IV.4.2-OPT3 CALIBRATION SYSTEM AUTOMATIC PARAMETER OPTIMIZATION PROGRAM (OPT3)

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Purpose

The Automatic Parameter Optimization Program (OPT3) is designed to enable users of NWSRFS models to further refine parameter estimates previously developed through manual calibration procedures.

These automatic optimization procedures are not a substitute for the manual calibration process.

The following optimization strategies are currently available:

- Adaptive Random Search (ARS) algorithm [Brazil, 1989] (see Section IV.4.2-OPT3-ARS [Hyperlink])
- Maximum Likelihood Estimator for the Heteroscedastic Error Case (HMLE) algorithm (see Section IV.4.2-OPT3-HMLE [Hyperlink])
- Pattern Search (PATSERCH) algorithm [Monro, 1971] (see Section IV.4.2-OPT3-PATSERCH [Hyperlink])
- Shuffled Complex Evolution (SCE) algorithm [Duan, 1991] (see Section IV.4.2-OPT3-SCE [Hyperlink])

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Background

An automatic optimization technique consists of two main components:

- a search algorithm
- an objective function or optimization criterion

The objective function is a statistical measure of the difference between the observed and simulated hydrographs. If N parameters are being optimized, the optimization criterion is a function of N dimensional space. The surface created by this criterion is called the response surface. The automatic optimization procedure searches this surface to locate a minimum point, corresponding to an optimal set of parameter values. The response surface is usually quite irregular with many bumps and dips, thus, it is difficult to know if the point at which the search algorithm stops is the global optimum or a local optimum corresponding to an inferior parameter set.

The optimization strategies are of two main types:

- global procedures, such as the ARS and SCE techniques, sample an entire portion of the response surface
- local search procedure, such as the Pattern Search technique, tries to find an optimum by starting at a particular point on the surface

Thus the ARS and SCE techniques are less likely to be trapped by local optima (i.e., small valleys on the response surface) than the Pattern Search technique. The primary difference between the ARS and SCE techniques is that the ARS technique approaches the parameter search process largely in a pure random manner, while the SCE technique conducts the parameter search using a strategy that has both probabilistic and deterministic elements. The advantage of the SCE approach over the ARS approach is that the SCE method can efficiently utilize information gained in the search process and information about the response surface. Because the ARS and SCE techniques search the entire parameter space while the Pattern Search technique searches about a given point, the number of trials required by the ARS and SCE routines (typically several hundred per parameter being optimized) is much greater than that required by the Pattern Search routine (typically 10 to 20 per parameter). Even with so many trials the chances of finding the global optimum are relatively small when the ARS scheme is used [Armour, 1990 and Wienig, 1991].

The Pattern Search algorithm should only be used to refine parameter values. The range to be searched for each parameter should be relatively small when using the Pattern Search technique. The SCE and ARS algorithms should be used if a larger range of possible values needs to be examined. However, the specified range should be as restrictive as possible so that only the portion of the response surface that is most likely to contain the optimum is searched. The efficiency of the ARS technique is particularly sensitive to the size of the response surface. For all of the techniques, only parameters with a significant amount of uncertainty should be included in order to reduce the complexity of the response surface as much as possible.

Parameters that are reasonably well known and parameters whose value is relatively insensitive to the objective function being used should not be included in an automatic optimization run.

The advantage of these optimization techniques is that they are able to test a large number of parameter sets, ultimately producing a set with a lower optimization criterion than the initial set. The great disadvantage of these techniques is that they evaluate the goodness of fit of a simulation based on a single value. The variability of all the hydrograph components are summarized by a single number, the objective function.

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General Features

The following objective functions (optimization criterion options) are available:

- Daily RMS Error (CMSD):

  Criterion=((mean_daily_QSIM-mean_daily_QOBS)**2/num_days)**.5

  This is the most frequently used option.

- Monthly Volume RMS Error (MM):

  Criterion=((month_vol_QSIM-month_vol_QOBS)**2/num_months)**.5

  This option is recommended for situations where monthly volume errors are more critical than daily flow errors.

- Criterion=(mean_daily_QSIM-mean_daily_QOBS))**Exponent

- Criterion=(log(mean_daily_QSIM)-log(mean_daily_QOBS))**Exponent

- Modified Correlation Coefficient [McCuen and Snyder, 1975]

  Criterion=1.0-Modified_R

- Maximum Likelihood Estimator for the Heteroscedastic Error Case [Sorooshian et al, 1983]
  This option may have advantages over the daily RMS error criterion in some cases. See Section IV.4.2-OPT3-HMLE.

where QSIM is the simulated discharge
QOBS is observed discharge

Options 3, 4 and 5 were developed mainly for use in research; however, there may be circumstances that warrant their use in calibration work. Additional objective functions can be added to the program in the future.

Data can be excluded from the optimization criterion by the following methods:

1. A buffer period ranging from 0 to 6 months at the beginning of the period of record can be specified.

2. A maximum of 10 data periods can be excluded by entering the dates when computation of the optimization criterion should stop and resume.

3. Low flow data may be excluded by specifying a discharge value (CMSD) below which the objective function will not be computed.

Parameters for the following Operations can be optimized:

1. SAC-SMA : PXADJ, PEADJ, UZTWM, UZFWM, UZK, PCTIM, ADIMP, RIVA, ZPERC, REXP, LZTWM, LZFSM, LZFPM, LZSK, LZPK, PFREE, RSERV, SIDE, EFC, ETHIGH, ETLOW. (ETHIGH and ETLOW are adjustment parameters for the ET-Demand or PE-Adjustment curve and always have an initial value of 1.0.)

2. SNOW-17 : PXADJ, ELEV, SCF, MFMAX, MFMIN, UADJ, SI, NMF, TIPM, MBASE, PLWHC, DAYGM, TAELEV.

3. UNIT-HG : UGH, UGV (These parameters reflect the horizontal and vertical adjustment of the unit hydrograph and always have an initial value of 1.0).

4. API-SLC : REC, LLMT, A, I, WN, WX, EI, E2, CP, K, M, POW, PSIG

5. XIN-SMA : K, IMP, WUM, WLM, WDM, SM, B, EX, C, KSS, KG+KSS, CI, CG, ETHIGH, ETLOW

6. API-CONT : AIXW, AIXD, CW, CD, CS, SMIX, FRSX, BFIM, AICR, CG, CP, CT, CSOIL

When a parameter in an Operation is optimized, only the value of the parameter in the specified Operation is changed (and carryover if specified by the carryover transfer rules). An option exists in the program to allow the same parameter in other Operations of the same type to change also. The other parameter values will be computed based on the ratio or difference between their initial values and the initial value of the parameter being optimized, depending on the type of parameter. Currently, ratios are maintained between parameters, for all Operations that can be optimized, except SAC-SMA and API-CONT. All parameters in SAC-SMA use ratios except for UZTWM, UZFWM and LZTWM, which use differences. In API-CONT differences are used for AIXW, AIXD, SMIX and CP.

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Input Summary

The input data for program OPT3 consists of the input for program MCP3 and the input needed to define the optimization options, the time series to be used for computing the objective function and the parameters to be optimized.

Card Group A consists of the MCP3 input data cards (see Section IV.4.1-MCP3).

Card Group B contains the optimization options and the information to define the time series to be used in computing the objective function. The B1 and B2 cards contain general optimization control parameters. The format of the B3 card is dependent on the scheme selected on B1. Formats are given for each available scheme. The B4 and B5 cards also contain general control information for the program.

Card	Format	Column	Contents
B1	A8	1-8	Optimization scheme to be used: 'PATSERCH' = Pattern Search algorithm 'ARS' = Adaptive Random Search algorithm 'SCE-UA' = Shuffled Complex Evolution algorithm
	I5	11-15	Number of months in buffer period (0 through 6)
	I5	16-20	Number of data periods to be dropped (maximum 10)
	A4	22-25	Option to display manual calibration output using parameters from the run with the best optimization criterion; enter 'MCP3' to the specify option
	I5	26-30	Option to punch Operations Table with parameters from run with the best optimization criterion; enter '1' to specify option
B2	I5	1-5	Optimization criterion: 1 = Daily RMS Error 2 = Monthly Volume RMS Error 3 = (S-O)**Exponent 4 = (logS-logO)**Exponent 5 = 1.0-ModifiedR 6 = ML Estimator (HMLE)
	I5	6-10	MAXN Maximum number of trials allowed before optimization is terminated; used to stop an optimization scheme before too much CPU time is used; should be set large enough so that optimization is generally completed before MAXN trials are performed; recommended values for MAXN are based on the optimization scheme used and are: PATSERCH: 20 times the number of parameters being optimized ARS: 1000 times the number of parameters

Card	Format	Column	Contents
			being optimized SCE-UA: 40 times the number of parameters being optimized times the number of complexes used
	F5.2	11-15	Exponent to be used with optimization criterion option 3 or 4; default is 2.0
	F10.2	16-25	Drainage area of basin (units of KM2)
	F10.2	26-35	Minimum observed discharge for which the objective function will be computed; default value is zero (objective function will be computed for all flows); this can be used to remove baseflow from the objective function when optimizing parameters only affecting high flows

B3 Card for Pattern Search scheme:

B3	I5	1-5	Type of parameter increment to be used; enter '0' for fixed quantity (absolute value); enter '1' for percentage parameter value; generally it is recommended that percentages be used
	I5	6-10	Maximum number of resolutions allowed before optimization is terminated; recommended value is 3
	I5	11-15	Number of trials in which the criterion value must change by the specified percentage or else optimization will be terminated; recommended value is 3
	F5.2	16-20	Percentage by which the criterion value must change in the specified number of trials or the optimization is terminated; use decimal equivalent (percentage/100); recommended value is 0.01.

B3 Card for Adaptive Random Search scheme:

B3	I5	1-5	IF1 Number of range levels in each cycle; recommended value is 4
	I5	6-10	IF3 Number of trials in the first range level: recommended value is 200
	I5	16-20	IF5 Number of successive cycles that

Card	Format	Column	Contents
			optimization must be in the minimum (smallest) range to stop; IF5 determines when the optimization process is finished; recommended value is 3
	I5	21-25	Seed value for random number generator; the choice of the seed value may affect CPU time (speed of convergence) but the final result should not vary much; recommended value is any odd integer
	I1	30	Output indicator set equal to 1 to obtain full output; default generates abbreviated output; recommended value is the default

B3 Card for Shuffled Complex Evolution scheme:

B3	I5	1-5	NGS Number of complexes used for optimization search; minimum value is 1; recommended value is based on the number of parameters being optimized as follows:

No. of Parameters	No. of Complexes
1 - 2	1
3 - 4	2
5 - 6	4
7 - 8	4
9 - 10	8
> 10	8

The more complexes used then the more robust is the procedure but the CPU time is increased.

	I5	6-10	Minimum number of complexes required if the number of complexes is allowed to reduce as the optimization search proceeds; the default value is equal to NGS
	I5	11-15	Random seed used in optimization search; enter any integer number; recommended value is any large integer
	I5	16-20	Number of shuffling loops in which the criterion must improve by the specified percentage or else optimization will be terminated; recommended value is 5
	F5.2	21-25	Percentage by which the criterion value must change in the specified number of shuffling loops or the optimization is

Card	Format	Column	Contents
			terminated; use decimal equivalent: (percentage/100); recommended value is 0.01
	I5	26-30	IDEFLT Indicator for setting the control variables of the SCE-UA algorithm; enter '0' for default setting; enter '1' for user specified setting; if option '1' is chosen then enter an optional input card B3a

B3a Optional Input Card for the Shuffled Complex Evolution scheme (needed only if IDEFLT=1):

B3a	I5	1-5	NPG Number of points in each complex; NPG should be greater or equal to 2; the default value is equal to (2 * number of optimized parameters + 1)
	I5	6-10	NPS Number of points in each sub-complex; NPS should be greater or equal to 2 and should be less than NPG; the default value is equal to (number of optimized parameters + 1).
	I5	11-15	Number of evolution steps taken by each complex before next shuffling loop; default value is equal to NPG
	I5	16-20	Indicator to control whether the initial point is included in the starting population; enter '1' if the initial point is to be included; enter '0' if the initial point is not to be included; the default value is '1'
	I5	21-25	Printout control indicator; enter '0' to only display the best set of values for each shuffling loop; enter '1' to print out every point in the entire sample population during each shuffling loop; default value is 0
B4	A8	1-8	Internal identifier for the simulated discharge time series to be used for optimization
	A4	11-14	Data type code of simulated discharge time series

Card	Format	Column	Contents
	I2	19-20	Data ime interval of simulated discharge time series; statistics computed only for 24 hour values at this time
	A8	26-33	Internal identifier for the observed discharge time series to be used for optimization.
	A4	36-39	Data type code of observed discharge time series.
	I2	44-45	Data time interval of observed discharge time series; statistics computed only for 24-hour values at this time

Repeat card B5 for each data period to be dropped from optimization criterion computations. (Note: The drop periods must not contain any days of the buffer period. Periods must be in chronological order.)

B5 (optional)			Date criterion computation stops:
	I2	1-2	Month
	I2	6-7	Day
	I4	11-14	Year
			Date criterion computation resumes:
	I2	16-17	Month
	I2	21-22	Day
	I4	26-29	Year

Card Group C contains the information on the parameters to be optimized. Repeat cards C1 and C2 for each parameter that is to be optimized (maximum of 16 separate parameters).

C1	A8	1-8	8-character identifier for the type of Operation
	A8	11-18	8-character user-supplied name for the Operation (same as in MCP3 input)
	A8	21-28	Parameter name (left justified)
	F5.2	31-35	Parameter increment; only needed for Pattern Search technique; if percentage is used then recommended value is 0.01
	F5.2	36-40	Lower constraint on parameter

	F5.2	41-45	Upper constraint on parameter
	I5	46-50	Number of other Operations to have ratio or difference maintained for the parameter being optimized

A separate C2 card is needed for each additional Operation that is to be affected by the optimization of the Operation and parameter defined in card C1.

C2	A8	1-8	Identifier for the type of Operation (see Section V.3.2 [Hyperlink])
	A8	11-18	User supplied name for the Operation (same as in MCP3 input)
C3	A4	1-4	'STOP'

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Program Execution Information

See Chapter I.2 [Hyperlink] for information about how to execute the program.

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Output Data

OPT3 generates the following types of output:

1. Printer output consisting of the time series and Operations used, the optimization options selected, the time series to be used in the optimization criterion, the parameters to be optimized, the results of optimization trials and the optimized parameter values. An option exists to generate MCP3 output from the Operations, using optimized parameters, on the last pass through the Operations Table.

2. Time series output to the calibration disk files on the last pass through the optimizer using the optimized parameter values. This occurs if the option is specified in card group D in the MCP3 input and if the final MCP3 display pass is specified for OPT3.

3. Punch cards consisting of the optimized input to the Operations for which punch subroutines have been written.

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Sample Input and Output

Sample input is shown in Figure 1 [Bookmark] and sample output is shown in Figure 2 [Bookmark].

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References

Armour, A., 'Adaptive Random Search Evaluated As A Method For Calibration Of The SMA-NWSRFS Model', MS Thesis, Department of Hydrology and Water Resources, University of Arizona, Tucson, AZ 85721, 1990.

Brazil, L.E., 'Multilevel Calibration Strategy for Complex Hydrologic Simulation Models', NOAA Technical Report, NWS 42, Silver Spring, Maryland, 1989.

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McCuen, R.H. and W.M. Snyder, 'A Proposed Index for Comparing Hydrographs', Water Resources Research, December, 1975.

Monro, J.C., 'Direct Search Optimization in Mathematical Modeling and a Watershed Model Application', NOAA Technical Memorandum NWS HYDRO 12, Silver Spring, Maryland, 1971.

Sorooshian, S., V. K. Gupta and J. L. Fulton, 'Evaluation of Maximum Likelihood Parameter Estimation Techniques for Conceptual Rainfall-Runoff Models: Influence of Calibration Data Variability and Length on Model Credibility', Water Resources Research, February, 1983.

Weinig, W., 'Calibration of the SMA-NWSRFS Model using the Adaptive Random Search Algorithm', MS Thesis, Hydrology and Water Resources Department, University of Arizona, 1991.

Figure 1. Sample input for program OPT3

```
                                    - Column -

    5   10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
```



```
FRENCH BROAD RIVER BASIN ABOVE BLANTYRE, NORTH CAROLINA
   10 1953   01 1954
DEF-TS
BLANTYRE   MAP     6            INPUT
serfc/Blantyre_MAP
BLANTYRE   RAIM    6
BLANTYRE   SASC   24
BLANTYRE   INFW    6
BLANTYRE   ROCL   24
BLANTYRE   SMZC   24
BLANTYRE   MAT     6            INPUT
serfc/FrenchBroad_MAT
GREENVIL   PTPE   24            INPUT
serfc/E.Greenville_PTPE
ROSMAN     QINE    3            INPUT
serfc/FrenchBroad_QINE
BREVARD    QINE    3            INPUT
serfc/Davidson_QINE
BLANTYRE   SQIN    3
BLANTYRE   QME    24            INPUT
serfc/Blantyre_QME
BLANTYRE   SQME   24
BLANTYRE   QIN     6            INPUT
serfc/FrenchBroad_QIN
END
SNOW-17     BLANTYRE
FRENCH BROAD-BLANTYE 915. 35.0           YES SUMS
    6  BLANTYRE MAP      1.000       BLANTYRE RAIM
  BLANTYRE MAT     6
                                BLANTYRE SASC   24
 1.30 0.90 0.400.100 125.
 0.15 0.50  0.0  1.0 0.10 0.20
 0.12 0.17 0.20 0.22 0.25 0.30 0.38 0.50 0.70
SAC-SMA     BLANTYRE
FRENCH BROAD-BLANTYE         6  BLANTYRE RAIM       BLANTYRE INFW
  BLANTYRE SASC   24  BLANTYRE  BLANTYRE SUMS
                     1.0001.000 85.0 25.00.3000.0350.1000.100    00.250
                       6.0 1.50 180.290.01000.0.100.00500.2000.300 0.0
  GREENVIL PTPE      0.700.500.360.220.321.201.101.101.100.900.750.75
                      70.0  0.0 130.  0.0 250. 200.                          10/53
UNIT-HG     BLANTYRE
FRENCH BROAD-BLANTYE          185.0   22
  BLANTYRE INFW    6  ROSMAN   QINE    3
    0.2600    3.0000    5.2900    3.1700    1.0500    0.7900    0.6300
    0.4700    0.4000    0.3400    0.3000    0.2700    0.2400    0.2100
    0.1800    0.1500    0.1200    0.0900    0.0700    0.0500    0.0300
    0.0200
LAG/K       ROSMAN
ROSMAN   QINE  3 BLANTYRE SQIN  3     5     0
    10.000     0.0      12.000   100.000    18.000   250.000           X
    18.000   300.000     9.000   450.000
     0.0
    0
UNIT-HG     BREVARD
FRENCH BROAD-BLANTYE          125.1   21
  BLANTYRE INFW    6  BREVARD  QINE    3
    0.1800    2.8200    4.0100    1.4800    0.5100    0.3900    0.3500
    0.2900    0.2600    0.2300    0.2000    0.1900    0.1700    0.1300
    0.1100    0.0800    0.0600    0.0500    0.0400    0.0200    0.0100
```

Figure 1. Sample input for program OPT3

```
                                    - Column -

    5   10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+

LAG/K       BREVARD
BREVARD  QINE  3 BLANTYRE SQIN  3     4     0
    5.000     0.0       6.000    70.000     9.000   200.000           X
     6.000   350.000
     0.0
    0
UNIT-HG     LOCAL
FRENCH BROAD-BLANTYE          176.0   22
  BLANTYRE INFW    6  BLANTYRE SQIN    3
    0.2500    2.8500    5.0300    3.0200    1.0000    0.7500    0.6000
    0.4500    0.3800    0.3200    0.2900    0.2600    0.2300    0.2000
    0.1700    0.1400    0.1100    0.0800    0.0700    0.0500    0.0300
    0.0200
LAG/K       BLANTYRE
BLANTYRE SQIN  3               0     0    12
     0.0
     9.000     0.0       3.000    50.000     9.000    90.000           X
    36.000   110.000    42.000   130.000    42.000   170.000           X
    36.000   180.000    21.000   200.000    12.000   260.000           X
     6.000   340.000     4.000   400.000     3.000   500.000
    0
MEAN-Q      BLANTYRE
  BLANTYRE SQIN    3  BLANTYRE SQME   24
INSQPLOT    BLANTYRE
FRENCH BROAD-BLANTYE    2    3    1
  BLANTYRE RAIM    6        RAIM+MELT
  BLANTYRE INFW    6        RUNOFF
  BLANTYRE QIN     6        OBSERVED        +
  BLANTYRE SQIN    3        SIMULATED       *
WY-PLOT     BLANTYRE
FRENCH BROAD-BLANTYE    2          767.0 200.  YES
  BLANTYRE QME         OBSERVED        +
  BLANTYRE SQME        SIMULATED       *
  BLANTYRE RAIM    6            BLANTYRE            BLANTYRE
STOP
PATSERCH      3    0 MCP3
    1   60        767.
    1    3    3  .01
BLANTYRE  SQME    24     BLANTYRE  QME     24
SAC-SMA   BLANTYRE  UZTWM       .02  20. 150.
SNOW-17   BLANTYRE  SCF         .02   .8  2.0
STOP
```

Figure 2. Sample Output for Program OPT3


```
NWSRFS CALIBRATION SYSTEM - PROGRAM OPT3     (VERSION: 3.2.24   - 01/20/99)               DATE=Mar  9, 1999 - 07:33:58

          ********************************************************************************************************
          ********************************************************************************************************
          *****                                                                                                  *****
          *****                                                                                                  *****
          *****     FRENCH BROAD RIVER BASIN ABOVE BLANTYRE, NORTH CAROLINA                                      *****
          *****                                                                                                  *****
          *****                                                                                                  *****
          *****          PERIOD USED FOR THIS RUN --  OCT/1953 TO  JAN/1954                                      *****
          *****                                                                                                  *****
          *****                                                                                                  *****
          ********************************************************************************************************
          ********************************************************************************************************

                TIME SERIES USED FOR THIS SEGMENT.

                                    TIME          TIME          FILE                    DATA                                EXTERNAL
    USER I.D.     DATA TYPE     INTERVAL     SERIES TYPE     TYPE PERIOD OF REC.  UNIT    "STAID"       DESCRIPTION      TS ID
    ---------     ---------     --------     -----------     ---- ---------------- ---- ------------ --------------------
-----------------

 1.  BLANTYRE        MAP         6 HOURS       INPUT         CARD 10/1953-10/1954 IN   BLAN-MAP     MAP ABV BLAN00000230
/users/scv/nwsrfs/calb/sample/area_ts/serfc/Blantyre_MAP

 2.  BLANTYRE        RAIM        6 HOURS       INTERNAL

 3.  BLANTYRE        SASC       24 HOURS       INTERNAL

 4.  BLANTYRE        INFW        6 HOURS       INTERNAL

 5.  BLANTYRE        ROCL       24 HOURS       INTERNAL

 6.  BLANTYRE        SMZC       24 HOURS       INTERNAL

 7.  BLANTYRE        MAT         6 HOURS       INPUT         CARD 10/1953-10/1954 DEGC BLAN-MAT     FRENCH BROAD00000260
/users/scv/nwsrfs/calb/sample/area_ts/serfc/FrenchBroad_MAT

 8.  GREENVIL        PTPE       24 HOURS       INPUT         CARD 10/1953-10/1954 IN   BLAN-PTPE    E-GREENVILLE00000290
/users/scv/nwsrfs/calb/sample/area_ts/serfc/E.Greenville_PTPE

 9.  ROSMAN          QINE        3 HOURS       INPUT         CARD 10/1953-10/1954 CMS  BLAN-QINE    FRENCH BROAD00000320
/users/scv/nwsrfs/calb/sample/area_ts/serfc/FrenchBroad_QINE

10.  BREVARD         QINE        3 HOURS       INPUT         CARD 10/1953-10/1954 CMS  BLAN-QINE    DAVIDSON R  00000350
/users/scv/nwsrfs/calb/sample/area_ts/serfc/Davidson_QINE

11.  BLANTYRE        SQIN        3 HOURS       INTERNAL

12.  BLANTYRE        QME        24 HOURS       INPUT         CARD 10/1953-10/1954 CFSD BLAN-QME     ME AT BLANTY00000380
/users/scv/nwsrfs/calb/sample/area_ts/serfc/Blantyre_QME

13.  BLANTYRE        SQME       24 HOURS       INTERNAL

14.  BLANTYRE        QIN         6 HOURS       INPUT         CARD 10/1953-10/1954 CFS  BLAN-QIN     FRENCH BRD B00000410
/users/scv/nwsrfs/calb/sample/area_ts/serfc/FrenchBroad_QIN

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

  456 OUT OF   750 SPACES IN THE TS ARRAY HAVE BEEN USED.
         (PRECEEDING ERROR MESSAGES INDICATE IF MORE SPACE WAS NEEDED.)

 1860 SPACES HAVE BEEN ALLOCATED TO TIME SERIES DATA IN THE D ARRAY.

DEFINITION OF THE OPERATIONS TABLE.

          NOTE.....A CLEAR-TS OPERATION IS AUTOMATICALLY INSERTED FOR TIME SERIES (I.D.=BLANTYRE   TYPE=SQIN   DT= 3 HOURS)

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

                    THE OPERATIONS USED FOR THIS SEGMENT ARE AS FOLLOWS.

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

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

SNOW-17  OPERATION     NAME=BLANTYRE

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

          SNOW MODEL OPERATION FOR FRENCH BROAD-BLANTYE     ELEV= 915. M   LAT.= 35.0

               COMPUTATIONAL TIME INTERVAL IS  6 HOURS.

                    TIME SERIES USED BY THIS OPERATION.

               CONTENTS              I.D.       TYPE     TIME INTERVAL     OTHER

          PRECIPITATION            BLANTYRE     MAP         6 HOURS      PXADJ= 1.00
          AIR TEMPERATURE          BLANTYRE     MAT         6 HOURS      TAELEV= 915.
          RAIN+MELT                BLANTYRE     RAIM        6 HOURS
          SIM. AREAL COVER         BLANTYRE     SASC       24 HOURS

          SUMS OF WATER BALANCE VARIABLES ARE STORED.

          SNOW COVER VARIABLES DISPLAYED ON ALL SIGNIFICANT DAYS.
```

Figure 2. Sample Output for Program OPT3 (Continued)

```
          PARAMETER VALUES

               MAJOR PARAMETERS    SCF  MFMAX  MFMIN   UADJ     SI
                                  1.30    .90    .40   .100   125.

               MINOR PARAMETERS    NMF   TIPM  MBASE PXTEMP  PLWHC  DAYGM
                                   .15    .50     .0    1.0    .10    .20

               DEPLETION CURVE   WE/AI     .0   .1   .2   .3   .4   .5   .6   .7   .8   .9  1.0
                                 COVER   0.05  .12  .17  .20  .22  .25  .30  .38  .50  .70  1.0

          SNOW COVER CONDITIONS FOR FRENCH BROAD-BLANTYE

               NO SNOW COVER EXISTS

**********

SAC-SMA  OPERATION     NAME=BLANTYRE

**********

          SACRAMENTO SOIL-MOISTURE ACCOUNTING OPERATION FOR FRENCH BROAD-BLANTYE

               COMPUTATIONAL TIME INTERVAL IS  6 HOURS.

                    TIME SERIES USED BY THIS OPERATION.

               CONTENTS              I.D.       TYPE     TIME INTERVAL

          RAIN+MELT                BLANTYRE     RAIM        6 HOURS
          CHANNEL INFLOW(RUNOFF)   BLANTYRE     INFW        6 HOURS
          POTENTIAL ET             GREENVIL     PTPE       24 HOURS
          AREAL EXTENT OF SNOW     BLANTYRE     SASC       24 HOURS
          RUNOFF COMPONENTS        BLANTYRE     ROCL       24 HOURS
          SOIL STORAGE CONTENTS    BLANTYRE     SMZC       24 HOURS

          SUMS OF WATER BALANCE VARIABLES ARE STORED.

          PARAMETER VALUES - CAPACITIES ARE IN MM.

            PX-ADJ  PE-ADJ   UZTWM   UZFWM     UZK   PCTIM   ADIMP    RIVA     EFC   DAILY ET DIST.
             1.000   1.000     85.     25.    .300    .035    .100    .100    .250    UNIFORM

             PBASE   ZPERC    REXP   LZTWM   LZFSM   LZFPM    LZSK    LZPK   PFREE   RSERV    SIDE
              34.0     6.0    1.50    180.    290.   1000.   .1000   .0050     .20     .30     .00

          16TH OF MONTH VALUES     1     2     3     4     5     6     7     8     9    10    11    12
          PE-ADJUSTMENT          .70   .50   .36   .22   .32  1.20  1.10  1.10  1.10   .90   .75   .75

          SOIL-MOISTURE CONTENTS(MM) FOR FRENCH BROAD-BLANTYE

                 UZTWC   UZFWC   LZTWC   LZFSC   LZFPC   ADIMC
                   70.      .0    130.      .0    250.    200.

**********

UNIT-HG  OPERATION     NAME=BLANTYRE

**********

          UNIT HYDROGRAPH OPERATION FOR FRENCH BROAD-BLANTYE

               COMPUTATIONAL TIME INTERVAL IS  6 HOURS.

                    TIME SERIES USED BY THIS OPERATION.

               CONTENTS              I.D.       TYPE     TIME INTERVAL

          CHANNEL INFLOW (RUNOFF)  BLANTYRE     INFW        6 HOURS
          INSTANTANEOUS DISCHARGE  ROSMAN       QINE        3 HOURS

           6-HOUR UNIT HYDROGRAPH:  22 ORDINATES DEFINED AT   3-HOUR INTERVALS

          THE UNIT HYDROGRAPH REPRESENTS AN AREA OF ABOUT   185.0 SQ.KM.

          ORDINATE        1        2        3        4        5        6        7        8        9       10

          Q (CMS/MM)      .26     3.00     5.29     3.17     1.05      .79      .63      .47      .40      .34

          ORDINATE       11       12       13       14       15       16       17       18       19       20

          Q (CMS/MM)      .30      .27      .24      .21      .18      .15      .12      .09      .07      .05

          ORDINATE       21       22

          Q (CMS/MM)      .03      .02

          NO BASEFLOW WILL BE ADDED TO THE COMPUTED DISCHARGES.

          UNIT HYDROGRAPH CARRYOVER VALUES FOR FRENCH BROAD-BLANTYE

          INITIAL CARRYOVER VALUES HAVE BEEN SET TO ZERO.

**********

CLEAR-TS OPERATION     NAME=

**********

          THE FOLLOWING TIME SERIES IS SET TO ALL ZERO VALUES.
```

Figure 2. Sample Output for Program OPT3 (Continued)

```
              I.D.=BLANTYRE   TYPE=SQIN   TIME INTERVAL= 3 HOURS

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

LAG/K    OPERATION     NAME=ROSMAN

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

          LAG AND/OR K OPERATION
              COMPUTATIONAL TIME INTERVAL IS  3 HOURS.
                TIME SERIES USED BY THIS OPERATION.
                   I.D.       TYPE     TIME INTERVAL
                 ROSMAN       QINE        3 HOURS
                 BLANTYRE     SQIN        3 HOURS

              NO FORT WORTH RFC TRANSMISSION LOSS COMPUTATIONS WILL BE DONE.

              LAG OPERATION WILL BE PERFORMED.
              A VARIABLE LAG WILL BE APPLIED.
              THE VARIABLE LAG TABLE CONTAINING   5 PAIRS OF LAG AND Q VALUES IS
              LAG (HOURS)       10.       12.       18.       18.        9.
              Q   (CMS)          .0     100.0     250.0     300.0     450.0

              K OPERATION WILL NOT BE PERFORMED.

          LAG AND/OR K CARRYOVER VALUES.
              LAG CARRYOVER HAS BEEN SET TO A DEFAULT VALUE OF ZERO.

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

UNIT-HG  OPERATION     NAME=BREVARD

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

         UNIT HYDROGRAPH OPERATION FOR FRENCH BROAD-BLANTYE

              COMPUTATIONAL TIME INTERVAL IS  6 HOURS.

                  TIME SERIES USED BY THIS OPERATION.

              CONTENTS              I.D.       TYPE     TIME INTERVAL

         CHANNEL INFLOW (RUNOFF)  BLANTYRE     INFW        6 HOURS
         INSTANTANEOUS DISCHARGE  BREVARD      QINE        3 HOURS

          6-HOUR UNIT HYDROGRAPH:  21 ORDINATES DEFINED AT   3-HOUR INTERVALS

         THE UNIT HYDROGRAPH REPRESENTS AN AREA OF ABOUT   125.1 SQ.KM.

         ORDINATE        1        2        3        4        5        6        7        8        9       10

         Q (CMS/MM)      .18     2.82     4.01     1.48      .51      .39      .35      .29      .26      .23

         ORDINATE       11       12       13       14       15       16       17       18       19       20

         Q (CMS/MM)      .20      .19      .17      .13      .11      .08      .06      .05      .04      .02

         ORDINATE       21

         Q (CMS/MM)      .01

         NO BASEFLOW WILL BE ADDED TO THE COMPUTED DISCHARGES.

         UNIT HYDROGRAPH CARRYOVER VALUES FOR FRENCH BROAD-BLANTYE

         INITIAL CARRYOVER VALUES HAVE BEEN SET TO ZERO.

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

LAG/K    OPERATION     NAME=BREVARD

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

          LAG AND/OR K OPERATION
              COMPUTATIONAL TIME INTERVAL IS  3 HOURS.
                TIME SERIES USED BY THIS OPERATION.
                   I.D.       TYPE     TIME INTERVAL
                 BREVARD      QINE        3 HOURS
                 BLANTYRE     SQIN        3 HOURS

              NO FORT WORTH RFC TRANSMISSION LOSS COMPUTATIONS WILL BE DONE.

              LAG OPERATION WILL BE PERFORMED.
              A VARIABLE LAG WILL BE APPLIED.
              THE VARIABLE LAG TABLE CONTAINING   4 PAIRS OF LAG AND Q VALUES IS
              LAG (HOURS)        5.        6.        9.        6.
              Q   (CMS)          .0      70.0     200.0     350.0

              K OPERATION WILL NOT BE PERFORMED.

          LAG AND/OR K CARRYOVER VALUES.
              LAG CARRYOVER HAS BEEN SET TO A DEFAULT VALUE OF ZERO.

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

UNIT-HG  OPERATION     NAME=LOCAL

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

         UNIT HYDROGRAPH OPERATION FOR FRENCH BROAD-BLANTYE
```

Figure 2. Sample Output for Program OPT3 (Continued)

```
          COMPUTATIONAL TIME INTERVAL IS  6 HOURS.

               TIME SERIES USED BY THIS OPERATION.

          CONTENTS              I.D.       TYPE     TIME INTERVAL

     CHANNEL INFLOW (RUNOFF)  BLANTYRE     INFW        6 HOURS
     INSTANTANEOUS DISCHARGE  BLANTYRE     SQIN        3 HOURS

      6-HOUR UNIT HYDROGRAPH:  22 ORDINATES DEFINED AT   3-HOUR INTERVALS

     THE UNIT HYDROGRAPH REPRESENTS AN AREA OF ABOUT   176.0 SQ.KM.

     ORDINATE        1        2        3        4        5        6        7        8        9       10

     Q (CMS/MM)      .25     2.85     5.03     3.02     1.00      .75      .60      .45      .38      .32

     ORDINATE       11       12       13       14       15       16       17       18       19       20

     Q (CMS/MM)      .29      .26      .23      .20      .17      .14      .11      .08      .07      .05

     ORDINATE       21       22

     Q (CMS/MM)      .03      .02

     NO BASEFLOW WILL BE ADDED TO THE COMPUTED DISCHARGES.

     UNIT HYDROGRAPH CARRYOVER VALUES FOR FRENCH BROAD-BLANTYE

     INITIAL CARRYOVER VALUES HAVE BEEN SET TO ZERO.

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

LAG/K    OPERATION     NAME=BLANTYRE

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

      LAG AND/OR K OPERATION
          COMPUTATIONAL TIME INTERVAL IS  3 HOURS.
            TIME SERIES USED BY THIS OPERATION.
               I.D.       TYPE     TIME INTERVAL
             BLANTYRE     SQIN        3 HOURS

          NO FORT WORTH RFC TRANSMISSION LOSS COMPUTATIONS WILL BE DONE.

          LAG OPERATION WILL NOT BE PERFORMED.

          K OPERATION WILL BE PERFORMED.
          A VARIABLE K WILL BE APPLIED.
          THE VARIABLE K TABLE CONTAINING  12 PAIRS OF K AND Q VALUES IS
          K   (HOURS)        9.        3.        9.       36.       42.       42.       36.       21.       12.        6.
          Q   (CMS)          .0      50.0      90.0     110.0     130.0     170.0     180.0     200.0     260.0     340.0
          K   (HOURS)        4.        3.
          Q   (CMS)       400.0     500.0

      LAG AND/OR K CARRYOVER VALUES.
          K CARRYOVER HAS BEEN SET TO A DEFAULT VALUE OF ZERO.

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

MEAN-Q   OPERATION     NAME=BLANTYRE

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

     MEAN DISCHARGE OPERATION

          COMPUTATIONAL TIME INTERVAL IS  3 HOURS.

               TIME SERIES USED BY THIS OPERATION.

          CONTENTS              I.D.       TYPE     TIME INTERVAL

     INSTANTANEOUS DISCHARGE  BLANTYRE     SQIN        3 HOURS
     MEAN DISCHARGE           BLANTYRE     SQME       24 HOURS

     MEAN DISCHARGES ARE COMPUTED FOR 24 HOUR TIME PERIODS.

     INITIAL CARRYOVER VALUES HAVE BEEN SET TO THEIR DEFAULT VALUES.

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

INSQPLOT OPERATION     NAME=BLANTYRE

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

     INSTANTANEOUS FLOW PLOT DISCHARGE FOR FRENCH BROAD-BLANTYE

     PLOT TIME INTERVAL = 3 HOURS   NUMBER OF DISCHARGE TIME SERIES TO BE PLOTTED = 2

               TIME SERIES USED BY THIS OPERATION

          CONTENTS                I.D.         TYPE      TIME INTERVAL     PLOTTING SYMBOL

          RAIM+MELT               BLANTYRE     RAIM        6 HOURS               N/A

          RUNOFF                  BLANTYRE     INFW        6 HOURS               N/A

          OBSERVED                BLANTYRE     QIN         6 HOURS                +

          SIMULATED               BLANTYRE     SQIN        3 HOURS                *
```

Figure 2. Sample Output for Program OPT3 (Continued)

```
          TIME SERIES ID=BLANTYRE TYPE=QIN  TIME INTERVAL= 6 HOURS MUST HAVE AT LEAST ONE NON-MISSING VALUE FOR
                                    A DAY BEFORE ANY TIME SERIES WILL BE PLOTTED

          THE FIRST 4 TIME SERIES WILL BE TABULATED

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

WY-PLOT  OPERATION     NAME=BLANTYRE

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

          PLOT MEAN DAILY FLOWS FOR FRENCH BROAD-BLANTYE

               AREA ABOVE FLOW-POINT=    767.0 KM2

               PLOT SCALE IS ARITHMETIC     MAX. ORDINATE=  200. CMSD

           2 DAILY FLOW TIME SERIES ARE PLOTTED

               T.S. I.D.   DATE TYPE       NAME     PLOT SYMBOL
               BLANTYRE      QME       OBSERVED          +
               BLANTYRE      SQME      SIMULATED         *

          DAILY TOTALS OF THE FOLLOWING TIME SERIES ARE TABULATED ON THE PLOT.

               T.S. I.D.     DATA TYPE     TIME INTERVAL
               BLANTYRE        RAIM           6 HOURS
               BLANTYRE        ROCL          24 HOURS
               BLANTYRE        SMZC          24 HOURS

          OPERATION USES RECORDS    1 THRU   24 ON SCRATCH FILE 10.

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

THIS IS THE END OF THE OPERATIONS TABLE FOR THIS SEGMENT.

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

THE MINIMUM TIME INTERVAL FOR WHICH THIS SEGMENT CAN BE EXECUTED IS  6 HOURS.

ACTUAL SPACE USED FOR THE P, C, T AND D ARRAYS FOR THIS SEGMENT:

     P ARRAY    653 OUT OF   3500 SPACES

     C ARRAY    180 OUT OF    400 SPACES

     T ARRAY    108 OUT OF    300 SPACES

     D ARRAY   2644 OUT OF   9000 SPACES

(PRECEEDING MESSAGES WILL INDICATE IF MORE SPACE WAS NEEDED FOR THE P, C AND T ARRAYS)

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

AUTOMATIC PARAMETER OPTIMIZATION OPTIONS

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

     OPTIMIZATION                MAX NO.             BASIN AREA              EXPONENT
      CRITERION                  OF RUNS                SIZE               IN CRIT 3 & 4
     ------------                -------             ----------             -------------

    DAILY RMS ERROR                 60                  767.00                  2.00

                           PATTERN SEARCH OPTIMIZATION SCHEME
                           ==================================

               PARAMETER           MAX NO.           REQUIRED IMPROVEMENT
               INCREMENT         RESOLUTIONS         PERCENT   NO. TRIALS
               ---------         -----------         -------   ----------

                PERCENT              3                1.0         3

MCP RUN WILL BE MADE WITH PARAMETER VALUES OBTAINED ON THE RUN WITH THE LOWEST CRITERION VALUE.

BUFFER PERIOD TO BE USED IS    3 CALENDAR MONTH(S).

NO DROP PERIODS HAVE BEEN SPECIFIED FOR THIS RUN.

                   TIME SERIES USED FOR OPTIMIZATION.

               CONTENTS     I.D.       TYPE     TIME INTERVAL

               SIMULATED  BLANTYRE     SQME       24 HOURS
               OBSERVED   BLANTYRE     QME        24 HOURS

THE FOLLOWING PARAMETERS WILL BE OPTIMIZED:

                                                                                                  OTHER OPERATIONS AFFECTED BY THIS CHANGE
                                        INITIAL    LOWER    UPPER    INCREMENT USED
   OPERATION    NAME    PARAMETER       VALUE     BOUND    BOUND     (PERCENTAGE)          NAME      RATIO OR DIFFERENCE MAINTAINED
   ---------    ----    ---------      -------    -----    -----    --------------         ----      ------------------------------

 1. SAC-SMA   BLANTYRE   UZTWM          85.000    20.000   150.000          .020

 2. SNOW-17   BLANTYRE   SCF             1.300      .800     2.000          .020

*** PRINT THE INITIAL POINT AND ITS STATISTICS ***
============================================================
```

Figure 2. Sample Output for Program OPT3 (Continued)

```
    UZTWM     SCF

    85.000     1.300

 DAILY RMS      MON VRMS     /O-S/**EXP  /LOG ERR/**EXP   % BIAS      1.-MOD RCOF      R COEF      HMLE VALUE   LAMDA VALUE
 ---------      --------     ----------  --------------   ------      -----------      ------      ----------   -----------

  .8490E+01     .6686E+01     .2234E+04     .2211E+00    -.4757E+01     .1525E+00     .9881E+00     .4052E+01    -.3000E+00

TRIAL RUN   CRITERION  % BIAS  R COEF   UZTWM     SCF
             (CMSD)          (DAILY Q'S)
                                         ------------------------------------------------------------------------------------

   1    1   .8490E+01   -4.76   .9881    85.000     1.300

TRIAL RUN   CRITERION  % BIAS  R COEF   UZTWM     SCF
                                         ------------------------------------------------------------------------------------

   1    2   .8491E+01   -4.77   .9881    86.700     1.300

   1    3   .8488E+01   -4.74   .9881    83.300     1.300

   1    4   .8487E+01   -4.71   .9880    83.300     1.326

PATTERN  MOVE

   2    5   .8485E+01   -4.66   .9880    81.600     1.352

TRIAL RUN   CRITERION  % BIAS  R COEF   UZTWM     SCF
                                         ------------------------------------------------------------------------------------

   2    6   .8483E+01   -4.65   .9880    79.934     1.352

   2    7   .8482E+01   -4.61   .9879    79.934     1.379

PATTERN  MOVE

   3    8   .8477E+01   -4.51   .9878    76.568     1.431

TRIAL RUN   CRITERION  % BIAS  R COEF   UZTWM     SCF
                                         ------------------------------------------------------------------------------------

   3    9   .8476E+01   -4.49   .9878    74.969     1.431

   3   10   .8475E+01   -4.45   .9878    74.969     1.459

PATTERN  MOVE

   4   11   .8474E+01   -4.29   .9876    70.005     1.539

TRIAL RUN   CRITERION  % BIAS  R COEF   UZTWM     SCF
                                         ------------------------------------------------------------------------------------

   4   12   .8473E+01   -4.27   .9876    68.505     1.539

   4   13   .8472E+01   -4.23   .9875    68.505     1.568

PATTERN  MOVE

*** OPTIMIZATION TERMINATED BECAUSE THE CRITERION VALUE WAS NOT CHANGED   1.00  PERCENT IN   3  TRIALS.

*** PRINT THE FINAL PARAMETER ESTIMATES AND THE STATISTICS ***
============================================================

    UZTWM     SCF

    68.505     1.568

 DAILY RMS      MON VRMS     /O-S/**EXP  /LOG ERR/**EXP   % BIAS      1.-MOD RCOF      R COEF      HMLE VALUE   LAMDA VALUE
 ---------      --------     ----------  --------------   ------      -----------      ------      ----------   -----------

  .8472E+01     .5949E+01     .2225E+04     .2257E+00    -.4233E+01     .1503E+00     .9875E+00     .4171E+01    -.4000E+00

THE FOLLOWING PARAMETERS HAVE BEEN OPTIMIZED:
     (OPTIMIZED VALUES OBTAINED ON RUN    13)
                                                                                  OTHER OPERATIONS AFFECTED BY THIS CHANGE

                                    INITIAL    OPTIMIZED                                          INITIAL          OPTIMIZED
   OPERATION    NAME    PARAMETER    VALUE      VALUE                              NAME            VALUE            VALUE
   ---------    ----    ---------   -------    ---------                           ----           -------          ---------

 1  SAC-SMA   BLANTYRE   UZTWM        85.000      68.505

 2  SNOW-17   BLANTYRE   SCF           1.300       1.568

INITIAL CARRYOVER VALUES HAVE BEEN CHANGED FOR THE FOLLOWING OPERATION(S):

OLD CARRYOVER FOR ID(SAC-SMA )  NAME(BLANTYRE)

          SOIL-MOISTURE CONTENTS(MM) FOR FRENCH BROAD-BLANTYE

                 UZTWC   UZFWC   LZTWC   LZFSC   LZFPC   ADIMC
                   70.      .0    130.      .0    250.    200.

NEW CARRYOVER

          SOIL-MOISTURE CONTENTS(MM) FOR FRENCH BROAD-BLANTYE

                 UZTWC   UZFWC   LZTWC   LZFSC   LZFPC   ADIMC
                   54.      .0    130.      .0    250.    184.
```

Figure 2. Sample Output for Program OPT3 (Continued)

```
'BLANTYRE'   SNOW-17 OUTPUT FOR FRENCH BROAD-BLANTYE      1/1954          (UNITS ARE 'MM' EXCEPT FOR AREAL COVER
          DAILY OUTPUT IS FOR HOUR 24     TIME ZONE=INTL                          AND PCT. LIQ. WATER)

                                  ENERGY   SIM. AREAL   PCT. LIQ.       HEAT                                    RAIN-SNOW
DAY      SNOWFALL        RAIN    EXCHANGE     COVER       WATER       DEFICIT     SIM. WE     OBS. WE  OBS. COVER   ELEVATION
 14           2.0         3.8         1.2       .21        10.0          .0           1.
 15           6.0         3.6         6.8       .00          .0          .0           0.

***** FRENCH BROAD-BLANTYE *****   INSTANTANEOUS DISCHARGE FROM JAN  1,1954 TO JAN 31,1954   TIME ZONE=INTL
     TIME SERIES TABULATED OR PLOTTED
   CONTENTS         I.D.    TYPE  TIME INTERVAL   PLOTTING SYMBOL     TABULATION LABEL(UNITS)
   RAIM+MELT     BLANTYRE  RAIM      6 HOURS           N/A                PCN  (MM)
   RUNOFF        BLANTYRE  INFW      6 HOURS           N/A                INFW (MM)
   OBSERVED      BLANTYRE  QIN       6 HOURS            +                 Q1  (CMS)
   SIMULATED     BLANTYRE  SQIN      3 HOURS            *                 Q2  (CMS)
TIME  PCN INFW    Q1     Q2  0.0      30.0      60.0      90.0     120.0     150.0     180.0     210.0     240.0     270.0     300.0
20- 3                   25.7 .        *.          .         .         .         .         .         .         .         .         .
20- 6 .00 .68    24.7   25.3 .        * .         .         .         .         .         .         .         .         .         .
20- 9                   25.0 .        * .         .         .         .         .         .         .         .         .         .
20-12 .25 .68    24.3   24.8 .        * .         .         .         .         .         .         .         .         .         .
20-15                   24.6 .        * .         .         .         .         .         .         .         .         .         .
20-18 5.3 1.2    23.6   24.8 .        * .         .         .         .         .         .         .         .         .         .
20-21                   25.9 .         *.         .         .         .         .         .         .         .         .         .
20-24  23 4.4    29.2   29.7 .         *         .         .         .         .         .         .         .         .         .
21- 3                   37.2 .       . *         .         .         .         .         .         .         .         .         .
21- 6  28 5.7    66.1   48.6 .         .     *   . +       .         .         .         .         .         .         .         .
21- 9                   63.9 .         .        .*         .         .         .         .         .         .         .         .
21-12 6.9 2.5    90.0   77.0 .         .         .     *   +         .         .         .         .         .         .         .
21-15                   87.8 .         .         .       *.          .         .         .         .         .         .         .
21-18 .00 1.2    92.9   93.9 .         .         .         .*        .         .         .         .         .         .         .
21-21                   96.2 .         .         .         . *       .         .         .         .         .         .         .
21-24  10 2.6    93.7   96.0 .         .         .         .+*       .         .         .         .         .         .         .
22- 3                   93.5 .         .         .         .*        .         .         .         .         .         .         .
22- 6  21 4.6    95.8   90.5 .         .         .         * +       .         .         .         .         .         .         .
22- 9                   89.3 .         .         .         *         .         .         .         .         .         .         .
22-12  53  17    124.   95.2 .         .         .         . *       .+        .         .         .         .         .         .
22-15                   105. .         .         .         .   *     .         .         .         .         .         .         .
22-18  12 4.3    144.   114. .         .         .         .     * .       + .         .         .         .         .         .
22-21                   124. .         .         .         .       .*        .         .         .         .         .         .
22-24 4.8 2.7    172.   133. .         .         .         .         .   *     .      +  .         .         .         .         .
23- 3                   141. .         .         .         .         .     *   .         .         .         .         .         .
23- 6 .00 1.7    185.   149. .         .         .         .         .       * .         . +       .         .         .         .
23- 9                   153. .         .         .         .         .         .*        .         .         .         .         .
23-12 .00 1.6    201.   153. .         .         .         .         .         .*        .       + .         .         .         .
23-15                   151. .         .         .         .         .         *         .         .         .         .         .
23-18 .00 1.6    202.   149. .         .         .         .         .         *         .       + .         .         .         .
23-21                   145. .         .         .         .         .       * .         .         .         .         .         .
23-24 .00 1.6    171.   142. .         .         .         .         .     *   .      +  .         .         .         .         .
24- 3                   138. .         .         .         .         .   *     .         .         .         .         .         .
24- 6 .00 1.5    151.   134. .         .         .         .         .     *   +         .         .         .         .         .
24- 9                   130. .         .         .         .         .   *     .         .         .         .         .         .
24-12 .00 1.5    133.   126. .         .         .         .         . * +     .         .         .         .         .         .
24-15                   122. .         .         .         .         .*        .         .         .         .         .         .
24-18 .00 1.5    119.   118. .         .         .         .       *+          .         .         .         .         .         .
24-21                   114. .         .         .         .       * .         .         .         .         .         .         .
24-24 .00 1.5    99.0   110. .         .         .         .  +    *  .         .         .         .         .         .         .
25- 3                   106. .         .         .         .    *    .         .         .         .         .         .         .
25- 6 .00 1.4    80.4   101. .         .         .       +   .   *   .         .         .         .         .         .         .
25- 9                   94.7 .         .         .         .  *      .         .         .         .         .         .         .
25-12 .00 1.4    68.0   84.2 .         .         .   +     * .         .         .         .         .         .         .         .
25-15                   74.2 .         .         .     *     .         .         .         .         .         .         .         .
25-18 .00 1.4    61.1   65.8 .         .         + *         .         .         .         .         .         .         .         .
25-21                   59.0 .         .         *           .         .         .         .         .         .         .         .
25-24 .00 1.4    56.8   55.3 .         .       *+.           .         .         .         .         .         .         .         .
26- 3                   53.0 .         .       * .           .         .         .         .         .         .         .         .
26- 6 .00 1.3    53.3   51.5 .         .      *+ .           .         .         .         .         .         .         .         .
26- 9                   50.4 .         .      *  .           .         .         .         .         .         .         .         .
26-12 .00 1.3    50.8   49.6 .         .      *  .           .         .         .         .         .         .         .         .
26-15                   48.9 .         .     *   .           .         .         .         .         .         .         .         .
26-18 .00 1.3    48.7   48.2 .         .     *   .           .         .         .         .         .         .         .         .
26-21                   47.6 .         .     *   .           .         .         .         .         .         .         .         .
26-24 .00 1.3    46.8   46.9 .         .     *   .           .         .         .         .         .         .         .         .
27- 3                   46.3 .         .    *    .           .         .         .         .         .         .         .         .
27- 6 .00 1.2    45.2   45.8 .         .    *    .           .         .         .         .         .         .         .         .
27- 9                   45.3 .         .    *    .           .         .         .         .         .         .         .         .
27-12 .76 1.2    44.3   44.9 .         .    *    .           .         .         .         .         .         .         .         .
27-15                   44.5 .         .    *    .           .         .         .         .         .         .         .         .
27-18 .00 1.2    43.2   44.1 .         .   +*    .           .         .         .         .         .         .         .         .
27-21                   43.8 .         .    *    .           .         .         .         .         .         .         .         .
27-24 .00 1.2    41.9   43.5 .         .   +*    .           .         .         .         .         .         .         .         .

WATER YEAR 1954   MEAN DAILY FLOW PLOT FOR FRENCH BROAD-BLANTYE     AREA=    767.0 SQ.KM     UNITS ARE CMSD
                                                                                            PCN=PRECIP. OR RAIN+MELT (MM)
                                                                                            INFW=RUNOFF OR CHANNEL INFLOW (MM)
          NUM.   T.S. I.D.   TYPE      NAME      SYM
            1     BLANTYRE   QME   OBSERVED       +
            2     BLANTYRE   SQME  SIMULATED      *

STREAMFLOW VOLUME SUMMARY

                  OCT     NOV     DEC     JAN     FEB     MAR     APR     MAY     JUN     JUL     AUG     SEP        ANNUAL

Q(1)             277.    317.    880.   1248.      0.      0.      0.      0.      0.      0.      0.      0.       2722. CMSD
                 31.2    35.7    99.1   140.5      .0      .0      .0      .0      .0      .0      .0      .0        306.6   MM

Q(2)             247.    287.    839.   1195.      0.      0.      0.      0.      0.      0.      0.      0.       2567. CMSD
                 27.8    32.3    94.5   134.6      .0      .0      .0      .0      .0      .0      .0      .0        289.2   MM
Q(2)-Q(1)        -3.4    -3.4    -4.6    -5.9      .0      .0      .0      .0      .0      .0      .0      .0        -17.4   MM

                                                                                                                RUNOFF COMPONENTS
```

Figure 2. Sample Output for Program OPT3 (Continued)

OCT, 1953 - NOV, 1953

DAY	PCN	Q(1)	Q(2)	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.	INFW	% OF TOTAL. PRM	IMP SUP	SUR DIR	INT
1	.000	11.7	2.1	.* +	.	.	.	.	17.5 .000	50.4 .000	248.	1.04	100	0 0	0 0	0
2	.000	11.1	8.3	. * +	.	.	.	.	19.4 .000	50.8 .000	247.	1.04	100	0 0	0 0	0
3	.000	10.6	8.9	. *+	.	.	.	.	22.7 .000	51.5 .000	246.	1.00	100	0 0	0 0	0
4	.000	8.67	8.78	. *	.	.	.	.	25.6 .000	52.3 .000	245.	.990	100	0 0	0 0	0
5	.000	9.85	8.59	. *+	.	.	.	.	28.2 .000	53.1 .000	243.	.980	100	0 0	0 0	0
6	.000	10.3	8.4	. *+	.	.	.	.	30.6 .000	54.0 .000	242.	.967	100	0 0	0 0	0
7	.000	8.92	8.31	. *	.	.	.	.	32.6 .000	54.9 .000	241.	.966	100	0 0	0 0	0
8	.000	9.09	8.25	. *+	.	.	.	.	34.2 .000	55.7 .000	240.	.968	100	0 0	0 0	0
9	.000	8.58	8.23	. *	.	.	.	.	36.0 .000	56.6 .000	238.	.947	100	0 0	0 0	0
10	.000	8.83	8.14	. *	.	.	.	.	37.6 .000	57.5 .000	237.	.937	100	0 0	0 0	0
11	.000	8.64	8.04	. *	.	.	.	.	39.2 .000	58.5 .000	236.	.927	100	0 0	0 0	0
12	.000	8.33	7.92	. *	.	.	.	.	40.8 .000	59.6 .000	235.	.911	100	0 0	0 0	0
13	.000	8.18	7.80	. *	.	.	.	.	42.3 .000	60.7 .000	234.	.901	100	0 0	0 0	0
14	9.40	8.38	8.43	. *	.	.	.	.	33.1 .000	60.8 .000	233.	1.33	75	0 25	0 0	0
15	1.02	9.43	9.56	. *	.	.	.	.	32.4 .000	60.9 .000	231.	1.03	97	0 3	0 0	0
16	.000	8.83	8.85	. *	.	.	.	.	34.1 .000	61.7 .000	230.	.922	100	0 0	0 0	0
17	.000	8.24	8.10	. *	.	.	.	.	35.5 .000	62.4 .000	229.	.919	100	0 0	0 0	0
18	.000	8.44	7.84	. *	.	.	.	.	36.9 .000	63.1 .000	228.	.911	100	0 0	0 0	0
19	.000	9.40	7.72	. *+	.	.	.	.	38.3 .000	63.9 .000	227.	.903	100	0 0	0 0	0
20	.000	10.5	7.6	. *+	.	.	.	.	39.6 .000	64.7 .000	226.	.888	100	0 0	0 0	0
21	.000	10.2	7.5	. *+	.	.	.	.	41.3 .000	65.8 .000	225.	.852	100	0 0	0 0	0
22	.000	7.02	7.39	. *	.	.	.	.	42.1 .000	66.4 .000	223.	.900	100	0 0	0 0	0
23	.000	6.91	7.53	. +*	.	.	.	.	43.2 .000	67.2 .000	222.	.872	100	0 0	0 0	0
24	.000	8.38	7.41	. *	.	.	.	.	44.3 .000	68.1 .000	221.	.857	100	0 0	0 0	0
25	.000	8.13	7.29	. *	.	.	.	.	45.2 .000	68.8 .000	220.	.873	100	0 0	0 0	0
26	.508	7.99	7.28	. *	.	.	.	.	45.5 .000	69.5 .000	219.	.884	98	0 2	0 0	0
27	13.7	7.90	8.10	. *	.	.	.	.	32.0 .000	69.7 .000	218.	1.41	66	0 34	0 0	0
28	1.02	10.2	10.4	. *	.	.	.	.	31.6 .000	69.9 .000	217.	.952	96	0 4	0 0	0
29	.000	8.89	8.77	. *	.	.	.	.	32.6 .000	70.3 .000	216.	.890	100	0 0	0 0	0
30	.000	8.04	7.75	. *	.	.	.	.	33.7 .000	70.7 .000	215.	.878	100	0 0	0 0	0
31	.000	7.50	7.40	. *	.	.	.	.	34.9 .000	71.2 .000	214.	.866	100	0 0	0 0	0
1	.000	6.63	7.27	. +*	.	.	.	.	35.9 .000	71.7 .000	212.	.865	100	0 0	0 0	0
2	.000	7.02	7.23	. *	.	.	.	.	36.9 .000	72.2 .000	211.	.853	100	0 0	0 0	0
3	.000	8.13	7.13	. *	.	.	.	.	38.1 .000	72.8 .000	210.	.840	100	0 0	0 0	0
4	.000	7.65	7.05	. *	.	.	.	.	38.8 .000	73.2 .000	209.	.860	100	0 0	0 0	0
5	.000	7.28	7.11	. *	.	.	.	.	39.5 .000	73.6 .000	208.	.854	100	0 0	0 0	0
6	.000	7.22	7.09	. *	.	.	.	.	40.3 .000	74.1 .000	207.	.842	100	0 0	0 0	0
7	.000	7.16	7.05	. *	.	.	.	.	40.8 .000	74.4 .000	206.	.850	100	0 0	0 0	0
8	.000	6.46	7.08	. +*	.	.	.	.	41.3 .000	74.7 .000	205.	.852	100	0 0	0 0	0
9	.000	6.77	7.04	. +*	.	.	.	.	42.1 .000	75.2 .000	204.	.819	100	0 0	0 0	0
10	.000	6.94	6.89	. *	.	.	.	.	42.9 .000	75.8 .000	203.	.807	100	0 0	0 0	0
11	.000	7.08	6.80	. *+	.	.	.	.	43.6 .000	76.3 .000	202.	.816	100	0 0	0 0	0
12	.000	7.08	6.81	. *+	.	.	.	.	44.3 .000	76.8 .000	201.	.803	100	0 0	0 0	0
13	.000	7.08	6.76	. *+	.	.	.	.	44.9 .000	77.3 .000	200.	.805	100	0 0	0 0	0
14	.000	6.80	6.74	. *	.	.	.	.	45.4 .000	77.7 .000	199.	.808	100	0 0	0 0	0
15	.000	6.23	6.74	. *	.	.	.	.	46.1 .000	78.2 .000	198.	.788	100	0 0	0 0	0
16	.000	6.23	6.63	. *	.	.	.	.	46.7 .000	78.8 .000	197.	.775	100	0 0	0 0	0
17	.000	6.80	6.56	. *	.	.	.	.	47.3 .000	79.3 .000	196.	.777	100	0 0	0 0	0
18	.000	6.80	6.54	. *	.	.	.	.	47.8 .000	79.7 .000	195.	.795	100	0 0	0 0	0
19	.000	6.94	6.55	. *	.	.	.	.	48.3 .000	80.2 .000	194.	.766	100	0 0	0 0	0
20	46.7	9.34	6.57	. * +	.	.	.	.	1.78 .000	80.4 .000	193.	2.46	34	0 66	0 0	0
21	2.03	17.6	16.7	. *+.	.	.	.	.	.428 .000	80.3 .006	192.	.912	92	0 8	0 0	0
22	45.2	35.7	16.3	. * . +	.	.	.	.	.048 .779	46.2 2.53	197.	5.34	16	1 30	33 0	20
23	.000	34.8	38.8	. + *.	.	.	.	.	1.37 .000	45.6 2.32	196.	1.08	79	21 0	0 0	0
24	4.32	18.1	17.5	. *.	.	.	.	.	.000 2.02	45.6 2.09	195.	1.30	65	15 12	8 0	0
25	.398	14.4	12.8	. *+	.	.	.	.	.741 .000	44.0 2.00	195.	1.05	81	18 1	0 0	0
26	.000	12.9	10.6	. *+	.	.	.	.	1.86 .000	44.0 1.80	194.	1.02	83	17 0	0 0	0
27	.000	11.9	9.7	. *+	.	.	.	.	3.15 .000	44.0 1.62	193.	.993	84	16 0	0 0	0
28	.000	10.6	9.2	. *	.	.	.	.	4.42 .000	44.0 1.46	192.	.972	86	14 0	0 0	0
29	.000	9.77	8.83	. *+	.	.	.	.	5.48 .000	44.1 1.31	191.	.953	87	13 0	0 0	0
30	.000	9.49	8.62	. *+	.	.	.	.	6.52 .000	44.1 1.18	190.	.936	88	12 0	0 0	0

UZTD AND LZTD=TENSION WATER DEFICITS

UZTD UZFW LZTD LZFS LZFP
UNITS ARE MM

DEC, 1953 - JAN, 1954

DAY	PCN	Q(1)	Q(2)	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.	INFW	PRM	IMP SUP	SUR DIR	INT
1	.000	9.34	8.48	. *+	.	.	.	.	7.55 .000	44.2 1.06	189.	.919	89	11 0	0 0	0
2	.000	9.68	8.35	. *+	.	.	.	.	8.56 .000	44.3 .955	188.	.904	90	10 0	0 0	0
3	22.4	9.54	8.10	. *+	.	.	.	.	.000 6.78	39.2 1.25	188.	2.47	33	3 32	28 0	4
4	41.7	32.8	35.8	.	. + * .	.	.	.	.000 .000	1.65 3.77	193.	6.44	13	4 23	40 0	20
5	.254	34.0	32.9	.	. *+ .	.	.	.	.316 .000	1.65 3.39	192.	1.17	71	28 1	0 0	0
6	39.9	33.7	28.5	.	. * + .	.	.	.	.048 .146	.000 13.6	217.	6.89	13	11 20	42 0	14
7	.000	52.4	43.4	.	. . * +	.	.	.	1.18 .000	.006 12.2	216.	2.12	44	56 0	0 0	0
8	.254	29.7	24.8	.	. * + .	.	.	.	2.05 .000	.023 11.0	215.	2.00	47	53 0	0 0	0
9	44.4	34.5	29.0	.	. * + .	.	.	.	.000 5.38	.000 20.3	238.	8.32	12	16 19	42 0	12
10	.000	61.2	57.6	.	. . *.+	.	.	.	1.32 .000	.006 19.7	241.	2.96	35	63 0	0 0	2
11	.508	38.2	33.6	.	. * +.	.	.	.	1.37 .000	.015 17.7	240.	2.77	38	62 1	0 0	0
12	31.5	45.9	42.1	.	. .* +	.	.	.	.048 .000	.000 24.3	259.	7.65	14	26 14	35 0	10
13	19.6	48.1	44.3	.	. . * +	.	.	.	.000 6.56	.000 25.6	266.	6.02	19	36 11	29 0	5
14	5.84	58.3	54.2	.	. . * +.	.	.	.	.285 .000	.000 26.5	273.	4.53	26	54 5	11 0	4
15	.254	44.5	40.0	.	. * + .	.	.	.	1.35 .000	.010 23.8	271.	3.48	34	66 0	0 0	0
16	.000	34.0	32.4	.	. *+ .	.	.	.	2.65 .000	.036 21.5	270.	3.24	36	64 0	0 0	0
17	.000	28.0	28.2	.	. * .	.	.	.	3.74 .000	.073 19.3	269.	3.02	39	61 0	0 0	0
18	.000	23.7	25.6	.	. +* .	.	.	.	4.45 .000	.105 17.4	267.	2.83	41	59 0	0 0	0
19	.000	22.0	23.8	.	.+* .	.	.	.	5.33 .000	.153 15.6	266.	2.66	44	56 0	0 0	0
20	.508	21.1	22.4	.	.* .	.	.	.	5.35 .000	.186 14.1	265.	2.52	46	54 1	0 0	0
21	10.2	21.5	23.2	.	.+* .	.	.	.	.047 .000	.000 14.1	266.	3.19	36	39 11	14 0	0
22	4.06	22.6	24.7	.	.+* .	.	.	.	.000 .000	.000 14.0	268.	2.92	40	43 5	13 0	0
23	.000	21.5	23.4	.	.+* .	.	.	.	.747 .000	.002 12.6	266.	2.37	49	51 0	0 0	0
24	.000	20.0	20.5	.	* .	.	.	.	1.85 .000	.016 11.3	265.	2.24	52	48 0	0 0	0
25	.000	19.0	19.1	.	+* .	.	.	.	2.40 .000	.028 10.2	264.	2.13	54	46 0	0 0	0
26	.000	18.2	18.0	.	*. .	.	.	.	3.65 .000	.068 9.16	262.	2.02	56	44 0	0 0	0
27	.000	17.5	17.1	.	*. .	.	.	.	4.70 .000	.115 8.24	261.	1.93	59	41 0	0 0	0
28	4.83	17.3	16.5	.	*+. .	.	.	.	.392 .000	.140 7.42	260.	2.01	56	35 8	0 0	0
29	4.57	18.0	18.2	.	*. .	.	.	.	.000 .000	.000 7.96	261.	2.36	48	29 7	16 0	0
30	.000	17.8	18.1	.	*. .	.	.	.	.369 .000	.001 7.16	260.	1.82	62	38 0	0 0	0
31	.000	15.7	16.2	.	* . .	.	.	.	1.46 .000	.010 6.45	258.	1.75	64	36 0	0 0	0
1	.000	14.9	15.2	.	+* . .	.	.	.	3.07 .000	.046 5.80	257.	1.68	67	33 0	0 0	0

```
 2  .508   14.5   14.6  .      *  .         .         .         .         .      3.78 .000 .094 5.22 256.  1.63  68 31  1  0  0  0
 3  3.30   14.4   14.4  .      *  .         .         .         .         .      1.89 .000 .135 4.70 255.  1.67  66 27  7  0  0  0
 4  .000   14.4   14.4  .      *  .         .         .         .         .      2.95 .000 .161 4.23 253.  1.51  73 27  0  0  0  0
 5  .000   14.0   13.6  .      *  .         .         .         .         .      4.16 .000 .207 3.81 252.  1.46  75 25  0  0  0  0
 6  .000   13.8   13.1  .      *  .         .         .         .         .      5.52 .000 .279 3.43 251.  1.42  77 23  0  0  0  0
 7  .000   13.4   12.8  .     *+  .         .         .         .         .      6.68 .000 .359 3.08 250.  1.38  79 21  0  0  0  0
 8  .000   13.2   12.4  .     *+  .         .         .         .         .      7.82 .000 .454 2.78 248.  1.34  80 20  0  0  0  0
 9  .000   13.1   12.2  .     *+  .         .         .         .         .      8.93 .000 .564 2.50 247.  1.31  82 18  0  0  0  0
10  4.83   13.1   12.0  .     *+  .         .         .         .         .      4.57 .000 .613 2.25 246.  1.45  74 15 12  0  0  0
11  3.81   14.4   12.9  .     *+  .         .         .         .         .      .936 .000 .619 2.02 245.  1.39  76 14 10  0  0  0
12  .000   14.4   13.0  .      *  .         .         .         .         .      1.99 .000 .634 1.82 243.  1.23  86 14  0  0  0  0
13  .000   12.4   11.6  .     *   .         .         .         .         .      2.68 .000 .651 1.64 242.  1.21  87 13  0  0  0  0
14  5.08   12.5   11.5  .     *   .         .         .         .         .      .000 2.25 .655 1.48 241.  1.58  67  9 11 13  0  0
15  43.0   14.6   15.5  .      +* .         .         .         .         .      .000 14.5 .000 10.6 259.  7.79  14  4 19 52  0 11
16  32.0   68.0   72.2  .         .         .         .   + *   .         .      .621 .000 .000 22.9 288.  8.65  14 21 13 35  0 17
17  .000   56.4   62.4  .         .         .       + .*        .         .      1.83 .000 .014 20.6 286.  3.23  39 61  0  0  0  0
18  .254   32.6   33.7  .         .     +*  .         .         .         .      1.92 .000 .021 18.5 285.  3.03  41 59  0  0  0  0
19  .508   26.9   27.2  .         .  +*     .         .         .         .      1.58 .000 .024 16.7 283.  2.85  43 56  1  0  0  0
20  29.5   24.4   25.5  .         . +*      .         .         .         .      .000 13.3 .000 19.6 291.  6.97  18 21 15 39  0  8
21  46.0   80.4   70.9  .         .         .         .    *    +         .      .000 5.99 .000 33.3 324.  12.0  11 22 13 38  0 15
22  91.9   124.   103.  .         .         .         .         .         . *       . +       .         .      29.3   5 14 11 31 26 13
23  .000   185.   147.  .         .         .         .         .         .         .         .   *     +      6.58  25 74  0  0  0  1
24  .000   136.   126.  .         .         .         .         .         .         .  *    + .         .      6.02  27 73  0  0  0  0
25  .000   73.3   83.4  .         .         .         .      +  . *       .      2.27 .000 .025 41.1 373.  5.57  29 71  0  0  0  0
26  .000   51.3   50.0  .         .         .    *+   .         .         .      3.05 .000 .047 37.0 372.  5.17  31 69  0  0  0  0
27  .762   44.5   45.0  .         .      . *  .         .         .         .      3.81 .000 .101 33.3 370.  4.83  33 66  1  0  0  0
28  .508   39.4   41.5  .         .     +*    .         .         .         .      4.64 .000 .162 30.0 368.  4.50  36 64  0  0  0  0
29  .000   35.4   38.2  .         .   +*.     .         .         .         .      5.37 .000 .203 27.0 366.  4.18  38 62  0  0  0  0
30  .000   32.6   35.5  .         .  + * .     .         .         .         .      6.50 .000 .279 24.3 364.  3.91  40 60  0  0  0  0
31  .000   30.3   33.1  .         .  + *  .    .         .         .         .      7.74 .000 .380 21.8 362.  3.67  43 57  0  0  0  0
                                 UZTD AND LZTD=TENSION WATER DEFICITS                UZTD UZFW LZTD LZFS LZFP
                                                                                        UNITS ARE MM
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SUMMARY OF ERRORS AND WARNINGS FOR THIS RUN:
TOTAL NUMBER OF ERRORS= 0
TOTAL NUMBER OF WARNINGS= 0

NATIONAL WEATHER SERVICE - RIVER FORECAST SYSTEM Mar 4, 1999 TIME 12:39:47.00

COMPLETION CODE= 0

****

[Next] [Previous] [Bookmarks] [Top]