unclassified flows. If this problem occurs check lowest and highest class values and be sure the input flows are within these values. Presently lowest flow is 0, highest flow is 200,000 cfs. This error will also occur if negative values of flow are input. Input data, a sample flow duration table and a plotted flow duration curve are shown in Figure 2 following the program listing.

This program has been primarily used for monthly analyses of up to 40 years of records. If long term daily analyses are to be made some test runs should be made to be sure the program will not take to much central processing time. If times seem to be to long the options are to go to a longer analyses period possibly monthly flows, use less classes or find a computer program that can perform the required computation in a more efficient manner.

PROGRAM 2
PROGRAM TO COMPUTE FLOW DURATION CURVES FROM A SERIES OF FLOWS USING A HP-41C CALCULATOR

This program will compute flow duration curves using the categorizing technique described in Chapter 4 of the main body of this report. A schematic diagram of the program is contained in Figure 3. The number of classes to be used and upper limit of flow for each class are entered first. Next the flows are entered. After the flows are entered the exceedance % are calculated and output. The minimum flow, maximum flow, mean flow and standard deviation of flow are also calculated and output. The program is written for the HP-41C calculator. With only this program in storage, 6 class intervals can be used without requiring additional calculator memory modules. Figure 4 and 5 contain a complete listing of the program, and data storage allocations respectively. An example problem using the program is shown in Figure 6.

FIGURE 3
FLOW DIAGRAM FOR HP-41C
FLOW DURATION CURVE COMPUTATION PROGRAM

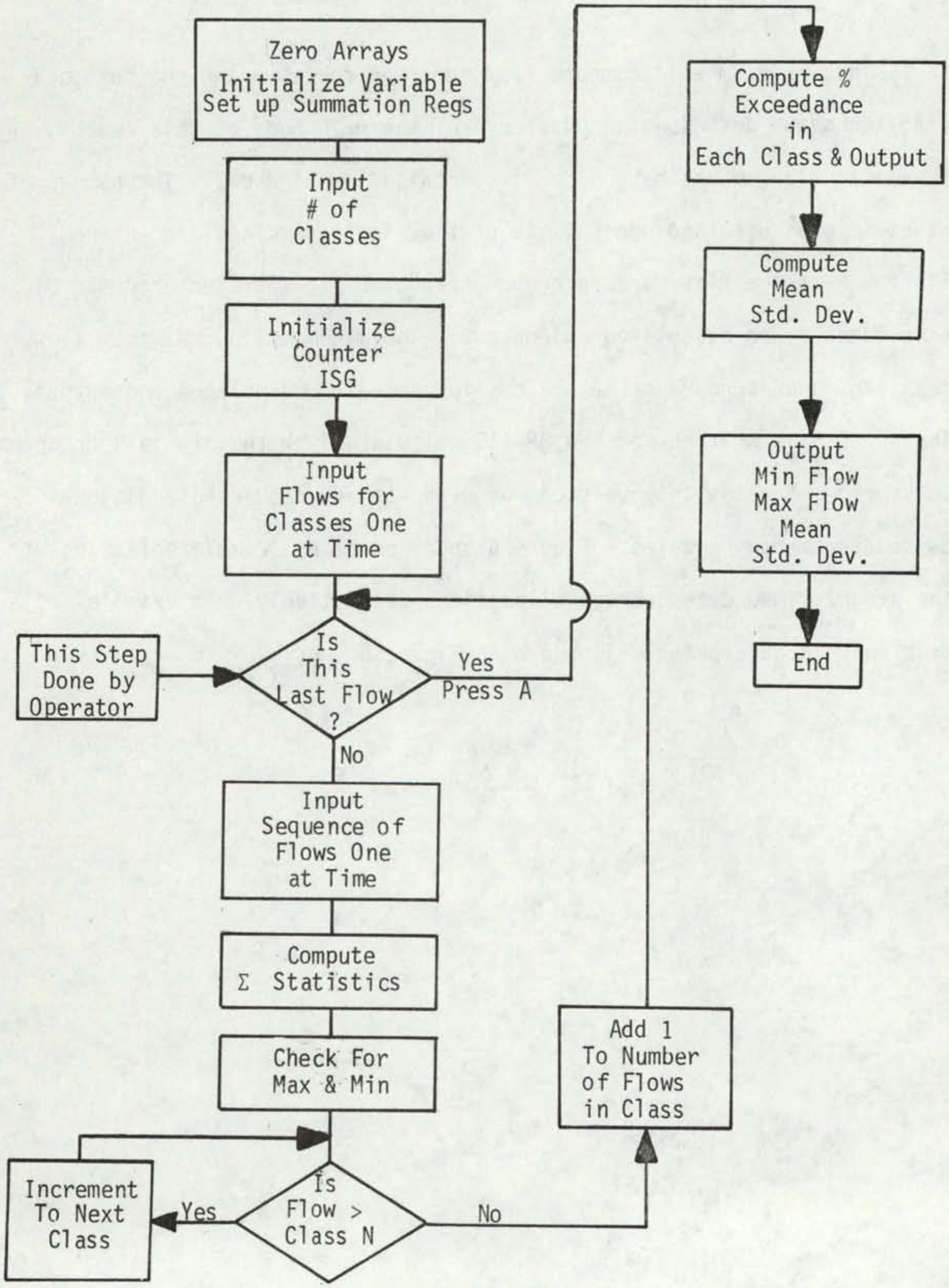


FIGURE 4
HP-41C PROGRAM "DUR" FOR
COMPUTING FLOW DURATION CURVES

STEP	KEY ENTRY	COMMENT	STEP	KEY ENTRY	COMMENT
01	♦LBL "DUR"	INITIALIZATION OF VARIABLES	49	1	
02	CLRG		50	ST+ 04	
03	99999999		51	"FLOW "	INPUT FLOWS
04	STO 03		52	ARCL 04	
05	ΣREG 08		53	PROMPT	
06	"NUM CLASS?"	INPUT NUMBER OF CLASSES	54	STO 01	
07	PROMPT		55	Σ+	COMPUTE STATS.
08	STO 05		56	RCL 01	
09	13		57	RCL 02	COMPUTE MAXIMUM FLOW
10	ENTER↑	COMPUTE INDEX FOR FLOW VALUES IN EACH CLASS	58	X>Y?	
11	ENTER↑		59	GTO 13	
12	RCL 05		60	X<>Y	
13	+		61	STO 02	
14	1000		62	♦LBL 13	
15	/		63	RCL 01	COMPUTE MINIMUM FLOW
16	+		64	RCL 03	
17	STO 06		65	X<=Y?	
18	13		66	GTO 14	
19	RCL 05	COMPUTE INDEX FOR TOTAL NUMBER OF FLOW VALUES IN EACH CLASS	67	X<>Y	
20	+		68	STO 03	
21	ENTER↑		69	♦LBL 14	
22	ENTER↑		70	♦LBL 05	
23	RCL 05		71	ISG 00	
24	+		72	GTO 13	
25	1000		73	1	
26	/		74	ST- 00	
27	+		75	GTO 06	
28	STO 07		76	♦LBL 13	DETERMINE WHICH CLASS FLOW BELONGS AND INCREMENT COUNTER FOR THAT CLASS
29	RCL 06		77	RCL 01	
30	STO 00		78	RCL IND 00	
31	♦LBL 02		79	X>Y?	
32	ISG 00		80	GTO 06	
33	GTO 01		81	GTO 05	
34	GTO 03	INPUT UPPER FLOW VALUE FOR EACH	82	♦LBL 06	
35	♦LBL 01		83	RCL 00	
36	RCL 00		84	RCL 05	
37	INT		85	+	
38	13		86	1	
39	-		87	ST+ IND Y	
40	"CLASS "		88	GTO 03	
41	ARCL X		89	STOP	
42	PROMPT		90	♦LBL A	
43	STO IND 00		91	RCL 07	
44	GTO 02		92	1	
45	♦LBL 03		93	+	SEE NEXT PAGE
46	RCL 06	INPUT FLOWS	94	STO 00	
47	STO 00		95	♦LBL 07	
48	♦LBL 04		96	ISG 00	

FIGURE 4 CONTINUED

STEP	KEY ENTRY	COMMENT	STEP	KEY ENTRY	COMMENT
97	GTO 08	COMPUTE EXCEEDANCE PERCENTS FOR EACH CLASS	145	SDEV	COMPUTE AND OUTPUT STANDARD DEVIATION
98	GTO 09		146	"STD = "	
99♦	LBL 08		147	ARCL X	
100	RCL 00		148	PROMPT	
101	1		149	.END.	
102	-				
103	RCL IND X				
104	RCL IND 00				
105	+				
106	STO IND 00				
107	GTO 07				
108♦	LBL 09				
109	RCL 07				
110	STO 00				
111♦	LBL 10				
112	ISG 00				
113	GTO 11				
114	GTO 12				
115♦	LBL 11				
116	RCL IND 00				
117	RCL 13				
118	X<>Y				
119	-				
120	RCL 13				
121	/				
122	RCL 00	OUTPUT EXCEEDANCE PERCENTS FOR EACH CLASS			
123	RCL 05				
124	-				
125	RCL IND X				
126	CLA				
127	ARCL X				
128	"⊢ "				
129	ARCL Z				
130	AVIEW				
131	STOP				
132	CLA				
133	GTO 10				
134♦	LBL 12	OUTPUT MINIMUM AND MAXIMUM FLOWS			
135	"MIN "				
136	ARCL 03				
137	PROMPT				
138	"MAX "				
139	ARCL 02				
140	PROMPT				
141	MEAN	COMPUTE AND OUTPUT MEAN			
142	"MEAN "				
143	ARCL X				
144	PROMPT				

FIGURE 5
STORAGE ALLOCATION
HP-41C PROGRAM
DUR

DATA REGISTERS

NUMBER	CONTENTS
00	Counter
01	Flow
02	Maximum Flow
03	Minimum Flow
04	Total number of flows
05	Total number of classes
06	Starting Index for flow values for each class
07	Starting Index for number of flows in each class
08 thru 13	Statistical variables used by Σ+ key
14 thru end*	Flow values for each class and number of in each class

* Storage = 14 + (2 x number of classes)

FIGURE 6
EXAMPLE PROBLEM
HP-41C PROGRAM DUR

SAMPLE PROBLEM

Determine a duration curve for the following flow values
50, 75, 100, 150, 225, 275

Class intervals are to be:
0 - 100
100 - 200
200 - 300

RESULTS:

Class	Lower Flow Cfs	Upper Flow Cfs	Exceedance %
1	0	100	67
2	100	200	33
3	200	300	0

Minimum flow = 50.0 cfs
Maximum flow = 275.0 cfs
Mean flow = 145.8 cfs
Standard deviation of flow = 88.6 cfs

SOLUTION

INPUT	FUNCTION	DISPLAY	COMMENTS
	INPUT PROGRAM		Use card reader or input through the keyboard
	XEQ Size n		Set Storage size: N = 14+
	FIX 02		2 x # of classes = 14+3x2=20
	XEQ DUR	NUM CLASS ?	Enter number of classes to be used
3	R/S	CLASS 1.00	Enter upper flow for class 1
100	R/S	CLASS 2.00	Enter upper flow for class 2
200	R/S	CLASS 3.00	Enter upper flow for class 3
300	R/S	FLOW 1.00	Enter flow 1
50	R/S	FLOW 2.00	Enter flow 2
	Continue this sequence until all flow values are entered		
Last Flow	R/S	FLOW (N+1)	Press LOCAL LABEL A
	USER (A)	100.00 .67	Flow=100 Exceedance = .67 Push R/S to continue
	R/S	200.00 .33	Flow=200 Exceedance = .33 Push R/S to continue
	R/S	300.00 .00	Flow=300 Exceedance .00 Push R/S to continue
	R/S	Min = 50.00	Minimum flow = 50.0 Push R/S to continue
	R/S	Max =275.00	Maximum flow =275.00 Push R/S to continue
	R/S	Mean =145.83	Mean flow = 145.83 Push R/S to continue

FIGURE 6 CONTINUED

SOLUTION (CONTINUED)

INPUT	FUNCTION	DISPLAY	COMMENTS
	R/S	Std = 88.62	Standard deviation of flows = 88.62 Push R/S to continue
	END OF PROGRAM		

PROGRAM 3
PROGRAM FOR COMPUTING POWER AND AVERAGE ANNUAL ENERGY VALUES FROM A FLOW DURATION CURVE ASSUMING CONSTANT HEAD AND EFFICIENCY
(WRITTEN IN BASIC)

The following program, "DURA1", is designed to compute power output and average annual energy production given flow duration curve flows and percent exceedance values and values for head and efficiency. A complete description of the technique used is contained in Chapter 8 of the main body of this report. This program is written in interactive format, therefore all input data is supplied by the operator during running of the program. By changing the input statements, to appropriate read statements the program could be modified to be used in a batch processing mode. Figure 7 contains a complete listing of program DURA1. Figure 8 shows a sample session using the program.

FIGURE 7
PROGRAM LISTING FOR PROGRAM DURA1

```
100 DIM P(7),Q(7)
110 FOR I=1 TO 7
120 PRINT ' INPUT PERCENT AND FLOW:';I
130 INPUT P(I),Q(I)
140 PRINT
150 NEXT I
160 PRINT 'INPUT DATA'
170 PRINT 'PERCENT       FLOW'
180 FOR I=1 TO 7
190 PRINT USING 200, P(I),Q(I)
200 :  ###    #######.#
210 NEXT I
220 PRINT 'IS DATA OK, 0=YES, 1=NO'
230 INPUT J
240 IF J=1 THEN 110
250 PRINT ' INPUT HEAD IN FEET, AND EFFICIENCY'
260 INPUT H,E
262 PRINT
264 PRINT
265 PRINT
270 PRINT '   POWER OUTPUT FOR HEAD =';H;'FT. AND EFFICIENCY =';E
280 PRINT
290 PRINT 'EXCEEDANCE    DISCHARGE      POWER      ENERGY      LOAD'
300 PRINT 'PERCENTAGE       CFS          KW          MWH      FACTOR'
310 FOR I=1 TO 7
320 A=0
330 FOR K= I TO 7
340 IF I=1 THEN 370
350 IF K>I THEN 370
360 A=P(K)*Q(K)
370 IF K=7 THEN 390
380 A=A+(P(K+1)-P(K))*((Q(K+1)+Q(K))/2)
390 NEXT K
400 R=Q(I)*H/11.82*E
410 S=A*H/11820*E*365*24*.01
420 L=S*1000/(R*365*24)
430 PRINT USING 440,P(I),Q(I),R,S,L
440 :   ###         #######.#  #######.##  ####.##      #.##
450 NEXT I
452 PRINT
454 PRINT
455 PRINT
460 PRINT 'INPUT'
470 PRINT '1. TO RERUN THE ENTIRE PROGRAM'
480 PRINT '2. TO RERUN DURATION CURVE WITH DIFFERENT HEAD OR EFFICIENCY'
490 PRINT '3. TO END PROGRAM'
500 INPUT O
510 IF O=1 THEN 110
520 IF O=2 THEN 250
530 IF O=3 THEN 540
540 END
```

FIGURE 8
EXAMPLE PROBLEM USING
COMPUTER PROGRAM
DURA1

It is desired to determine the plant capacity for various exceedance percent flows and to compute the average annual generation for these various sized plants for a site where the duration curve of outflow will be as shown in the table below. The head and efficiency values are assumed to be constant at 75 ft. and 0.8 respectively.

Exceedance%	Flow
0	100
10	80
30	70
50	60
80	50
95	40
100	30

The computer solution to the above problem is shown on the next page.

FIGURE 8 CONTINUED

```
 INPUT PERCENT AND FLOW: 1
?
0,100

 INPUT PERCENT AND FLOW: 2
?
10,80

 INPUT PERCENT AND FLOW: 3
?
30,70

 INPUT PERCENT AND FLOW: 4
?
50,60

 INPUT PERCENT AND FLOW: 5
?
80,50

 INPUT PERCENT AND FLOW: 6
?
95,40

 INPUT PERCENT AND FLOW: 7
?
100,30

INPUT DATA
PERCENT       FLOW
    0         100.0
   10          80.0
   30          70.0
   50          60.0
   80          50.0
   95          40.0
  100          30.0
IS DATA OK, 0-YES, 1=NO
?
0
 INPUT HEAD IN FEET, AND EFFICIENCY
?
75,.8


  POWER OUTPUT FOR HEAD = 75   FT. AND EFFICIENCY = .8

EXCEEDANCE   DISCHARGE     POWER     ENERGY     LOAD
PERCENTAGE      CFS         KW        MWH      FACTOR
     0          100.0      507.61   2756.95     .62
    10           80.0      406.09   2712.49     .76
    30           70.0      355.33   2623.55     .84
    50           60.0      304.57   2445.68     .92
    80           50.0      253.81   2156.65     .97
    95           40.0      203.05   1767.56     .99
   100           30.0      152.28   1334.01    1.00


INPUT
1. TO RERUN THE ENTIRE PROGRAM
2. TO RERUN DURATION CURVE WITH DIFFERENT HEAD OR EFFICIENCY
3. TO END PROGRAM
?
3
```

PROGRAM 4
PROGRAMS FOR COMPUTING POWER AND ENERGY FROM FLOW DURATION CURVES ASSUMING CONSTANT HEAD AND EFFICIENCY USING AN HP-41C CALCULATOR

The following program is desiqned to compute power output and average annual energy production given flow duration curve flow and percent exceedance values and values for head and efficiency. A complete description of the technique used is contained in Chapter 8 of the main body of this report. Two versions of the program have been written. One is to be used with a printer (Program "Powen") the other version will work without the printer accessory (Program "Powen1"). Figure 9 contains a listing of the non printer version of the program and Figure 10 contains a listing of the printer version. Figure 11 contains a listing of the storage allocation requirement and identifies what data is stored in which location. The storage allocations are the same for both the printer and non printer versions of the program.

Figure 12 contains an example problem and the required steps to solve the problem using the non printer program. Figure 13 contains an example problem for the printer version of the program. The only difference between the printer and non printer version is that the Flow, Power, and Energy vs. Exceedance Percent Table are output to the printer in the printer version. Using the printer gives a permanent record of the input data and the results of the computations.

FIGURE 9
HP-41C PROGRAM LISTING
PROGRAM POWEN1
(NONPRINTER VERSION)

STEP	KEY ENTRY	COMMENT	STEP	KEY ENTRY	COMMENT
01	♦LBL "POWEN1"		49	FIX 0	
02	2.00901		50	ARCL IND 00	OUTPUT SUBROUTINE CONTINUED
03	STO 00		51	"├ % "	
04	♦LBL 01		52	FIX 3	
05	ISG 00		53	RCL 00	
06	GTO 02		54	7	
07	GTO 04		55	+	
08	♦LBL 02		56	ARCL IND X	
09	RCL 00		57	PROMPT	
10	2		58	GTO 05	
11	-		59	♦LBL 07	
12	INT	INPUT EXCEEDANCE PERCENTS AND FLOWS	60	RTN	
13	" %, Q "		61	♦LBL 12	
14	FIX 0		62	2.0090	
15	ARCL X		63	STO 00	
16	FIX 1		64	♦LBL 09	
17	"├ ?"		65	ISG 00	
18	PROMPT		66	GTO 10	
19	X<>Y		67	GTO 11	
20	STO IND 00		68	♦LBL 10	
21	X<>Y		69	RCL 00	
22	RCL 00		70	7	
23	7		71	+	COMPUTE POWER VALUES
24	+		72	RCL IND X	
25	X<>Y		73	RCL 02	
26	STO IND Y		74	*	
27	GTO 01		75	RCL 01	
28	♦LBL 04		76	*	
29	"HD, EFF?"		77	11.82	
30	PROMPT	INPUT HEAD AND EFFICIENCY	78	/	
31	STO 01		79	RCL 00	
32	X<>Y		80	7	
33	STO 02		81	+	
34	"Q VALUES"		82	X<>Y	
35	PROMPT	CALL OUTPUT SUBROUTINE TO DISPLAY FLOWS	83	STO IND Y	
36	XEQ 08		84	GTO 09	
37	"Q VALS OK ?"		85	♦LBL 11	CALL OUTPUT SUBROUTINE TO DISPLAY POWER VALUES
38	PROMPT		86	"POWER KW"	
39	GTO 12	OUTPUT SUBROUTINE DISPLAYS EXCEEDANCE PERCENTS AND EITHER, FLOW, POWER OR ENERGY	87	PROMPT	
40	♦LBL 08		88	XEQ 08	
41	2.00901		89	0	
42	STO 00		90	STO 18	
43	♦LBL 05		91	RCL 16	COMPUTE ENERGY VALUES
44	ISG 00		92	RCL 09	
45	GTO 06		93	*	
46	GTO 07		94	.0876	
47	♦LBL 06		95	*	
48	" "		96	STO 17	

FIGURE 9 CONTINUED

STEP	KEY ENTRY	COMMENT	STEP	KEY ENTRY	COMMENT
97	16.00901		145	♦LBL 15	
98	STO 00		146	RCL 17	
99	♦LBL 13		147	STO 10	
100	DSE 00		148	"ENERGY MWH"	CALL OUTPUT
101	GTO 14		149	PROMPT	SUBROUTINE TO
102	GTO 15		150	XEQ 08	DISPLAY ENERGY
103	♦LBL 14		151	"END POWEN1"	VALUES
104	RCL 00		152	AVIEW	
105	1				
106	+				
107	RCL IND X				
108	RCL IND 00				
109	+				
110	2				
111	/				
112	STO 19				
113	RCL 00				
114	6				
115	-				
116	RCL IND X				
117	RCL 00				
118	7				
119	-	ENERGY			
120	X<>Y	COMPUTATION			
121	RCL IND Y	SUBROUTINE			
122	-				
123	RCL 19				
124	*				
125	ST+ 18				
126	RCL 00				
127	7				
128	-				
129	RCL IND X				
130	RCL IND 00				
131	*				
132	RCL 18				
133	+				
134	.0876				
135	*				
136	RCL 00				
137	1				
138	+				
139	RCL 17				
140	STO IND Y				
141	RDN				
142	RDN				
143	STO 17				
144	GTO 13				

FIGURE 10

HP -41C PROGRAM LISTING
PROGRAM POWEN
(PRINTER VERSION)

STEP	KEY ENTRY	COMMENT
01	♦LBL "POWEN"	INPUT EXCEEDANCE PERCENTS AND FLOWS
02	2.00901	
03	STO 00	
04	♦LBL 01	
05	ISG 00	
06	GTO 02	
07	GTO 04	
08	♦LBL 02	
09	RCL 00	
10	2	
11	-	
12	INT	
13	" %, Q "	
14	FIX 0	
15	ARCL X	
16	FIX 1	
17	"⊦ ?"	
18	PROMPT	
19	X<>Y	
20	STO IND 00	
21	X<>Y	
22	RCL 00	
23	7	
24	+	
25	X<>Y	
26	STO IND Y	
27	GTO 01	
28	♦LBL 04	INPUT HEAD AND EFFICIENCY
29	"HD, EFF?"	
30	PROMPT	
31	STO 01	
32	X<>Y	
33	STO 02	
34	"HD, EFF"	PRINT HEAD AND EFFICIENCY
35	PRA	
36	CLA	
37	ARCL 02	
38	"⊦ , "	
39	ARCL 01	
40	PRA	
41	CLA	
42	PRA	
43	"Q VALUES"	CALL OUTPUT SUBROUTINE TO PRINT FLOW VALUES
44	PRA	
45	XEQ 08	
46	"Q VALS OK ?"	
47	PROMPT	
48	GTO 12	

STEP	KEY ENTRY	COMMENT
49	♦LBL 08	OUTPUT SUBROUTINE PRINTS EXCEEDANCE PERCENTS AND EITHER FLOW, POWER OR ENERGY
50	2.00901	
51	STO 00	
52	♦LBL 05	
53	ISG 00	
54	GTO 06	
55	GTO 07	
56	♦LBL 06	
57	" "	
58	FIX 0	
59	ARCL IND 00	
60	"⊦ % "	
61	FIX 3	
62	RCL 00	
63	7	
64	+	
65	ARCL IND X	
66	PRA	
67	GTO 05	
68	♦LBL 07	
69	CLA	
70	PRA	
71	RTN	
72	♦LBL 12	COMPUTE POWER VALUES
73	2.0090	
74	STO 00	
75	♦LBL 09	
76	ISG 00	
77	GTO 10	
78	GTO 11	
79	♦LBL 10	
80	RCL 00	
81	7	
82	+	
83	RCL IND X	
84	RCL 02	
85	*	
86	RCL 01	
87	*	
88	11.82	
89	/	
90	RCL 00	
91	7	
92	+	
93	X<>Y	
94	STO IND Y	
95	GTO 09	
96	♦LBL 11	

FIGURE 10 CONTINUED

STEP	KEY ENTRY	COMMENT	STEP	KEY ENTRY	COMMENT
97	"POWER KW"	CALL SUBROUTINE	145	.0876	
98	PRA	TO PRINT POWER	146	*	
99	XEQ 08	VALUES	147	RCL 00	
100	0		148	1	
101	STO 18		149	+	
102	RCL 16		150	RCL 17	ENERGY
103	RCL 09		151	STO IND Y	COMPUTATIONS
104	*		152	RDN	CONTINUED
105	.0876		153	RDN	
106	*		154	STO 17	
107	STO 17		155	GTO 13	
108	16.00901		156	♦LBL 15	
109	STO 00		157	RCL 17	
110	♦LBL 13		158	STO 10	
111	DSE 00		159	"ENERGY MWH"	CALL SUBROUTINE
112	GTO 14		160	PRA	TO PRINT ENERGY
113	GTO 15		161	XEQ 08	VALUES
114	♦LBL 14		162	"END POWEN"	
115	RCL 00		163	AVIEW	
116	1		164	.END.	
117	+				
118	RCL IND X				
119	RCL IND 00				
120	+	COMPUTE			
121	2	ENERGY			
122	/	VALUES			
123	STO 19				
124	RCL 00				
125	6				
126	-				
127	RCL IND X				
128	RCL 00				
129	7				
130	-				
131	X<>Y				
132	RCL IND Y				
133	-				
134	RCL 19				
135	*				
136	ST+ 18				
137	RCL 00				
138	7				
139	-				
140	RCL IND X				
141	RCL IND 00				
142	*				
143	RCL 18				
144	+				

FIGURE 11
STORAGE ALLOCATION
HP 41-C PROGRAMS
POWEN, POWEN1

DATA REGISTERS

NUMBER	CONTENTS
00	Counter
01	Efficiency
02	Head
03–09	Exceedance Percent Array
10–16	Flow, Power, and Energy Array
17–19	Temporary Computation Registers

FIGURE 12
EXAMPLE PROBLEM
HP-41C PROGRAM POWEN1 (NONPRINTER VERSION)

SAMPLE PROBLEM

Determine power plant size and average annual energy for power plants sized at the exceedance flow values shown below.
Assume head = 75 ft. Efficiency = 0.80

INPUT DATA			RESULT			
#	%	Flow (cfs)	%	Flow cfs	Power KW	Energy MWH
1	0	100	0	100	507.614	2756.954
2	10	80	10	80	406.091	2712.487
3	30	70	30	70	355.330	2623.553
4	50	60	50	50	304.569	2445.685
5	80	50	80	50	253.807	2156.650
6	95	40	95	40	203.046	1767.563
7	100	30	100	30	152.284	1334.010

SOLUTION

INPUT	FUNCTION	DISPLAY	COMMENTS
	INPUT PROGRAM		Use card reader or input through keyboard
	XEQ SIZE 020		Set storage size
	XEQ POWEN 1	%, Q 1. ?	Enter % 1 *
0	ENTER	0.0	Enter flow (cfs) for % 1
100	R/S	%, Q 2. ?	Enter % 2
10	ENTER	10.0	Enter flow (cfs) for % 2
80	R/S	%, Q 3. ?	Enter % 3
	Continue this sequence until all seven % and flow values have been entered		
		HD, EFF ?	Enter head
75	ENTER	75.0	Enter efficiency
.80	R/S	Q VALUES	Push R/S to continue
	R/S	0% 100.000	Plant discharge at % 1 Push R/S to continue
	R/S	10% 80.000	Plant discharge at % 2 Push R/S to continue
	Continue until all Q values are displayed		
		Q VALUES OK?	If Qs are ok push R/S If not rerun program
	R/S	POWER KW	Push R/S to continue
	R/S	0% 507.614	Power (KW) at % 1 Push R/S to continue
	R/S	10% 406.091	Power (KW) at % 2 Push R/S to continue
	Continue until all power values are displayed		

* Exceedance percents are entered from lowest to highest percent value

FIGURE 12 CONTINUED

SOLUTION (CONTINUED)

INPUT	FUNCTION	DISPLAY	COMMENTS
	R/S	ENERGY MWH	Push R/S to continue
	R/S	0% 2756.954	Energy (MWh) at % 1 Push R/S to continue
	R/S	10% 2712.487	Energy (MWh) at % 2 Push R/S to continue
	Continue until all energy values are displayed		
	R/S	END POWEN1	End of Program

FIGURE 13
EXAMPLE PROBLEM
HP-41C PROGRAM POWEN
(PRINTER VERSION)

SAMPLE PROBLEM

Determine power plant size and average annual energy for power plants sized at the exceedance flow values shown below.
Assume head = 75 ft. Efficiency = 0.80

INPUT DATA			RESULT			
#	%	Flow (cfs)	%	Flow cfs	Power KW	Energy MWH
1	0	100	0	100	507.614	2756.954
2	10	80	10	80	406.091	2712.487
3	30	70	30	70	355.330	2623.553
4	50	60	50	50	304.569	2445.685
5	80	50	80	50	253.807	2156.650
6	95	40	95	40	203.046	1767.563
7	100	30	100	30	152.284	1334.010

SOLUTION

INPUT	FUNCTION	DISPLAY	COMMENTS
	INPUT PROGRAM		Use card reader or input through keyboard
	XEQ SIZE 020		Set storage size
	XEQ POWEN	%, Q 1. ?	Enter % 1 *
0	ENTER	0.0	Enter flow (cfs) for % 1
100	R/S	%, Q 2. ?	Enter % 2
10	ENTER	10.0	Enter flow (cfs) for % 2
80	R/S	%, Q 3. ?	Enter % 3
	Continue this sequence until all seven % and flow values have been entered		
		HD, EFF ?	Enter head
75	ENTER	75.0	Enter efficiency
.80	R/S		

HEAD EFFICIENCY AND Q VALUES WILL NOW BE PRINTED

```
[illegible]

Q VALUES
 0. % 100.000
 10. % 80.000
 30. % 70.000
 50. % 60.000
 80. % 50.000
 95. % 40.000
 100. % 30.000
```

* Exceedance % are entered from lowest to highest value

FIGURE 13 CONTINUED

SOLUTION (CONTINUED)

INPUT	FUNCTION	DISPLAY	COMMENTS
		Q VALUES OK?	If not rerun program Push R/S to continue
	R/S		

POWER AND ENERGY VALUES WILL NOW BE PRINTED

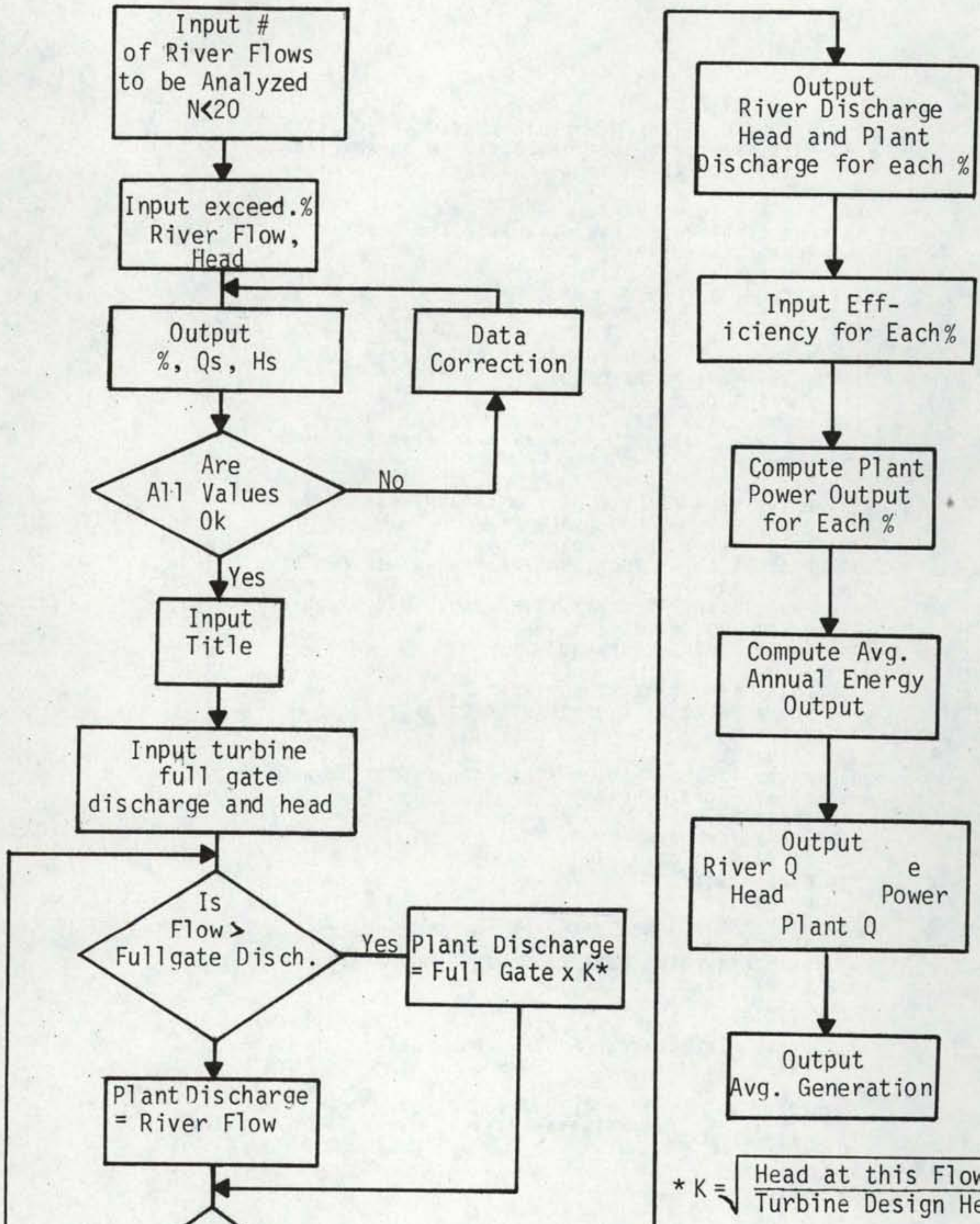
```
POWER  KW
 0. % 507.614
 10. % 406.091
 30. % 355.330
 50. % 304.569
 80. % 253.807
 95. % 203.046
 100. % 152.284

ENERGY MWH
 0. % 2,756.954
 10. % 2,712.487
 30. % 2,623.553
 50. % 2,445.685
 80. % 2,156.650
 95. % 1,767.563
 100. % 1,334.010

END POWEN
```

PROGRAM 5
PROGRAM FOR COMPUTING POWER AND ENERGY FROM FLOW DURATION CURVE VALUES ASSUMING CHANGING HEAD AND EFFICIENCY (WRITTEN IN BASIC)

Computer program TURB is an interactive program designed to compute both plant power output and average annual energy production given exceedance percents and corresponding river flows heads, and efficiencies for a particular power plant configuration. This program gives much more realistic results than both programs DURA1 and POWEN since varying efficiencies and heads can be input and the turbines ability to handle flows greater than the full gate discharge are adequately accounted for. A flow diagram for the program is contained in Figure 14. Although the author developed the computer program, the basic procedure for this technique was developed by Mr. Jim Carson, of International Engineering Company and has been presented in several small hydro short courses sponsored by the University of Idaho, Department of Continuing Education.

A complete listing of the program and sample program session are contained in Figures 15 and 16 respectively.

FIGURE 14
SCHEMATIC DIAGRAM OF PROGRAM
TURB



$$* K = \sqrt{\frac{\text{Head at this Flow}}{\text{Turbine Design Head}}}$$

FIGURE 15
PROGRAM LISTING
FOR COMPUTER PROGRAM
TURB

```
100 DIM P(20),R(20),H(20),D(20),E(20),W(20),M(20)
110 PRINT 'INPUT NUMBER OF POINTS TO BE ANALYZED'
120 PRINT 'NUMBER MUST BE LESS THAN 20'
130 INPUT N
140 FOR I=1 TO N
150 PRINT'INPUT PERCENT,RIVERFLOW,AND HEAD'
160 PRINT'FOR POINT';I
170 INPUT P(I),R(I),H(I)
171 NEXT I
172 PRINT
173 PRINT
174 PRINT '        EXCEEDANCE    DISCHARGE  HEAD'
175 PRINT 'POINT  PERCENT            CFS       FT'
176 FOR I=1 TO N
177 PRINT USING 178,I,P(I),R(I),H(I)
178 :  ##      ###          ########## ####.#
179 NEXT I
180 PRINT
181 PRINT 'ARE ALL %,Q, AND H VALUES CORRECT'
182 INPUT B$
183 IF B$='YES' THEN 190
184 PRINT ' INPUT POINT NUMBER OF DATA IN ERROR'
185 INPUT M3
186 PRINT 'INPUT PERCENT,RIVER FLOW, AND HEAD '
187 PRINT 'FOR POINT';M3
188 INPUT P(M3),R(M3),H(M3)
189 GOTO 172
190 PRINT 'INPUT TITLE FOR RUN'
200 PRINT 'MUST BE LESS THAN 18 CHARACTERS'
205 PRINT '                  $'
210 INPUT A$
220 PRINT 'INPUT TURBINE FULL GATE DISCHARGE AND'
230 PRINT 'NORMAL HEAD'
240 INPUT D1,H1
250 FOR I=1 TO N
260 IF R(I)>D1 GOTO 290
270 D(I) = R(I)
280 GOTO 300
290 D(I) = D1 *(SQR(H(I)/H1))
300 NEXT I
310 PRINT 'TURBINE FULL GATE DISCHARGE =';D1;'CFS'
320 PRINT 'HEAD =';H1;'FT'
330 PRINT
340 PRINT'               RIVER                PLANT'
350 PRINT 'EXCEEDANCE    DISCHARGE  HEAD     DISCHARGE'
360 PRINT 'PERCENT          CFS      FT         CFS'
370 FOR I=1 TO N
380 PRINT USING 390,P(I),R(I),H(I),D(I)
390 : ###        ########### ####.# ##########   ########
400 NEXT I
410 PRINT
420 PRINT
430 FOR I=1 TO N
440 PRINT 'INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW =';D(I);'CFS'
450 INPUT E(I)
```

FIGURE 15 CONTINUED

```
460 W(I) = D(I) * H(I)*E(I)/11.820
470 NEXT I
480 M1 = 0
490 FOR I=2 TO N
500 K=I-1
510 M(I) = (P(I)-P(K))/100*(W(I)+W(K))/2*8.76
520 M1=M1+M(I)
540 NEXT I
550 PRINT
560 PRINT
570 PRINT
580 PRINT'              ';A$
590 PRINT
600 PRINT 'FULL GATE TURBINE DISCHARGE =';D1;'CFS    NORMAL HEAD =';H1;'FT'
610 PRINT
620 PRINT '              RIVER                PLANT                   PLANT'
630 PRINT 'EXCEEDANCE   DISCHARGE  HEAD    DISCHARGE                  POWER'
640 PRINT ' PERCENT        CFS      FT        CFS     EFFICIENCY       KW'
650 FOR I=1 TO N
660 PRINT USING 665,P(I),R(I),H(I),D(I),E(I),W(I)
665 :    ###      #######.#  ####.#  #######.#      #.###     ########
670 NEXT I
680 PRINT
690 PRINT 'TOTAL ENERGY =';M1;'MWH'
700 PRINT 'INPUT'
710 PRINT ' 1. TO RERUN ENTIRE PROGRAM'
720 PRINT ' 2. TO RERUN CHANGING ONLY TURBINE SIZE AND HEAD'
730 PRINT ' 3. TO END PROGRAM'
740 INPUT O
750 IF O=1 THEN 110
760 IF O=2 THEN 190
770 END
```

FIGURE 16
EXAMPLE PROBLEM
USING COMPUTER PROGRAM TURB

It is desired to determine the power outut and average annual energy production for a power site known as Grimes site. The flow duration and available head values for each particular flow for the site are shown below. The trial turbine that is to be evaluated has a full gate capacity of 2700 cfs and normal operating head of 82.3ft. operating efficiencies for the required head and flows have been determined from turbine performance curves and are also shown below:

AVAILABLE FLOWS AND HEAD			TURBINE PERFORMANCE DATA		
EXCEEDANCE PERCENT	RIVER DISCHARGE	HEAD FT	HEAD FT	PLANT DISCHARGE	EFFICIENCY
0	8000.0	80.0	80.0	2662.0	.880
5	4200.0	80.9	80.9	2676.9	.890
10	3400.0	81.6	81.6	2688.5	.900
15	2700.0	82.3	82.3	2700.0	.900
20	2150.0	83.0	83.0	2150.0	.900
25	1800.0	83.5	83.5	1800.0	.890
30	1550.0	83.5	83.5	1550.0	.880
40	1150.0	83.5	83.5	1150.0	.870
50	850.0	83.5	83.5	850.0	.870
60	650.0	83.5	84.6	650.0	.830
70	500.0	83.5	83.5	500.0	.750
80	420.0	83.5	83.5	420.0	.700
90	400.0	83.5	83.5	400.0	.600
100	100.0	83.5	83.5	100.0	.500

The complete computer solution is contained on the following three pages.

```
INPUT NUMBER OF POINTS TO BE ANALYZED
NUMBER MUST BE LESS THAN 20
?
14
INPUT PERCENT,RIVERFLOW,AND HEAD
FOR POINT 1
?
0,8000,80
INPUT PERCENT,RIVERFLOW,AND HEAD
FOR POINT 2
?
5,4200,80.9
INPUT PERCENT,RIVERFLOW,AND HEAD
FOR POINT 3
?
10,3400,81.6
INPUT PERCENT,RIVERFLOW,AND HEAD
FOR POINT 4
?
15,2700,82.3
INPUT PERCENT,RIVERFLOW,AND HEAD
FOR POINT 5
?
20,2150,83
INPUT PERCENT,RIVERFLOW,AND HEAD
FOR POINT 6
?
25,1800,83.5
INPUT PERCENT,RIVERFLOW,AND HEAD
FOR POINT 7
?
30,1550,83.5
INPUT PERCENT,RIVERFLOW,AND HEAD
FOR POINT 8
?
40,1150,83.5
INPUT PERCENT,RIVERFLOW,AND HEAD
FOR POINT 9
?
50,850,83.5
INPUT PERCENT,RIVERFLOW,AND HEAD
FOR POINT 10
?
60,650,83.5
INPUT PERCENT,RIVERFLOW,AND HEAD
FOR POINT 11
?
70,500,83.5
INPUT PERCENT,RIVERFLOW,AND HEAD
FOR POINT 12
?
80,420,83.5
INPUT PERCENT,RIVERFLOW,AND HEAD
FOR POINT 13
?
90,400,83.5
INPUT PERCENT,RIVERFLOW,AND HEAD
FOR POINT 14
```

```
?
100,100,93.5

      EXCEEDANCE     DISCHARGE  HEAD
POINT  PERCENT          CFS      FT
   1       0           8000    80.0
   2       5           4200    80.9
   3      10           3400    81.6
   4      15           2700    82.3
   5      20           2150    83.0
   6      25           1800    83.5
   7      30           1550    83.5
   8      40           1150    83.5
   9      50            850    83.5
  10      60            650    83.5
  11      70            500    83.5
  12      80            420    83.5
  13      90            400    83.5
  14     100            100    93.5

ARE ALL %,Q, AND H VALUES CORRECT
?
no
 INPUT POINT NUMBER OF DATA IN ERROR
?
14
INPUT PERCENT,RIVER FLOW, AND HEAD
FOR POINT 14
?
100,100,83.5

      EXCEEDANCE     DISCHARGE  HEAD
POINT  PERCENT          CFS      FT
   1       0           8000    80.0
   2       5           4200    80.9
   3      10           3400    81.6
   4      15           2700    82.3
   5      20           2150    83.0
   6      25           1800    83.5
   7      30           1550    83.5
   8      40           1150    83.5
   9      50            850    83.5
  10      60            650    83.5
  11      70            500    83.5
  12      80            420    83.5
  13      90            400    83.5
  14     100            100    83.5

ARE ALL %,Q, AND H VALUES CORRECT
?
yes
INPUT TITLE FOR RUN
MUST BE LESS THAN 18 CHARACTERS
                  $
?
grimes site run 1
INPUT TURBINE FULL GATE DISCHARGE AND
NORMAL HEAD
```

FIGURE 16 CONTINUED

```
?
2700,82.3
TURBINE FULL GATE DISCHARGE = 2700     CFS
HEAD = 82.3     FT

                 RIVER              PLANT
EXCEEDANCE     DISCHARGE   HEAD   DISCHARGE
PERCENT           CFS       FT       CFS
    0            8000      80.0      2662
    5            4200      80.9      2677
   10            3400      81.6      2688
   15            2700      82.3      2700
   20            2150      83.0      2150
   25            1800      83.5      1800
   30            1550      83.5      1550
   40            1150      83.5      1150
   50             850      83.5       850
   60             650      83.5       650
   70             500      83.5       500
   80             420      83.5       420
   90             400      83.5       400
  100             100      83.5       100

INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW = 2662.004    CFS
?
.88
INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW = 2676.936    CFS
?
.89
INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW = 2688.493    CFS
?
.90
INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW = 2700    CFS
?
.90
INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW = 2150    CFS
?
.90
INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW = 1800    CFS
?
.89
INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW = 1550    CFS
?
.88
INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW = 1150    CFS
?
.87
INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW = 850  CFS
?
.87
INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW = 650  CFS
?
.83
INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW = 500  CFS
?
.75
INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW = 420  CFS
?
.70
```

FIGURE 16 CONTINUED

```
INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW = 400  CFS
?
.60
INPUT EFFICIENCY (DECIMAL FRACTION) FOR FLOW = 100  CFS
?
.50
```

GRIMES SITE RUN 1

FULL GATE TURBINE DISCHARGE = 2700 CFS NORMAL HEAD = 82.3 FT

EXCEEDANCE PERCENT	RIVER DISCHARGE CFS	HEAD FT	PLANT DISCHARGE CFS	EFFICIENCY	PLANT POWER KW
0	8000.0	80.0	2662.0	.880	15855
5	4200.0	80.9	2676.9	.890	16306
10	3400.0	81.6	2688.5	.900	16704
15	2700.0	82.3	2700.0	.900	16920
20	2150.0	83.0	2150.0	.900	13588
25	1800.0	83.5	1800.0	.890	11317
30	1550.0	83.5	1550.0	.880	9636
40	1150.0	83.5	1150.0	.870	7068
50	850.0	83.5	850.0	.870	5224
60	650.0	83.5	650.0	.830	3811
70	500.0	83.5	500.0	.750	2649
80	420.0	83.5	420.0	.700	2077
90	400.0	83.5	400.0	.600	1695
100	100.0	83.5	100.0	.500	353

```
TOTAL ENERGY = 62466.58   MWH
INPUT
 1. TO RERUN ENTIRE PROGRAM
 2. TO RERUN CHANGING ONLY TURBINE SIZE AND HEAD
 3. TO END PROGRAM
?
3
```

PROGRAM 6
PROGRAMS FOR COMPUTING POWER AND AVERAGE ANNUAL ENERGY FROM FLOW DURATION CURVE VALUES ASSUMING CHANGING HEAD AND EFFICIENCY USING AN HP-41C CALCULATOR

This program is simply a programmable calculator adaptation of the Basic program TURB described earlier. The flow diagram and other details of the program can be found in the write up for program TURB. This program is designed to compute both plant power output and average annual energy production given exceedance percents and the corresponding river flows head and efficiencies for a particular power plant configuration.

The program is written in two forms. One for use with a printer (TABEN) and one using only the normal display capabilities of the calculator (TABEN1). Listings for both programs are shown in Figures 17 and 18. Storage allocations are shown in Fiqure 19 and sample problems using both programs are presented in Figure 20 and 21.

FIGURE 17
HP-41C PROGRAM LISTING
PROGRAM TABEN1 (NON PRINTER VERSION)

STEP	KEY ENTRY	COMMENT	STEP	KEY ENTRY	COMMENT
01	♦LBL "TABEN1"	INPUT EXCEEDANCE PERCENT AVAILABLE FLOW HEAD	49	X>Y?	PLANT DISCHARGE COMPUTATION CONTINUED
02	2.00901		50	GTO 06	
03	STO 00		51	RCL 00	
04	♦LBL 01		52	7	
05	ISG 00		53	+	
06	GTO 02		54	RCL IND X	
07	GTO 04		55	RCL 02	
08	♦LBL 02		56	/	
09	RCL 00		57	SQRT	
10	2		58	RCL 01	
11	-		59	*	
12	INT		60	RCL 00	
13	" %, Q, H-"		61	14	
14	FIX 0		62	+	
15	ARCL X		63	X<>Y	
16	FIX 1		64	STO IND Y	
17	"F ?"		65	GTO 05	
18	PROMPT		66	♦LBL 06	
19	RCL 00		67	X<>Y	
20	RCL T		68	RCL 00	
21	STO IND Y		69	14	
22	RDN		70	+	
23	7		71	X<>Y	
24	+		72	STO IND Y	
25	RCL Z		73	GTO 05	
26	STO IND Y		74	♦LBL 08	DISPLAY COMPUTED PLANT DISCHARGES
27	RDN		75	"PLANT Q"	
28	7		76	PROMPT	
29	+		77	23.03001	
30	X<>Y		78	STO 00	
31	STO IND Y		79	XEQ 09	
32	GTO 01		80	GTO 22	
33	♦LBL 04	INPUT TURBINE FULL GATE CAPACITY AND NORMAL HEAD	81	♦LBL 09	SUBROUTINE TO DISPLAY PLANT DISCHARGES, EFFICIENCIES AND POWER VALUES
34	♦LBL A		82	RCL 00	
35	"TURB-Q, H ?"		83	2	
36	PROMPT		84	-	
37	STO 02		85	STO 38	
38	X<>Y		86	♦LBL 10	
39	STO 01		87	ISG 00	
40	9.01601	COMPUTE PLANT DISCHARGE	88	GTO 11	
41	STO 00		89	GTO 12	
42	♦LBL 05		90	♦LBL 11	
43	ISG 00		91	RCL 00	
44	GTO 07		92	RCL 38	
45	GTO 08		93	-	
46	♦LBL 07		94	CLA	
47	RCL IND 00		95	FIX 0	
48	RCL 01		96	ARCL IND X	

FIGURE 17 CONTINUED

STEP	KEY ENTRY	COMMENT	STEP	KEY ENTRY	COMMENT
97	"⊢ % "	OUTPUT SUBROUTINE CONTINUED	145	-	POWER VALUE COMPUTATIONS CONTINUED
98	FIX 3		146	X<>Y	
99	ARCL IND 00		147	RCL IND Y	
100	PROMPT		148	*	
101	GTO 10		149	X<>Y	
102	♦LBL 12		150	14	
103	RTN		151	+	
104	♦LBL 22	INPUT PLANT EFFICIENCIES FOR THE COMPUTED PLANT DISCHARGE AND KNOWN HEAD VALUES	152	X<>Y	
105	23.03001		153	RCL IND Y	
106	STO 00		154	*	
107	♦LBL 13		155	11.82	
108	ISG 00		156	/	
109	GTO 14		157	8	
110	GTO 15		158	ST+ Z	
111	♦LBL 14		159	RDN	
112	"Q "		160	STO IND Y	
113	FIX 0		161	GTO 16	
114	ARCL IND 00		162	♦LBL 18	DISPLAY COMPUTED POWER VALUES
115	"⊢H"		163	"POWER KW"	
116	FIX 1		164	PROMPT	
117	RCL 00		165	38.04501	
118	7		166	STO 00	
119	-		167	XEQ 09	
120	ARCL IND X		168	0	COMPUTE AVERAGE ANNUAL ENERGY OUTPUT
121	"⊢E?"		169	STO 46	
122	PROMPT		170	39.0450	
123	RCL 00		171	STO 00	
124	7		172	♦LBL 19	
125	+		173	ISG 00	
126	X<>Y		174	GTO 20	
127	STO IND Y		175	GTO 21	
128	GTO 13		176	♦LBL 20	
129	♦LBL 15	DISPLAY INPUT EFFICIENCY VALUES	177	RCL IND 00	
130	30.03701		178	RCL 00	
131	STO 00		179	1	
132	"EFFICIENCY"		180	-	
133	PROMPT		181	X<>Y	
134	XEQ 09		182	RCL IND Y	
135	23.03001	COMPUTE POWER VALUES	183	+	
136	STO 00		184	2	
137	♦LBL 16		185	/	
138	ISG 00		186	35	
139	GTO 17		187	ST- Z	
140	GTO 18		188	RDN	
141	♦LBL 17		189	RCL IND Y	
142	RCL IND 00		190	1	
143	RCL 00		191	ST- T	
144	7				

FIGURE 17 CONTINUED

STEP	KEY ENTRY	COMMENT
193	RCL IND Z	
194	-	
195	100	
196	/	ENERGY
197	*	COMPUTATIONS
198	8.76	CONTINUED
199	*	
200	ST+ 46	
201	GTO 19	----------------
202	♦LBL 21	DISPLAY
203	"ENERGY MWH"	AVERAGE
204	PROMPT	ANNUAL
205	CLA	ENERGY
206	FIX 3	OUTPUT
207	ARCL 46	
208	PROMPT	
209	"END TABEN"	
210	.END.	----------------

FIGURE 18
HP 41-C PROGRAM LISTING
PROGRAM TABEN (PRINTER VERSION)

STEP	KEY ENTRY	COMMENT	STEP	KEY ENTRY	COMMENT
	01♦LBL "TABEN"	INPUT EXCEEDANCE PERCENT, AVAILABLE FLOW, AND HEAD		49 X>Y?	PLANT DISCHARGE COMPUTATION CONTINUED
	02 2.00901			50 GTO 06	
	03 STO 00			51 RCL 00	
	04♦LBL 01			52 7	
	05 ISG 00			53 +	
	06 GTO 02			54 RCL IND X	
	07 GTO 04			55 RCL 02	
	08♦LBL 02			56 /	
	09 RCL 00			57 SQRT	
	10 2			58 RCL 01	
	11 -			59 *	
	12 INT			60 RCL 00	
	13 " %, Q, H-"			61 14	
	14 FIX 0			62 +	
	15 ARCL X			63 X<>Y	
	16 FIX 1			64 STO IND Y	
	17 "⊢ ?"			65 GTO 05	
	18 PROMPT			66♦LBL 06	
	19 RCL 00			67 X<>Y	
	20 RCL T			68 RCL 00	
	21 STO IND Y			69 14	
	22 RDN			70 +	
	23 7			71 X<>Y	
	24 +			72 STO IND Y	
	25 RCL Z			73 GTO 05	
	26 STO IND Y			74♦LBL 08	PRINT COMPUTED PLANT DISCHARGES
	27 RDN			75 "PLANT Q"	
	28 7			76 PRA	
	29 +			77 23.03001	
	30 X<>Y			78 STO 00	
	31 STO IND Y			79 XEQ 09	
	32 GTO 01			80 GTO 22	
	33♦LBL 04	INPUT TURBINE FULL GATE CAPACITY AND NORMAL HEAD		81♦LBL 09	SUBROUTINE USED TO PRINT PLANT DISCHARGES EFFICIENCIES AND POWER VALUES
	34♦LBL A			82 RCL 00	
	35 "TURB-Q, H ?"			83 2	
	36 PROMPT			84 -	
	37 STO 02			85 STO 38	
	38 X<>Y			86♦LBL 10	
	39 STO 01			87 ISG 00	
	40 9.01601	COMPUTE PLANT DISCHARGE		88 GTO 11	
	41 STO 00			89 GTO 12	
	42♦LBL 05			90♦LBL 11	
	43 ISG 00			91 RCL 00	
	44 GTO 07			92 RCL 38	
	45 GTO 08			93 -	
	46♦LBL 07			94 CLA	
	47 RCL IND 00			95 FIX 0	
	48 RCL 01			96 ARCL IND X	

FIGURE 18 CONTINUED

STEP	KEY ENTRY	COMMENT	STEP	KEY ENTRY	COMMENT
97	"⊢ %	OUTPUT SUBROUTINE CONTINUED	145	RCL 00	POWER VALUE COMPUTATIONS CONTINUED
98	FIX 3		146	7	
99	ARCL IND 00		147	-	
100	PRA		148	X<>Y	
101	GTO 10		149	RCL IND Y	
102	♦LBL 12		150	*	
103	CLA		151	X<>Y	
104	PRA		152	14	
105	RTN		153	+	
106	♦LBL 22	INPUT PLANT EFFICIENCIES FOR THE COMPUTED PLANT DISCHARGES AND KNOW HEAD VALUES	154	X<>Y	
107	23.03001		155	RCL IND Y	
108	STO 00		156	*	
109	♦LBL 13		157	11.82	
110	ISG 00		158	/	
111	GTO 14		159	8	
112	GTO 15		160	ST+ Z	
113	♦LBL 14		161	RDN	
114	"Q "		162	STO IND Y	
115	FIX 0		163	GTO 16	
116	ARCL IND 00		164	♦LBL 18	PRINT COMPUTED POWER VALUES
117	"⊢H"		165	"POWER KW"	
118	FIX 1		166	PRA	
119	RCL 00		167	38.04501	
120	7		168	STO 00	
121	-		169	XEQ 09	
122	ARCL IND X		170	0	COMPUTE AVERAGE ANNUAL ENERGY OUTPUT
123	"⊢E?"		171	STO 46	
124	PROMPT		172	39.0450	
125	RCL 00		173	STO 00	
126	7		174	♦LBL 19	
127	+		175	ISG 00	
128	X<>Y		176	GTO 20	
129	STO IND Y		177	GTO 21	
130	GTO 13		178	♦LBL 20	
131	♦LBL 15	PRINT INPUT EFFICIENCIES	179	RCL IND 00	
132	30.03701		180	RCL 00	
133	STO 00		181	1	
134	"EFFICIENCY"		182	-	
135	PRA		183	X<>Y	
136	XEQ 09		184	RCL IND Y	
137	23.03001	COMPUTE POWER VALUES	185	+	
138	STO 00		186	2	
139	♦LBL 16		187	/	
140	ISG 00		188	35	
141	GTO 17		189	ST- Z	
142	GTO 18		190	RDN	
143	♦LBL 17		191	RCL IND Y	
144	RCL IND 00				

FIGURE 18 CONTINUED

STEP	KEY ENTRY	COMMENT	STEP	KEY ENTRY	COMMENT
...	..				
194	RDN				
195	RCL IND Z				
196	-				
197	100	ENERGY			
198	/	COMPUTATIONS			
199	*	CONTINUED			
200	8.76				
201	*				
202	ST+ 46				
203	GTO 19				
204	♦LBL 21				
205	"ENERGY MWH"				
206	PRA	PRINT			
207	CLA	AVERAGE			
208	FIX 3	ANNUAL			
209	ARCL 46	ENERGY			
210	PRA	OUTPUT			
211	"END TABEN"				
212	PRA	PRINT			
213	PROMPT	"END TABEN"			
214	END				

FIGURE 19
STORAGE ALLOCATION
HP-41C PROGRAMS
TABEN, TABEN1

DATA REGISTERS

NUMBER	CONTENTS
00	Counter
01	Turbine Full Gate Discharge
02	Turbine Normal Head
03–09	Exceedance Percent Array
10–16	Available Flows Array
17–23	Available Head Array
24–30	Computed Plant Discharge Array
31–37	Efficiency Array
38	Counter Variable
39–45	Computed Power Array
46	Annual Energy

FIGURE 20
EXAMPLE PROBLEM
HP-41C PROGRAM TABEN1 (NON PRINTER VERSION)

SAMPLE PROBLEM

Determine power output and average annual energy production for a power plant operating with the following available flow and head conditions. Turbine full gate capacity is 4700 cfs and normal head is 21 ft.

FLOW AND HEAD DATA

%	Flow cfs	Head ft
0	10,000	15.5
10	6,350	18.8
20	4,700	21.0
30	3,900	23.0
50	3,100	26.1
80	2,550	29.5
100	1,000	31.2

EFFICIENCIES USED

% Flow	Plant cfs	Head ft	Efficiency
0	4038	15.5	.86
10	4447	18.8	.87
20	4700	21.0	.89
30	3900	23.0	.85
50	3100	26.1	.75
80	2550	29.5	.70
100	1000	31.2	.60

SOLUTION

INPUT	FUNCTION	DISPLAY	COMMENTS
	Input Program		Use card reader or input through the keyboard
	XEQ SIZE 047		Set storage size
	XEQ TABEN1		
		%, Q, H - 1	Enter % 1 *
0	ENTER	0.0	Enter Flow (cfs) 1
10,000	ENTER	10,000.0	Enter Head (ft) 1
15.5	R/S	%, Q, H - 2	Enter % 2
10	ENTER	10.0	Enter Flow (cfs) 2
6350	ENTER	6350.0	Enter Head (ft) 2
18.8	R/S	%, Q, H - 3	
	Continue this sequence until all seven %, FLOW, and head values have been entered.		
		TURB-Q, H?	Enter turbine full gate capacity (cfs)
4700	ENTER	4700.0	Enter normal head
21	R/S	PLANT Q	Push R/S to continue
		0% 4037. 886	Plant discharge 1, Push R/S to display next value
	R/S	10% 4447.000	Plant discharge 2, Push R/S to display next value
	Continue this sequence until all Plant Qs are displayed Push R/S after last Plant Q is displayed		
		Q4038 H15.5 E?	Enter efficiency of selected turbine for this flow and head

* Enter exceedance percents from lowest to highest values

FIGURE 20 CONTINUED

SOLUTION (CONTINUED)

INPUT	FUNCTION	DISPLAY	COMMENTS
.86	R/S	Q4447 H 18.8 E?	Enter efficiency of selected turbine for this flow and head
.87	R/S	Q4700 H 21.0 E	Enter efficiency of selected turbine for this flow and head
	Continue this sequence until all efficiencies are entered		
		EFFICIENCY	Push R/S to continue
		0% 0.860	Efficiency 1, Push R/S to display next value
	R/S	0% 0.870	Efficiency 2, Push R/S to display next value
	Continue this sequence until all efficiencies are displayed Push R/S after last value is displayed		
		POWER KW	Push R/S to continue
		0% 4553.724	Power output at 0%. Push R/S to display next value
		10% 6153.565	Power output at 10%. Push R/S to display next value
	Continue this sequence until all power output values are displayed. Push R/S after last value is displayed.		
		ENERGY MWH	Push R/S to continue
	R/S	42,758.126	Average Annual Energy Production

FIGURE 21
EXAMPLE PROBLEM
HP-41C PROGRAM TABEN (PRINTER VERSION)

SAMPLE PROBLEM

Determine power output and average annual energy production for a power plant operating with the following avaiable flow and head conditions. Turbine full gate capacity is 4700 cfs and normal head is 21 ft.

AVAILABLE HEAD & FLOW			TURBINE PERFORMANCE DATA			
%	Flow cfs	Head ft	%	Plant Flow	Head	Efficiency
0	10,000	15.5	0	4038	18.5	.86
10	6,350	18.8	10	4447	18.8	.87
20	4,700	21.0	20	4700	21.0	.89
30	3,900	23.0	30	3900	23.0	.85
50	3,100	26.1	50	3100	26.1	.75
80	2,550	29.5	80	2550	29.5	.70
100	1,000	31.2	100	1000	31.2	.60

SOLUTION

INPUT	FUNCTION	DISPLAY	COMMENTS
	Input Program		Use card reader or input through the keyboard
	XEQ SIZE 047		Set Storage Size
	XEQ TABEN1		
		%, Q, H - 1	Enter % 1* cfs
0	ENTER	0.0	Enter Flow (cfs) 1
10,000	ENTER	10,000.0	Enter Head (ft) 1
15.5	R/S	%, Q, H - 2	Enter % 2
10	ENTER	10.0	Enter Flow (cfs) 2
6350	ENTER	6350.0	Enter Head (ft) 2
18.8	R/S	%, Q, H - 3	
	Continue this sequence until all seven %, flow, and head values have been entered.		
		TURB-Q,H?	Enter turbine full gate capacity (cfs)
4700	ENTER	4700.0	Enter normal head
21	R/S		
	Plant discharge values are now printed		
	0. % 4,037.886 10. % 4,447.000 20. % 4,700.000 30. % 3,900.000 50. % 3,100.000 80. % 2,550.000 100. % 1,000.000		

* Enter exceedance percents from lowest to highest percent value

FIGURE 21 CONTINUED

SOLUTION (CONTINUED)

INPUT	FUNCTION	DISPLAY	COMMENTS
		Q 4038. H 15.5 E?	Enter efficiency of selected turbine for this flow and head
.86	R/S	Q 4447. H 18.8 E?	Enter efficiency of selected turbine for this flow and head
.87	R/S	Q 4700. H 21.0	Enter efficiency of selected turbine for this flow and head
	Continue this sequence until all efficiency values are input. Push R/S after last efficiency value is entered		
	Efficiency values are now printed		
	0. % 0.860 10. % 0.870 20. % 0.890 30. % 0.850 50. % 0.750 80. % 0.700 100. % 0.600		
	Power values are now printed		
	0. % 4,553.724 10. % 6,153.565 20. % 7,431.726 30. % 6,450.508 50. % 5,133.883 80. % 4,454.949 100. % 1,583.756		
	Average Annual Energy Production is now printed		
	[illegible] 44,758.126 END TABEN		
		END TABEN	

APPENDIX B

IDAHO REGULATED
FLOW MODEL

APPENDIX B

TABLE OF CONTENTS

APPENDIX B
LIST OF FIGURES

FIGURE — Page

INTRODUCTION TO IDAHO REGULATED FLOW MODEL

The purpose of this appendix is to describe the regulated flow computer program developed at the Idaho Water and Energy Resources Research Institute at the University of Idaho. The objectives will be to: 1) introduce the Idaho Regulated Flow Techniques; 2) describe each of the subroutine building blocks in the program; 3) explain how, through call statements in the main programs, the subroutines are made to model a particular basin; 4) show examples of application of the model from data set up to final output.

The model was developed out of a need to be able to quickly analyze the hydropower potential of streams that are affected by a high degree of regulation. In order to make these analyses a method was needed to predict the flows downstream from the regulation points. This method had to account for both the upstream regulation and tributary inflows below the point of regulation. The method developed was called the Idaho Regulated Flow Technique. The computer program which will be described in this appendix is a computerized adaptation of this technique. Input to the computer program include gaged, assumed, or synthesized reservoir outflows, average annual runoff from tributary drainage areas and gaged outflows from so called "representative" gages. Output from the model include monthly flows, duration tables, and plotted duration curves for selected points in the stream system.

A complete description of the regulated flow technique is contained in Chapter 7 of this dissertation. The technique itself and the computer program were both developed by the author and Rickey L. Emmert (M.S.C.E, University of Idaho, 1979) in connection with a hydropower inventory of the Pacific Northwest Region made for the U.S. Department of Energy.

The program consists of a very simple main program and several computational subroutines. The main program consists of set up statements for the plotter and a series of call statements for the computational subroutines. A complete listing of an example main program and all subroutines used in the model is shown in Figure 13 at the end of this appendix. The configuration of the basin model is determined by the sequence of the call statements in the main program. Unlike most basin models this program acquires its flexibility by complete changes in the main program rather than a complex data entry system to describe the configuration of the basin being modeled.

If a very simple basin is being modeled, then a very simple main program is constructed. If a complex basin is being modeled, then the main program is tailored to the difficulty of the job. Changes in the model are very simple. All that is required is to rearrange, add or subtract the required subroutine call statements. Of course data requirements change as the model change. Again for simple jobs very little data is required, for more complex jobs more data must be input. Each subroutine requires certain data items. Data decks are assembled simply by providing the required data in the same order as the order of the subroutines requiring the data in the main program.

DISCUSSION OF COMPUTATIONAL SUBROUTINES

The individual subroutines will be described in detail, before attempting to describe the entire model as a whole. The first subroutine to be discussed will be Subroutine READ. All flow data required in the model are input using this subroutine. This should always be the first subroutine to be used. Both the flows to be used as starting points (e.g., outflows from a reservoir) and flows to be used as representative gage data are input at this time. The data required for this subroutine include, number of stations to be read, station number, a special code for identifying the type of flow data to be read for each station to be read and lastly the flow data for each station. The station number, code and flow data sequence are separated for each station input. Input flows can be an average monthly cfs or monthly acre feet. A complete listing of format requirements for this subroutine is shown in Figure 1. Note that the last card for each station must be a blank card following the last year's data.

The format of the input flow data can be easily changed by changing the read and format statements following the comment card 'C READ STATION FLOWS'. By changing these, any flow data format can be read. This allows the use of previously formatted data to be used. The program has been set up for card use, but with minor changes in the read and format statements, tape or disk files could be used.

The next subroutine that will be described will be Subroutine COMM. The tributary inflows are computed and added to the upstream flows in this subroutine. This subroutine simply automates the procedures described in Chapter 8 of the main report. Flow fractions are computed for the input comparison gage. These fractions are multiplied by the input tributary average annual runoff to obtain tributary inflows. These inflows are then summed with the upstream flows to get the flows at the desired point. Six downstream points can be evaluated at one time with one COMM call statement. COMM statements can be put in sequence if more than six downstream points are desired. The outflows computed in

FIGURE 1
INPUT DATA FOR SUBROUTINE READ

COMMENTS	Columns 1–4	Column 5	Columns 7–80
CARD 1	XXXX I4 NUMBER OF STATIONS TO BE READ		
CARD 2	XXXX I4 STATION NUMBER	X INCODE I1	NAME OF STATION (NOT USED BY PROGRAM) FOR I.D. PURPOSES ONLY NCODE=1 FOR FLOWS IN 100 AC. FT. PER MONTH NCODE=0 FOR FLOWS IN CFS

CARD 3:

XX	XXXXX.	XXXXX.	XXXXX.	XXXXX.	XXXXX.	XXXXX.	XXXXX.	XXXXX.	XXXXX.	XXXXX.	XXXXX.	XXXXX.
I2	F6.0	F6.0	F6.0	F6.0	F6.0	F6.0	F6.0	F6.0	F6.0	F6.0	F6.0	F6.0
YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	FLOW	FLOW	FLOW	FLOW	FLOW	FLOW	FLOW	FLOW	FLOW	FLOW	FLOW	FLOW

FOLLOW LAST CARD FOR EACH STATION WITH A BLANK CARD the first COMM can be used as inflow to the second COMM statement. The limitation as to the number of stations analyzed comes in that the sum of the number of stations input with the read statement plus the number of points generated with the COMM, AVER and SUMM Subroutines cannot exceed 23. This limitation can be changed by changing the dimension of array "STA" in the common statements of the main program and the READ, AVER, SUMM and COMM Subroutines. Adjustment of this value may also be required based on Core memory size of the computer on which the program is being used. If the program will not fit in a particular machine simply reduce the 23 dimension in the common statements. Of course this will reduce the number of stations that can be used from 23 to the new number in the dimension statement.

One must also input the analyses period to be used by the COMM Subroutine. It is essential that the analyses period be chosen so there are values of flow at the representative gage for all months during this period. A complete listing of data requirement and format for this subroutine is shown in Figure 2.

Output from this subroutine includes a complete listing of monthly average flows for all computed downstream points along with a duration table plus a plot of the duration curve. If punched cards for the computed stations are desired the appropriate write and format statements can be inserted between the comment cards identified for this purpose in the program listing.

The flow duration curve computation and plotting subroutines have been set up to require no input data. The flow duration curve program uses the class interval technique (See Chapter 4 of the main report for an explanation of this technique). The number of intervals and upper and

FIGURE 2
INPUT DATA FOR SUBROUTINE COMM

ONE CARD ONLY

Card columns	Format	Field
1–2	I2	STATION NUMBER FOR FIRST COMPUTATION POINT
3–4	I2	NUMBER OF COMPUTATION POINTS
5–6	I2	REPRESENTATIVE GAGE NUMBER
7–8	I2	UPSTREAM INFLOW GAGE NUMBER
9–10	I2	BEGINNING YEAR FOR ANALYSIS
11–12	I2	ENDING YEAR FOR ANALYSIS
13–22	F10.0 (XXXXXXXXX.)	TRIBUTARY AREA 1 AVERAGE ANNUAL INFLOW CFS DAYS
23–32	F10.0 (XXXXXXXXX.)	TRIBUTARY AREA 2 AVERAGE ANNUAL INFLOW CFS DAYS
33–42	F10.0 (XXXXXXXXX.)	TRIBUTARY AREA 3 AVERAGE ANNUAL INFLOW CFS DAYS
43–52	F10.0 (XXXXXXXXX.)	TRIBUTARY AREA 4 AVERAGE ANNUAL INFLOW CFS DAYS
53–62	F10.0 (XXXXXXXXX.)	TRIBUTARY AREA 5 AVERAGE ANNUAL INFLOW CFS DAYS
63–72	F10.0 (XXXXXXXXX.)	TRIBUTARY AREA 6 AVERAGE ANNUAL INFLOW CFS DAYS
73–80		

COMMENTS

lower values have been set by data statements in the program. There are 45 classes with values from 0 to 200,000 cfs. If other values for class intervals are desired the data statements can be easily changed. Comment cards identify the area where the changes should be made.

The duration program checks to see if all flows have been classified. If not the following error statement is written. "Total counts = n Total Flows = M, Check Intervals" the difference between total flows and total counts is how many flow values were not classified. The minimum flow value must be greater than the minimum value of class interval. This is 0.0 in the program as it stands. The maximum flow value must be less than the largest value of class interval. This is 200,000 in the program as it stands. If the flow values are out of these ranges the class values must be changed in the data statements as described above.

The flow duration program outputs both percent exceedance for all class values and the values for the 95, 80, 50, 30 and 10 percent exceedance flow values. These specific exceedance values are interpolated using a semi log interpolation scheme with flows as log values and exceedance percents as linear values.

The plotting subroutine is called PLTDUR. This subroutine is designed to be used with the Cal Comp (916) plotter and Cal Comp plotter software. If other plotters or software are to be used appropriate changes will have to be made in the plotter call statements. If no plotting is desired the subroutine can be removed. Also the "Call Pltdur" statement in subroutine "DURA" and the "Call Plot" and "Call Plots" statements in the main program must be removed.

Subroutine PLTDUR is set up to do either semi log (log of flow vs. exceedance percent) or straight arithmetic plots. The program defaults to the semi log plots. If linear plots are desired, the statement "log = 1" must be changed to "log = 0". The statement is identified by appropriate comment statements.

Subroutine "AVER" is used as a special purpose subroutine to create a representative gage record that is a weighted composite of up to five gages. In this way the runoff from the tributary can be typified by a weighted composite of more than one gage.

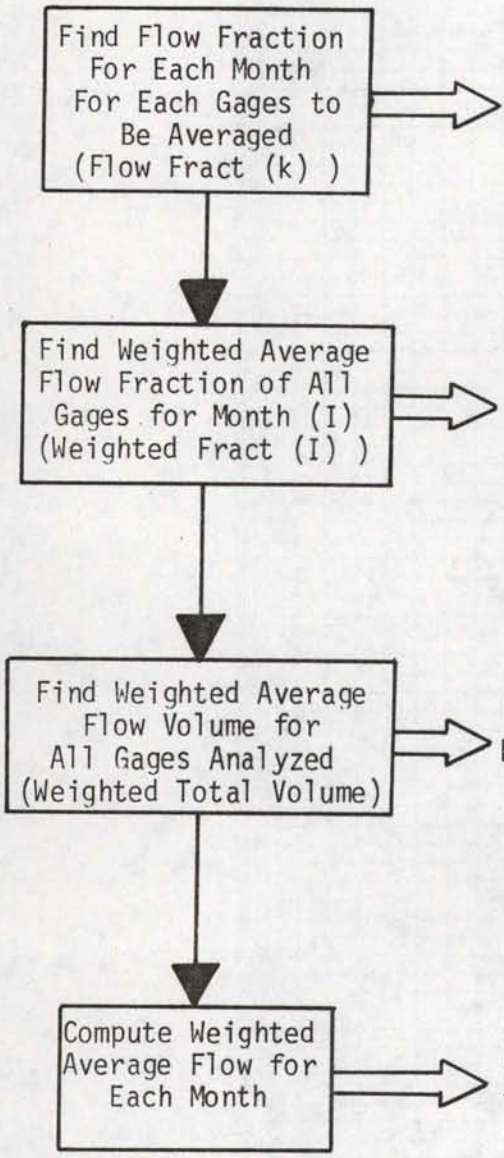
An example of its use would be if there were two gages that were considered to be equally representative of the runoff from the tributary area. Subroutine AVER could be used to compute a weighted average of these gages to be used as a respresentative gage for tributary inflow computations. The weighting assigned to the gages are variable but must add up to 1.0.

The weighted average flows are not just the weighted average of the actual flows at the gages. These weighted average flows are obtained by computing first the weighted average of what has been described earlier (Chapter 1) as the monthly gage flow fraction. The final weighted average flows are obtained by multiplying this flow fraction by a total weighted average runoff. A flow diagram of the method is shown in Figure 3.

Input to this subroutine includes starting and ending years to be averaged, number of gages used in the weighting, station number of gages to be used in the weighting, station number where weighted average array is to be stored, and weighting factors for each gage. A complete listing of input data and format required for this subroutine is shown in Figure 4.

The last subroutine is subroutine SUMM. This subroutine simply adds or subtracts two station records. This subroutine is useful for

FIGURE 3
PROCEDURE FOR COMPUTING
WEIGHTED AVERAGE FLOW
TO BE USED AS A REPRESENTATIVE GAGE



$$\frac{\text{FLOW VOLUME MONTH (I)}}{\sum_{k=1}^{n} \text{Flow Volume Month (k)}}$$

n = number of month analyzed

$$\sum_{k=1}^{m} W(k) \times \text{FLOW FRACT (k)}$$

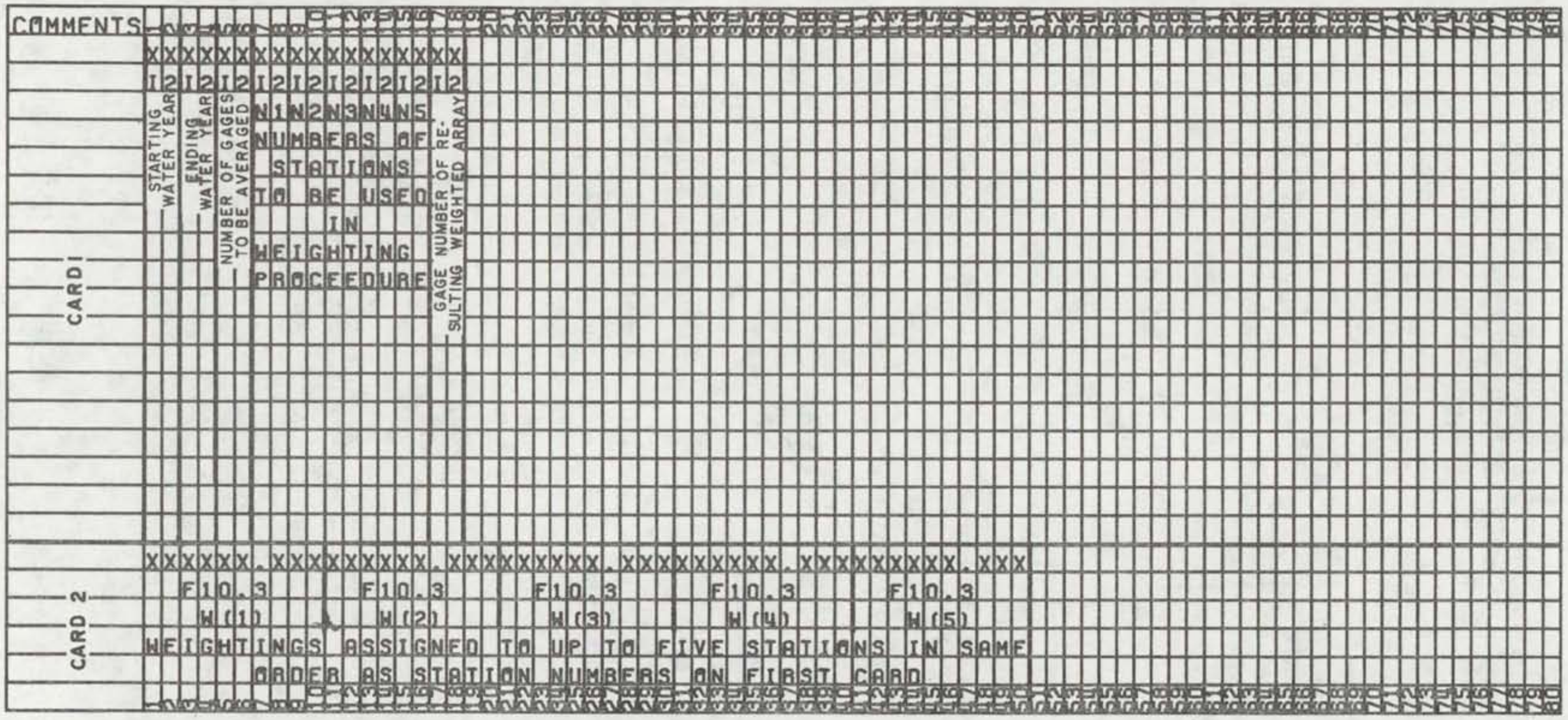
W(k) = input gage weighting for gage k
m = number of gages analyzed

$$\sum_{k=1}^{m} \sum_{I=1}^{n} \text{Flow Volume Gage (k)(For Month (I))} \times W(K)$$

n = number of months analyzed
m = number of gages analyzed

$$\frac{\text{Weighted Fract (I)} \times \text{Weighted Total Volume}}{\text{Number of Days in Month}}$$

FIGURE 4
INPUT DATA FOR SUBROUTINE AVER



modeling flows downstream of a confluence of two regulated flow streams. It is also useful in cases such as irrigation diversion where withdrawals from a stream must be modeled. In this case one prepares a station record of the proposed diversion or withdrawals. By adding a minus sign to the diversion station number, which would be the second station number on the SUMM data card, these flows are subtracted from the first station listed on the card. A listing of the data required and format of the data for subroutine SUMM is shown in Figure 5.

A complete listing of each of the subroutines is presented in Figure 13 at the end of this appendix. A card deck or magnetic tape listing of the subroutines can be obtained by contacting the Idaho Water Resources Research Institute, University of Idaho, Moscow, Idaho.

SIMPLE APPLICATION OF THE MODEL

Now that each of the subroutines has been discussed the next discussion will center on how the subroutines are integrated into the basin model. Figure 6 has been provided as a quick synopsis of each of the four main computational subroutines. The order of the call statements to these subroutines in the main program will determine the make up of the model.

The easiest way to explain the application of the model is to go through some examples of its use. To begin with an example of a very simple basin will be presented and then an application of the program to a more complex basin will be examined.

The first example will be the same as that used in Chapter 7 of the dissertation. This example involves the determination of a flow duration curve at a proposed run-of-river site downstream from a reservoir. Figure 7 is a map of the basin of interest.

FIGURE 5
INPUT DATA FOR SUBROUTINE SUMM

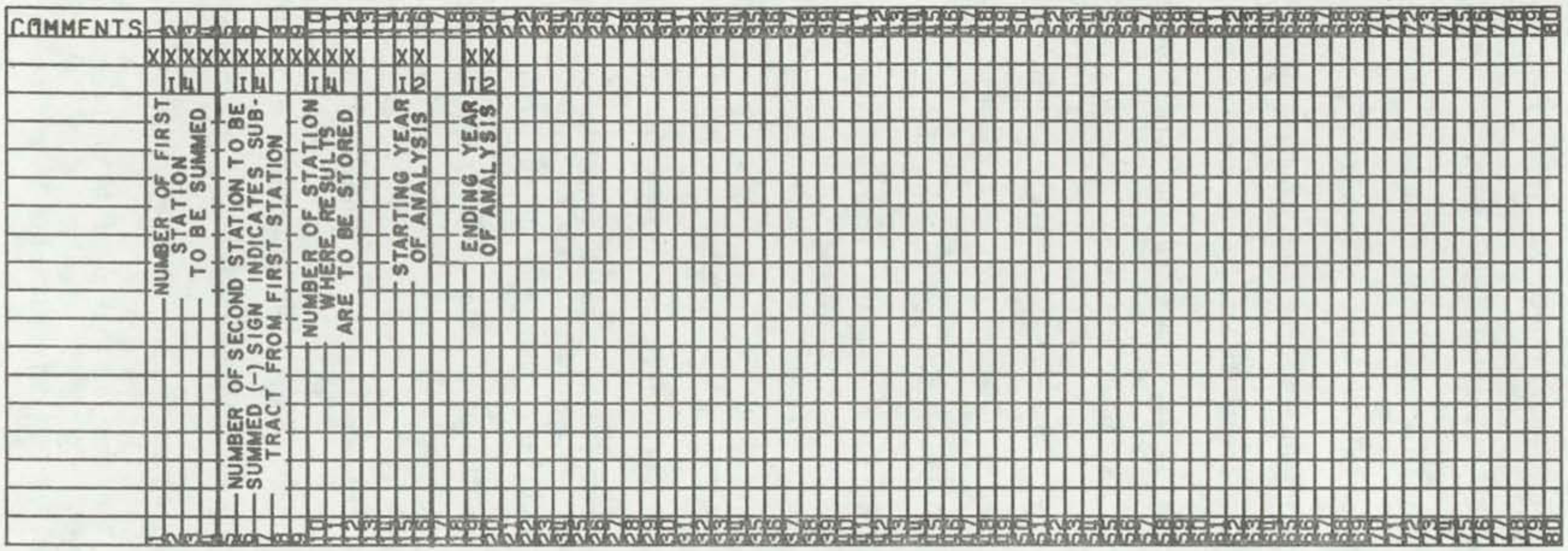
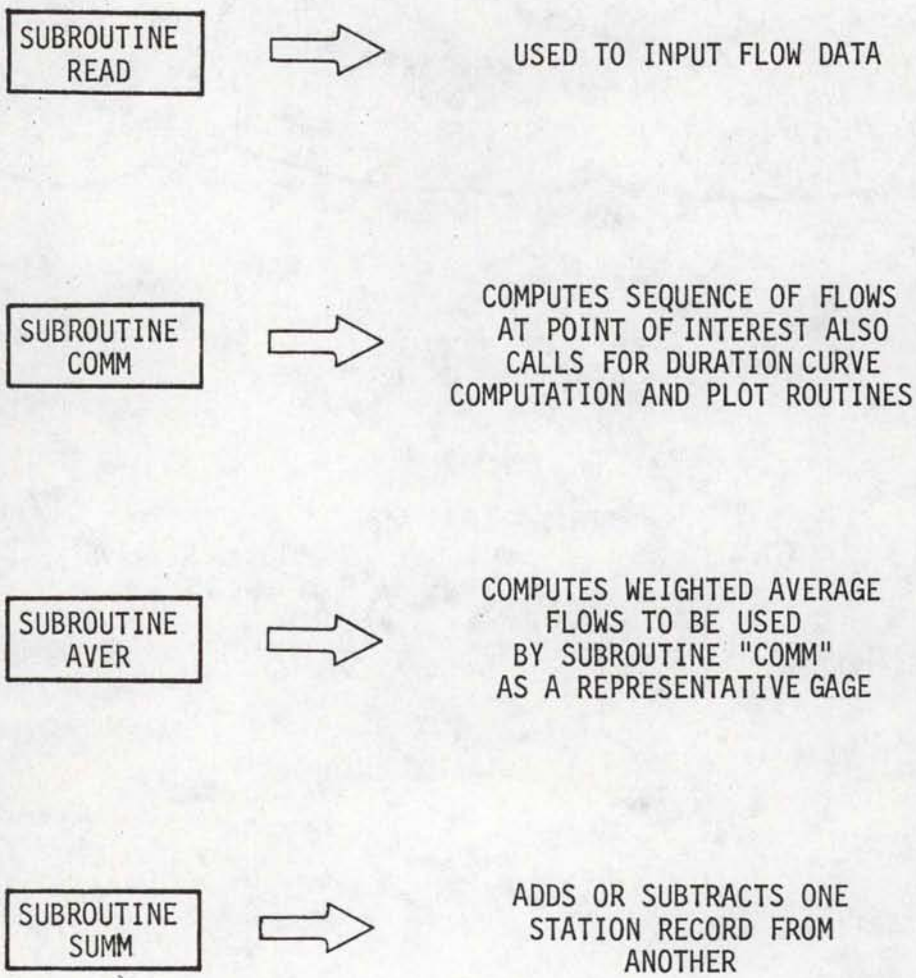


FIGURE 6
MAIN COMPUTATIONAL
SUBROUTINES
FOR THE IDAHO REGULATED
FLOW MODEL



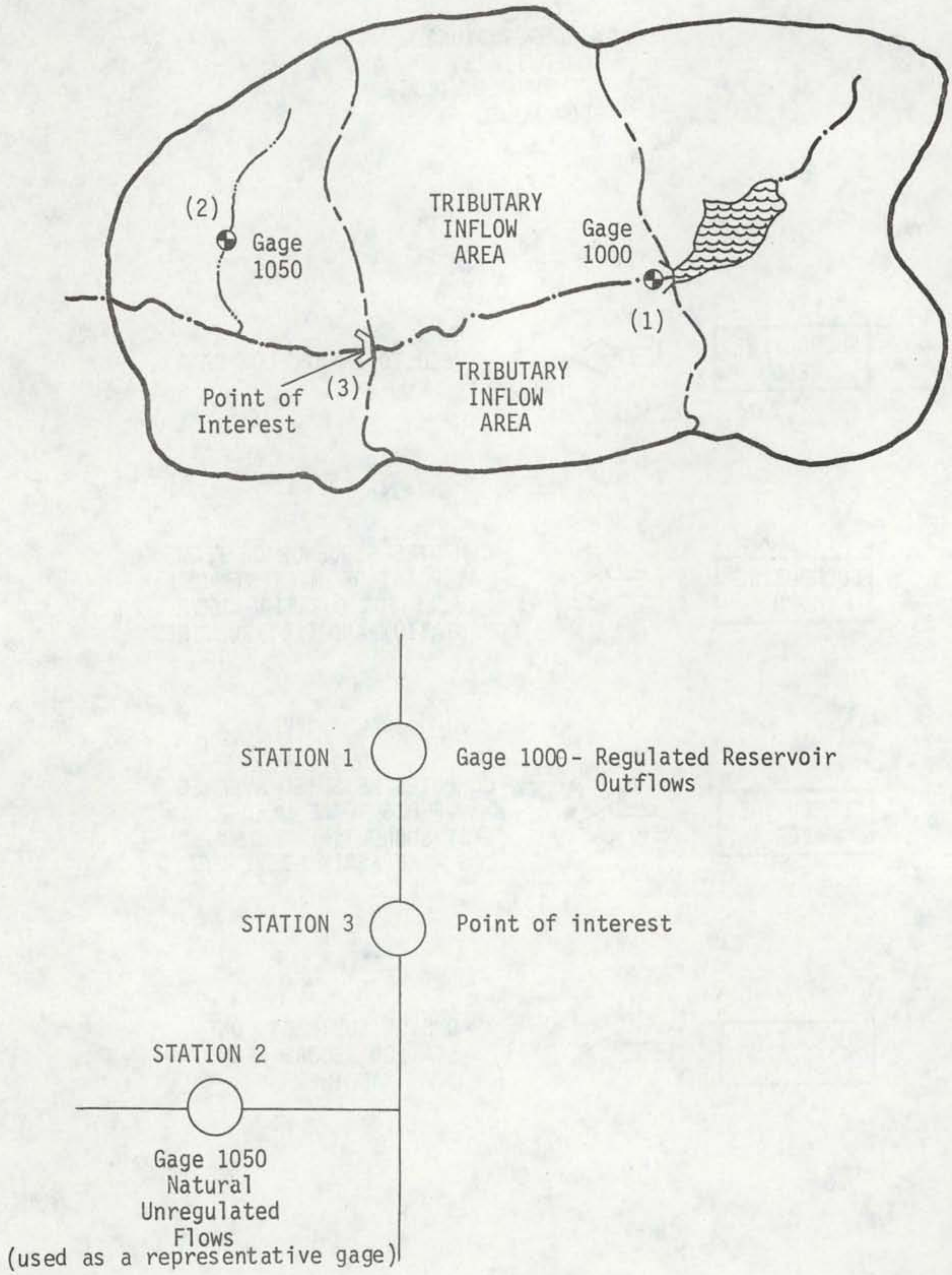


FIGURE 7 EXAMPLE BASIN FOR APPLICATION OF THE REGULATED FLOW TECHNIQUES

The basic technique used in applying the computer program is the same no matter how complex the basin. A flow diagram of this technique is shown in Figure 8. Step 1 in the procedure is to identify all points where regulated flows or duration curves of flow are desired. For the first example, there is only one point where it is desired to obtain the regulated flows. This is labeled as "Point of Interest" in Figure 7.

The next step is to identify the gaged flow stations that can be used in the analyses. For our first example Gage 1 and Gage 2 are the known flow gaging sites. Gage 1 is the starting point flows and Gage 2 is the representative gage which is used to compute the tributary inflow values.

Step 4 and 5 are combined and shown in the stream schematic diagram of Figure 7. One note of caution should be observed when assigning station numbers for the computed points of interest. If more than one point is computed in a single Call COMM statement the station numbers must be in consecutive order or errors will result. Also no duplicate numbering of stations is allowed.

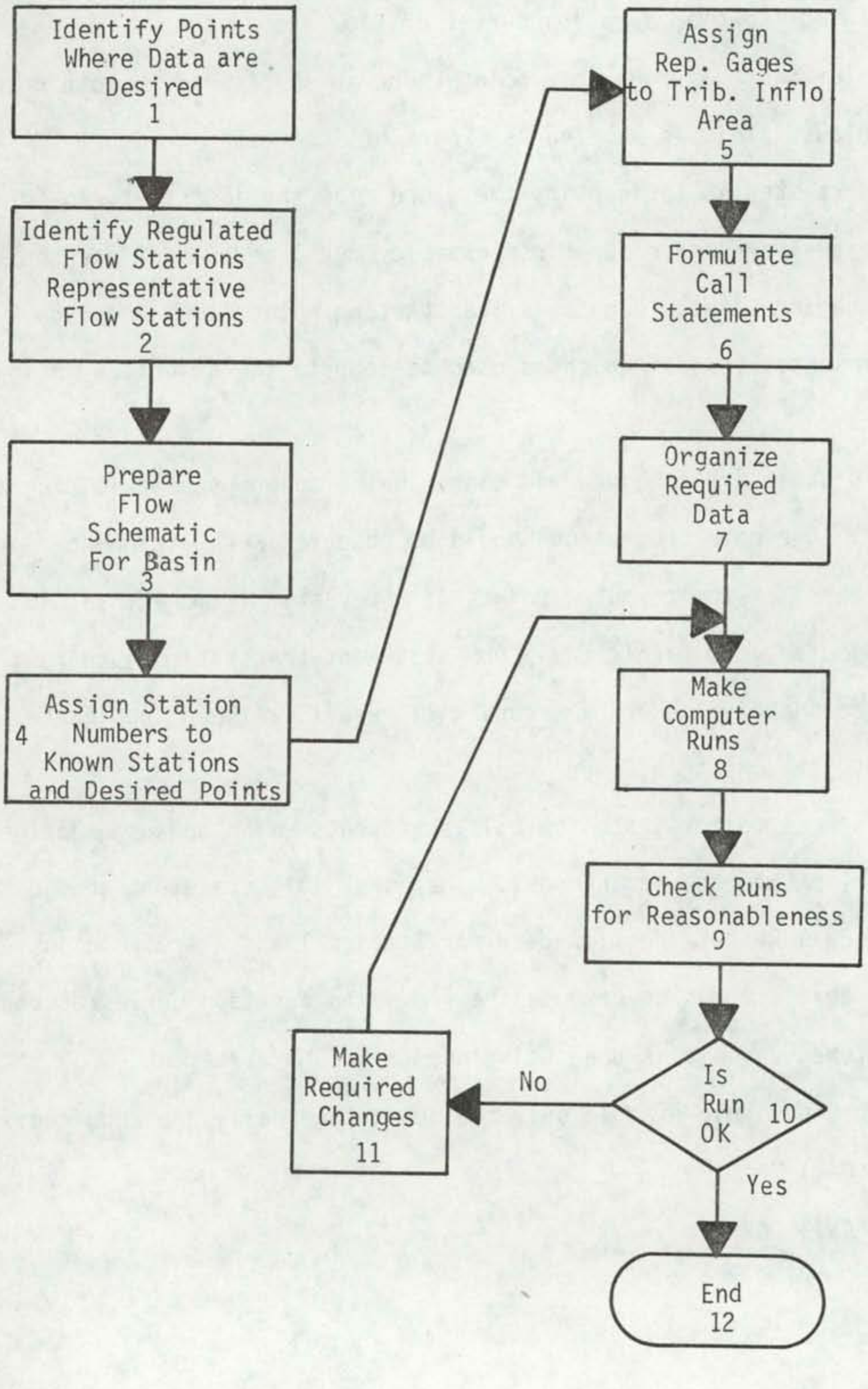
Step six is to formulate the call statements which are used in the main program to form the basin model. The first call statement should always be a Call READ. The flow data for Station 1 and 2 are read in first. The next step is to compute the flows and duration curves at the point of interest. This is done using one Call COMM statement.

So far the simple example only two subroutine calls are required:

"Call READ"

"Call COMM"

FIGURE 8
FLOW DIAGRAM
OF THE
REGULATED FLOW
COMPUTER ANALYSES
TECHNIQUE



The next step is to organize the computer input data. This is best done by referring to Figure 1 through 5 which describe all the data required for the subroutines. At this time the computational period to be used for the subroutines must also be decided. It is best to first identify all periods of record available for the regulated outflow stations and representative stations. In general, its best to use the longest analyses period possible, but due to the nature of the modeling technique flow data for some stations may not be useable. In subroutines COMM, AVER, and SUMM, the period of record for the stations which are used in the subroutines must overlap. The period of record used in the analyses must be such that there is a complete record of flows for both the upstream inflow station and the representative station for the period being analyzed. Subroutine AVER requires a complete record of flows for the analyses period for all stations used in the weighted averaging. Subroutine SUMM requires a complete record of flows for the analyses period for both stations to be summed. Figure 9 shows a complete listing of the main program and data for Example 1.

In steps 7 and 9 the required computer runs are made and the results are checked for reasonableness. If the resulting runs are satisfactory then the job is complete. If the results are unreasonable, more computer runs may be required.

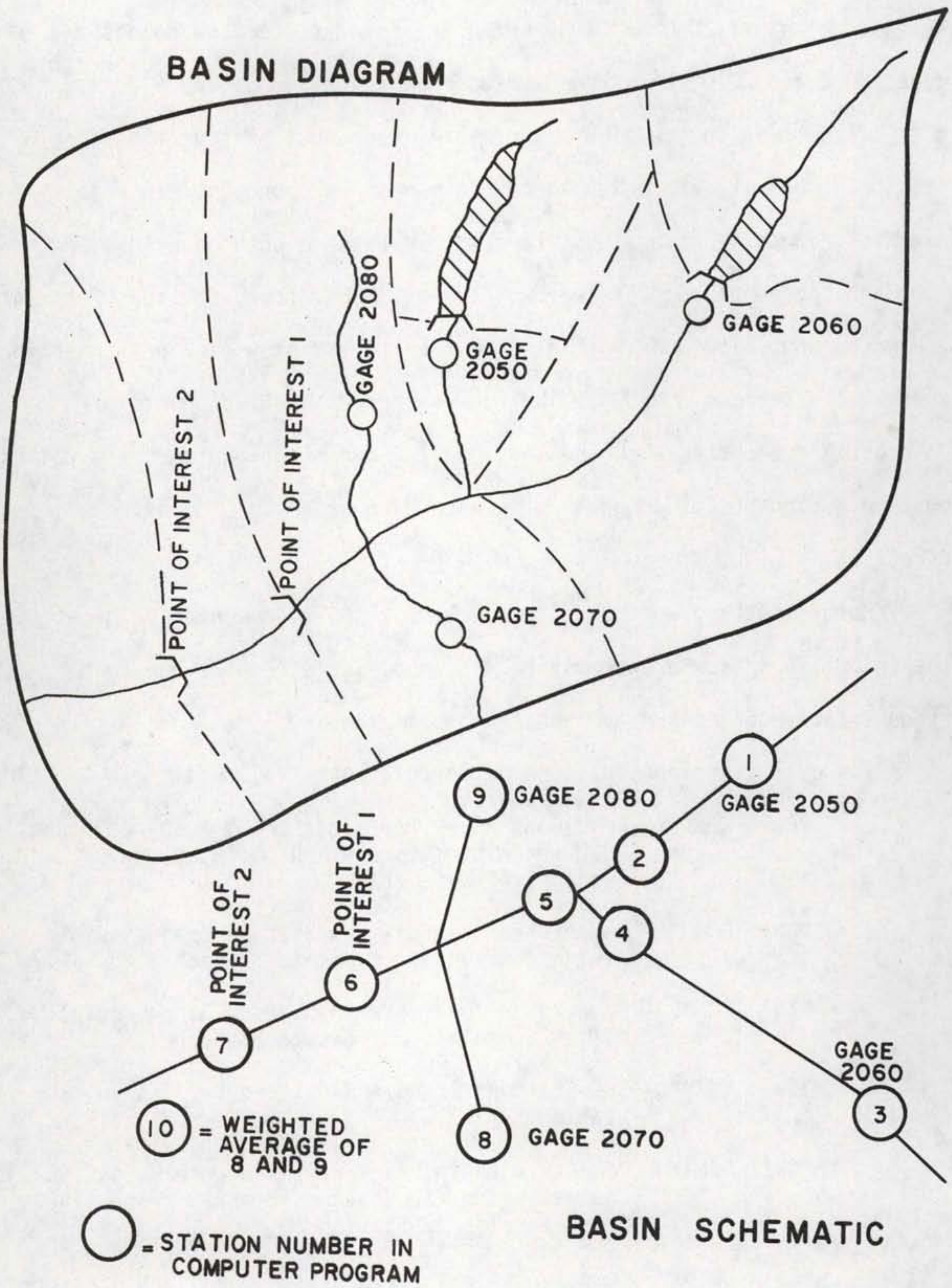
APPLICATION OF MODEL TO A COMPLEX FLOW SITUATION

A second example problem is presented in order to demonstrate the use of the remaining subroutines. The basin to be modeled is shown in Figure 10. The basic approach to the problem is the same as used in Example 1 and shown in Figure 8. The points of interest are run-of-

FIGURE 9
MAIN PROGRAM
AND SAMPLE INPUT
DATA FOR EXAMPLE 1

```
COMMENTS
                                      MAIN PROGRAM
C MAIN LINE PROGRAM
      COMMON STA (23,100,13)
      CALL PLOTS (0,0,13)
      CALL PLOT (2.0,-15.0,-3)
      CALL PLOT (0.0,2.0,-3)
      CALL SYMBOL (0.0,-.5,.07,'I',0.0,1)
      CALL SYMBOL (0.0,10.15,0.07,'I',0.0,1)
C INSERT SUBROUTINE CARDS BETWEEN THIS AND FOLLOWING COMMENT CARD
      CALL READ
      CALL COMM
C INSERT SUBROUTINE CARDS BETWEEN THIS AND THE PREVIOUS COMMENT CARD
      CALL PLOT (6.0,0.0,999)
      STOP
      END

                                            DATA
   2
   10     FLOW DATA FOR STATION 2 GAGE 1000 FOLLOWS
      50     65.    60.    55.    50.    45.    80.   100.   200.   250.   250.   200.    70.
      51     75.    71.    70.    60.    53.    95.   125.   300.   225.   200.   175.    80.
                 FLOW CARDS REPEATED FOR EACH YEAR OF RECORD TO BE USED FOR STATION
   20     FLOW DATA FOR STATION 2 GAGE 1050 FOLLOWS
      50     40.    30.    25.    25.    20.    40.    50.   100.   300.    75.    60.    50.
      51     45.    36.    29.    32.    26.    45.    56.   110.   320.    80.    62.    51.
                 FLOW CARDS REPEATED FOR EACH YEAR OF RECORD TO BE USED FOR STATION
3 1 2 15075     43000.
```

FIGURE 10
BASIN AND SCHEMATIC
DIAGRAM FOR EXAMPLE 2



river sites labeled points of interest 2 and 3 on the basin diagram and flow schematic diagram. The known flow data consists of controlled outflows at gages 2050 and 2060 which are used as starting points and gages 2080 and 2070 which are used as representative gages.

In setting up the flow diagram, the user must be sure to assign a station number at each point where flows must be computed. In this example tributary inflows must be computed between both gage 2050 and 2060 and the confluence of the two streams. Therefore, Stations 2 and 4 are necessary. The user must also be sure to assign a station number for the sum of stations 3 and 4. The flow values at the two points of interest are computed with the same "Call COMM" statement so these points must be assigned station numbers in ascending order in a downstream direction.

Before setting up the call statements, the representative gages to the tributary inflow areas must be assigned. Table 1 shows how the representative gages are assigned for this example.

The call statements can now be formulated as follows:

"Call READ" - Read Gage Flows for gages 2060, 2050, 2070 and 2080 and assign to stations 1, 3, 9 and 8 respectively.

"Call COMM" - Compute inflows between Station 1 and Mouth. Assign cummulative flows to Station 2.

"Call COMM" - Compute inflows between Station 3 and Mouth. Assign cummulative flows to Station 4.

"Call SUMM" - Sum Stations 2 and 4 and store results in Station 5.

"Call AVER" - Compute a new average weighted gage using .50, .50 weighting for Stations 8 and 9 respectively. Store results in Station 10.

"Call COMM" - Compute inflows between Stations 5 and 6, store resulting flows in 6, compute inflows between Stations 6 and 7, store results in Station 7.

TABLE 1
REPRESENTATIVE GAGE ASSIGNMENTS
EXAMPLE 2

Tributary Inflow Area Description	Representative Gage
1) Area Between Gage 2050 and Confluence of the Two Streams	Gage 2080 (Station 9)
2) Area Between Gage 2060 and Confluence of the Two Streams	Gage 2070 (Station 8)
3) Area Between Confluence and Last Downstream Point of Interest	Weighted Average of Gage 2080 and Gage 2070 - use 50%- 50% weighting respectively Assign "Aver" Results to Station 10

A listing of the main program for Example 2 is contained in Figure 11. The next step is to organize the computer input data. Again the best way to do this is to refer to Figure 1 through Figure 5 which give a column by column listing of the data required for each subroutine. Data for each subroutine should be input in the same order as the respective call statements in the main program. Figure 12 shows the data set up for Example 2. A complete listing of the main program, subroutines and input data for Example 2 is shown in Figure 13.

The computer output and plotted duration curves from the runs for Example 2 are shown in Figure 14. Annotations have been made to the output to aid in explaining the output data.

This program offers a quick method to analyze a number of different sites in an area. Once the inflow and representative gage flows have been coded, the remainder of the modeling is relatively easy. The model was used with good success on several streams in Idaho during the course of the U.S. Department of Energy Hydro Resource Survey Studies. Chapter 7 shows some comparisons of model predicted duration curves with flow duration curves for the same point in the stream computed from gaged flow values.

FIGURE 11
MAIN PROGRAM
FOR EXAMPLE 2

```
C MAIN LINE PROGRAM
      COMMON STA (23,100,13)
      CALL PLOTS (0,0,13)
      CALL PLOT (2.0,-15.0,-3)
      CALL PLOT (0.0,2.0,-3)
      CALL SYMBOL (0.0,-.5,.07,'I',0.0,1)
      CALL SYMBOL (0.0,10.15,0.07,'I',0.0,1)
C INSERT SUBROUTINE CARDS BETWEEN THIS AND FOLLOWING COMMENT CARD
      CALL READ
      CALL COMM
      CALL COMM
      CALL SUMM
      CALL AVER
      CALL COMM
C INSERT SUBROUTINE CARDS BETWEEN THIS AND THE PREVIOUS COMMENT CARD
      CALL PLOT (6.0,0.0,999)
      STOP
      END
```

FIGURE 12
INPUT DATA
FOR
EXAMPLE 2

```
COMMENTS
   4
  10    FLOW DATA FOR STATION 1 GAGE 2050 FOLLOWS
      28     49      2      2      2      2      2     16    418    585    773    911    350
      29    285      2      2      2      2      2      2      2      5    324   1049    100
     FLOW CARDS REPEATED FOR EACH YEAR OF RECORD TO BE USED FOR STATION 1
     LAST CARD OF EACH STATION FLOW DATA SET MUST BE A BLANK CARD
  30    FLOW DATA FOR STATION 3 GAGE 2060 FOLLOWS
      28   1000    200    300    546   1038   2477   1218    200   1949   1200   1870   2252
      29   1000    385    794    862    825    371    200    200    200   1434   1934   2485
     FLOW CARDS REPEATED FOR EACH YEAR OF RECORD TO BE USED FOR STATION 3
     LAST CARD OF EACH STATION FLOW DATA SET MUST BE A BLANK CARD
  80    FLOW DATA FOR STATION 8 GAGE 2070 FOLLOWS
      29    45.    39.    36.    35.    33.    37.    66.   293.   387.    98.    38.    35.
     FLOW CARDS REPEATED FOR EACH YEAR OF RECORD TO BE USED FOR STATION 8
     LAST CARD FOR EACH STATION FLOW DATA SET MUST BE A BLANK CARD
  90    FLOW DATA FOR STATION 9 GAGE 2080 FOLLOWS
      41     0.     0.     0.     0.     0.     0.     0.     0.  1824.   729.   487.   375.
     FLOW CARDS REPEATED FOR EACH YEAR OF RECORD TO BE USED FOR STATION 9
     LAST CARD FOR EACH STATION FLOW DATA SET MUST BE A BLANK CARD
 2 1 9 14260     10000.
 4 1 8 34260    150000.
   2   4    5   42   60
4260 2 8 9        10
       .5        .5
 6 210 54260    100000.      40000.
```

FIGURE 13
MAIN PROGRAM, SUBROUTINES AND COMPLETE INPUT DATA FOR EXAMPLE 2

MAIN PROGRAM

```
C MAIN LINE PROGRAM
      COMMON STA (23,100,13)
      CALL PLOTS (0,0,13)
      CALL PLOT (2.0,-15.0,-3)
      CALL PLOT (0.0,2.0,-3)
      CALL SYMBOL (0.0,-.5,.07,'I',0.0,1)
      CALL SYMBOL (0.0,10.15,0.07,'I',0.0,1)
C INSERT SUBROUTINE CARDS BETWEEN THIS AND FOLLOWING COMMENT CARD
      CALL READ
      CALL COMM
      CALL COMM
      CALL SUMM
      CALL AVER
      CALL COMM
C INSERT SUBROUTINE CARDS BETWEEN THIS AND THE PREVIOUS COMMENT CARD
      CALL PLOT (6.0,0.0,999)
      STOP
      END
```

SUBROUTINE READ

```
      SUBROUTINE READ
C SUBROUTINE READ:  READS MONTHLY FLOW DATA
C STA (I,J,K) = FLOW DATA I=STA# J=YEAR K= MONTH
C DNA(I,J) = TEMPORARY VARIABLE FOR FLOW DATA READ FROM CARD
C NUM = STA NUMBER
C NUMSTA = TOTAL NUMBER OF STATIONS TO BE READ
C NZ(I) = YEAR OF DATA
      COMMON STA (23,100,13)
      DIMENSION  DAY (12)
      DIMENSION DNA(100,13),NZ(100)
      DATA DAY /31.0,30.0,31.0,31.0,28.0,31.0,30.0,31.0,30.0,31.0,
     131.0,30.0/
C  ZERO OUT STATION ARRAYS
      DO 9 I = 1,23
      DO 8 J = 1,100
      DO 7 K = 1,13
      STA(I,J,K) = 0
    7 CONTINUE
    8 CONTINUE
    9 CONTINUE
C  READ # OF STATIONS TO BE INPUT WITH READ SUBROUTINE
      READ ( 5,5) NUMSTA
    5 FORMAT (I4)
      WRITE (6,31)  NUMSTA
   31 FORMAT ( '1SUBROUTINE READ',/,' ',I3,' STATIONS WILL BE READ')
      DO 20 N= 1,NUMSTA
C  READ  STA #
      READ (5,11)  NUM,NCODE
   11 FORMAT (I4,I1)
C  READ STATION FLOWS
      DO 15 I=1,100
      READ (5,12) NZ(I),(DNA(I,J),J=1,12)
      IF (NZ(I).EQ.0) GO TO 30
   12 FORMAT (6X,I2,12F6.0)
   15 CONTINUE
   30 CONTINUE
      NYRST = NZ(1)
      NYREN = NZ(I-1)
      IF (NCODE.EQ.1) GO TO 41
      GO TO 42
```

FIGURE 13 CONTINUED

```
   41 DO 43 I=NYRST,NYREN
      DO 44 J=1,12
      DNA(I,J)=DNA(I,J)*50.42/DAY(J)
   44 CONTINUE
   43 CONTINUE
   42 CONTINUE
C  PUT FLOW DATA INTO 3 DIMENSIONAL ARRAY
      DO 17 J = NYRST,NYREN
      DO 16 K =2,13
      L =J-NYRST+ 1
      STA(NUM,J,K) = DNA(L,K-1)
   16 CONTINUE
      STA(NUM,J,1) = NZ(L) + 1900
   17 CONTINUE
C  PRINT OUT STATION ARRAY
      WRITE (6,21) NUM
   21 FORMAT('1',40X,'MONTHLY FLOW DATA FOR STATION',I4,/)
      IF (NCODE.EQ.0)  GO TO 23
      WRITE (6,25)
   25 FORMAT(' ',44X,'FLOW IN 100 AF/MONTH',/)
      GO TO 27
   23 WRITE(6,26)
   26 FORMAT(' ',49X,'FLOW IN CFS',/)
   27 WRITE (6,22)
   22 FORMAT(' ',T6,'YEAR',T16,'OCT',T25,'NOV',T34,'DEC',T43,'JAN',T52,'
     1FEB',T61,'MAR',T70,'APR',T79,'MAY',T88,'JUN',T97 ,'JUL',T106,'AUG'
     2,T115,'SEP')
       DO 18 NN= NYRST,NYREN
   18 WRITE (6,19) (STA(NUM,NN,K),K=1,13)
   19 FORMAT (' ',13F9.0 )
   20 CONTINUE
      RETURN
      END
```

SUBROUTINE AVER

```
      SUBROUTINE AVER
C THIS SUBROUTINE FINDS WEIGHTED AVERAGE OF UP TO 5 GAGES THE
C WEIGHTED GAGE WILL BE USED AS A REPRESENTATIVE GAGE LATER
C NA=STARTING YEAR,  NB = ENDING YEAR
C N= NUMBER OF GAGES TO BE AVERAGED
C NC(I) = NUMBERS OF GAGES TO BE AVERAGED
C NN = WHERE TO PUT AVERAGED GAGE WITHIN COMMON ARRAY
C  W(I) = WEIGHTINGS ASSIGNED TO EACH GAGE
C   COSTA ARRAY = MONTHLY FLOW * DAYS IN MONTH
C   ROSTA ARRAY = MONTHLY VOLUME FRACTION
C   SUM(I) = TOTAL CFS DAYS FOR GAGE I
C   TSUM == WEIGHTED SUM = SUM OF SUM(I) * WEIGHT(I)
C   SUBROUTINE WILL NOT HANDLE ZEROS FOR FLOWS BETWEEN YEARS NA AND NB
      COMMON STA (23,100,13)
      DIMENSION W(5),NC(5),RASTA(1,100,13),COSTA(5,100,13),SUM(5)
      DIMENSION  DAY(12)
      DATA DAY /31.0,30.0,31.0,31.0,28.0,31.0,30.0,31.0,30.0,31.0,31.0,
     130.0/
C   READ INPUT DATA
      READ (5,1) NA,NB,N,(NC(I),I=1,5),NN
    1 FORMAT (9I2)
      READ (5,2) (W(I),I=1,N)
    2 FORMAT (5F10.3)
C   PRINT SUBROUTINE HEADINGS
      WRITE (6,40)  (NC(I),W(I),I=1,N)
   40 FORMAT ('1SUBROUTINE AVER',/,' THE FOLLOWING STATIONS',/,
     1  ' ARE AVERAGED',//,' STATION  WEIGHT',/,5(I5,  F10.3,/))
C   ZERO ARRAYS AND SUMMING VARIABLES
      DO  15 I=1,N
   15 SUM(I)=0.0
```

```
      DO 17 J=1,100
      DO 18 K=1,13
   18 RASTA(1,J,K)=0.0
   17 CONTINUE
C   PUT YEAR VALUES IN VARIABLE ARRAYS RASTA AND COSTA
      DO 3 I=1,N
      DO 4 J=NA,NB
      II=NC(I)
      RASTA(1,J,1) =STA(II,J,1)
      COSTA(I,J,1)=STA(II,J,1)
C   COMPUTE FLOW VOLUMES FOR COSTA ARRAY
      DO 5 K=2,13
      COSTA (I,J,K)=STA(II,J,K)*DAY(K-1)
      SUM(I)=SUM(I)+STA(II,J,K)*DAY(K-1)
    5 CONTINUE
    4 CONTINUE
C   COMPUTE FLOW FRACTION VALUES FOR RASTA ARRAY
      DO 6 J=NA,NB
      DO 7 K=2,13
    7 RASTA(1,J,K)=COSTA(I,J,K)/SUM(I)*W(I)+RASTA(1,J,K)
    6 CONTINUE
    3 CONTINUE
C   COMPUTE WEIGHTED SUM OF FLOWS
      TSUM = 0.0
      DO 42 I = 1,N
   42 TSUM = TSUM + W(I) * SUM(I)
C   COMPUTE NEW WEIGHTED STATION FLOWS
      DO 8 J=NA,NB
      STA (NN,J,1)=STA(II,J,1)
      DO 9 K=2,13
    9 STA(NN,J,K)=RASTA(1,J,K)*TSUM/DAY(K-1)
    8 CONTINUE
C PRINT WEIGHTED FLOWS
      WRITE (6,45) NN
   45 FORMAT(' ',50X,'WEIGHTED FLOWS',/,48X,'STATION NUMBER',
     1I3,/,51X,'FLOW IN CFS',/)
      DO 11 J=NA,NB
      WRITE (6,10) (STA(NN,J,K),K=1,13)
   10 FORMAT (1X,13F9.2 )
   11 CONTINUE
      RETURN
      END
```

SUBROUTINE SUMM

```
      SUBROUTINE SUMM
C SUBROUTINE SUMATION ADDS TWO STATION FLOW VALUES STORES AND
C  WRITES SUMATION IN A STATION FILE
C  A NEGATIVE STATION VALUE FOR NN CAUSES SUMMATION TO BE N - NN
      COMMON STA (23,100,13)
C READ #S OF TWO STATIONS TO BE ADDED,# OF STATION WHERE SUM IS STORED
      READ (5,5) N,NN,NNN,NA,NB
    5 FORMAT (5I4)
C SUM STATION N AND NN FLOW VALUES AND STORE IN PROPER STATION
C  IF NEGATIVE FLOWS RESULTS THEY ARE ASSIGNED Q=.2 CFS
      MM=NN
      IF(NN.GT.0) GO TO 2
      NN = -NN
    2 CONTINUE
      DO 9 J = NA,NB
      DO 8 K = 2,13
      IF (STA(N,J,K).EQ.0) GO TO 8
      IF (STA(NN,J,K).EQ.0) GO TO 8
      IF(MM.LT.0) GO TO 6
C   SUM STA1 AND STA2
```

```
      STA(NNN,J,K) = STA(N,J,K) + STA (NN,J,K)
      IF(STA(NNN,J,K).GE.0.0) GO TO 8
      STA(NNN,J,K)  = 0.2
      GO TO 8
C   TAKE DIFFERENCE OF STA1 AND STA2
    6 STA(NNN,J,K) = STA(N,J,K) - STA  (NN,J,K)
      IF(STA(NNN,J,K).GE.0.0) GO TO 8
      STA(NNN,J,K)  = 0.2
    8 CONTINUE
      STA(NNN,J,1) = STA(N,J,1)
    9 CONTINUE
C WRITE OUT SUMMATIONS
      WRITE (6,3)
    3 FORMAT('1 SUBROUTINE SUMM')
      WRITE (6,12) N,NN,NNN
   12 FORMAT(' THE FOLLOWING IS THE SUM OF',/,' STATION'
     1,I3,' AND',I3,//,50X,'SUMMATION FLOWS',/,49X,
     2'STATION NUMBER',I3,/,52X,'FLOW IN CFS',/)
      WRITE(6,22)
   22 FORMAT(' ',T6,'YEAR',T16,'OCT',T25,'NOV',T34,'DEC',T43,'JAN',T52,'
     1FEB',T61,'MAR',T70,'APR',T79,'MAY',T88,'JUN',T97 ,'JUL',T106,'AUG'
     2,T115,'SEP')
      DO 18 M= NA,NB
   18 WRITE ( 6,19)  (STA(NNN,M,K),K=1,13)
   19 FORMAT (' ',13F9.0 )
      RETURN
      END
```

SUBROUTINE COMM

```
      SUBROUTINE COMM
C  THIS SUBROUTINE COMPUTES A RECORD OF MONTHLY FLOWS AT
C  UNGAGED POINTS
      COMMON STA (23,100,13)
      DIMENSION RATIO(12)
      DIMENSION DAY(12),VOL(10),PL(100,13),DNA(100,13),AVEMO(13)
      DIMENSION  Q(1200),NCHECK(100)
      DIMENSION P(100,13)
      DIMENSION PLL(100,13),DNAA(100,13),F(100,13)
C DAYS IN EACH MONTH
      DATA DAY/31.0,30.0,31.0,31.0,28.0,31.0,30.0,31.0,30.0,31.0,31.0,
     130.0/
   72 FORMAT(' ',T6,'YEAR',T16,'OCT',T25,'NOV',T34,'DEC',T43,'JAN',T52,'
     1FEB',T61,'MAR',T70,'APR',T79,'MAY',T88,'JUN',T97 ,'JUL',T106,'AUG'
     2,T115,'SEP')
C READ DATA CARD
      READ(5,10) NUSR,NUMR,NCG,NO,NNA,NNB,(VOL(I),I=1,NUMR)
   10 FORMAT(6I2,6F10.0)
C   PRINT HEADINGS FOR SUBROUTINE
      WRITE (6,25) NUMR,NCG,NO
   25 FORMAT('1','SUBROUTINE COMM',/,' FLOWS FOR',I2,
     1' STATIONS WILL BE COMPUTED',/,' REPRESENTATIVE STATION=',
     2I3,/,' UPSTREAM STATION =',I3,/)
      MM = NUMR + NUSR - 1
      WRITE (6,26)  (J,VOL(J-NUSR+1),J=NUSR,MM)
   26 FORMAT(' COMPUTED  AVERAGE RUNOFF',/,' STATION     CFS DAYS',
     1/,5(I6,F17.0,/))
C ZERO OUT ARRAYS
```

```
      DO 121 I=1,100
      DO 122 J=1,13
      P(I,J)=0
      PL(I,J)=0
      DNA(I,J)=0
  122 CONTINUE
  121 CONTINUE
      DO 23 J=1,13
   23 AVEMO(J)=0
C PUT DATA INTO TWO-DIMENSIONAL ARRAYS
      DO 15 I=NNA,NNB
      PL(I,1)=STA(NCG,I,1)
      DNA(I,1)=STA(NO,I,1)
      DO 16 J=2,13
      PL(I,J)=STA(NCG,I,J)*DAY(J-1)
      DNA(I,J)=STA(NO,I,J)*DAY(J-1)
   16 CONTINUE
   15 CONTINUE
C CHECK FOR ZEROS
      NZ=0
      DO 17 I=NNA,NNB
   17 NCHECK(I)=1
      DO 18 I=NNA,NNB
      DO 19 J=2,13
      IF (PL(I,J).LT.0.1) GO TO 1000
      IF (DNA(I,J).GT.0.1) GO TO 19
 1000 NCHECK(I)=0
      NZ=NZ+1
      GO TO 18
   19 CONTINUE
   18 CONTINUE
C COPY ARRAYS INTO NONZERO ARRAYS
      NB=NNA-1
      DO 21 I=NNA,NNB
      IF (NCHECK(I).EQ.0) GO TO 21
      NB=NB+1
      PLL(NB,1)=PL(I,1)
      DNAA(NB,1)=DNA(I,1)
      DO 22 J=2,13
      PLL(NB,J)=PL(I,J)/DAY(J-1)
      DNAA(NB,J)=DNA(I,J)/DAY(J-1)
   22 CONTINUE
   21 CONTINUE
C WRITE OUT ARRAYS IN CFS
      SUM=0
      NNB=NNB-NZ
      DO 116 I=1,NUMR
  116 VOL(I)=VOL(I)*(NNB-NNA+1)
      WRITE(6,902) NCG
  902 FORMAT(' ',50X,'REPRESENTATIVE STATION FLOW',/,55X,
     1'STATION NUMBER',I4,/,59X,'FLOW IN CFS',/)
      WRITE(6,72)
      DO 901 I=NNA,NNB
  901 WRITE(6,202) (PLL(I,J),J=1,13)
      WRITE (6,904) NO
```

```
  904 FORMAT('1',54X,'UPSTREAM INFLOW',/,53X,
     1'STATION NUMBER',I4,/,57X,'FLCW IN CFS',/)
      WRITE(6,72)
      DO 905 I=NNA,NNB
  905 WRITE(6,202) (DNAA(I,J),J=1,13)
      DO 117 I=NNA,NNB
      DO 118 J=2,13
      PLL(I,J)=PLL(I,J)*DAY(J-1)
  118 DNAA(I,J)=DNAA(I,J)*DAY(J-1)
  117 CONTINUE
      DO 98 I=NNA,NNB
      DO 97 J=2,13
   97 SUM=SUM+PLL(I,J)
   98 CONTINUE
C DETERMINE FRACTIONAL ARRAY
      DO 105 I=NNA,NNB
      DO 106 J=2,13
  106 F(I,J)=PLL(I,J)/SUM
  105 CONTINUE
C COMPUTE SYNTHETIC GAGE RECORDS FOR REACHES
      NY=1
  110 NUM=0
      NYEAR =0
      DO 108 I=NNA,NNB
      NYEAR=NYEAR+1
      DO 109 J=2,13
      P(I,1)=PLL(I,1)
      P(I,J)=DNAA(I,J)+F(I,J)*VOL(NY)
      IF(P(I,J).GE.0.0) GO TO 2
      P(I,J) = 0.2
    2 NUM = NUM + 1
      Q(NUM)=P(I,J)/DAY(J-1)
      AVEMO(J)=AVEMO(J)+P(I,J)
  109 CONTINUE
  108 CONTINUE
C  COMPUTE AVERAGE ANNUAL RUNOFF AND AVERAGE MONTHLY FLOWS
      AAR=0
      DO 250 J=2,13
      AAR = AAR + AVEMO(J)
      AVEMO(J)=AVEMO(J)/NYEAR/DAY(J-1)
  250 CONTINUE
      AAR=AAR/NYEAR/365
      DO 601 J = 2,13
  601 RATIO(J-1) = AVEMO(J)/AAR
      DO 113 I=NNA,NNB
      DNAA(I,1)= P(I,1)
      DO 111 J=2,13
  111 DNAA(I,J)=P(I,J)
  113 CONTINUE
      DO 503 I=1,100
      IF (P(I,1).GT.0.1) GO TO 500
      GO TO 503
  500 KKK=P(I,1)-1900
  501 DO 504 J=2,13
      STA(NUSR,KKK,1)=P(I,1)
```

FIGURE 13 CONTINUED

```
  504 STA(NUSR,KKK,J)=P(I,J)/DAY(J-1)                                  MOD03310
  503 CONTINUE                                                         MOD03320
C  WRITE OUT ARRAYS                                                    MOD03330
      WRITE (6,545) NUSR                                               MOD03340
  545 FORMAT ('1',50X,'COMPUTED FLOW',/,49X,'STATION NUMBER',          MOD03350
     1I3,/,52X,'FLOW IN CFS',/)                                        MOD03360
      WRITE(6,72)                                                      MOD03370
      DO 201 I=NNA,NNB                                                 MOD03380
  201 WRITE(6,202)  (STA(NUSR,I,J),J=1,13)                             MOD03390
  202 FORMAT (1X,13F9.0 )                                              MOD03400
      WRITE (6,29)                                                     MOD03410
   29 FORMAT (///,50X,'MONTHLY AVERAGES IN CFS',/)                     MOD03420
      WRITE (6,73)                                                     MOD03430
   73 FORMAT(' ',          T16,'OCT',T25,'NOV',T34,'DEC',T43,'JAN',T52,'MOD03440
     1FEB',T61,'MAR',T70,'APR',T79,'MAY',T88,'JUN',T97 ,'JUL',T106,'AUG'MOD03450
     2,T115,'SEP')                                                     MOD03460
      WRITE (6,30)  (AVEMO(J),J=2,13)                                  MOD03470
   30 FORMAT (10X,12F9.0 )                                             MOD03480
      WRITE (6,31) AAR                                                 MOD03490
   31 FORMAT (/,1X,' AVERAGE ANNUAL FLOW=',F10.0,' CFS')               MOD03500
      WRITE (6,605)                                                    MOD03510
  605 FORMAT (' ',40X,'RATIO OF AVG MONTHLY FLOW TO AVG ANNUAL FLOW',/) MOD03520
      WRITE(6,73)                                                      MOD03530
      WRITE (6,607)  (RATIO(J), J=1,12)                                MOD03540
  607 FORMAT (10X,12F9.3 )                                             MOD03550
      CALL DURA(NUSR,NUM,Q,NNA,NNB)                                    MOD03560
      IF(NY.EQ.NUMR) GO TO 700                                         MOD03570
      NY=NY+1                                                          MOD03580
      NUSR=NUSR+1                                                      MOD03590
      GO TO 110                                                        MOD03600
  700 RETURN                                                           MOD03610
      END                                                              MOD03620
```

SUBROUTINE DURA

```
      SUBROUTINE DURA (NSTA,NUM,Q,NYRST,NYREN)                         MOD03630
      DIMENSION CLASS(46),NCOUNT(47),NTOTGT(47),PERCEN(47),B(47)       MOD03640
C  THIS SUBROUTINE COMPUTES DURATION VALUES FOR FLOW RECORD 'Q'        MOD03650
C  SUBROUTINE USES FLOW CLASS SCHEME OF COMPUTATION                    MOD03660
      DIMENSION Q(1200),MONTHS(12)                                     MOD03670
      DIMENSION QPER(7),CPER(7)                                        MOD03680
      DATA CPER/95.,80.,50.,30.,10./                                   MOD03690
      DATA NCLASS/46/                                                  MOD03700
C  THE FOLLOWING STATEMENT CONTAINS THE CLASS INTERVAL BOUNDARIES      MOD03710
C  THESE VALUES CAN BE CHANGED BY CHANGING THE NUMBERS IN THE          MOD03720
C  DATA STATEMENT                                                      MOD03730
      DATA CLASS /0.,5.,10.,30.,50.,70.,100.,150.,200.,300.,400.,500., MOD03740
     1600.,700.,800.,900.,1000.,1200.,1500.,1800.,2000.,2500.,3000.,   MOD03750
     13500.,4000.,4500.,5000.,5500.,6000.,6500.,7000.,7500.,8000.,8500.,MOD03760
     19000.,9500.,10000.,15000.,20000.,25000.,30000.,35000.,40000.,    MOD03770
     145000.,50000.,200000./                                           MOD03780
      QSUM=0                                                           MOD03790
C     COMPUTE CLASS FOR EACH FLOW AND TOTAL COUNTS IN EACH CLASS       MOD03800
      DO 30 N=1,NCLASS                                                 MOD03810
   30 NCOUNT(N)=0                                                      MOD03820
      N = NCLASS/2                                                     MOD03830
      DO 40 I=1,NUM                                                    MOD03840
      IF(Q(I).GE.CLASS(NCLASS))  GO TO 40                              MOD03850
```

```
      IF (Q(I).LT.CLASS(1))  GO TO 40
   26 CONTINUE
      IF (Q(I).GE.CLASS(N).AND.Q(I).LT.CLASS(N+1)) GO TO 32
      IF(Q(I).LT.CLASS(N))  GO TO 27
      N = N+ 1
      GO TO 26
   27 N = N- 1
      GO TO 26
   32 NCOUNT(N+1)=NCOUNT(N+1)+1
   40 CONTINUE
C     COMPUTE TOTAL COUNTS ANDCHECK AGAINST TOTAL # OF FLOWS
      NTOT=0
      DO 45 I=1,NCLASS
   45 NTOT=NTOT+NCOUNT(I)
      IF(NTOT.EQ.NUM) GO TO 48
      WRITE (6,46) NTOT,NUM
   46 FORMAT (//,' TOTAL COUNTS =',I6,' TOTAL FLOWS =',I6,
     1' CHECK INTERVALS',/)
C     COMPUTE PERCENTAGES
   48 NTOTGT(NCLASS +1)=0
      NCOUNT(NCLASS+1)=0
      DO 52 M=1,NCLASS
      N=NCLASS+1-M
      NTOTGT(N)=  (NTOTGT(N+1)-NCOUNT(N+1)   )
      B(N)=-NTOTGT(N)
      C=NTOT
   52 PERCEN(N)=B(N)/C * 100.
C     OUTPUT DURATION TABLE
      WRITE (6,47) NSTA,NYRST,NYREN
   47 FORMAT('1',22X,'STATION',I3,/,23X,'WATER YEAR',/,22X,
     1I3,' THRU',I3,/)
      WRITE(6,60)
   60 FORMAT(' CLASS',5X,'LOWER',5X,'UPPER   INTERVAL     NUMBER    PERCENT
     1',/,10X,  ' LIMIT     LIMIT    COUNT     GREATER     GREATER',/,
     210X,'  CFS         CFS')
      DO 62  N= 2,NCLASS
      M=N-1
      WRITE(6,65) M,CLASS(N-1),CLASS(N),NCOUNT(N),      B(N),PERCEN (N)
   65 FORMAT(I5,2F10.2,I10,F10.0,F10.0)
   62 CONTINUE
   70 CONTINUE
      N= 2
C COMPUTE SEMI-LOG INTERPOLATED 95,80,50,30,AND 10 PERCENT
C  EXCEEDANCE FLOWS
      DO 560 I = 1,5
      DO 550 K = N,NCLASS
      IF (PERCEN(K).LT.CPER(I))GO TO 500
      IF (PERCEN(K+1).GT.CPER(I)) GO TO 550
      QPER(I)=10**(((ALOG10(CLASS(K+1))-ALOG10(CLASS(K)))
     1/(PERCEN(K)-PERCEN(K+1))*(PERCEN(K)-CPER(I)))+ALOG10(CLASS(K)))
      GO TO 560
  550 CONTINUE
  500 QPER (I) = CLASS(K-1)
      WRITE (6,502) CPER(I)
  502 FORMAT (/,' ALL EXCEEDANCE % LESS THAN',F6.0,' PERCENT',/)
```

FIGURE 13 CONTINUED

```
  560 CONTINUE
C  WRITE OUT INTERPOLATED FLOWS
      WRITE (6,504) NSTA
  504 FORMAT(/,'          STATION ',I3 ,/,' EXCEEDANCE       FLOW')
      WRITE (6,506) (CPER(I),QPER(I),I=1,5)
  506 FORMAT(F8.0,3X,F12.2)
C  CALL PLOTTING SUBROUTINE
      CALL PLTDUR(NSTA  ,NCLASS,CLASS,PERCEN,CPER,QPER,NYRST,NYREN)
      RETURN
      END
```

SUBROUTINE PLTDUR

```
      SUBROUTINE PLTDUR (NSTA,NCLASS,CLASS,PERCEN,CPER,QPER,NYRST,NYREN)
C    SUBROUTINE PLTDUR USED TO MAKE PLOTS OF DURATION DATA
      DIMENSION  CLASS (46),PERCEN(47),X(50),Y(50),CPER(7),QPER(7)
      STA = FLOAT (NSTA)
C  ROUTINE TO ELIMINATE ALL BUT ONE ZERO VALUE AND ALL
C  BUT ONE 100 PERCENT VALUE
      N = 0
      DO 20 I = 2,NCLASS
      IF (PERCEN(I).GT.99.999)  GO TO 20
      IF (PERCEN(I).LT..0001) GO TO 15
      N = N + 1
      IF (I.EQ.2)  GO TO 17
      IF (N.GT.1)  GO TO 17
      X(N) = PERCEN(I-1)
      Y(N) = CLASS (I-1)
      N = N + 1
       GO TO 17
   15 N = N+ 1
       X(N) = PERCEN (I)
      Y(N) = CLASS (I)
      GO TO 21
   17 X(N) = PERCEN(I)
      Y(N) = CLASS(I)
   20 CONTINUE
   21 NMPTS = N
      CALL PLOT (1.5,0.0,-3)
C  THE FOLLOWING STATEMENT CONTROLS WHETHER A LOG OR ARITHMETIC
C  PLOT IS MADE. 'LOG =1' = LOG PLOT, 'LOG=0' = ARITHMETIC PLOT
      CALL PLOT (1.5,0.0,-3)
      LOG = 1
      IF(LOG.EQ.1) GO TO 65
      CALL SCALE(Y,9.0,NMPTS,1)
      CALL AXIS (0.0,0.0,'FLOW IN CFS',11,9.0,90.,
     1Y(NMPTS+1),Y(NMPTS+2))
      GO TO 67
   65 CALL SCALG (Y,9.0,NMPTS,1)
      CALL LBAXS (0.0,0.0,'FLOW IN CFS', 11,9.0,90.,Y(NMPTS+1),Y(NMPTS
     1+ 2))
   67 CONTINUE
      X(NMPTS+1) = 0.0
      X(NMPTS+2) = 20.0
      CPER(6) = X(NMPTS + 1)
      CPER(7) = X(NMPTS + 2)
      QPER(6) = Y(NMPTS+ 1)
      QPER(7) = Y(NMPTS + 2)
```

```
      CALL AXIS (0.0,0.0,'EXCEEDANCE PERCENTAGE',-21,5.0,0.0,X(NMPTS+1),
     1X(NMPTS+2))
      IF(LOG.EQ.1)  GO TO 69
      CALL LINE (X,Y,NMPTS,1,-1,4)
      CALL GRID (0.0,0.0,1.0,1.0,5,9)
      GO TO 72
   69 CALL LGLIN (X,Y,NMPTS,1,-1,4,+1)
   72 CONTINUE
      CALL SYMBOL(.75,9.75,.14,        'DURATION CURVE FOR STATION',0.0,
     126)
      YRST = FLOAT (NYRST )
      YREN = FLOAT (NYREN)
      CALL NUMBER (2.3,9.55,.14,STA,0.0,-1)
      CALL SYMBOL (1.8,9.35,.14,'WATER YEAR',0.0,10)
      IF ((NYRST+1).NE.NYREN)  GO TO 61
      CALL NUMBER (2.4,9.15,.14,YRST,0.0,4)
      GO TO 63
   61 CONTINUE
      CALL NUMBER (1.82,9.15,.14,YRST,0.0,-1)
      CALL SYMBOL (2.2,9.15,.14,'THRU',0.0,4)
      CALL NUMBER (2.9,9.15,.14,YREN,0.0,-1)
   63 CONTINUE
      IF (LOG.NE.1)  GO TO 25
C PLOT LOG GRIDS
      NMGRD = 9.1 * Y(NMPTS + 2)
      DO 25 I = 1,NMGRD
      X1 = 0.0
      Y1 = I/Y(NMPTS + 2)
      CALL PLOT (X1,Y1,3)
      X2 = 5
      CALL PLOT (X2,Y1,2)
   25 CONTINUE
C   PLOT 10,30,50,80,95 LINES AND LABEL
      DO 40 I = 1,6
      Y1 =0.02
      IF (I.GT.3) GO TO 28
      X1 = .5 + (I-1) -.14
      PER = 10.+ (I-1) * 20.
      GO TO 35
   28 CONTINUE
      IF ( I.GT.4) GO TO 30
      X1 = 3.86
      PER = 80
      GO TO 35
   30 CONTINUE
      IF ( I.GT.5) GO TO 32
      X1 = 4.61
      PER = 95.
      GO TO 35
   32 X1 = 5.0
      Y1 = 0.0
   35 CONTINUE
      IF (Y1.LT.0.0001)  GO TO 37
      CALL NUMBER (X1,Y1,.14,PER,0.0,-1)
      Y1 = .27
```

FIGURE 13 CONTINUED

```
      X1 = X1 + .14
   37 CONTINUE
      CALL PLOT (X1,Y1,3)
      Y2 = 9.0
      CALL PLOT (X1,Y2,2)
   40 CONTINUE
      CALL SYMBOL(5.3,8.6,.14,'%      Q',0.0,7)
      DO 50  I=1,5
      YPOS = 8.4-I*.2
      CPES = CPER(I)
      QPES = QPER(I)
      CALL NUMBER(6.2,YPOS,.10,QPES    ,0,2)
      CALL NUMBER(5.3,YPOS,.10,CPES    ,0,0)
   50 CONTINUE
      CALL PLOT (7.0,0.0,-3)
      CALL SYMBOL (0.0,-.5,.07,'I',0.0,1)
      CALL SYMBOL (0.0,10.15,0.07,'I',0.0,1)
      RETURN
      END
```

FIGURE 13 CONTINUED

INPUT DATA FOR EXAMPLE 2

```
4
10   FLOW DATA FOR STATION 1 GAGE 2050 FOLLOWS
  28    49     2     2     2     2     2    16   418   585   773   911   350
  29   285     2     2     2     2     2     2     2     5   324  1049   100
  30   337     2     2     2     2     2     2     2   155   708   620   159
  31   231     2     2     2     2     2     2   107     2   219   836   100
  32     4     2     2     2     2     2     2     2   438   652   867   350
  33   381     2     2     2     2     2     2     2   144   625   864   343
  34   415     2     2     2     2     2     2   262   208   250   992   160
  35   229     2     2     2     2     2     2     2     5   795   906   168
  36   218     2     2     2     2     2     2     2   255   706   844   339
  37   368     2     2     2     2     2     2     2   154   631   828   100
  38    14     2     2     2     2     2     2     2   803   750   850   422
  39   245     2     2     2     2     2     2     2    40   603   979   100
  40   279     2     2     2     2     2     2     2   314   589   821   350
  41   175     2     2     2     2     2     2     2   242   621   906   350
  42   318     2     2     2     2     2     2     2   250   680   881   339
  43   382     2     2     2     2     2   541   480   208   750   850   624
  44   152     2     2     2     2     2     2   144     5   392   990   100
  45   261     2     2     2     2     2     2     2    43   678   862   341
  46   248     2     2     2     2     2     2   193   770   750   850   350
  47     4     2     2     2     2     2    52   354   660   750   850   350
  48     4     2     2     2     2     2    51   200   674   750   880   339
  49   233     2     2     2     2     2     2     2   461   694   862   339
  50    97     2     2     2     2     2    18     2   653   750   850   602
  51   158     2     2     2     2     2   155   128   788   750   850   350
  52     4     2     2     2     2     2   754   252   593   750   850   350
  53   339     2     2     2     2     2     2     2   551   750   850   625
  54   324     2     2     2     2     2     2    97   798   750   850   357
  55   311     2     2     2     2     2     2     2     5   693   930   350
  56    89     2     2     2     2     2   873   522   529   750   850   350
  57     4     2     2     2     2     2   544     2   779   750   951   350
  58   170     2     2     2     2     2     2   428   672   799   973   346
  59   397     2     2     2     2     2     2     2   250   805   833   350
  60     4     2     2     2     2     2     2     2   544   742   894   341
  61   395     2     2     2     2     2     2     2     5   491   855   350
  62   199     2     2     2     2     2     2     2   457   777   935   350
  63     4     2     2     2     2    46     2   260   795   799   888   350
  64   197     2     2     2     2     2     2     2   289   750   850   350
  65   380     2     2     2     2     2   203   691   931   750   850   583
  66     4     2     2     2     2     2     2     2   338   597   829   350
  67   359     2     2     2     2     2     2     2   287   750   850   499
  68     4     2     2     2     2     2     2   363   131   662   860   350
  69   149     2     2     2     2     2   600   350   289   799   825   350
  70   103     2     2     2     2     2     2     2  1020   750   850   506
  71   196     2     2     2     2     2   692   509  1146   786   850   750
  72    75     2     2     2     2     2   402   244   797   750   850   353
  73    79     2     2     2     2     2     2     2   189   595   880   350
  74   178     2     2     2     2     2   854   758   544  1034   850   750
  75   160     2     2     2     2     2   307   179    77   750   850   501

30   FLOW DATA FOR STATION 3 GAGE 2060 FOLLOWS
  28  1000   200   300   546  1038  2477  1218   200  1949  1200  1870  2252
  29  1000   385   794   862   825   371   200   200   200  1434  1934  2485
  30  1000   590   467   620   367   165   165   200   243  1101  1906  1551
```

FIGURE 13 CONTINUED

31	1018	376	305	200	200	329	165	165	776	800	798	656
32	350	200	200	200	200	165	165	200	200	1000	1962	2283
33	1000	351	971	880	891	347	200	200	200	1462	2026	2113
34	1029	353	604	200	259	200	200	399	1618	2248	1733	2000
35	1000	381	230	249	223	560	165	200	200	1149	1607	1697
36	1138	200	200	200	200	272	200	200	200	1873	2179	2289
37	1102	672	814	200	200	319	165	200	200	924	1317	1430
38	1192	254	200	488	392	165	200	200	1907	1236	1676	2122
39	1000	486	886	1020	717	200	200	200	1946	1684	1716	2430
40	1186	571	486	481	200	200	200	200	200	2003	2237	1784
41	1000	210	482	553	502	200	200	200	200	1558	1872	1983
42	1000	200	238	666	242	200	200	200	2174	1431	2154	2387
43	1000	200	200	400	567	2997	1751	363	867	1971	1633	1868
44	1000	426	1001	1334	735	717	200	200	200	1674	2028	2290
45	1000	383	896	500	200	165	165	200	200	1174	1941	2187
46	1000	232	269	231	263	200	578	200	949	1343	1983	2039
47	1000	200	300	908	302	2560	956	693	2165	1304	1980	2052
48	1000	414	776	778	365	1362	1054	200	3296	1391	2011	2231
49	1000	406	721	916	250	200	200	1743	1282	1720	2112	2219
50	1000	309	896	527	200	200	1297	200	896	1717	1955	1982
51	1000	323	583	895	408	2983	1312	200	849	1000	1824	2138
52	1000	379	300	1055	2369	2081	678	1311	2119	1096	1942	2113
53	1000	580	817	400	200	1215	1297	289	1398	1381	1890	2017
54	1000	528	795	881	200	1316	1614	219	1544	1098	1939	2152
55	1000	464	919	857	889	646	200	200	200	1000	2013	2138
56	1000	200	300	400	2588	2350	783	802	1805	1000	1991	2247
57	1000	473	469	1103	435	1810	571	595	2046	1190	1919	2271
58	1000	454	589	521	200	722	1390	824	1560	1210	1860	2167
59	1000	322	545	754	494	342	200	200	1711	1314	1967	1500
60	1000	565	995	1185	253	200	200	459	2267	1715	1932	2229
61	1000	375	773	769	200	200	200	200	330	2303	2234	2017
62	1000	442	673	727	200	200	200	200	200	1359	1924	2198
63	1000	200	323	1061	1042	1341	200	881	2186	1121	1839	1977
64	1000	374	636	1103	740	218	200	200	1861	1000	2084	2173
65	1000	565	300	780	3041	2135	1245	829	2245	1000	1500	1500
66	1166	591	895	982	928	210	200	419	900	2200	2265	2313
67	1000	437	682	298	392	200	241	200	395	1101	2220	2278
68	1000	592	750	1076	200	200	896	200	200	1863	1500	1934
69	1000	200	498	400	1292	2343	421	413	997	1234	2054	2284
70	1000	561	901	400	200	1034	699	200	2974	1000	2120	1787
71	1000	200	300	1351	3120	2616	996	1286	2534	1439	1713	1659
72	1000	624	684	400	2215	2611	200	367	2027	1000	1840	1938
73	1000	626	458	586	785	200	368	200	544	2049	2177	2037
74	1000	200	200	400	2164	3486	988	1695	1722	2091	1659	1891
75	1000	713	1019	1123	335	326	1206	200	691	1942	1695	2138

80 FLOW DATA FOR STATION 8 GAGE 2070 FOLLOWS

29	45.	39.	36.	35.	33.	37.	66.	293.	387.	98.	38.	35.
30	42.	37.	57.	47.	43.	49.	381.	500.	316.	81.	43.	37.
31	44.	31.	22.	21.	24.	39.	164.	476.	127.	35.	19.	27.
32	32.	39.	37.	36.	40.	48.	131.	516.	577.	162.	59.	38.
33	41.	43.	28.	29.	27.	28.	49.	155.	628.	129.	56.	39.
34	37.	34.	32.	31.	37.	76.	316.	365.	131.	54.	31.	28.
35	40.	51.	40.	35.	35.	41.	121.	457.	418.	86.	39.	31.
36	32.	34.	30.	32.	35.	38.	252.	698.	348.	77.	40.	36.

FIGURE 13 CONTINUED

37	28.	26.	26.	24.	27.	30.	60.	383.	280.	81.	38.	31.
38	32.	38.	95.	50.	45.	57.	210.	650.	772.	185.	65.	47.
39	53.	50.	40.	35.	30.	47.	204.	429.	147.	63.	33.	30.
40	33.	30.	40.	40.	41.	73.	252.	582.	310.	71.	37.	45.
41	57.	57.	46.	42.	40.	63.	154.	524.	378.	99.	58.	49.
42	50.	88.	147.	70.	54.	55.	246.	393.	516.	143.	55.	39.
43	38.	63.	48.	45.	51.	60.	436.	564.	751.	363.	87.	51.
44	50.	52.	44.	36.	36.	36.	84.	287.	284.	83.	44.	37.
45	33.	46.	34.	37.	32.	38.	77.	427.	492.	131.	52.	41.
46	40.	46.	46.	60.	50.	56.	294.	713.	504.	127.	53.	48.
47	58.	65.	75.	51.	51.	85.	211.	825.	505.	126.	53.	46.
48	67.	50.	46.	65.	48.	45.	126.	624.	691.	128.	56.	43.
49	45.	48.	38.	35.	35.	45.	229.	805.	408.	90.	46.	37.
50	44.	49.	45.	45.	47.	61.	150.	445.	795.	282.	73.	52.
51	79.	87.	72.	56.	73.	69.	311.	667.	513.	168.	66.	47.
52	87.	60.	57.	51.	48.	47.	272.	825.	604.	148.	59.	42.
53	35.	34.	38.	53.	48.	51.	174.	372.	759.	276.	72.	44.
54	41.	47.	43.	39.	44.	60.	248.	703.	507.	192.	69.	47.
55	41.	41.	34.	33.	33.	37.	58.	298.	599.	148.	49.	41.
56	44.	59.	112.	84.	61.	74.	338.	899.	710.	142.	59.	42.
57	47.	48.	44.	39.	48.	54.	140.	804.	716.	136.	52.	42.
58	52.	42.	39.	33.	45.	38.	117.	844.	589.	128.	59.	42.
59	40.	60.	63.	51.	46.	44.	175.	399.	551.	116.	56.	69.
60	88.	61.	43.	40.	43.	68.	182.	398.	498.	96.	55.	37.

90 FLOW DATA FOR STATION 9 GAGE 2080 FOLLOWS

41	0.	0.	0.	0.	0.	0.	0.	0.	1824.	729.	487.	375.
42	353.	515.	684.	381.	340.	357.	1152.	1450.	2070.	1079.	450.	337.
43	306.	378.	355.	399.	381.	501.	2209.	2655.	3447.	2601.	845.	485.
44	448.	423.	325.	304.	284.	280.	568.	1429.	1562.	816.	386.	303.
45	258.	300.	253.	263.	292.	326.	602.	1854.	2306.	1073.	454.	337.
46	310.	321.	348.	337.	299.	491.	1541.	2692.	2434.	1031.	483.	392.
47	431.	425.	481.	341.	360.	583.	1054.	3037.	2308.	1094.	492.	393.
48	438.	366.	316.	352.	316.	304.	778.	2344.	3247.	1039.	479.	350.
49	332.	336.	298.	251.	252.	349.	1170.	2826.	2271.	797.	418.	332.
50	334.	355.	329.	327.	344.	397.	1014.	1996.	3293.	2006.	646.	459.
51	483.	507.	420.	337.	422.	390.	1536.	2779.	2743.	1570.	691.	426.
52	511.	398.	394.	330.	333.	321.	1462.	3085.	3079.	1243.	558.	380.
53	320.	283.	287.	336.	320.	377.	964.	1551.	3288.	1963.	629.	391.
54	328.	337.	312.	304.	368.	472.	1248.	2957.	2574.	1626.	589.	396.
55	325.	299.	265.	271.	253.	254.	384.	1611.	2737.	1175.	474.	339.
56	324.	384.	678.	466.	378.	517.	1670.	3673.	3953.	1458.	640.	425.
57	394.	389.	356.	298.	339.	424.	870.	2902.	3138.	1109.	498.	377.
58	369.	316.	314.	297.	347.	333.	729.	3701.	2898.	961.	487.	365.
59	324.	404.	412.	358.	339.	361.	971.	1483.	2652.	926.	450.	439.
60	546.	412.	325.	300.	287.	468.	987.	1542.	2358.	702.	398.	326.
61	300.	303.	256.	224.	290.	346.	649.	1759.	2023.	549.	343.	317.
62	315.	303.	297.	288.	317.	311.	1217.	1606.	2508.	1006.	503.	351.
63	598.	473.	454.	316.	644.	426.	695.	2266.	2648.	1098.	518.	403.
64	359.	395.	309.	286.	262.	285.	725.	1857.	2782.	1225.	503.	380.
65	321.	307.	735.	503.	424.	477.	1466.	2707.	4203.	2319.	871.	539.
66	423.	369.	332.	321.	266.	361.	838.	1733.	1418.	568.	327.	278.
67	275.	280.	269.	275.	271.	326.	447.	1935.	3285.	1382.	511.	371.
68	420.	377.	320.	282.	408.	476.	628.	1425.	2094.	753.	525.	413.
69	430.	469.	356.	441.	370.	445.	1645.	3207.	2636.	993.	475.	363.

FIGURE 13 CONTINUED

70	338.	300.	292.	383.	360.	405.	537.	2177.	3700.	1571.	563.	444.
71	371.	497.	416.	464.	462.	448.	1150.	3410.	4610.	2218.	773.	472.
72	394.	349.	323.	331.	345.	813.	907.	2895.	4958.	1644.	619.	455.
73	404.	342.	335.	335.	297.	340.	559.	1664.	1602.	661.	372.	333.
74	313.	648.	442.	694.	474.	679.	1465.	2661.	5751.	2463.	813.	481.

```
 2 1 9 14260     10000.
 4 1 8 34260    150000.
   2   4   5  42  60
4260 2 8 9       10
       .5          .5
 6 210 54260    100000.    40000.
```

FIGURE 14
COMPUTER OUTPUT AND PLOTTED
DURATION CURVES FOR EXAMPLE 2

SUBRCUTINE REAC
4 STATICNS WILL BE READ

MCNTHLY FLOW DATA FCR STATICN 1

FLOW IN CFS

YEAR	CCT	NOV	CEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1928.	49.	2.	2.	2.	2.	2.	16.	418.	585.	773.	911.	350.
1929.	285.	2.	2.	2.	2.	2.	2.	2.	5.	324.	1049.	100.
1930.	337.	2.	2.	2.	2.	2.	2.	2.	155.	708.	620.	159.
1931.	231.	2.	2.	2.	2.	2.	2.	107.	2.	219.	836.	100.
1932.	4.	2.	2.	2.	2.	2.	2.	2.	438.	652.	867.	350.
1933.	381.	2.	2.	2.	2.	2.	2.	2.	144.	625.	864.	343.
1934.	415.	2.	2.	2.	2.	2.	2.	262.	208.	250.	992.	160.
1935.	229.	2.	2.	2.	2.	2.	2.	2.	5.	795.	906.	168.
1936.	218.	2.	2.	2.	2.	2.	2.	2.	255.	706.	844.	339.
1937.	368.	2.	2.	2.	2.	2.	2.	2.	154.	631.	828.	100.
1938.	14.	2.	2.	2.	2.	2.	2.	2.	803.	750.	850.	422.
1939.	245.	2.	2.	2.	2.	2.	2.	2.	40.	603.	979.	100.
1940.	279.	2.	2.	2.	2.	2.	2.	2.	314.	589.	821.	350.
1941.	175.	2.	2.	2.	2.	2.	2.	2.	242.	621.	906.	350.
1942.	318.	2.	2.	2.	2.	2.	2.	2.	250.	680.	881.	339.
1943.	382.	2.	2.	2.	2.	2.	541.	480.	208.	750.	850.	624.
1944.	152.	2.	2.	2.	2.	2.	2.	144.	5.	392.	990.	100.
1945.	261.	2.	2.	2.	2.	2.	2.	2.	43.	678.	862.	341.
1946.	248.	2.	2.	2.	2.	2.	2.	193.	770.	750.	850.	350.
1947.	4.	2.	2.	2.	2.	2.	52.	354.	660.	750.	850.	350.
1948.	4.	2.	2.	2.	2.	2.	51.	200.	674.	750.	880.	339.
1949.	233.	2.	2.	2.	2.	2.	2.	2.	461.	694.	862.	339.
1950.	97.	2.	2.	2.	2.	2.	18.	2.	653.	750.	850.	602.
1951.	158.	2.	2.	2.	2.	2.	155.	128.	788.	750.	850.	350.
1952.	4.	2.	2.	2.	2.	2.	754.	252.	593.	750.	850.	350.
1953.	339.	2.	2.	2.	2.	2.	2.	2.	551.	750.	850.	625.
1954.	324.	2.	2.	2.	2.	2.	2.	97.	798.	750.	850.	357.
1955.	311.	2.	2.	2.	2.	2.	2.	2.	5.	693.	930.	350.
1956.	89.	2.	2.	2.	2.	2.	873.	522.	529.	750.	850.	350.
1957.	4.	2.	2.	2.	2.	2.	544.	2.	779.	750.	951.	350.
1958.	170.	2.	2.	2.	2.	2.	2.	428.	672.	799.	973.	346.
1959.	397.	2.	2.	2.	2.	2.	2.	2.	250.	805.	833.	350.
1960.	4.	2.	2.	2.	2.	2.	2.	2.	544.	742.	894.	341.
1961.	395.	2.	2.	2.	2.	2.	2.	2.	5.	491.	855.	350.
1962.	199.	2.	2.	2.	2.	2.	2.	2.	457.	777.	935.	350.

FIGURE 14 CONTINUED

1963.	4.	2.	2.	2.	2.	46.	2.	260.	795.	799.	888.	350.
1964.	197.	2.	2.	2.	2.	2.	2.	2.	289.	750.	850.	350.
1965.	380.	2.	2.	2.	2.	2.	203.	691.	931.	750.	850.	583.
1966.	4.	2.	2.	2.	2.	2.	2.	2.	338.	597.	829.	350.
1967.	359.	2.	2.	2.	2.	2.	2.	2.	287.	750.	850.	499.
1968.	4.	2.	2.	2.	2.	2.	2.	363.	131.	662.	860.	350.
1969.	149.	2.	2.	2.	2.	2.	600.	350.	289.	799.	825.	350.
1970.	103.	2.	2.	2.	2.	2.	2.	2.	1020.	750.	850.	506.
1971.	196.	2.	2.	2.	2.	2.	692.	509.	1146.	786.	850.	750.
1972.	75.	2.	2.	2.	2.	2.	402.	244.	797.	750.	850.	353.
1973.	79.	2.	2.	2.	2.	2.	2.	2.	189.	595.	880.	350.
1974.	178.	2.	2.	2.	2.	2.	854.	758.	544.	1034.	850.	750.
1975.	160.	2.	2.	2.	2.	2.	307.	179.	77.	750.	850.	501.

MONTHLY FLOW DATA FOR STATION 3

FLOW IN CFS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1928.	1000.	200.	300.	546.	1038.	2477.	1218.	200.	1949.	1200.	1870.	2252.
1929.	1000.	385.	794.	862.	825.	371.	200.	200.	200.	1434.	1934.	2485.
1930.	1000.	590.	467.	620.	367.	165.	165.	200.	243.	1101.	1906.	1551.
1931.	1018.	376.	305.	200.	200.	329.	165.	165.	776.	800.	798.	656.
1932.	350.	200.	200.	200.	200.	165.	165.	200.	200.	1000.	1962.	2283.
1933.	1000.	351.	971.	880.	891.	347.	200.	200.	200.	1462.	2026.	2113.
1934.	1029.	353.	604.	200.	259.	200.	200.	399.	1618.	2248.	1733.	2000.
1935.	1000.	381.	230.	249.	223.	560.	165.	200.	200.	1149.	1607.	1697.
1936.	1138.	200.	200.	200.	200.	272.	200.	200.	200.	1873.	2179.	2289.
1937.	1102.	672.	814.	200.	200.	319.	165.	200.	200.	924.	1317.	1430.
1938.	1192.	254.	200.	488.	392.	165.	200.	200.	1907.	1236.	1676.	2122.
1939.	1000.	486.	886.	1020.	717.	200.	200.	200.	1946.	1684.	1716.	2430.
1940.	1186.	571.	486.	481.	200.	200.	200.	200.	200.	2003.	2237.	1784.
1941.	1000.	210.	482.	553.	502.	200.	200.	200.	200.	1558.	1872.	1983.
1942.	1000.	200.	238.	666.	242.	200.	200.	200.	2174.	1431.	2154.	2387.
1943.	1000.	200.	200.	400.	567.	2997.	1751.	363.	867.	1971.	1633.	1868.
1944.	1000.	426.	1001.	1334.	735.	717.	200.	200.	200.	1674.	2028.	2290.
1945.	1000.	383.	896.	500.	200.	165.	165.	200.	200.	1174.	1941.	2187.
1946.	1000.	232.	269.	231.	263.	200.	578.	200.	949.	1343.	1983.	2039.
1947.	1000.	200.	300.	908.	302.	2560.	956.	693.	2165.	1304.	1980.	2052.
1948.	1000.	414.	776.	778.	365.	1362.	1054.	200.	3296.	1391.	2011.	2231.
1949.	1000.	406.	721.	916.	250.	200.	200.	1743.	1282.	1720.	2112.	2219.
1950.	1000.	309.	896.	527.	200.	200.	1297.	200.	896.	1717.	1955.	1982.
1951.	1000.	323.	583.	895.	408.	2983.	1312.	200.	849.	1000.	1824.	2138.

FIGURE 14 CONTINUED

1952.	1000.	379.	300.	1055.	2369.	2081.	678.	1311.	2119.	1096.	1942.	2113.
1953.	1000.	580.	817.	400.	200.	1215.	1297.	289.	1398.	1381.	1890.	2017.
1954.	1000.	528.	795.	881.	200.	1316.	1614.	219.	1544.	1098.	1939.	2152.
1955.	1000.	464.	919.	857.	889.	646.	200.	200.	200.	1000.	2013.	2138.
1956.	1000.	200.	300.	400.	2588.	2350.	783.	802.	1805.	1000.	1991.	2247.
1957.	1000.	473.	469.	1103.	435.	1810.	571.	595.	2046.	1190.	1919.	2271.
1958.	1000.	454.	589.	521.	200.	722.	1390.	824.	1560.	1210.	1860.	2167.
1959.	1000.	322.	545.	754.	494.	342.	200.	200.	1711.	1314.	1967.	1500.
1960.	1000.	565.	995.	1185.	253.	200.	200.	459.	2267.	1715.	1932.	2229.
1961.	1000.	375.	773.	769.	200.	200.	200.	200.	330.	2303.	2234.	2017.
1962.	1000.	442.	673.	727.	200.	200.	200.	200.	200.	1359.	1924.	2198.
1963.	1000.	200.	323.	1061.	1042.	1341.	200.	881.	2186.	1121.	1839.	1977.
1964.	1000.	374.	636.	1103.	740.	218.	200.	200.	1861.	1000.	2084.	2173.
1965.	1000.	565.	300.	780.	3041.	2135.	1245.	829.	2245.	1000.	1500.	1500.
1966.	1166.	591.	895.	982.	928.	210.	200.	419.	900.	2200.	2265.	2313.
1967.	1000.	437.	682.	298.	392.	200.	241.	200.	395.	1101.	2220.	2278.
1968.	1000.	592.	750.	1076.	200.	200.	896.	200.	200.	1863.	1500.	1934.
1969.	1000.	200.	498.	400.	1292.	2343.	421.	413.	997.	1234.	2054.	2284.
1970.	1000.	561.	901.	400.	200.	1034.	699.	200.	2974.	1000.	2120.	1787.
1971.	1000.	200.	300.	1351.	3120.	2616.	996.	1286.	2534.	1439.	1713.	1659.
1972.	1000.	624.	684.	400.	2215.	2611.	200.	367.	2027.	1000.	1840.	1938.
1973.	1000.	626.	458.	586.	785.	200.	368.	200.	544.	2049.	2177.	2037.
1974.	1000.	200.	200.	400.	2164.	3486.	988.	1695.	1722.	2091.	1659.	1891.
1975.	1000.	713.	1019.	1123.	335.	326.	1206.	200.	691.	1942.	1695.	2138.

FIGURE 14 CONTINUED

MONTHLY FLOW DATA FOR STATION 8

FLOW IN CFS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1929.	45.	39.	36.	35.	33.	37.	66.	293.	387.	98.	38.	35.
1930.	42.	37.	57.	47.	43.	49.	381.	500.	316.	81.	43.	37.
1931.	44.	31.	22.	21.	24.	39.	164.	476.	127.	35.	19.	27.
1932.	32.	39.	37.	36.	40.	48.	131.	516.	577.	162.	59.	38.
1933.	41.	43.	28.	29.	27.	28.	49.	155.	628.	129.	56.	39.
1934.	37.	34.	32.	31.	37.	76.	316.	365.	131.	54.	31.	28.
1935.	40.	51.	40.	35.	35.	41.	121.	457.	418.	86.	39.	31.
1936.	32.	34.	30.	32.	35.	38.	252.	698.	348.	77.	40.	36.
1937.	28.	26.	26.	24.	27.	30.	60.	383.	280.	81.	38.	31.
1938.	32.	38.	95.	50.	45.	57.	210.	650.	772.	185.	65.	47.
1939.	53.	50.	40.	35.	30.	47.	204.	429.	147.	63.	33.	30.
1940.	33.	30.	40.	40.	41.	73.	252.	582.	310.	71.	37.	45.
1941.	57.	57.	46.	42.	40.	63.	154.	524.	378.	99.	58.	49.
1942.	50.	88.	147.	70.	54.	55.	246.	393.	516.	143.	55.	39.
1943.	38.	63.	48.	45.	51.	60.	436.	564.	751.	363.	87.	51.
1944.	50.	52.	44.	36.	36.	36.	84.	287.	284.	83.	44.	37.
1945.	33.	46.	34.	37.	32.	38.	77.	427.	492.	131.	52.	41.
1946.	40.	46.	46.	60.	50.	56.	294.	713.	504.	127.	53.	48.
1947.	58.	65.	75.	51.	51.	85.	211.	825.	505.	126.	53.	46.
1948.	67.	50.	46.	65.	48.	45.	126.	624.	691.	128.	56.	43.
1949.	45.	48.	38.	35.	35.	45.	229.	805.	408.	90.	46.	37.
1950.	44.	49.	45.	45.	47.	61.	150.	445.	795.	282.	73.	52.
1951.	79.	87.	72.	56.	73.	69.	311.	667.	513.	168.	66.	47.
1952.	87.	60.	57.	51.	48.	47.	272.	825.	604.	148.	59.	42.
1953.	35.	34.	38.	53.	48.	51.	174.	372.	759.	276.	72.	44.
1954.	41.	47.	43.	39.	44.	60.	248.	703.	507.	192.	69.	47.
1955.	41.	41.	34.	33.	33.	37.	58.	298.	599.	148.	49.	41.
1956.	44.	59.	112.	84.	61.	74.	338.	899.	710.	142.	59.	42.
1957.	47.	48.	44.	39.	48.	54.	140.	804.	716.	136.	52.	42.
1958.	52.	42.	39.	33.	45.	38.	117.	844.	589.	128.	59.	42.
1959.	40.	60.	63.	51.	46.	44.	175.	399.	551.	116.	56.	69.
1960.	88.	61.	43.	40.	43.	68.	182.	398.	498.	96.	55.	37.

FIGURE 14 CONTINUED

MONTHLY FLOW DATA FOR STATION 9

FLOW IN CFS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1941.	0.	0.	0.	0.	0.	0.	0.	0.	1824.	729.	487.	375.
1942.	353.	515.	684.	381.	340.	357.	1152.	1450.	2070.	1079.	450.	337.
1943.	306.	378.	355.	399.	381.	501.	2209.	2655.	3447.	2601.	845.	485.
1944.	448.	423.	325.	304.	284.	280.	568.	1429.	1562.	816.	386.	303.
1945.	258.	300.	253.	263.	292.	326.	602.	1854.	2306.	1073.	454.	337.
1946.	310.	321.	348.	337.	299.	491.	1541.	2692.	2434.	1031.	483.	392.
1947.	431.	425.	481.	341.	360.	583.	1054.	3037.	2308.	1094.	492.	393.
1948.	438.	366.	316.	352.	316.	304.	778.	2344.	3247.	1039.	479.	350.
1949.	332.	336.	298.	251.	252.	349.	1170.	2826.	2271.	797.	418.	332.
1950.	334.	355.	329.	327.	344.	397.	1014.	1996.	3293.	2006.	646.	459.
1951.	483.	507.	420.	337.	422.	390.	1536.	2779.	2743.	1570.	691.	426.
1952.	511.	398.	394.	330.	333.	321.	1462.	3085.	3079.	1243.	558.	380.
1953.	320.	283.	287.	336.	320.	377.	964.	1551.	3288.	1963.	629.	391.
1954.	328.	337.	312.	304.	368.	472.	1248.	2957.	2574.	1626.	589.	396.
1955.	325.	299.	265.	271.	253.	254.	384.	1611.	2737.	1175.	474.	339.
1956.	324.	384.	678.	466.	378.	517.	1670.	3673.	3953.	1458.	640.	425.
1957.	394.	389.	356.	298.	339.	424.	870.	2902.	3138.	1109.	498.	377.
1958.	369.	316.	314.	297.	347.	333.	729.	3701.	2898.	961.	487.	365.
1959.	324.	404.	412.	358.	339.	361.	971.	1483.	2652.	926.	450.	439.
1960.	546.	412.	325.	300.	287.	468.	987.	1542.	2358.	702.	398.	326.
1961.	300.	303.	256.	224.	290.	346.	649.	1759.	2023.	549.	343.	317.
1962.	315.	303.	297.	288.	317.	311.	1217.	1606.	2508.	1006.	503.	351.
1963.	598.	473.	454.	316.	644.	426.	695.	2266.	2648.	1098.	518.	403.
1964.	359.	395.	309.	286.	262.	285.	725.	1857.	2782.	1225.	503.	380.
1965.	321.	307.	735.	503.	424.	477.	1466.	2707.	4203.	2319.	871.	539.
1966.	423.	369.	332.	321.	266.	361.	838.	1733.	1418.	568.	327.	278.
1967.	275.	280.	269.	275.	271.	326.	447.	1935.	3285.	1382.	511.	371.
1968.	420.	377.	320.	282.	408.	476.	628.	1425.	2094.	753.	525.	413.
1969.	430.	469.	356.	441.	370.	445.	1645.	3207.	2636.	993.	475.	363.
1970.	338.	300.	292.	383.	360.	405.	537.	2177.	3700.	1571.	563.	444.
1971.	371.	497.	416.	464.	462.	448.	1150.	3410.	4610.	2218.	773.	472.
1972.	394.	349.	323.	331.	345.	813.	907.	2895.	4958.	1644.	619.	455.
1973.	404.	342.	335.	335.	297.	340.	559.	1664.	1602.	661.	372.	333.
1974.	313.	648.	442.	694.	474.	679.	1465.	2661.	5751.	2463.	813.	481.

FIGURE 14 CONTINUED

```
SUBROUTINE COMM
FLOWS FOR 1 STATIONS WILL BE COMPUTED
REPRESENTATIVE STATION=  9
UPSTREAM STATION =  1

COMPUTED  AVERAGE RUNOFF
STATION     CFS DAYS
   2          10000.
```

REPRESENTATIVE STATION FLOW
STATION NUMBER 9
FLOW IN CFS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1942.	353.	515.	684.	381.	340.	357.	1152.	1450.	2070.	1079.	450.	337.
1943.	306.	378.	355.	399.	381.	501.	2209.	2655.	3447.	2601.	845.	485.
1944.	448.	423.	325.	304.	284.	280.	568.	1429.	1562.	816.	386.	303.
1945.	258.	300.	253.	263.	292.	326.	602.	1854.	2306.	1073.	454.	337.
1946.	310.	321.	348.	337.	299.	491.	1541.	2692.	2434.	1031.	483.	392.
1947.	431.	425.	481.	341.	360.	583.	1054.	3037.	2308.	1094.	492.	393.
1948.	438.	366.	316.	352.	316.	304.	778.	2344.	3247.	1039.	479.	350.
1949.	332.	336.	298.	251.	252.	349.	1170.	2826.	2271.	797.	418.	332.
1950.	334.	355.	329.	327.	344.	397.	1014.	1996.	3293.	2006.	646.	459.
1951.	483.	507.	420.	337.	422.	390.	1536.	2779.	2743.	1570.	691.	426.
1952.	511.	398.	394.	330.	333.	321.	1462.	3085.	3079.	1243.	558.	380.
1953.	320.	283.	287.	336.	320.	377.	964.	1551.	3288.	1963.	629.	391.
1954.	328.	337.	312.	304.	368.	472.	1248.	2957.	2574.	1626.	589.	396.
1955.	325.	299.	265.	271.	253.	254.	384.	1611.	2737.	1175.	474.	339.
1956.	324.	384.	678.	466.	378.	517.	1670.	3673.	3953.	1458.	640.	425.
1957.	394.	389.	356.	298.	339.	424.	870.	2902.	3138.	1109.	498.	377.
1958.	369.	316.	314.	297.	347.	333.	729.	3701.	2898.	961.	487.	365.
1959.	324.	404.	412.	358.	339.	361.	971.	1483.	2652.	926.	450.	439.
1960.	546.	412.	325.	300.	287.	468.	987.	1542.	2358.	702.	398.	326.

FIGURE 14 CONTINUED

UPSTREAM INFLOW
STATION NUMBER 1
FLOW IN CFS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1942.	318.	2.	2.	2.	2.	2.	2.	2.	250.	680.	881.	339.
1943.	382.	2.	2.	2.	2.	2.	541.	480.	208.	750.	850.	624.
1944.	152.	2.	2.	2.	2.	2.	2.	144.	5.	392.	990.	100.
1945.	261.	2.	2.	2.	2.	2.	2.	2.	43.	678.	862.	341.
1946.	248.	2.	2.	2.	2.	2.	2.	193.	770.	750.	850.	350.
1947.	4.	2.	2.	2.	2.	2.	52.	354.	660.	750.	850.	350.
1948.	4.	2.	2.	2.	2.	2.	51.	200.	674.	750.	880.	339.
1949.	233.	2.	2.	2.	2.	2.	2.	2.	461.	694.	862.	339.
1950.	97.	2.	2.	2.	2.	2.	18.	2.	653.	750.	850.	602.
1951.	158.	2.	2.	2.	2.	2.	155.	128.	788.	750.	850.	350.
1952.	4.	2.	2.	2.	2.	2.	754.	252.	593.	750.	850.	350.
1953.	339.	2.	2.	2.	2.	2.	2.	2.	551.	750.	850.	625.
1954.	324.	2.	2.	2.	2.	2.	2.	97.	798.	750.	850.	357.
1955.	311.	2.	2.	2.	2.	2.	2.	2.	5.	693.	930.	350.
1956.	89.	2.	2.	2.	2.	2.	873.	522.	529.	750.	850.	350.
1957.	4.	2.	2.	2.	2.	2.	544.	2.	779.	750.	951.	350.
1958.	170.	2.	2.	2.	2.	2.	2.	428.	672.	799.	973.	346.
1959.	397.	2.	2.	2.	2.	2.	2.	2.	250.	805.	833.	350.
1960.	4.	2.	2.	2.	2.	2.	2.	2.	544.	742.	894.	341.

FIGURE 14 CONTINUED

COMPUTED FLOW
STATION NUMBER 2
FLOW IN CFS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1942.	329.	18.	23.	14.	13.	13.	38.	47.	314.	713.	895.	349.
1943.	391.	14.	13.	14.	14.	17.	609.	562.	314.	830.	876.	639.
1944.	166.	15.	12.	11.	11.	11.	20.	188.	53.	417.	1002.	109.
1945.	269.	11.	10.	10.	11.	12.	21.	59.	114.	711.	876.	351.
1946.	258.	12.	13.	12.	11.	17.	50.	276.	845.	782.	865.	362.
1947.	17.	15.	17.	13.	13.	20.	85.	448.	731.	784.	865.	362.
1948.	18.	13.	12.	13.	12.	11.	75.	272.	774.	782.	895.	350.
1949.	243.	12.	11.	10.	10.	13.	38.	89.	531.	719.	875.	349.
1950.	107.	13.	12.	12.	13.	14.	49.	64.	755.	812.	870.	616.
1951.	173.	18.	15.	12.	15.	14.	202.	214.	873.	798.	871.	363.
1952.	20.	14.	14.	12.	12.	12.	799.	347.	688.	788.	867.	362.
1953.	349.	11.	11.	12.	12.	14.	32.	50.	653.	811.	869.	637.
1954.	334.	12.	12.	11.	13.	17.	41.	188.	878.	800.	868.	369.
1955.	321.	11.	10.	10.	10.	10.	14.	52.	90.	729.	945.	360.
1956.	99.	14.	23.	16.	14.	18.	925.	635.	651.	795.	870.	363.
1957.	16.	14.	13.	11.	12.	15.	571.	92.	876.	784.	966.	362.
1958.	181.	12.	12.	11.	13.	12.	25.	542.	762.	829.	988.	357.
1959.	407.	14.	15.	13.	12.	13.	32.	48.	332.	834.	847.	364.
1960.	21.	15.	12.	11.	11.	16.	32.	50.	617.	764.	906.	351.

MONTHLY AVERAGES IN CFS

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
196.	14.	14.	12.	12.	14.	192.	222.	571.	762.	896.	388.

AVERAGE ANNUAL FLOW= 276. CFS

RATIO OF AVG MONTHLY FLOW TO AVG ANNUAL FLOW

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
0.708	0.049	0.049	0.044	0.044	0.051	0.696	0.804	2.066	2.758	3.240	1.405

FIGURE 14 CONTINUED

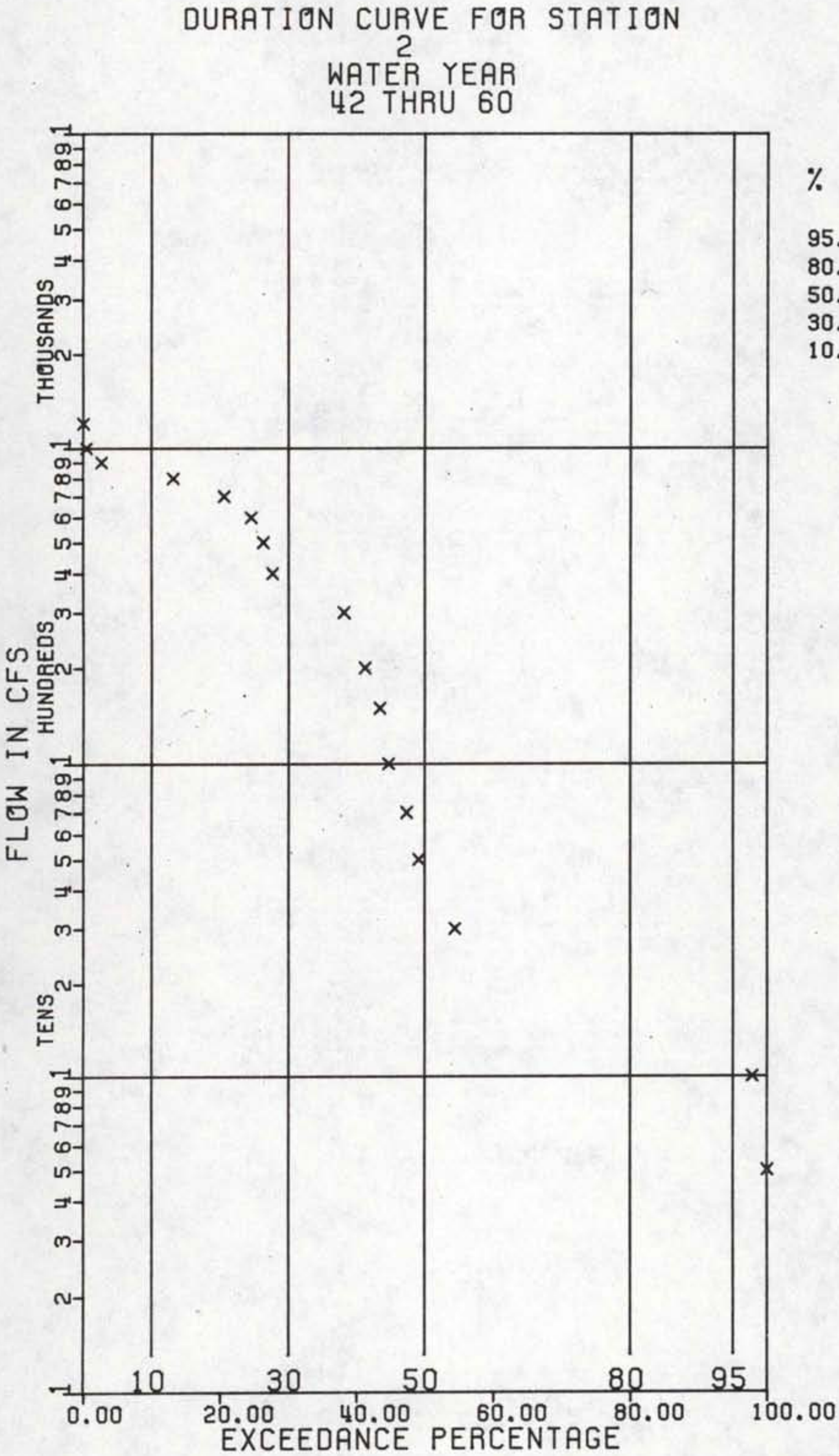
STATION 2
WATER YEAR
42 THRU 60

CLASS	LOWER LIMIT CFS	UPPER LIMIT CFS	INTERVAL COUNT	NUMBER GREATER	PERCENT GREATER
1	0.0	5.00	0	228.	100.
2	5.00	10.00	5	223.	98.
3	10.00	30.00	99	124.	54.
4	30.00	50.00	12	112.	49.
5	50.00	70.00	4	108.	47.
6	70.00	100.00	6	102.	45.
7	100.00	150.00	3	99.	43.
8	150.00	200.00	5	94.	41.
9	200.00	300.00	7	87.	38.
10	300.00	400.00	24	63.	28.
11	400.00	500.00	3	60.	26.
12	500.00	600.00	4	56.	25.
13	600.00	700.00	9	47.	21.
14	700.00	800.00	17	30.	13.
15	800.00	900.00	24	6.	3.
16	900.00	1000.00	5	1.	0.
17	1000.00	1200.00	1	0.	0.
18	1200.00	1500.00	0	0.	0.
19	1500.00	1800.00	0	0.	0.
20	1800.00	2000.00	0	0.	0.
21	2000.00	2500.00	0	0.	0.
22	2500.00	3000.00	0	0.	0.
23	3000.00	3500.00	0	0.	0.
24	3500.00	4000.00	0	0.	0.
25	4000.00	4500.00	0	0.	0.
26	4500.00	5000.00	0	0.	0.
27	5000.00	5500.00	0	0.	0.
28	5500.00	6000.00	0	0.	0.
29	6000.00	6500.00	0	0.	0.
30	6500.00	7000.00	0	0.	0.
31	7000.00	7500.00	0	0.	0.
32	7500.00	8000.00	0	0.	0.
33	8000.00	8500.00	0	0.	0.
34	8500.00	9000.00	0	0.	0.
35	9000.00	9500.00	0	0.	0.
36	9500.00	10000.00	0	0.	0.
37	10000.00	15000.00	0	0.	0.
38	15000.00	20000.00	0	0.	0.
39	20000.00	25000.00	0	0.	0.
40	25000.00	30000.00	0	0.	0.
41	30000.00	35000.00	0	0.	0.
42	35000.00	40000.00	0	0.	0.
43	40000.00	45000.00	0	0.	0.
44	45000.00	50000.00	0	0.	0.
45	50000.00	200000.00	0	0.	0.

STATION 2

EXCEEDANCE	FLOW
95.	10.74
80.	15.69
50.	45.92
30.	374.93
10.	828.77

FIGURE 14 CONTINUED



%	Q
95.	10.74
80.	15.69
50.	45.92
30.	374.93
10.	828.77

FIGURE 14 CONTINUED

```
SUBRCUTINE COMM
FLOWS FOR 1 STATIONS WILL BE COMPUTED
REPRESENTATIVE STATION=  8
UPSTREAM STATION =  3

CCMPUTED  AVERAGE RUNOFF
STATION     CFS DAYS
   4          150000.
```

REPRESENTATIVE STATION FLOW
STATION NUMBER 8
FLOW IN CFS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1942.	50.	88.	147.	70.	54.	55.	246.	393.	516.	143.	55.	39.
1943.	38.	63.	48.	45.	51.	60.	436.	564.	751.	363.	87.	51.
1944.	50.	52.	44.	36.	36.	36.	84.	287.	284.	83.	44.	37.
1945.	33.	46.	34.	37.	32.	38.	77.	427.	492.	131.	52.	41.
1946.	40.	46.	46.	60.	50.	56.	294.	713.	504.	127.	53.	48.
1947.	58.	65.	75.	51.	51.	85.	211.	825.	505.	126.	53.	46.
1948.	67.	50.	46.	65.	48.	45.	126.	624.	691.	128.	56.	43.
1949.	45.	48.	38.	35.	35.	45.	229.	805.	408.	90.	46.	37.
1950.	44.	49.	45.	45.	47.	61.	150.	445.	795.	282.	73.	52.
1951.	79.	87.	72.	56.	73.	69.	311.	667.	513.	168.	66.	47.
1952.	87.	60.	57.	51.	48.	47.	272.	825.	604.	148.	59.	42.
1953.	35.	34.	38.	53.	48.	51.	174.	372.	759.	276.	72.	44.
1954.	41.	47.	43.	39.	44.	60.	248.	703.	507.	192.	69.	47.
1955.	41.	41.	34.	33.	33.	37.	58.	298.	599.	148.	49.	41.
1956.	44.	59.	112.	84.	61.	74.	338.	899.	710.	142.	59.	42.
1957.	47.	48.	44.	39.	48.	54.	140.	804.	716.	136.	52.	42.
1958.	52.	42.	39.	33.	45.	38.	117.	844.	589.	128.	59.	42.
1959.	40.	60.	63.	51.	46.	44.	175.	399.	551.	116.	56.	69.
1960.	88.	61.	43.	40.	43.	68.	182.	398.	498.	96.	55.	37.

FIGURE 14 CONTINUED

UPSTREAM INFLOW
STATION NUMBER 3
FLOW IN CFS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1942.	1000.	200.	238.	666.	242.	200.	200.	200.	2174.	1431.	2154.	2387.
1943.	1000.	200.	200.	400.	567.	2997.	1751.	363.	867.	1971.	1633.	1868.
1944.	1000.	426.	1001.	1334.	735.	717.	200.	200.	200.	1674.	2028.	2290.
1945.	1000.	383.	896.	500.	200.	165.	165.	200.	200.	1174.	1941.	2187.
1946.	1000.	232.	269.	231.	263.	200.	578.	200.	949.	1343.	1983.	2039.
1947.	1000.	200.	300.	908.	302.	2560.	956.	693.	2165.	1304.	1980.	2052.
1948.	1000.	414.	776.	778.	365.	1362.	1054.	200.	3296.	1391.	2011.	2231.
1949.	1000.	406.	721.	916.	250.	200.	200.	1743.	1282.	1720.	2112.	2219.
1950.	1000.	309.	896.	527.	200.	200.	1297.	200.	896.	1717.	1955.	1982.
1951.	1000.	323.	583.	895.	408.	2983.	1312.	200.	849.	1000.	1824.	2138.
1952.	1000.	379.	300.	1055.	2369.	2081.	678.	1311.	2119.	1096.	1942.	2113.
1953.	1000.	580.	817.	400.	200.	1215.	1297.	289.	1398.	1381.	1890.	2017.
1954.	1000.	528.	795.	881.	200.	1316.	1614.	219.	1544.	1098.	1939.	2152.
1955.	1000.	464.	919.	857.	889.	646.	200.	200.	200.	1000.	2013.	2138.
1956.	1000.	200.	300.	400.	2588.	2350.	783.	802.	1805.	1000.	1991.	2247.
1957.	1000.	473.	469.	1103.	435.	1810.	571.	595.	2046.	1190.	1919.	2271.
1958.	1000.	454.	589.	521.	200.	722.	1390.	824.	1560.	1210.	1860.	2167.
1959.	1000.	322.	545.	754.	494.	342.	200.	200.	1711.	1314.	1967.	1500.
1960.	1000.	565.	995.	1185.	253.	200.	200.	459.	2267.	1715.	1932.	2229.

FIGURE 14 CONTINUED

COMPUTED FLOW
STATION NUMBER 4
FLOW IN CFS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1942.	1126.	422.	609.	843.	378.	339.	821.	1191.	3476.	1792.	2293.	2485.
1943.	1096.	359.	321.	514.	696.	3148.	2851.	1786.	2762.	2887.	1852.	1997.
1944.	1126.	557.	1112.	1425.	826.	808.	412.	924.	916.	1883.	2139.	2383.
1945.	1083.	499.	982.	593.	281.	261.	359.	1277.	1441.	1504.	2072.	2290.
1946.	1101.	348.	385.	382.	389.	341.	1320.	1999.	2220.	1663.	2117.	2160.
1947.	1146.	364.	489.	1037.	431.	2774.	1488.	2774.	3439.	1622.	2114.	2168.
1948.	1169.	540.	892.	942.	486.	1476.	1372.	1774.	5039.	1714.	2152.	2339.
1949.	1114.	527.	817.	1004.	338.	314.	778.	3774.	2311.	1947.	2228.	2312.
1950.	1111.	433.	1010.	641.	319.	354.	1675.	1323.	2902.	2428.	2139.	2113.
1951.	1199.	542.	765.	1036.	592.	3157.	2097.	1883.	2143.	1424.	1991.	2257.
1952.	1219.	530.	444.	1184.	2490.	2200.	1364.	3392.	3643.	1469.	2091.	2219.
1953.	1088.	666.	913.	534.	321.	1344.	1736.	1227.	3313.	2077.	2072.	2128.
1954.	1103.	647.	903.	979.	311.	1467.	2240.	1993.	2823.	1582.	2113.	2271.
1955.	1103.	567.	1005.	940.	972.	739.	346.	952.	1711.	1373.	2137.	2241.
1956.	1111.	349.	583.	612.	2742.	2537.	1636.	3070.	3596.	1358.	2140.	2353.
1957.	1119.	594.	580.	1201.	556.	1946.	924.	2623.	3852.	1533.	2050.	2377.
1958.	1131.	560.	687.	604.	314.	818.	1685.	2953.	3046.	1533.	2009.	2273.
1959.	1101.	473.	704.	883.	610.	453.	641.	1207.	3101.	1607.	2108.	1674.
1960.	1222.	719.	1103.	1286.	361.	372.	659.	1463.	3523.	1957.	2071.	2322.

MONTHLY AVERAGES IN CFS

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1130.	510.	753.	876.	706.	1308.	1284.	1978.	2908.	1756.	2099.	2230.

AVERAGE ANNUAL FLOW= 1465. CFS

RATIO OF AVG MONTHLY FLOW TO AVG ANNUAL FLOW

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
0.771	0.348	0.514	0.598	0.482	0.893	0.877	1.351	1.986	1.199	1.433	1.522

FIGURE 14 CONTINUED

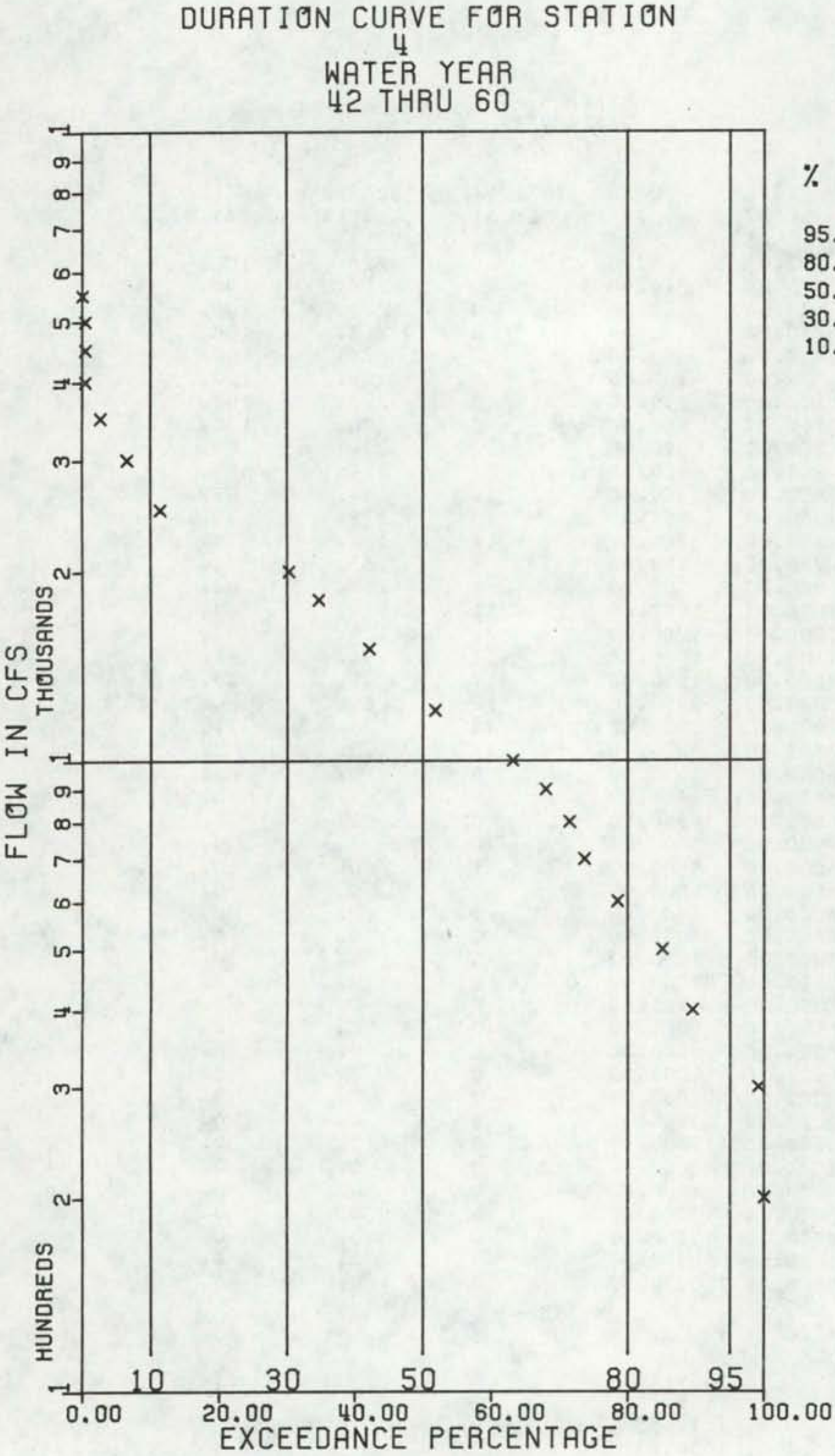
STATION 4
WATER YEAR
42 THRU 60

CLASS	LOWER LIMIT CFS	UPPER LIMIT CFS	INTERVAL COUNT	NUMBER GREATER	PERCENT GREATER
1	0.0	5.00	0	228.	100.
2	5.00	10.00	0	228.	100.
3	10.00	30.00	0	228.	100.
4	30.00	50.00	0	228.	100.
5	50.00	70.00	0	228.	100.
6	70.00	100.00	0	228.	100.
7	100.00	150.00	0	228.	100.
8	150.00	200.00	0	228.	100.
9	200.00	300.00	2	226.	99.
10	300.00	400.00	22	204.	89.
11	400.00	500.00	10	194.	85.
12	500.00	600.00	15	179.	79.
13	600.00	700.00	11	168.	74.
14	700.00	800.00	5	163.	71.
15	800.00	900.00	8	155.	68.
16	900.00	1000.00	11	144.	63.
17	1000.00	1200.00	26	118.	52.
18	1200.00	1500.00	22	96.	42.
19	1500.00	1800.00	17	79.	35.
20	1800.00	2000.00	10	69.	30.
21	2000.00	2500.00	43	26.	11.
22	2500.00	3000.00	11	15.	7.
23	3000.00	3500.00	9	6.	3.
24	3500.00	4000.00	5	1.	0.
25	4000.00	4500.00	0	1.	0.
26	4500.00	5000.00	0	1.	0.
27	5000.00	5500.00	1	0.	0.
28	5500.00	6000.00	0	0.	0.
29	6000.00	6500.00	0	0.	0.
30	6500.00	7000.00	0	0.	0.
31	7000.00	7500.00	0	0.	0.
32	7500.00	8000.00	0	0.	0.
33	8000.00	8500.00	0	0.	0.
34	8500.00	9000.00	0	0.	0.
35	9000.00	9500.00	0	0.	0.
36	9500.00	10000.00	0	0.	0.
37	10000.00	15000.00	0	0.	0.
38	15000.00	20000.00	0	0.	0.
39	20000.00	25000.00	0	0.	0.
40	25000.00	30000.00	0	0.	0.
41	30000.00	35000.00	0	0.	0.
42	35000.00	40000.00	0	0.	0.
43	40000.00	45000.00	0	0.	0.
44	45000.00	50000.00	0	0.	0.
45	50000.00	200000.00	0	0.	0.

STATION 4

EXCEEDANCE	FLOW
95.	339.24
80.	575.71
50.	1249.68
30.	2006.23
10.	2636.17

FIGURE 14 CONTINUED



%	Q
95.	339.24
80.	575.71
50.	1249.68
30.	2006.23
10.	2636.17

FIGURE 14 CONTINUED

SUBROUTINE SUMM
THE FOLLOWING IS THE SUM OF
STATION 2 AND 4

SUMMATION FLOWS
STATION NUMBER 5
FLOW IN CFS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1942.	1455.	440.	632.	856.	391.	352.	858.	1238.	3790.	2505.	3188.	2835.
1943.	1487.	373.	334.	528.	709.	3166.	3460.	2348.	3076.	3717.	2729.	2636.
1944.	1292.	572.	1124.	1436.	837.	818.	431.	1112.	970.	2301.	3141.	2493.
1945.	1352.	510.	992.	603.	292.	273.	380.	1336.	1555.	2216.	2948.	2642.
1946.	1358.	360.	398.	395.	400.	358.	1369.	2275.	3066.	2445.	2982.	2522.
1947.	1164.	379.	506.	1049.	444.	2794.	1573.	3222.	4170.	2406.	2979.	2530.
1948.	1187.	553.	904.	955.	498.	1487.	1447.	2047.	5814.	2496.	3047.	2689.
1949.	1357.	539.	828.	1014.	348.	326.	816.	3863.	2842.	2666.	3103.	2662.
1950.	1218.	446.	1022.	653.	331.	368.	1725.	1386.	3656.	3240.	3009.	2729.
1951.	1372.	560.	780.	1049.	607.	3171.	2299.	2097.	3016.	2222.	2862.	2620.
1952.	1239.	545.	458.	1196.	2502.	2211.	2163.	3740.	4331.	2258.	2958.	2581.
1953.	1437.	677.	924.	546.	333.	1357.	1768.	1277.	3965.	2888.	2941.	2765.
1954.	1438.	659.	915.	991.	324.	1484.	2280.	2181.	3701.	2383.	2981.	2640.
1955.	1424.	579.	1015.	951.	982.	749.	360.	1004.	1801.	2103.	3081.	2602.
1956.	1210.	363.	605.	628.	2756.	2555.	2560.	3705.	4247.	2153.	3010.	2716.
1957.	1135.	608.	593.	1213.	569.	1961.	1495.	2715.	4728.	2317.	3017.	2739.
1958.	1313.	572.	699.	615.	326.	830.	1710.	3496.	3807.	2362.	2997.	2630.
1959.	1508.	488.	719.	896.	623.	466.	673.	1254.	3433.	2440.	2955.	2038.
1960.	1243.	734.	1116.	1297.	372.	388.	692.	1513.	4140.	2721.	2977.	2673.

FIGURE 14 CONTINUED

SUBROUTINE AVER
THE FOLLOWING STATIONS
ARE AVERAGED

STATION	WEIGHT
8	0.500
9	0.500

WEIGHTED FLOWS
STATION NUMBER 10
FLOW IN CFS

1942.00	185.02	294.19	439.26	225.53	187.62	194.26	737.27	1062.31	1443.96	549.70	221.78	162.56
1943.00	151.78	213.37	182.39	190.58	194.92	244.93	1356.19	1694.42	2230.09	1354.57	390.23	225.69
1944.00	213.13	208.96	167.07	147.96	142.05	140.86	303.43	885.30	919.82	375.20	185.12	149.28
1945.00	129.52	162.89	129.65	137.44	137.97	157.70	302.21	1236.64	1475.13	528.59	218.13	165.79
1946.00	156.18	169.11	177.10	196.40	169.04	235.53	929.72	1945.45	1532.34	509.72	228.32	193.34
1947.00	220.99	230.50	263.18	183.08	188.70	309.48	651.87	2228.00	1496.67	526.75	230.99	190.41
1948.00	237.57	188.87	167.63	208.90	170.85	162.47	433.24	1699.06	2074.23	513.70	231.97	172.85
1949.00	170.75	176.77	149.41	130.67	130.97	175.78	715.20	2133.34	1329.42	380.86	197.81	157.86
1950.00	169.73	184.00	169.86	169.27	177.52	215.77	541.75	1307.67	2255.41	1047.98	308.78	219.61
1951.00	270.22	290.21	240.30	189.95	242.50	226.58	955.63	1897.07	1638.28	735.28	310.82	201.79
1952.00	291.39	214.45	208.43	179.83	175.88	170.72	870.89	2242.20	1884.33	606.29	260.19	180.12
1953.00	151.09	138.53	146.16	184.82	172.03	193.73	565.62	1058.36	2195.93	1025.59	302.14	186.60
1954.00	163.12	175.45	161.61	152.80	179.79	236.35	768.90	2007.75	1578.60	790.52	285.47	192.91
1955.00	162.23	154.54	133.20	133.36	128.04	134.78	207.09	956.88	1775.08	586.17	219.22	166.38
1956.00	166.77	208.70	381.09	273.24	210.14	272.22	1038.79	2535.44	2313.76	660.24	284.45	193.44
1957.00	192.32	192.45	176.24	151.02	177.66	212.48	483.02	2154.22	2082.26	547.30	231.15	179.23
1958.00	192.98	161.18	155.76	141.06	175.19	159.77	404.24	2455.10	1806.60	490.62	239.18	175.68
1959.00	160.33	216.23	223.43	188.11	174.43	177.72	569.31	1081.74	1672.58	460.92	223.39	241.08
1960.00	303.36	220.20	165.46	153.23	154.21	248.05	585.32	1097.59	1500.18	362.41	206.39	156.09

FIGURE 14 CONTINUED

```
SUBROUTINE COMM
FLOWS FOR 2 STATIONS WILL BE COMPUTED
REPRESENTATIVE STATICN= 10
UPSTREAM STATION =  5

COMPUTED  AVERAGE RUNOFF
STATION      CFS DAYS
    6          100000.
    7           40000.
```

REPRESENTATIVE STATICN FLCW
STATICN NUMBER 10
FLOW IN CFS

YEAR	OCT	NOV	CEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1942.	185.	294.	439.	226.	188.	194.	737.	1062.	1444.	550.	222.	163.
1943.	152.	213.	182.	191.	195.	245.	1356.	1694.	2230.	1355.	390.	226.
1944.	213.	209.	167.	148.	142.	141.	303.	885.	920.	375.	185.	149.
1945.	130.	163.	130.	137.	138.	158.	302.	1237.	1475.	529.	218.	166.
1946.	156.	169.	177.	196.	169.	236.	930.	1945.	1532.	510.	228.	193.
1947.	221.	230.	263.	183.	189.	309.	652.	2228.	1497.	527.	231.	190.
1948.	238.	189.	168.	209.	171.	162.	433.	1699.	2074.	514.	232.	173.
1949.	171.	177.	149.	131.	131.	176.	715.	2133.	1329.	381.	198.	158.
1950.	170.	184.	170.	169.	178.	216.	542.	1308.	2255.	1048.	309.	220.
1951.	270.	290.	240.	190.	242.	227.	956.	1897.	1638.	735.	311.	202.
1952.	291.	214.	208.	180.	176.	171.	871.	2242.	1884.	606.	260.	180.
1953.	151.	139.	146.	185.	172.	194.	566.	1058.	2196.	1026.	302.	187.
1954.	163.	175.	162.	153.	180.	236.	769.	2008.	1579.	791.	285.	193.
1955.	162.	155.	133.	133.	128.	135.	207.	957.	1775.	586.	219.	166.
1956.	167.	209.	381.	273.	210.	272.	1039.	2535.	2314.	660.	284.	193.
1957.	192.	192.	176.	151.	178.	212.	483.	2154.	2082.	547.	231.	179.
1958.	193.	161.	156.	141.	175.	160.	404.	2455.	1807.	491.	239.	176.
1959.	160.	216.	223.	188.	174.	178.	569.	1082.	1673.	461.	223.	241.
1960.	303.	220.	165.	153.	154.	248.	585.	1098.	1500.	362.	206.	156.

FIGURE 14 CONTINUED

UPSTREAM INFLOW
STATION NUMBER 5
FLOW IN CFS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1942.	1455.	440.	632.	856.	391.	352.	858.	1238.	3790.	2505.	3188.	2835.
1943.	1487.	373.	334.	528.	709.	3166.	3460.	2348.	3076.	3717.	2729.	2636.
1944.	1292.	572.	1124.	1436.	837.	818.	431.	1112.	970.	2301.	3141.	2493.
1945.	1352.	510.	992.	603.	292.	273.	380.	1336.	1555.	2216.	2948.	2642.
1946.	1358.	360.	398.	395.	400.	358.	1369.	2275.	3066.	2445.	2982.	2522.
1947.	1164.	379.	506.	1049.	444.	2794.	1573.	3222.	4170.	2406.	2979.	2530.
1948.	1187.	553.	904.	955.	498.	1487.	1447.	2047.	5814.	2496.	3047.	2689.
1949.	1357.	539.	828.	1014.	348.	326.	816.	3863.	2842.	2666.	3103.	2662.
1950.	1218.	446.	1022.	653.	331.	368.	1725.	1386.	3656.	3240.	3009.	2729.
1951.	1372.	560.	780.	1049.	607.	3171.	2299.	2097.	3016.	2222.	2862.	2620.
1952.	1239.	545.	458.	1196.	2502.	2211.	2163.	3740.	4331.	2258.	2958.	2581.
1953.	1437.	677.	924.	546.	333.	1357.	1768.	1277.	3965.	2888.	2941.	2765.
1954.	1438.	659.	915.	991.	324.	1484.	2280.	2181.	3701.	2383.	2981.	2640.
1955.	1424.	579.	1015.	951.	982.	749.	360.	1004.	1801.	2103.	3081.	2602.
1956.	1210.	363.	605.	628.	2756.	2555.	2560.	3705.	4247.	2153.	3010.	2716.
1957.	1135.	608.	593.	1213.	569.	1961.	1495.	2715.	4728.	2317.	3017.	2739.
1958.	1313.	572.	699.	615.	326.	830.	1710.	3496.	3807.	2362.	2997.	2630.
1959.	1508.	488.	719.	896.	623.	466.	673.	1254.	3433.	2440.	2955.	2038.
1960.	1243.	734.	1116.	1297.	372.	388.	692.	1513.	4140.	2721.	2977.	2673.

FIGURE 14 CONTINUED

COMPUTED FLOW
STATION NUMBER 6
FLOW IN CFS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1942.	1552.	593.	861.	974.	489.	453.	1243.	1793.	4543.	2792.	3303.	2920.
1943.	1567.	484.	429.	627.	811.	3294.	4168.	3232.	4240.	4424.	2932.	2753.
1944.	1403.	681.	1211.	1513.	911.	892.	590.	1574.	1450.	2496.	3238.	2571.
1945.	1420.	595.	1059.	675.	364.	355.	538.	1982.	2325.	2492.	3062.	2728.
1946.	1440.	448.	490.	497.	489.	481.	1855.	3290.	3865.	2711.	3101.	2623.
1947.	1279.	499.	643.	1145.	542.	2956.	1913.	4385.	4951.	2681.	3099.	2630.
1948.	1311.	652.	991.	1064.	587.	1572.	1673.	2933.	6896.	2764.	3168.	2779.
1949.	1446.	632.	906.	1082.	416.	418.	1189.	4977.	3536.	2864.	3206.	2744.
1950.	1307.	542.	1110.	741.	424.	481.	2007.	2069.	4833.	3787.	3170.	2844.
1951.	1513.	712.	905.	1148.	734.	3289.	2798.	3087.	3871.	2606.	3024.	2725.
1952.	1391.	657.	567.	1290.	2594.	2301.	2618.	4910.	5314.	2574.	3094.	2675.
1953.	1516.	749.	1000.	643.	423.	1458.	2063.	1830.	5111.	3423.	3099.	2862.
1954.	1523.	751.	999.	1071.	418.	1607.	2681.	3229.	4524.	2795.	3130.	2740.
1955.	1509.	659.	1084.	1020.	1049.	820.	468.	1503.	2727.	2409.	3196.	2689.
1956.	1297.	472.	804.	771.	2865.	2697.	3102.	5029.	5455.	2498.	3158.	2817.
1957.	1235.	709.	685.	1291.	661.	2072.	1747.	3839.	5815.	2603.	3137.	2832.
1958.	1413.	656.	780.	689.	418.	914.	1921.	4777.	4750.	2618.	3122.	2722.
1959.	1592.	601.	835.	994.	714.	559.	971.	1819.	4306.	2681.	3072.	2163.
1960.	1401.	849.	1202.	1377.	453.	517.	997.	2086.	4923.	2910.	3085.	2755.

MONTHLY AVERAGES IN CFS

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1427.	628.	872.	980.	808.	1428.	1818.	3071.	4391.	2849.	3126.	2714.

AVERAGE ANNUAL FLOW= 2015. CFS

RATIO OF AVG MONTHLY FLOW TO AVG ANNUAL FLOW

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
0.708	0.312	0.433	0.486	0.401	0.709	0.902	1.524	2.179	1.414	1.551	1.347

FIGURE 14 CONTINUED

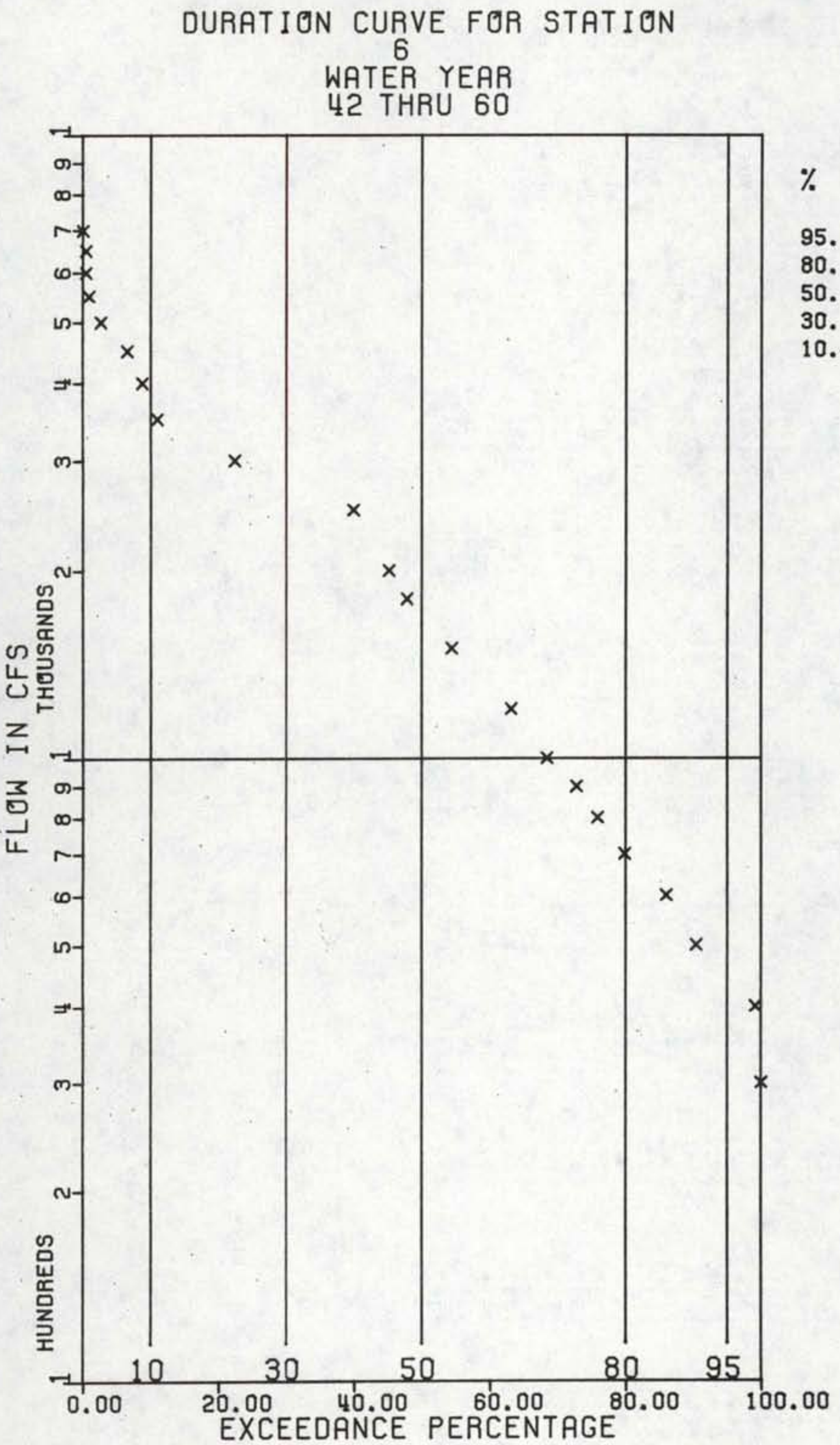
STATION 6
WATER YEAR
42 THRU 60

CLASS	LOWER LIMIT CFS	UPPER LIMIT CFS	INTERVAL COUNT	NUMBER GREATER	PERCENT GREATER
1	0.0	5.00	0	228.	100.
2	5.00	10.00	0	228.	100.
3	10.00	30.00	0	228.	100.
4	30.00	50.00	0	228.	100.
5	50.00	70.00	0	228.	100.
6	70.00	100.00	0	228.	100.
7	100.00	150.00	0	228.	100.
8	150.00	200.00	0	228.	100.
9	200.00	300.00	0	228.	100.
10	300.00	400.00	2	226.	99.
11	400.00	500.00	20	206.	90.
12	500.00	600.00	10	196.	86.
13	600.00	700.00	14	182.	80.
14	700.00	800.00	9	173.	76.
15	800.00	900.00	7	166.	73.
16	900.00	1000.00	10	156.	68.
17	1000.00	1200.00	12	144.	63.
18	1200.00	1500.00	20	124.	54.
19	1500.00	1800.00	15	109.	48.
20	1800.00	2000.00	6	103.	45.
21	2000.00	2500.00	12	91.	40.
22	2500.00	3000.00	40	51.	22.
23	3000.00	3500.00	26	25.	11.
24	3500.00	4000.00	5	20.	9.
25	4000.00	4500.00	5	15.	7.
26	4500.00	5000.00	9	6.	3.
27	5000.00	5500.00	4	2.	1.
28	5500.00	6000.00	1	1.	0.
29	6000.00	6500.00	0	1.	0.
30	6500.00	7000.00	1	0.	0.
31	7000.00	7500.00	0	0.	0.
32	7500.00	8000.00	0	0.	0.
33	8000.00	8500.00	0	0.	0.
34	8500.00	9000.00	0	0.	0.
35	9000.00	9500.00	0	0.	0.
36	9500.00	10000.00	0	0.	0.
37	10000.00	15000.00	0	0.	0.
38	15000.00	20000.00	0	0.	0.
39	20000.00	25000.00	0	0.	0.
40	25000.00	30000.00	0	0.	0.
41	30000.00	35000.00	0	0.	0.
42	35000.00	40000.00	0	0.	0.
43	40000.00	45000.00	0	0.	0.
44	45000.00	50000.00	0	0.	0.
45	50000.00	200000.00	0	0.	0.

STATION 6

EXCEEDANCE	FLOW
95.	444.23
80.	696.92
50.	1693.86
30.	2771.25
10.	3711.79

FIGURE 14 CONTINUED



%	Q
95.	444.23
80.	696.92
50.	1693.86
30.	2771.25
10.	3711.79

FIGURE 14 CONTINUED

COMPUTED FLOW
STATION NUMBER 7
FLOW IN CFS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1942.	1590.	655.	953.	1021.	528.	494.	1397.	2014.	4845.	2907.	3350.	2954.
1943.	1598.	529.	467.	667.	852.	3345.	4451.	3586.	4706.	4707.	3014.	2801.
1944.	1448.	725.	1246.	1544.	940.	921.	653.	1759.	1642.	2575.	3276.	2602.
1945.	1447.	629.	1086.	704.	393.	388.	601.	2240.	2633.	2602.	3108.	2763.
1946.	1473.	484.	527.	538.	524.	531.	2049.	3696.	4185.	2818.	3148.	2663.
1947.	1325.	548.	698.	1183.	582.	3021.	2049.	4850.	5264.	2791.	3148.	2669.
1948.	1360.	691.	1026.	1107.	623.	1606.	1763.	3288.	7329.	2871.	3217.	2816.
1949.	1482.	669.	937.	1110.	444.	455.	1338.	5422.	3814.	2944.	3247.	2777.
1950.	1342.	580.	1146.	776.	461.	526.	2121.	2342.	5304.	4006.	3235.	2890.
1951.	1570.	772.	955.	1187.	784.	3337.	2997.	3483.	4213.	2760.	3089.	2767.
1952.	1452.	701.	610.	1327.	2631.	2336.	2800.	5378.	5708.	2701.	3148.	2712.
1953.	1548.	778.	1031.	681.	459.	1499.	2181.	2051.	5570.	3637.	3162.	2901.
1954.	1557.	787.	1033.	1102.	456.	1657.	2842.	3648.	4854.	2960.	3190.	2781.
1955.	1543.	692.	1112.	1048.	1076.	848.	511.	1703.	3098.	2531.	3241.	2723.
1956.	1332.	515.	884.	828.	2909.	2754.	3319.	5558.	5938.	2636.	3217.	2857.
1957.	1275.	749.	722.	1323.	698.	2117.	1848.	4289.	6250.	2717.	3185.	2870.
1958.	1454.	689.	813.	718.	454.	947.	2005.	5289.	5127.	2720.	3172.	2759.
1959.	1625.	646.	882.	1033.	750.	596.	1089.	2045.	4655.	2777.	3118.	2214.
1960.	1465.	895.	1236.	1409.	485.	569.	1119.	2315.	5236.	2986.	3128.	2787.

MONTHLY AVERAGES IN CFS

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1470.	671.	915.	1018.	846.	1473.	1958.	3424.	4764.	2986.	3184.	2758.

AVERAGE ANNUAL FLOW= 2128. CFS

RATIO OF AVG MONTHLY FLOW TO AVG ANNUAL FLOW

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
0.691	0.315	0.430	0.478	0.398	0.692	0.920	1.609	2.239	1.403	1.496	1.296

FIGURE 14 CONTINUED

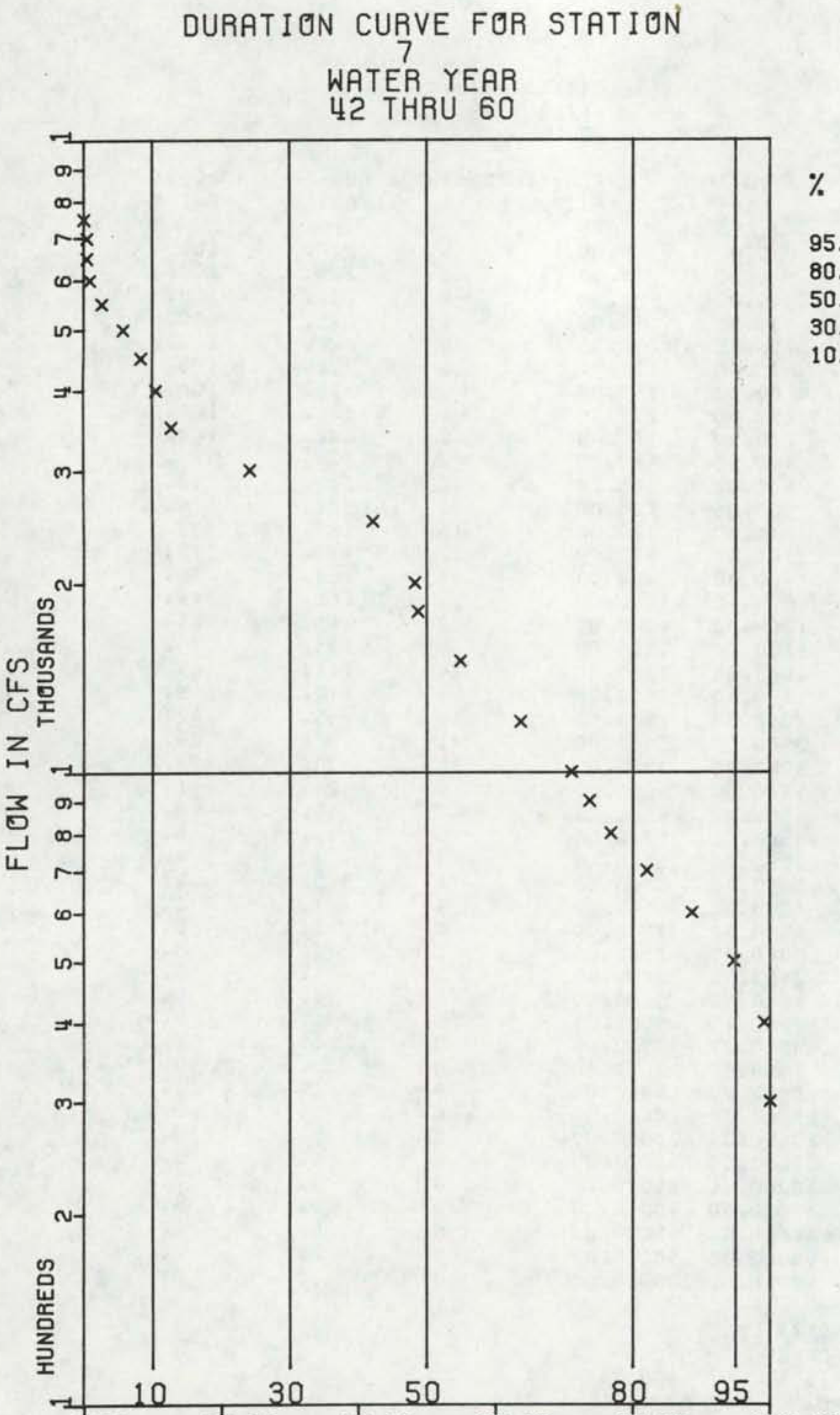
STATION 7
WATER YEAR
42 THRU 60

CLASS	LOWER LIMIT CFS	UPPER LIMIT CFS	INTERVAL COUNT	NUMBER GREATER	PERCENT GREATER
1	0.0	5.00	0	228.	100.
2	5.00	10.00	0	228.	100.
3	10.00	30.00	0	228.	100.
4	30.00	50.00	0	228.	100.
5	50.00	70.00	0	228.	100.
6	70.00	100.00	0	228.	100.
7	100.00	150.00	0	228.	100.
8	150.00	200.00	0	228.	100.
9	200.00	300.00	0	228.	100.
10	300.00	400.00	2	226.	99.
11	400.00	500.00	10	216.	95.
12	500.00	600.00	14	202.	89.
13	600.00	700.00	15	187.	82.
14	700.00	800.00	12	175.	77.
15	800.00	900.00	7	168.	74.
16	900.00	1000.00	6	162.	71.
17	1000.00	1200.00	17	145.	64.
18	1200.00	1500.00	20	125.	55.
19	1500.00	1800.00	14	111.	49.
20	1800.00	2000.00	1	110.	48.
21	2000.00	2500.00	14	96.	42.
22	2500.00	3000.00	41	55.	24.
23	3000.00	3500.00	26	29.	13.
24	3500.00	4000.00	5	24.	11.
25	4000.00	4500.00	5	19.	8.
26	4500.00	5000.00	6	13.	6.
27	5000.00	5500.00	7	6.	3.
28	5500.00	6000.00	4	2.	1.
29	6000.00	6500.00	1	1.	0.
30	6500.00	7000.00	0	1.	0.
31	7000.00	7500.00	1	0.	0.
32	7500.00	8000.00	0	0.	0.
33	8000.00	8500.00	0	0.	0.
34	8500.00	9000.00	0	0.	0.
35	9000.00	9500.00	0	0.	0.
36	9500.00	10000.00	0	0.	0.
37	10000.00	15000.00	0	0.	0.
38	15000.00	20000.00	0	0.	0.
39	20000.00	25000.00	0	0.	0.
40	25000.00	30000.00	0	0.	0.
41	30000.00	35000.00	0	0.	0.
42	35000.00	40000.00	0	0.	0.
43	40000.00	45000.00	0	0.	0.
44	45000.00	50000.00	0	0.	0.
45	50000.00	200000.00	0	0.	0.

STATION 7

EXCEEDANCE	FLOW
95.	493.35
80.	736.76
50.	1731.03
30.	2826.45
10.	4114.67

FIGURE 14 CONTINUED



%	Q
95.	493.35
80.	736.76
50.	1731.03
30.	2826.45
10.	4114.67