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U.S. DEPARTMENT OF COMMERCE
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National Weather Service

National Weather Service River Forecast System—Snow Accumulation and Ablation Model

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November 1973

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WBTM HYDRO 11 — Joint Probability Method of Tide Frequency Analysis Applied to Atlantic City and Long Beach Island, N.J. Vance A. Myers, April 1970. (PB-192-745)

NOAA Technical Memoranda

NWS HYDRO 12 — Direct Search Optimization in Mathematical Modeling and a Watershed Model Application. John C. Monro, April 1971. (COM-71-00616)

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U.S. DEPARTMENT OF COMMERCE
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NOAA Technical Memorandum NWS-HYDRO-17

NATIONAL WEATHER SERVICE RIVER FORECAST SYSTEM- SNOW ACCUMULATION AND ABLATION MODEL

Eric A. Anderson

WASHINGTON, D.C.
November 1973

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CHAPTER 1. INTRODUCTION

1.1 BACKGROUND

The techniques used by the National Weather Service (NWS) for making river and flood forecasts have been changing in recent years (Sittner, 1973). Conceptual watershed models are replacing previously used empirical procedures. In 1972 the Hydrologic Research Laboratory of the Office of Hydrology, NWS, prepared a technical memorandum entitled "National Weather Service River Forecast System, Forecast Procedures" (referred to as HYDRO-14 throughout this report) as a guide for the implementation of conceptual river forecasting models by field offices. HYDRO-14 describes the techniques and computer programs needed for developing operational river forecasts based on the use of a continuous conceptual watershed model from the processing of the basic data to the preparation of the forecasts. The procedures described in HYDRO-14 did not include techniques to model snow accumulation and snowmelt. This Technical Memorandum describes a conceptual model of the snow accumulation and ablation process and the associated computer subroutines and programs which enable the model to be used in conjunction with the National Weather Service River Forecast System (NWSRFS). Guidelines and methods for determining model parameter values for a given area are also presented. Even though the snow subroutines are written for use with the NWSRFS, the snow accumulation and ablation model itself can be used with almost any soil-moisture accounting (rainfall-runoff relationship) and channel routing procedure. The output from the snow model would be the input to the soil-moisture accounting procedure. The output from the snow model is snowpack outflow (snowmelt water and rainwater leaving the snowpack) plus rain that fell on bare ground.

1.2 DATA REQUIREMENTS

The snow accumulation and ablation model uses air temperature as the sole index to energy exchange across the snow-air interface. Air temperature is the only additional data needed to use the snow model in conjunction with the NWSRFS soil-moisture accounting and channel routing models. Streamflow, precipitation, and some form of potential evapotranspiration (PE) data are needed for the NWSRFS (see chapter 2, HYDRO-14). The basic computational interval of the NWSRFS is six hours, thus, six-hourly mean areal air temperature data are required. Chapter 2 of this Technical Memorandum describes a procedure and associated computer programs for computing six-hourly mean areal air temperature from daily maximum-minimum air temperature observations. Since the NWSRFS models and the snow model are continuous models, a continuous record of six-hourly mean areal air temperature data is required. However, the snow subroutines contain a provision that eliminates the requirement for valid air temperature data during periods when there is no snow on the ground.

There are two basic reasons for using air temperature as the sole index to energy exchange across the snow-air interface:

a. Air temperature data are readily available throughout the United States on a real time operational basis.

b. Comparison tests conducted by the Hydrologic Research Laboratory have shown that on two experimental watersheds the temperature index method of estimating energy exchange across the snow-air interface has produced simulation results which are at least as good as those produced using a combination energy balance - aerodynamic method. The combination energy balance - aerodynamic method tested is essentially the same as the method described by Anderson (1968). The two watersheds on which these tests were made are Upper Castle Creek, Central Sierra Snow Laboratory, and Watershed W-3, Agricultural Research Service (ARS), Sleepers River Research Watershed.

The combination method will give more accurate estimates of energy exchange at a point than the temperature index method if accurate measurements of all the necessary meteorological variables are available (these variables are air temperature, dew-point, wind speed, incoming and reflected solar radiation, and atmospheric longwave radiation). However, on the two experimental watersheds the combination method results were affected by several sources of error: 1) errors in point measurements, especially in regard to incoming solar radiation, 2) errors in estimating variables which were not measured (primarily atmospheric longwave radiation), and 3) errors in estimating mean areal values of the variables (primarily determining the effect of slope, aspect, and forest cover on incoming solar and atmospheric longwave radiation, determining the areal albedo of the snowpack, and determining the mean areal wind speed). The integrated effect of these errors was estimates of energy-exchange across the snow-air interface which were no better than estimates from the temperature index method on the two experimental watersheds.

It is felt that the data available at these two experimental watersheds is superior to that which is generally available on a real-time operational basis in the United States. Thus, it does not appear practicable to use a physical energy balance approach like the combination method to estimate energy exchange across the snow air interface until improved measurements of the meteorological variables affecting snowpack energy exchange are obtained and until improved methods of accounting for the effects of physiographic factors on snowpack energy exchange variables are developed.

The Hydrologic Research Laboratory is currently involved in a project to obtain the highest possible quality data for the purpose of developing and testing snowpack energy exchange equations at a point. This study is the NOAA - ARS Cooperative Snow Hydrology Project on the Sleepers River Research Watershed (Johnson and Anderson, 1968). Ultimately these measurements of the variables affecting snowpack energy exchange will be used along with data from an adjacent watershed to develop improved methods of accounting for the effect of physiographic factors, such as slope, aspect, elevation, and forest cover on the mean areal values of the meteorological variables.

Air temperature is a very good index to snowpack energy exchange in a dense coniferous forest. The only energy exchange mechanism showing much variability is longwave radiation exchange, which is a function of the difference between canopy temperature and snow surface temperature. Canopy temperature is closely related to air temperature. The other primary energy exchange mechanisms, shortwave radiation exchange, sensible heat exchange, and latent heat exchange show very little variability because there is only a slight amount of solar radiation penetrating the forest canopy and because wind movement is limited. On the other hand, in an open area there generally is a large amount of variability in solar radiation exchange, longwave radiation exchange, sensible heat exchange, and latent heat exchange. Because of this variability, air temperature is not nearly as good an index to snowpack energy exchange in an open area. Therefore, there is a greater potential for improvement in estimating snowpack energy exchange by using a physical energy balance method, rather than a temperature index method, in areas where the values of the variables affecting energy transfer can exhibit large variations. It is felt that in the near future when accurate measurements of the variables affecting snowpack energy exchange are available and when techniques of accounting for the areal variability of the variables are improved that physical energy balance equations will provide a more accurate estimate of the energy exchange across the snow-air interface.

In regard to the data period required for model parameter calibration, the recommendation given in HYDRO-14 is generally applicable to watersheds where snow is included. HYDRO-14 indicates that it is desirable to sample each mathematical relationship in the model over its maximum possible range; thus, a long data period is indicated. However, in many cases watershed characteristics change with time. For river forecasting we are interested in parameters which express the near future. Since the future cannot be sampled, a short record representing the immediate past is the second choice. Based on these considerations, HYDRO-14 recommends that "A suitable compromise seems to be the most recent 10 years of record.". For most watersheds, 10 years of record is completely adequate for determining model parameter values. However, in arid or semi-arid areas and in areas where significant snowpacks do not accumulate every year, more than 10 years of data may be required to determine adequately all the model parameters. In areas with considerable hydrologic activity and where large snowpacks accumulate every winter, less than 10 years of data may be sufficient to determine model parameter values.

1.3 TEST WATERSHEDS AND RESULTS

This Technical Memorandum does not present detailed results of tests of the snow accumulation and ablation model. However, for the benefit of potential users it is felt that a listing of the watersheds tested to date and a brief summary of the simulation results on these watersheds might be informative. Table 1-1 lists the watersheds tested and presents several statistics which summarize the comparison between observed and simulated mean daily discharge. Data from the Central Sierra Snow Laboratory were used for testing various mathematical formulations during the development stage of the snow model. The estimation of energy exchange when air temperature is below 32°F was modified based on tests using data from Sleepers River Watershed W-3. The other watersheds were used to test the applicability of the model to different size areas and to different physiographic and climatic conditions.

1.4 COMPUTER PROGRAMS AND COMPUTER REQUIREMENTS

There are three basic computer programs in the NWSRFS which include the snow accumulation and ablation model. These are: 1) the verification program (NWSRFS4) which is used to check the simulation accuracy of various sets of parameter values, 2) the optimization program (NWSRFS3) which is used to determine parameter values by an automatic optimization technique, and 3) the operational river forecasting program (NWSRFS5) which is used to prepare river discharge forecasts on an operational basis. The NWSRFS also contains a number of data processing programs (see chapter 3 of HYDRO-14). Chapter 2 of this Technical Memorandum describes three additional data processing programs for use in computing mean areal air temperature. These are: 1) the basic mean areal air temperature program (MAT Program), 2) the MAT consistency check program (Program MATCØN) which checks the consistency of each station used in the mean areal temperature analysis, and 3) the MAT temperature check program (Program TEMPCK) which compares the estimated and observed maximum and minimum temperatures at a given air temperature observation station. Table 1-2 lists the program dimensions, storage requirements, and typical run times for the six programs involving the snow accumulation and ablation model and the computation of mean areal air temperature. The programs are written in FØRTRAN IV for use on a CDC 6600 computer system. Minor revisions may be necessary for use on other computer systems.

The computer programs and test data sets described in HYDRO-14 are available on magnetic tape from:

Acquisition Office
National Technical Information Service
U. S. Department of Commerce
Springfield, Virginia 22151

Accession number: COM 73-10298
Cost: $97.50

These programs contain all the necessary statements for use with the snow subroutines (One exception; a few changes were made to Program NWSRFS5 after preparation of the magnetic tape. The changes are only needed when the snow model is included. Appendix H lists these changes to Program NWSRFS5). Information on how to obtain the snow subroutines for programs NWSRFS3, NWSRFS4, and NWSRFS5, plus the programs for the computation of mean areal air temperature can be obtained from:

Hydrologic Research Laboratory, W23
Office of Hydrology
National Weather Service, NOAA
Silver Spring, Maryland 20910

1.5 ACKNOWLEDGMENTS

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REFERENCES

Anderson, E. A., "Development and Testing of Snow Pack Energy Balance Equations", Water Resources Research, Vol. 4, No. 1, February 1968, pp. 19-37.

Johnson, Martin L., and Anderson, Eric, "The Cooperative Snow Hydrology Project - ESSA Weather Bureau and ARS Sleepers River Watershed", Proceedings of the Eastern Snow Conference, 1968, pp. 13-23.

Sittner, W. T., "Modernization of National Weather Service River Forecasting Techniques", Water Resources Bulletin, Vol. 9, No. 4, August 1973.

Staff, Hydrologic Research Laboratory, "National Weather Service River Forecast System, Forecast Procedures", NOAA Technical Memorandum NWS HYDRO-14, U. S. Department of Commerce, Silver Spring, Md., December 1972.

Table 1-1.--Summary of simulation results on the watersheds tested with the snow accumulation and ablation model in conjunction with the NWSRFS as of June 1973.

Watershed	Data Period	Area mi^2	Elev. Range[1]	Number of Stations				Mean Annual Runoff Inches and CFSD	RMS Error CFSD	Correl Coef.	% Bias	Best Fit Line Obs.=a+b·Sim.	
				Precip	Elev. Range	Air Temp.	Elev. Range					a CFSD	b
Upper Castle Creek, Central Sierra Snow Laboratory	10/46-9/51	3.96	6880-9105 7050-8250	1	6890	1	6890	46.1" 13.5 CFSD	8.3	.971	-2.0	-0.4	1.05
Skyland Creek, Upper Columbia Snow Laboratory (UCSL)	10/46-9/50	8.1	4800-7610 5200-6800	1	4840	1	4840	31.5" 18.8 CFSD	6.7	.981	1.5	-0.3	1.0
Bear Creek, UCSL[2]	10/46-9/50	12.6	4480-8605 4900-6350	1	4840	1	4840	29.5" 45 CFSD	13.8	.983	0.2	-0.3	1.01
W-3, ARS Sleepers River Watershed	10/62-9/67	3.23	1140-2260 Unknown	3	1350-2200	1	1140	21.7" 5.2 CFSD	2.1	.955	1.6	0.2	0.95
W-8, ARS Sleepers River Watershed[2]	10/62-9/67	2.81	920-1680 Unknown	2	1150-1350	1	1140	17.2" 7.7 CFSD	2.2	.970	2.3	0.2	0.95
W-1, ARS Sleepers River Watershed[2]	10/62-9/67	10.54	740-2430 Unknown	4	1150-2200	1	1140	17.1" 20.9 CFSD	8.7	.964	3.5	-1.7	1.04

Table 1.1 (continued)

Passumpsic R. at Passumpsic, Vermont	10/63-9/71	436.	530-3400 780-2240	4	699-1140	3	699-1140	20.3" 653 CFSD	294.	.939	-1.5	49.	0.94
Rock River at Rock Rapids, Iowa	10/59-9/69	788.	1330-1950 Unknown	6	1350-1700	6	1350-1700	3.1" 179 CFSD	444.	.906	5.9	28.	0.80

1 First range is for the total area. Second range is for 90 percent of the area, excluding the upper and lower 5 percent. All elevation ranges are in feet above m.s.l.

2 Streamgage is downstream from another calibrated watershed. Local area was calibrated using observed upstream inflows. Area, elevation range, and station information are for local area only. Mean daily discharge comparisons are based on the total flow at the streamgage.

Table 1-2.--Program dimensions, storage requirements[1], and typical run times[1] for NWSRFS programs using the snow model and programs for computing mean areal air temperature.

Program	Dimensions	Storage Requirements Decimal Words	Typical Run Times
Verification Program (NWSRFS4)	5 snowpack and soil-moisture accounting areas. 5 streamflow points. 3 upstream inflow points. 2 PE stations	39K	2 sec./year for each snowpack and soil-moisture accounting area, plus 3 sec./year for each streamflow point
Optimization Program (NWSRFS3)	2 snowpack and soil-moisture accounting areas. 1 streamflow point. 4 upstream inflow points. 2 PE stations 50 months of data	32K for program, plus 75K for data storage	5.5 sec./50 months for each snowpack and soil-moisture accounting area, plus 1 sec./50 months for the streamflow point
Operational River Forecasting Program (NWSRFS5)	10 snowpack and soil-moisture accounting areas. 10 streamflow points. 5 upstream inflow points. 3 PE stations. 14 days of data.	29K To enlarge river system requires approx. 350 words/snowpack and soil-moisture accounting area, plus 600 words/streamflow point	1 sec./14 days for each streamflow point
Mean Areal Air Temperature Program (MAT Program)	40 maximum-minimum air temperature stations 10 areas to compute mean areal temperature 4800 months of data storage	37K for program, plus 744 words of random access data storage per station year	7 sec./year for an analysis involving 10 stations

Table 1-2. (continued)

MAT Consistency Check Program (Program MATCON)	40 maximum-minimum air temperature stations 5 groups for double mass analysis 25 years of record	33K for program, plus 24 words of data storage per station year (data are generated by MAT Program)	1 sec./year for an analysis involving 10 stations
Program TEMPCK		40K for program, plus 1488 words of data storage per year (data are generated by MAT Program)	0.5 sec./year

1 Storage requirements and run times are based on a CDC 6600 computer system.

CHAPTER 2. DATA PROCESSING

2.1 INTRODUCTION

In order to calibrate a conceptual model for use in forecasting streamflow in a river system, large amounts of continuous hydrologic data are required. The conversion of the raw data into the form required for model calibration must be accomplished in an efficient manner.

HYDRO-14 (Appendix B) describes the format of data tapes containing raw hydrologic data which can be obtained from the National Climatic Center (NCC) at Asheville, North Carolina. Tapes containing two types of data are available: 1) hourly precipitation data, and 2) daily observations (precipitation, maximum-minimum air temperature, snowfall, snow on ground, water-equivalent of snow on ground, wind movement, and evaporation). HYDRO-14 (Chapter 3) also describes a method of estimating point values, for periods of missing data or locations having no data, and for computing areal means of precipitation. The computer program which utilizes this method and the NCC data tapes to compute mean areal precipitation is also described.

This chapter discusses the methods and the computer programs needed to compute mean areal air temperature for use in the calibration of the snow accumulation and ablation model. In addition, two supplementary data programs for the tabulation of monthly and annual means of precipitation, air temperature, wind movement, and evaporation are described. A summary of the necessary steps to process the raw data into the form required by the NWSRFS model calibration programs concludes the chapter.

2.2 ESTIMATION OF POINT VALUES OF AIR TEMPERATURE

2.2.1 INTRODUCTION

Since maximum-minimum air temperature data are measured as point values, the use of the data to compute mean areal values involves, implicitly or explicitly, inferences concerning the air temperature at all other points within the area. This section outlines a method of estimating the maximum and minimum daily air temperature at any point as a function of that at surrounding points. The method is objective in non-mountainous areas and quasi-objective in mountainous areas. The method can easily be programmed for use in computing mean areal air temperature for a long period of record. The program will use a minimum of computer time.

2.2.2 THEORY OF ESTIMATION

Referring to Figure 2-1, let point X be the point at which the maximum or minimum air temperature is to be estimated. Points A through G are points at which the maximum or minimum temperature is known.

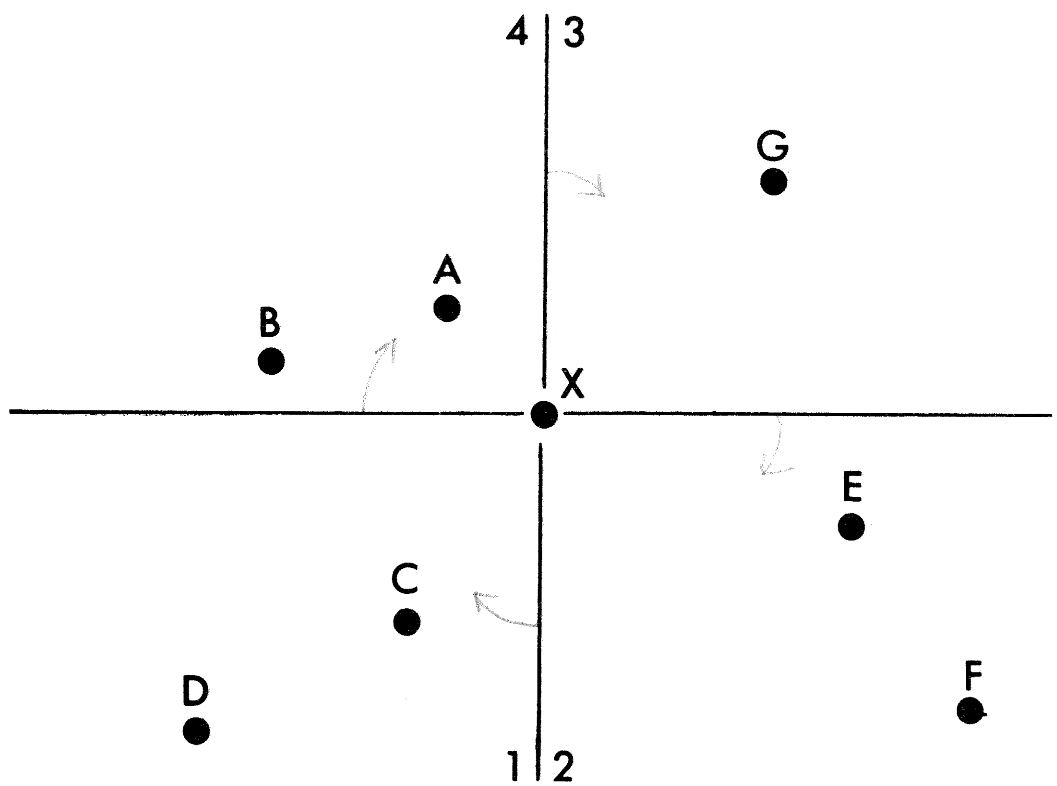


Figure 2-1.--Station location and quadrants for the estimation of air temperature at station X.

Perpendicular lines through point X divide the surrounding area into four quadrants. It should be noted that perpendicular axes of any orientation can be used.

The estimate of temperature at X is now computed as a weighted average of "adjusted" station temperatures, using the station within each quadrant with the largest station weight. Thus, the estimate of the temperature at any point X can be expressed as:

$$T_x = \frac{\sum_{i=1}^{i=n} [AT_i \cdot W_i]}{\sum_{i=1}^{i=n} W_i}, \qquad (2.1)$$

where: T_x = maximum or minimum temperature at the station being estimated,
i = the station used as an estimator,
n = number of estimators (the station with the largest station weight in each quadrant is used as an estimator),
AT_i = "adjusted" maximum or minimum temperature at station i, and
W_i = **weight function** for station i.

The procedure used to calculate "adjusted" station temperatures and the weight functions depends on whether the area is mountainous or non-mountainous.

2.2.2.1 Non-mountainous Areas

As far as temperature estimation is concerned, a non-mountainous area is an area where topography does not appear to affect temperature variations and the gradients observed are approximately a linear function of distance. The weight function in this case is equal to the reciprocal of the distance from the station to point X. The "adjusted" temperature for each station used to estimate point X is then the same as the measured temperature at that station. Thus, the estimation equation for non-mountainous areas is:

$$T_x = \frac{\sum_{i=1}^{i=n} \left[T_i \cdot \frac{1.0}{d_{i,x}}\right]}{\sum_{i=1}^{i=n} \frac{1.0}{d_{i,x}}}, \qquad (2.2)$$

where: T_i = maximum or minimum temperature at estimator station i, and
$d_{i,x}$ = the distance from the station being estimated to the estimator station i, in terms of map coordinates.

2.2.2.2 Mountainous Areas

In reality, the differences in temperature between a number of stations in a mountainous region can vary from day to day depending on the meteorological situation. Operationally, the temperature differences between stations could be expressed as a function of a number of topographic and meteorological variables. However, in calibrating a conceptual hydrologic model, due to retrieval and processing problems, it is generally not feasible to use any additional meteorological data other than air temperature measurements. Experience has shown that the differences between station means are a good indication of the typical variations in temperature that exist over a mountainous area. In some cases, these differences are small (e.g., stations at approximately the same elevation may have slightly different means because of the exposure of the thermometers) and for practical purposes can be ignored. However, in other cases, especially in areas with significant topographic variation, these differences between stations are important and must be accounted for. Thus, as far as temperature estimation is concerned, a mountainous area is an area over which considerable variations in temperature usually exist.

Because of seasonal variations, a procedure for estimating point values in mountainous regions should use the mean monthly maximum and minimum temperature for each station as indices. Therefore, the "adjusted" station temperature can be expressed as:

$$AT_i = T_i + (N_x - N_i), \qquad (2.3)$$

where: N_x = mean maximum or minimum temperature at the station being estimated, and

N_i = mean maximum or minimum temperature at the estimator station i.

By substituting Eq. 2.3 for AT_i and rearranging the terms, Eq. 2.1 can be expressed as:

$$T_x - N_x = \frac{\sum_{i=1}^{i=n} [(T_i - N_i) \cdot W_i]}{\sum_{i=1}^{i=n} W_i} . \qquad (2.4)$$

Thus, it can be seen readily that for a mountainous area the deviation of temperature at point X from the mean at the same point can be estimated from the deviation of temperatures at surrounding stations from their respective means.

In regard to station weights, the most important factors in mountainous areas are probably distance and elevation. If two stations are equi-distant from station X, studies have shown that the one closest in terms of elevation is usually the best estimator. This suggests that the weight function used in the estimation scheme should include elevation difference as a parameter. A functional form for W_i which has produced improved estimates of temperature is:

$$W_i = \frac{1.0}{G_1 \cdot d_{i,x} + F_e \cdot \Delta E_{i,x}} , \qquad (2.5)$$

where: $d_{i,x}$ = the distance between stations X and i expressed in map coordinates,

G_1 = a scale factor to convert map coordinates to miles,

$\Delta E_{i,x}$ = the absolute difference in elevation, expressed in 1,000 feet, between stations X and i, and

F_e = an arbitrarily selected elevation weighting factor (if F_e = 10, then two stations, one which is 10 miles further from station X in distance, but 1,000 feet closer in elevation, would have the same station weight).

When either $\Delta E_{i,x}$ is zero or F_e selected to be zero, Eq. 2.5 is, of course, equivalent to the weight function used in Eq. 2.2.

The final equation for the estimation of maximum or minimum air temperature at a point in a mountainous area can be determined by the substitution of Eqs. 2.3 and 2.5 into Eq. 2.1. This substitution yields:

$$T_x = \frac{\sum_{i=1}^{i=n} \{[T_i + (N_x - N_i)] \cdot [\frac{1.0}{G_1 \cdot d_{i,x} + F_e \cdot \Delta E_{i,x}}]\}}{\sum_{i=1}^{i=n} [\frac{1.0}{G_1 \cdot d_{i,x} + F_e \cdot \Delta E_{i,x}}]} \qquad (2.6)$$

2.2.3 DETERMINATION OF F_e

It can be seen readily from Eq. 2.6 that F_e affects the station weight of each station being used to estimate the temperature at point X. Increasing F_e will give more weight to stations with the smallest values of $\Delta E_{i,x}$ and less weight to stations with the largest values of $\Delta E_{i,x}$. The estimate of temperature at point X is computed using the station within each quadrant with the largest station weight. Thus, as F_e is increased, the stations used to estimate the temperature at point X may change. Changes will occur if the station weight of more distant stations in each quadrant becomes greater than the station weight of stations which are closer to point X. This will occur as F_e increases if the distant stations have a smaller value of $\Delta E_{i,x}$. The dominant effect of F_e in most cases is the effect it has on the selection of the stations used to estimate temperature at point X.

Eq. 2.6 is used in mountainous areas for two purposes: (1) to estimate periods of missing data at an air temperature observation station, and (2) to estimate the maximum-minimum air temperature at a location which has no observed data. To estimate periods of missing data, the optimum value of F_e can be determined through a cut-and-try (iterative) technique, utilizing the available valid data from the station. To estimate air temperature at a location which has no observed data, the magnitude of F_e must be arbitrarily selected. F_e values for other stations in the area may provide a guideline for the selection. However, it should be noted that the optimum value of F_e for a station is dependent on the location of the stations being used to make the estimate (e.g., the magnitude of F_e could vary considerably depending on whether distant stations had large values of $\Delta E_{i,x}$ or small values of $\Delta E_{i,x}$ relative to stations that are close to point X).

A computer program is provided for determining the optimum value of F_e at any selected temperature observation station (program is described in section 2.4.4). The program compares the estimated and observed maximum and minimum air temperatures. By varying the magnitude of F_e, the effect of F_e on the results can be determined. The root-mean-square (RMS) error (square root of the sum of the squares of the observed minus estimated values) is used to compare results. Figs. 2-2 and 2-3 show the effect of various values of F_e on RMS for two locations; one in Arizona, and the other in New Hampshire. These figures suggest that the magnitude of F_e for estimating maximum temperatures should be different from the magnitude of F_e for estimating minimum temperatures.

If a plot of RMS versus F_e is not prepared and thus the magnitude of F_e is selected arbitrarily, experience would indicate the following guidelines:

1. If the stations that are closest to point X also have the smallest values of $\Delta E_{i,x}$, the magnitude of F_e is not critical. $F_e = 0.0$ would be appropriate.

2. If the stations that are closest to point X have the largest values of $\Delta E_{i,x}$, a value of F_e in the range 10.0 to 30.0 would be appropriate.

It should be noted that these guidelines are based on a limited amount of testing of the temperature estimation procedure on data from Arizona, Vermont, and New Hampshire.

2.2.4 TYPICAL ESTIMATION RESULTS

In order to give the user a feel for the accuracy that can be expected from Eq. 2.6, a summary of typical results is given in Table 2-1. In all cases F_e was arbitrarily selected as 10.0. In addition to the station elevations, the observation times should be noted. For stations taking their observations in the afternoon (including midnight) the maximum and minimum are assumed to have occurred on the day of observation. For stations taking morning observations the minimum is assumed to have occurred on the day of observation while the maximum is assumed to have occurred on the previous day. In reality these assumptions do not always hold, thus, a group of stations with mixed observation times can have mismatched maximums and minimums on some days. In addition to the RMS error, the standard deviation of the observed temperatures about the monthly mean is also given. If the RMS error exceeds the standard deviation, no intelligence is imparted by the technique, as the monthly mean would make a better daily estimate. Table 2-1 shows only the RMS error and standard deviation for the total test period. The monthly ratios of the RMS error to the standard deviation were similar to those for the total test period. However, in most cases both figures are greater during cold periods than during warm periods.

2.3 COMPUTATION OF MEAN AREAL AIR TEMPERATURE

2.3.1 INTRODUCTION

Mean areal air temperature is computed by utilizing stations within or close to the area and in some cases other available meteorological information. The basic procedure consists of: 1) examine the available maximum-minimum air temperature data to determine if the available data adequately represents all portions of the area, 2) if the available data does not represent all portions of the area, assign "dummy" stations to those portions that are not represented, 3) determine the mean monthly maximum and minimum temperature for each "dummy" station, 4) determine station area weights for all stations, 5) estimate daily maximum and minimum temperature at all stations having missing periods of record, and 6) multiply station temperatures by station area weights to get mean areal air temperature. This section elaborates on the use of this basic procedure in non-mountainous and mountainous areas.

2.3.2 NON-MOUNTAINOUS AREAS

Since temperature varies linearly with distance in non-mountainous areas, "dummy" stations are not needed. Any area weight assigned to a "dummy" station could be proportioned to the stations used to estimate the temperature at the "dummy" station. Thus, the use of "dummy" stations would not change the estimate of mean areal temperature.

Several procedures could be used for computing station area weights in non-mountainous areas. One method is the use of grid point weights (section 3.3.4 of HYDRO-14) where the grid points correspond to the X, Y coordinate system used to locate the stations. For temperature the reciprocal of the distance is used rather than the reciprocal of the distance squared as with precipitation. Other methods would include Thiessen weights or an arithmetic average, if stations are distributed in a reasonably uniform manner.

Missing data should be estimated using Equation 2.2. It should be noted that to get a good estimate for missing data periods at stations near the border of the area, it is usually necessary to include additional outlying stations.

2.3.3 MOUNTAINOUS AREAS

In some cases there is an adequate distribution of temperature observation stations to represent all portions of a mountainous area. However, for most mountainous areas this is not the case. This is especially true for the high elevation portions of most mountainous areas. Thus, it is usually necessary to create "dummy" stations to represent those portions of a mountainous area for which actual data does not exist.

If "dummy" stations are needed, the next step is to determine the mean monthly maximum and minimum temperature for each "dummy" station. An analysis to determine these values would include an examination of the variation in monthly means for stations with actual data that are within the area, an examination of monthly means for stations with actual data in the surrounding area, especially high elevation stations, and possibly an examination of other meteorological information, such as radiosonde data. If radiosonde data are used, the difference in the thermal gradient up the side of a mountain and the lapse rate in the atmosphere must be considered.

The station area weight for each station in a mountainous area is equal to the portion of the area that the station represents.

Missing daily maximum and minimum temperatures at all stations should be estimated using Eq. 2.6. This will complete the data record at all actual stations, plus create a data record for each "dummy" station (since a "dummy" station is just a station with all missing data).

2.4 COMPUTER PROGRAMS FOR COMPUTING MEAN AREAL TEMPERATURE

2.4.1 INTRODUCTION

A computer program has been written which uses the techniques described in previous sections of this chapter to compute mean areal air temperature. The basic computational interval of the NWSRFS is six hours, thus, the final product of the program is six hourly mean areal temperature. In addition to the basic program to compute mean areal temperature, there are two programs to aid in preliminary analysis, a program to check the consistency of the basic temperature data, and a program to compare estimated and observed data at an individual station.

2.4.2 PROGRAMS TO AID IN PRELIMINARY ANALYSIS

To aid in station selection and to provide helpful data for isohyetal, temperature variation, and model calibration analyses, two preliminary data processing programs are provided to summarize the data on the NWSRFS-NCC tapes. In each program the stations and the period of record to be summarized are preselected. A brief description of the tasks performed by each program is as follows:

a. Daily observation tape program (Program PRELIM2).
   1. Lists snowfall and snow on ground for each month that there was snowfall or snow on ground.
   2. Computes average daily evaporation and wind movement for each month at stations that make pan evaporation measurements.
   3. Computes mean monthly and mean annual precipitation, maximum temperature, minimum temperature, evaporation, and wind movement for the period being summarized.
   4. Writes the data for the selected stations and for the selected period onto a new tape. The format of the new tape is exactly the same as the original NWSRFS-NCC tape. Thus, the daily data for a reasonably large area (maximum number of stations equal 75), which may encompass several states, can be placed on a single tape. This will save on tape reading and tape handling costs during the computation of mean areal temperature and precipitation.

b. Hourly precipitation data tape program (Program PRELIM1).
   1. Computes mean monthly and mean annual precipitation.
   2. Writes the selected data onto a new tape.

A listing of programs PRELIM1 and PRELIM2 are given in Appendix A.

2.4.3 MEAN AREAL TEMPERATURE PROGRAM

The Mean Areal Temperature (MAT) program provides an efficient means to process air temperature data for use in the snow accumulation and ablation model. The program is described in sequential order of the major steps involved in the computation of MAT.

2.4.3.1 Input Data

The program uses maximum-minimum temperature observations to compute areal means. The maximum-minimum temperature data are input in NWSRFS-NCC daily observation tape format (Appendix B.2.3, HYDRO-14). In addition to the raw temperature data, station and areal information is also needed. Appendix B.1 contains the input summary for the MAT program.

2.4.3.2 Estimation of Missing Maximum-Minimum Temperature Data

The MAT program uses Eq. 2.2 for non-mountainous areas and Eq. 2.6 for mountainous areas to estimate missing data at each station. When using Eq. 2.6, the program allows for different values of F_e for maximum temperature and minimum temperature at each individual station. The program is written so that no estimated value will be used in the estimation of another missing value. If all the stations are missing on a given day, the temperature at each remains as a missing value and a message is printed. The six hourly means resulting from periods when all the maximums or minimums are missing will also be missing and must be estimated later by hand. To avoid cases of missing data remaining in the program output, a reasonable number of stations should always be included in the analysis. When more than five stations are used, cases of missing data in the program output will probably never occur.

2.4.3.3 Conversion of Maximum-Minimum Temperature Data to Six-hourly

In the MAT program, the maximum temperature is assumed to occur in the afternoon and the minimum near sunrise. The relationship between each six-hour period and the maximum and minimum temperature varies throughout the year because of variations in the number of daylight hours. In snow computations, the most important time of the year is the spring melt period. The relationships used in the MAT program were derived from maximum-minimum and hourly air temperature data available for the spring snowmelt period from the Central Sierra Snow Laboratory near Donner Summit, California and the NOAA-ARS Cooperative Snow Research Station near Danville, Vermont. The relationships used in the MAT program are:

a. Midnight to 6 a.m.

$$T_6 = 0.95 \cdot T_{min_n} + 0.05 \cdot T_{max_{n-1}} \qquad (2.7)$$

b. 6 a.m. to noon

$$T_6 = 0.40 \cdot T_{min_n} + 0.60 \cdot T_{max_n} \qquad (2.8)$$

c. Noon to 6 p.m.

$$T_6 = 0.925 \cdot T_{max_n} + 0.025 \cdot T_{min_n} + 0.05 \cdot T_{min_{n+1}} \qquad (2.9)$$

d. 6 p.m. to midnight

$$T_6 = 0.33 \cdot T_{max_n} + 0.67 \cdot T_{min_{n+1}} \qquad (2.10)$$

where: T_6 = Mean six-hourly air temperature,
T_{min} = Minimum air temperature,
T_{max} = Maximum air temperature, and
n = Current day.

2.4.3.4 Computation of Areal Means

The computation of six-hour areal means is simply a matter of multiplying the six-hourly temperatures for each station by the station weight for that station. Station area weights for MAT computations can be predetermined, based on the portion of the area represented by each station, or grid point weights can be computed within the program. It is strongly recommended that predetermined station area weights be used in mountainous areas. The final product, six-hourly mean areal air temperature, can be output onto tape in

NWSRFS Standard Tape Format (section 3.7.2 in HYDRO-14) or on Office of Hydrology Standard Format cards (Appendix A in HYDRO-14) with a field length equal to three.

2.4.3.5 Consistency Checks

A separate program to be used in conjunction with the MAT program is provided to check the consistency of the basic maximum-minimum temperature data. The data needed for the consistency checks are written onto a disk or scratch tape in the MAT program. The consistency check program is then executed immediately after the MAT program. The consistency check program has no input other than that given it by the MAT program.

The difference in monthly mean temperature between two stations should be nearly constant, though in some cases the difference may exhibit a seasonal variation. Thus, a double-mass plot showing the deviation of the cumulative mean monthly temperature at an individual station from the average cumulative mean temperature at a group of stations should be a good check on the consistency of the temperature data at the individual station. For a consistent record the double-mass plot should be a straight line, or a straight line with waves on it if a seasonal variation between stations exists. Figure 2-4 shows some typical consistency check plots. Stations A and B are consistent over the period while station C is not. The consistency check program produces such a plot for both maximum and minimum temperatures at all the stations used in the areal analysis.

In addition to the consistency of the record, the plots also give some insight as to how representative certain stations are. For example, if there are a number of stations within the same area at a similar elevation, their consistency plots should be fairly similar. If the plot for one station shows large negative deviations from the others, it is likely that the station is influenced significantly by cold air drainage and, thus, may not be a representative station.

2.4.3.6 Correcting Inconsistent Stations

The initial run of the MAT program and the consistency check program may show that certain stations have inconsistent records while others may not be representative of the portion of the area that they are supposed to represent. Thus, the program needs to be rerun to correct these deficiencies. Unrepresentative stations can be dropped from the analysis, or their station weight can be revised, or they can be corrected by the addition or subtraction of a constant temperature so that their data will be representative. Inconsistent stations need to be corrected so that their record will be consistent. For example, in Fig. 2-4 station C could be made consistent by applying a correction of $-1^{\circ}F$ to all observations from November 1965 through April 1968. A provision for making such corrections is included in the input to the MAT program. It should be noted that when applying a correction it is necessary to adjust the mean station temperature if the data being corrected were used to compute the station mean.

2.4.3.7 Sample Input and Output

A set of sample input cards for the computation of mean areal temperature for the Passumpsic River at Passumpsic, Vermont for the period October 1963 through September 1971 is listed in Appendix B.2. A map of the Passumpsic basin, showing station location, is shown in Figure 2-5. Appendix B.3 contains examples of the output from the MAT program and the consistency check program.

2.4.4 TEMPERATURE ESTIMATION COMPARISON PROGRAM

A program is provided to compare estimated and observed data at an individual station for the purpose of checking the accuracy of the estimation technique or to determine the magnitude of F_e. This program (TEMPCK) must be run in conjunction with the MAT program. A "dummy" station is positioned at exactly the same coordinate location as the actual station for which the comparison is to be made. The MAT program estimates the daily maximum and minimum temperatures for the "dummy" station using Eq. 2.2 or Eq. 2.6, depending on the type of area. The MAT program then writes the daily maximum and minimum temperatures for the "dummy" station and its real counterpart onto a disk or tape. Program TEMPCK uses these data to compare the estimated and observed temperatures. The comparison is summarized by a plot of estimated versus observed maximum and minimum temperatures and by a table of the RMS error and the standard deviation of the observed maximum and minimum temperatures for each month and for the total period that was compared.

The input for the MAT program varies slightly from that listed in Appendix B.1 when the MAT program is being used to prepare input for TEMPCK. The changes are as follows:

Card No.	Changes
1	Punch a zero in column 30. Column 40 has no effect. Punch the run number in columns 56-60 of the actual station for which the comparison of observed versus estimated temperatures is to be made. Run number is determined by the station input order as defined by card 3.
4 & 5	F_e should be the same for the "dummy" station and its real counterpart.
6-8	Do not input these cards.

In addition to the data prepared by the MAT program, program TEMPCK requires one input card. The form of this card is as follows:

Format	Contents
I5	Initial ordinate for estimated versus observed maximum temperature plot. Plots are 120°F by 120°F, thus, if initial ordinate is -9°F, then

Format	Contents
	observed and estimated values from -9°F to +110°F will be plotted.
I5	Initial ordinate for estimated versus observed minimum temperature plot.
F5.0	EMAX. When the estimated temperature varies by more than EMAX degrees from the observed, program TEMPCK prints a message listing the observed temperature, the estimated temperature, and the date of occurrence.

Appendix B.4 lists a set of sample input for using program TEMPCK in conjunction with the MAT program. Appendix B.5 contains sample output from program TEMPCK.

2.5 SUMMARY OF STEPS IN DATA PROCESSING

As a reference for users of the data processing programs presented in this chapter and in chapter 3 of HYDRO-14, the steps required to prepare the data necessary for model calibration are summarized. To illustrate the steps a typical basin is used as an example; the Passumpsic River at Passumpsic, Vermont. Data were prepared for the period October 1963 through September 1971.

a. Obtain NWSRFS-NCC hourly and daily data tapes, including table of contents, for all states involved in the analysis from the National Climatic Center, Asheville, North Carolina. (Tapes described in Appendix B of HYDRO-14) In this case, tapes were obtained for Vermont and New Hampshire.

b. With the aid of the Annual Summaries of Climatological Data published by the Environmental Data Service, NOAA, and the tape table of contents, select all the stations which could possibly be useful in the analysis. In this case, 40 daily stations and 21 hourly stations were selected for use in calibration of the Passumpsic River and for future analysis of the Ammonoosuc and White River basins.

c. Run programs PRELIM1 and PRELIM2 for the selected stations.

d. Determine changes in location of all stations from the Annual Summaries of Climatological Data and observation times for daily stations from monthly Climatological Data bulletins.

e. Perform an isohyetal analysis to determine "characteristic precipitation" (section 3.3.2 in HYDRO-14) for each station if the area is mountainous. Also locate "dummy" precipitation stations if they are needed. For the Passumpsic basin "characteristic precipitation" was determined from the mean monthly precipitation values computed by programs PRELIM1and PRELIM2 and from an isohyetal analysis performed by Knox and Nordenson (1955).

f. Run the Mean Basin Precipitation program (section 3.4 in HYDRO-14). For the Passumpsic, mean areal precipitation was computed for three areas; the basin as a whole, the area below 1,330 feet elevation, and the area above 1,330 feet elevation. The output was put onto tape.

g. Examine the available maximum-minimum air temperature data to determine if the available data adequately represents all portions of the area. If the available data does not represent all portions of the area, assign "dummy" stations to those portions that are not represented. Determine the mean monthly maximum and minimum temperature for each "dummy" station from available actual temperature records or possibly other meteorological information. For the Passumpsic basin temperature records for stations within or near the basin, plus several high elevation stations in northern New England, were used to determine the mean monthly maximum and minimum temperature for the assigned "dummy" station.

h. Run the Meán Areal Temperature program. For the Passumpsic basin mean temperature was computed for the same areas as was precipitation. The output was put onto tape.

i. Obtain mean daily discharge records. In the case of the Passumpsic River, daily discharge was punched directly from the U.S.G.S. Water Supply Papers and converted to Office of Hydrology Standard Format Cards (Appendix A in HYDRO-14). The data could also have been obtained from the U.S.G.S. on magnetic tape and converted to Office of Hydrology Standard Format Cards with program DAILYF (Appendix D in HYDRO-14).

j. Determine daily potential evapotranspiration (PE) and put the results on Office of Hydrology Standard Format Cards. For the Passumpsic basin daily PE was computed from meteorological variables (Equations given in section 3.5 of HYDRO-14) collected by NOAA and the Agricultural Research Service near Danville, Vermont. For periods when the meteorological variables were not available, daily PE was estimated from mean monthly PE computed for Burlington, Vermont.

k. Put all data currently on Office of Hydrology Standard Format Cards onto tape in NWSRFS Standard Tape Format. Program NWSRFS2 (Appendix E.1 in HYDRO-14) performs this task. For the Passumpsic basin PE and mean daily discharge data were converted from cards to tape.

l. Combine the basic data from individual tapes onto one master tape for use in model calibration. Program SUPERTP (Appendix E.2 in HYDRO-14) is used to merge tapes. For the Passumpsic basin the three individual tapes; one containing mean areal precipitation, one containing mean areal temperature, and one containing PE and mean daily discharge, were combined.

Reference:

Knox, C. E. and Nordenson, T. J.,"Average Annual Runoff and Precipitation in the New England-New York Area," Hydrologic Investigations Atlas HA7, Department of the Interior, United States Geological Survey, 1955.

TABLE 2-1 Accuracy of point temperature estimates from Eq. 2.6 with $F_e = 10.0$

Case	Estimated Station Elevation, Observation Time and Test Period	Stations Used for Estimate-- Elevation and Observation Time	RMS-°F		Standard Deviation °F	
			Max	Min	Max	Min
High elevation station estimated from stations at or below it.	Flagstaff, Arizona 7006' 12PM 10/63 - 9/71	Chevelon RS 7006' 5PM Cottonwood 3360' 6PM Groom Creek 6100' 5PM Williams 6750' 5PM Winslow 4895' 12PM Wupatki N.M. 4908' 5PM	3.4	4.4	8.6	7.5
	Flagstaff, Arizona 7006' 12PM 10/63 - 9/71	Chevelon RS 7006' 5PM Cottonwood 3360' 6PM Fort Valley 7347' 8AM Groom Creek 6100' 5PM Winslow 4895' 12PM Wupatki N.M. 4908' 5PM	3.7	4.8	8.6	7.5
	Fort Valley, Arizona 7347' 8AM 10/63 - 9/71	Chevelon RS 7006' 5PM Cottonwood 3360' 6PM Groom Creek 6100' 5PM Williams 6750' 5PM Winslow 4895' 12PM Wupatki N.M. 4908' 5PM	5.0	5.8	8.5	8.2
Middle elevation station estimated from stations above and below it.	Junipine, Arizona 5134' 6PM 10/63 - 9/71	Cottonwood 3360' 6PM Flagstaff 7006' 12PM Montezuma Castle 3180' 6PM Williams 6750' 5PM	2.1	2.8	8.1	5.8

TABLE 2-1 (continued)

High elevation station estimated from low elevation stations	Palisade RS, Arizona 7945' 5PM 1/65 - 9/71	Oracle 2SE 4540' 6PM Sabino Canyon 2640' 5PM San Manuel 3560' 6PM	3.9	4.6	7.4	6.7
	Palisade RS, Arizona 7945' 5PM 1/65 - 9/71	Sabino Canyon 2640' 5PM San Manuel 3560' 6PM Willow Springs Ranch 3690' 5AM	3.9	4.8	7.4	6.7
	Mt. Washington, N.H. 6262' 12PM 10/63 - 9/71	Bethelehem 1380' 10/63 - 11/65 7AM 12/65 - 9/71 5PM Fabyan 1620' 7PM Pinkham Notch 2029' 10/63 - 9/64 7PM 10/64 - 9/71 7AM Woodstock 720' 6PM	5.6	8.4	9.9	10.5
	Mt. Mansfield, Vt. 3950' 5PM 10/63 - 9/71	Burlington WSO 332' 12PM Montpelier 1126' 12PM Morrisville 680' 5PM	4.4	6.6	9.8	10.1
Station estimated from other stations at nearly the same elevation	North Danville, Vt. 1140' 12PM 10/63 - 9/71	Newport 766' 12PM St. Johnsbury 699' 4PM West Burke 900' 7AM	3.1	4.8	9.7	10.1

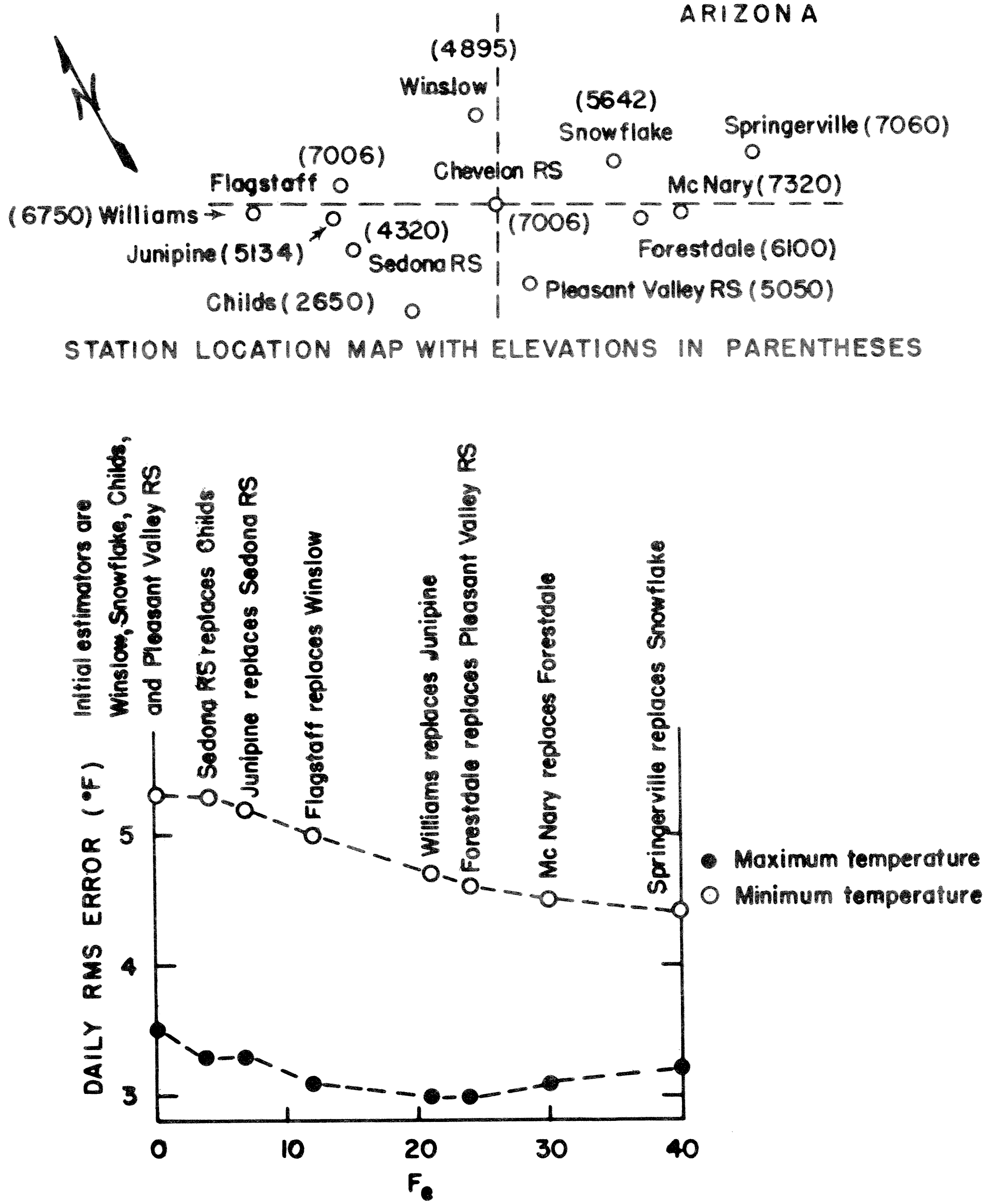
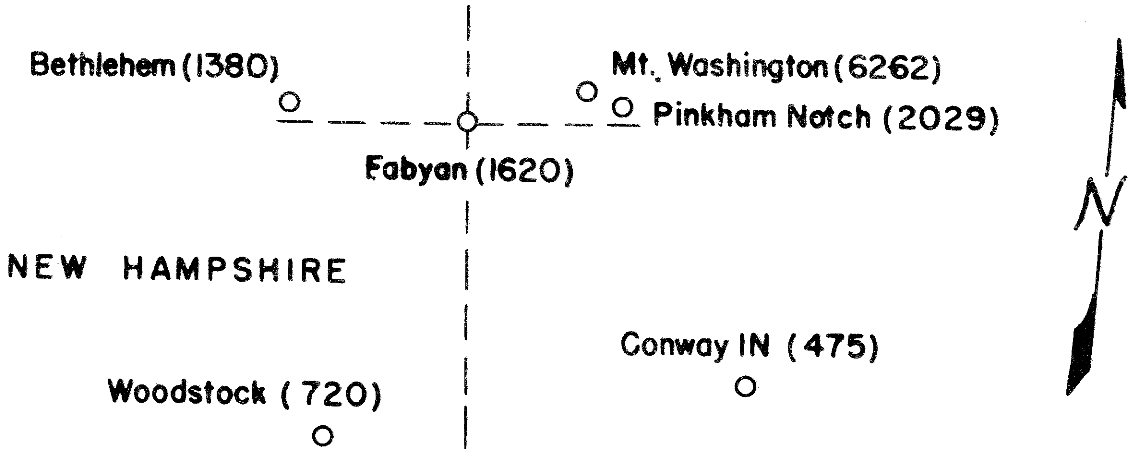


Figure 2-2. F_e versus RMS error plot for Chevelon Ranger Station, Arizona, 10/63 - 9/71.



STATION LOCATION MAP WITH ELEVATIONS IN PARENTHESES

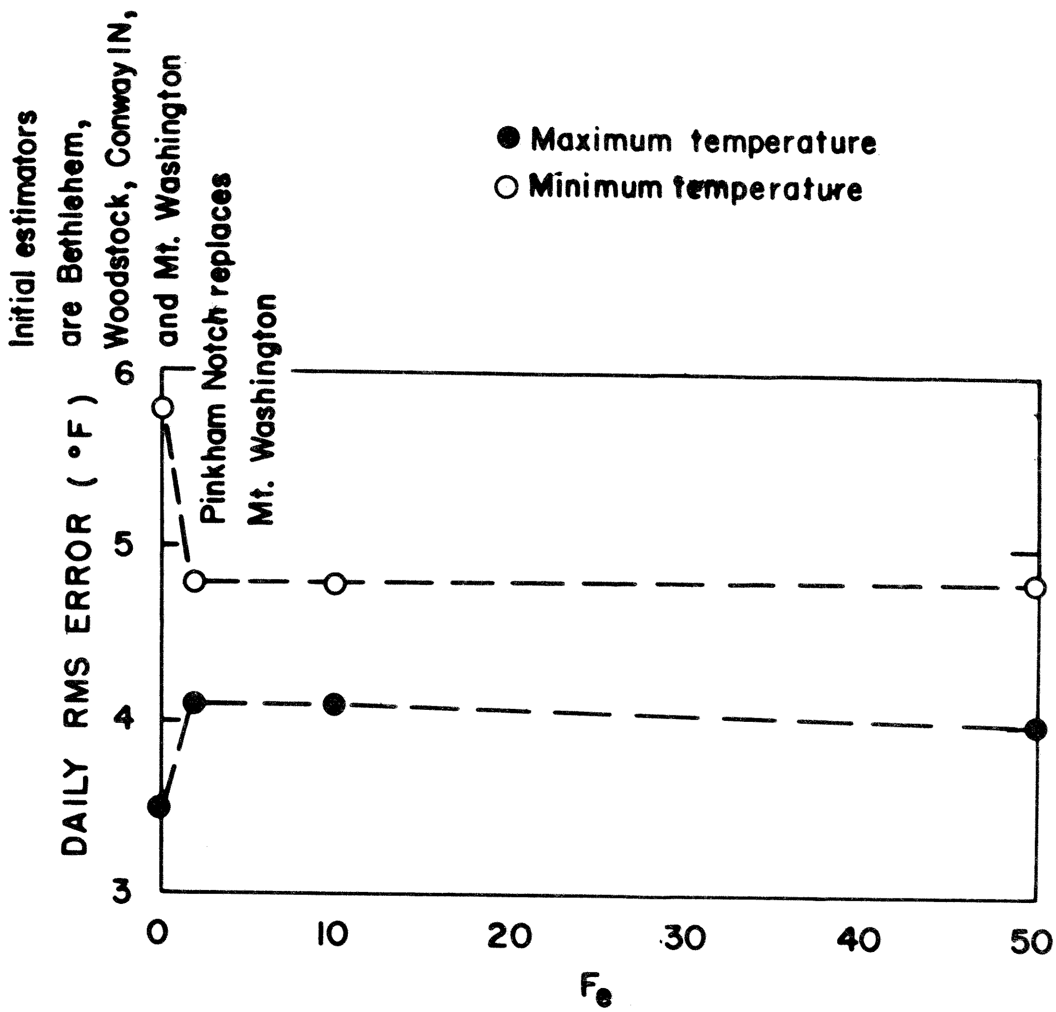


Figure 2-3. F_e versus RMS error plot for Fabyan, New Hampshire, 10/63 - 7/70.

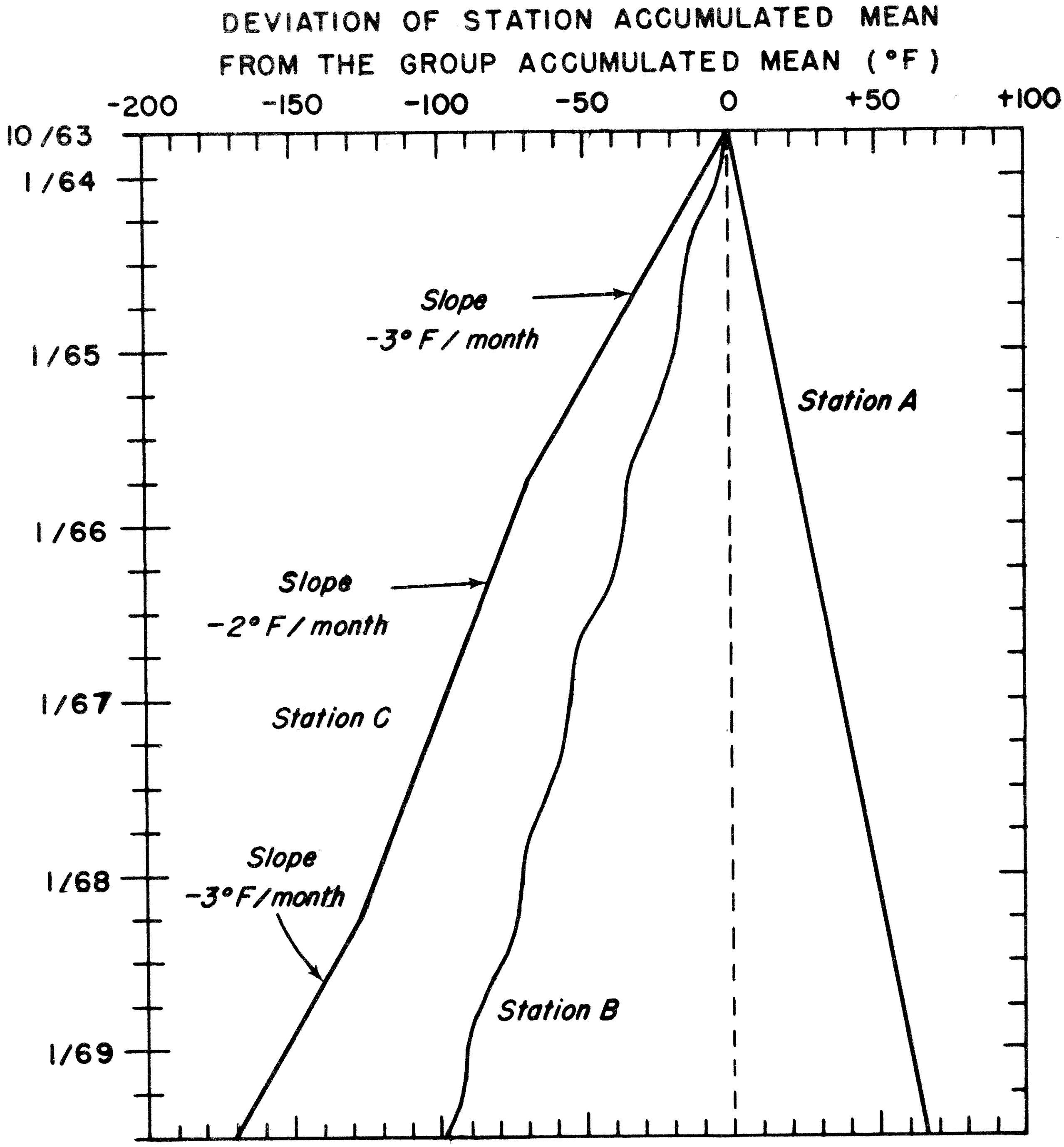
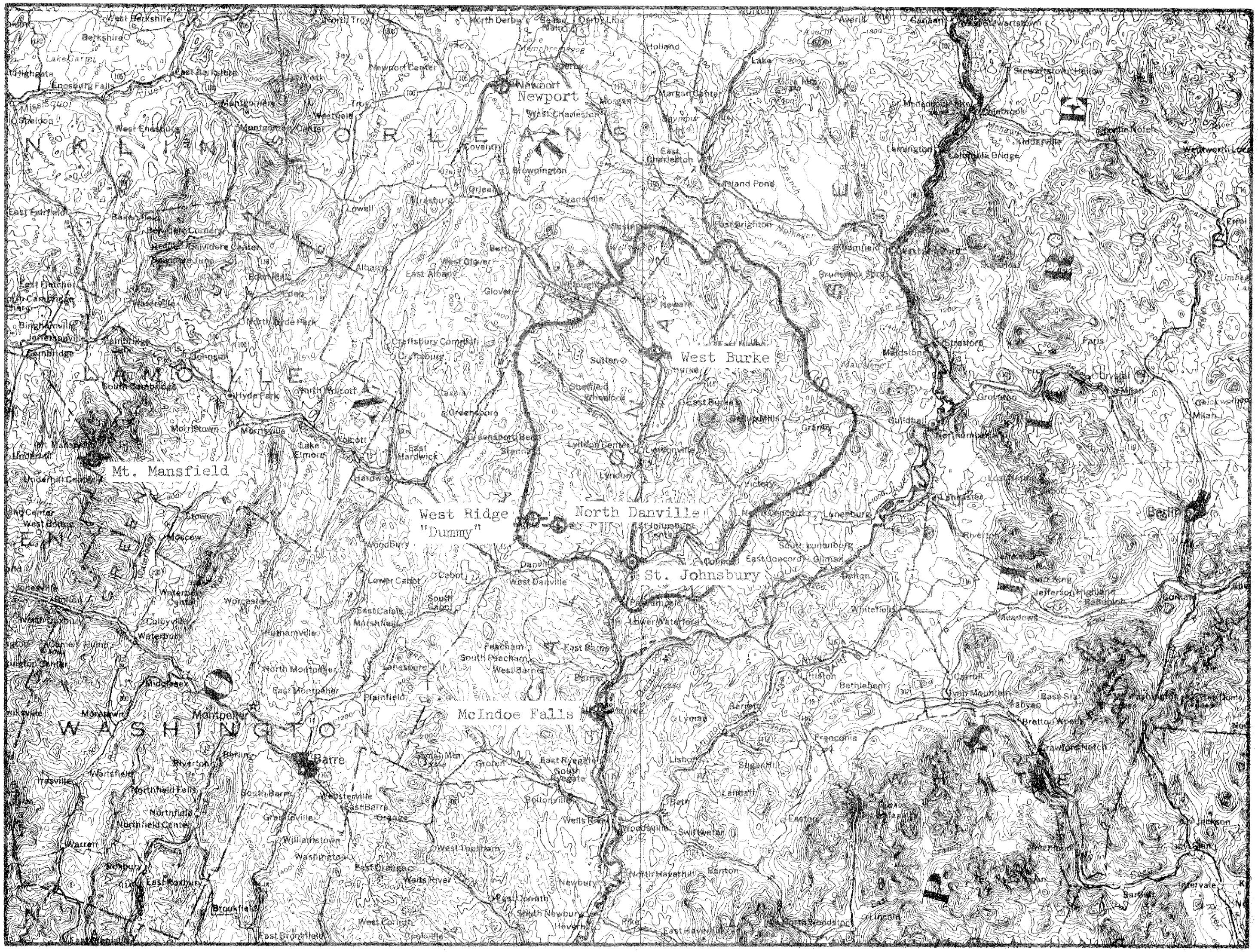


Figure 2-4. Typical temperature consistency check plot.



Scale: 1:500,000

Contour Interval 200 feet

Figure 2-5. Passumpsic River at Passumpsic, Vermont, showing location of temperature stations.

CHAPTER 3. SNOW ACCUMULATION AND ABLATION MODEL

3.1 INTRODUCTION

This chapter describes the basic model representing the physical processes which are needed to simulate the accumulation and ablation of a snowpack. The basic philosophy of the model is that each significant physical component be represented separately, rather than to use a single index to explain several processes, e.g., the use of degree-day-factors as described by Linsley et al. (1958). As noted in Chapter 1, air temperature and precipitation are the only meteorological variables that are required for this model. Guidelines for determining model parameters are not included in this chapter. Model parameter guidelines are included in the discussion of model calibration in Chapter 5.

3.2 FLOWCHART

Figure 3-1 shows a flowchart of the snow accumulation and ablation model. This flowchart shows each of the physical components which are represented in the model. These include, accumulation of the snowpack, heat exchange at the air-snow interface, areal extent of snow cover, heat storage within the snowpack, liquid-water retention and transmission, and heat exchange at the soil-snow interface.

3.3 DESCRIPTION OF MODEL COMPONENTS

This section describes the mathematical relationships which are used to model each of the basic components of the snow accumulation and ablation process. It should be noted that in the model all snowpack variables are expressed in terms of mean values over the entire area. Thus, if the total snowpack water equivalent is computed as 6.30 inches and the areal extent of snow cover is 50 percent, then the mean water equivalent over the area actually covered by snow is 12.60 inches.

3.3.1 ACCUMULATION OF THE SNOWPACK

The first decision which must be made is whether precipitation entering the model is in the form of rain or snow. Air temperature is used as the index to the form of precipitation. The parameter PXTEMP is the delineation point between rain and snow.

$TA > PXTEMP$ Precipitation is rain, and
$TA \leq PXTEMP$ Precipitation is snow,

where:

TA is the air temperature in degrees F, and
PXTEMP is in degrees F.

For heat storage computations or for computing the melt caused by rain water, the temperature of the precipitation is assumed to be equal to the air temperature. When snow is falling at air temperatures greater than 32°F, the temperature of the snow is set to 32°F.

In order to simulate the accumulation of the snowpack correctly, not only does the form of precipitation need to be determined, but the amount of precipitation must be reasonably accurate. The catch of a precipitation gage can be in error by a considerable amount during snowfall events; especially if the gage is not shielded or if the gage is exposed to high winds. The parameter SCF is used to correct for gage catch deficiency during snowfall, i.e.,

$$PX_a = SCF \cdot PX_g, \qquad (3\text{-}1)$$

where:

PX_g is the precipitation as recorded by the gage in inches, and
PX_a is the actual water equivalent of the snowfall in inches.

In this model SCF is a mean gage catch deficiency correction factor. For an individual storm PX_a can be in error because of variations in wind speed and direction. However, as the number of storms contributing to the snowpack becomes large, the errors from individual storms will tend to cancel each other.

3.3.2 HEAT EXCHANGE AT THE AIR-SNOW INTERFACE

The heat exchange at the air-snow interface is the most critical factor controlling the ablation of a snowpack. This model uses air temperature as the index to the heat exchange mechanisms which control heat flow into or out of the snowpack. There are two basic situations for which heat exchange needs to be estimated: (1) when the air is warm enough so that melt takes place at the snow surface, and (2) when the air is too cold for melt to occur.

3.3.2.1 Melt at Snow Surface

The model assumes melt can occur at the snow surface when the air temperature is above 32°F. The relative importance of various heat exchange mechanisms varies with meteorological conditions. Since only air temperature and precipitation are assumed known in this model, it is impossible to distinguish each condition. However, the rate of melt during rain can be separated from the rate of melt during other conditions. In the model the equation for melt during rain is used when the amount of rain exceeds 0.1 inch in six hours.

a. Melt during rain. During rain several assumptions are made so that melt can be computed from an energy balance equation. The assumptions are: (1) solar radiation is zero, (2) incoming longwave radiation equals the blackbody radiation at the ambient air temperature, (3) snow surface temperature is 32°F, (4) dew point is equal to ambient air temperature, and (5) temperature of the rain water is equal to the ambient air temperature.

A brief derivation of the energy balance equation is as follows:

1. The energy balance of a melting snowpack can be expressed as:

$$M = Q_n + Q_e + Q_h + Q_{P_X} , \qquad (3.1)$$

where: Q_n = net radiative heat transfer,
Q_e = latent heat transfer,
Q_h = sensible heat transfer,
Q_{P_X} = heat transfer by rain water, and
M = amount of melt.

Units of all quantities are inches water equivalent.

2. Based on the preceding assumptions, net radiative transfer during rain on a melting snowpack is:

$$Q_n = \sigma \cdot T_{aK}^4 - \sigma \cdot T_{sK}^4 , \qquad (3.2)$$

where: σ = Stefan Boltzmann constant (5.78×10^{-10} inches of melt $\cdot$ day^{-1} $\cdot$ $^{\circ}K^{-4}$),
T_{aK} = ambient air temperature $^{\circ}K$, and
T_{sK} = snow surface temperature $^{\circ}K$ (in this case $T_{sK} = 273^{\circ}K$).

Assuming linearity of $\sigma \cdot T_{aK}^4$ over the temperature region of main interest, Eq. 3.2 can be expressed as:

$$Q_n = 0.007 \cdot (T_a - 32) , \qquad (3.3)$$

where: T_a is the ambient air temperature, $^{\circ}F$, and Q_n is in terms of inches/6 hr.

Eq. 3.3 yields values within 5 percent of Eq. 3.2 over the temperature range $32^{\circ} < T_a < 75^{\circ}F$.

3. A Dalton-type equation is commonly used to compute vapor transfer. During a rain on snow event, condensation will occur, thus the equation for vapor transfer would be:

$$V = f(u) \cdot (e_a - e_s), \qquad (3.4)$$

where: V = condensation - inches/6 hr.,
$f(u)$ = wind function - inches/(inches H_g $\cdot$ 6 hr.),

e_a = vapor pressure of air - inches H_g, and
e_s = vapor pressure of snow surface - inches H_g (assumed to be the saturation vapor pressure at the snow surface temperature = 0.18 in. H_g at 32°F).

Thus, the latent heat transfer during a rain on snow event is:

$$Q_e = L_V \cdot V , \qquad (3.5)$$

where: L_V = latent heat of vaporization (7.5 inches of melt/inch of condensate).

Combining Eqs. 3.4 and 3.5, the equation for latent heat transfer during a rain on snow event is:

$$Q_e = 7.5 \cdot f(u) \cdot (e_a - 0.18), \qquad (3.6)$$

where: Q_e is in inches/6 hr.

However, for every 7.5 inches of latent heat melt, one inch of condensate is also added to the snowpack. Thus, the total amount of liquid water produced by latent heat exchange during a rain on snow event (W_{Q_e}) is:

$$W_{Q_e} = 8.5 \cdot f(u) \cdot (e_a - 0.18), \qquad (3.7)$$

where: W_{Q_e} is in inches/6 hr.

4. If it is assumed that the eddy transfer coefficients for heat and vapor are equal, then the ratio of Q_h/Q_e, commonly referred to as Bowen's ratio, can be expressed as:

$$\frac{Q_h}{Q_e} = \gamma \cdot \frac{T_a - T_s}{e_a - e_s} , \qquad (3.8)$$

where: γ is the psychrometric constant - inches H_g/°F (γ = 0.000359·PA where PA is atmospheric pressure - in. H_g), and T_s is the snow surface temperature - °F.

Substituting Eq. 3.6 for Q_e, the expression for sensible heat transfer becomes:

$$Q_h = 7.5 \cdot \gamma \cdot f(u) \cdot (T_a - 32) \ . \tag{3.9}$$

5. The heat transferred by rain water to the snow is the difference between the initial and final heat content of the rain water. This can be expressed as:

$$Q_{px} = C_p \cdot P_x \cdot T_a - C_p \cdot P_x \cdot 32^{o}F, \tag{3.10}$$

where: C_p = specific heat of water, 0.007 inches water equivalent/ ^{o}F, and
P_x = amount of precipitation - inches.

Cp = specific heat / heat of fusion
units, °F⁻¹

Thus, the melt caused by rain water is:

$$Q_{px} = 0.007 \cdot P_x \cdot (T_a - 32). \tag{3.11}$$

1 cal/gm °C · gm °C/80 cal · 1/1.8°F = .007/°F

Substituting Eq. 3.3, 3.6, 3.9 and 3.11 into Eq. 3.1 and including the amount of condensate, the equation used in the model for melt during a rain on snow event becomes:

$$M = 0.007 \cdot (T_a - 32) + 7.5 \cdot \gamma \cdot UADJ \cdot (T_a - 32),$$
$$+ 8.5 \cdot UADJ \cdot (e_a - 0.18) + 0.007 \cdot P_x \cdot (T_a - 32), \tag{3.12}$$

where: UADJ is a parameter representing the average six-hour wind function during rain on snow events, and M is in units of inches/6 hr.

b. Melt during non-rain periods. During non-rain periods melt at the snow surface is assumed to be linearily related to the difference between the air temperature and a base temperature, MBASE (units are ^{o}F). The most commonly used base temperature is $32^{o}F$. Thus, melt during non-rain periods can be expressed as:

$$M = M_f \cdot (T_a - MBASE), \tag{3.13}$$

where: M_f = melt factor - inches/(6 hr. $\cdot$ ^{o}F).

This relationship is adequate for any single period of the snow season. However, the melt factor for one portion of the snow season differs from the melt factor for other portions because of the changing relationship between the meteorological factors which affect melt and the quantity (T_a - MBASE). Thus, the model uses a seasonally varying melt-factor. The minimum melt factor (MFMIN) is assumed to occur on December 21 and the maximum melt factor (MFMAX) on June 21. A sine curve is used to extrapolate melt factors for other dates, as shown in Figure 3-2.

3.3.2.2 Heat Exchange During Non-Melt Periods

When the air temperature is below 32°F the model assumes melt does not occur. In this situation the heat exchange can be positive (snowpack gaining heat) or negative (snowpack losing heat). The direction of heat flow depends on whether the air is warmer or colder than the surface layer of the snowpack. An antecedent temperature index (ATI) is used as an index to the temperature of the surface layer of the snowpack. This index is computed as follows:

$$ATI_2 = ATI_1 + TIPM \cdot (T_{a_2} - ATI_1), \qquad (3.14)$$

where: subscripts refer to time period one and two. TIPM is an anteceden temperature index parameter ($0.0 < TIPM \leq 1.0$).

Exceptions to Eq. 3.14 are:

a. When ATI is greater than 32°F, ATI is set to 32°F.
b. When the snowpack is isothermal at 32°F, ATI is set to 32°F.
c. When more than 0.2 inches water equivalent of snowfall occurs in six hours then ATI is set equal to the temperature of the new snow, since the new snow is now the surface layer.

The heat exchange during a non-melt period is assumed proportional to the temperature gradient defined by air temperature and the antecedent temperature index. Thus the change in the heat storage of the snowpack when $T_a < 32°F$ is:

$$\Delta HS_2 = NM_f \cdot (T_{a_2} - ATI_1), \qquad (3.15)$$

where: ΔHS = change in snowpack heat storage - inches water equivalent/ 6 hr., and
NM_f = negative melt factor - inches/(6 hr. · °F).

Subscripts refer to time periods and indicate that ΔHS is calculated using the value of ATI at the end of the previous six-hour period.

The conduction of heat into or out of the snowpack is primarily a function of snow density in addition to the temperature gradient. The density of the upper layer of the snowpack is variable, but tends to increase as the snow "ripens" and melt progresses. Thus, the negative melt factor should vary seasonally. Since heat transfer during non-melt periods is much less significant than during melt periods, additional mathematical relationships and parameters to describe this seasonal variation are not warranted. In this model the same seasonal variation used for the non-rain melt factor is used for the negative melt factor. Therefore, the only parameter needed for non-melt heat exchange is NMF, the maximum negative melt factor. The minimum negative melt factor (NMF_{min}) is:

$$NMF_{min} = NMF \cdot \frac{MFMIN}{MFMAX} \tag{3.16}$$

and the seasonal variation is the same as for the non-rain melt factor, as shown in Figure 3-2.

To conclude this section, Table 3-1 summarizes the calculation of heat exchange at the air-snow interface for each heat exchange situation.

3.3.3 AREAL EXTENT OF SNOW COVER

The percent of the area which is covered by snow must be estimated to determine the area over which heat exchange is taking place and, in the case of rain on snow, to determine how much rain falls on bare ground. The areal depletion of snow is predominantly a function of how much of the original water-equivalent of the snowpack remains. Because of a similarity in accumulation versus elevation and vegetal cover and a similarity in drift patterns from year to year, each area should have a reasonably unique areal depletion curve. An areal depletion curve, as used in the model, is a plot of the areal extent of snow cover versus the ratio of mean areal water equivalent to an index value, A_i (units are inches water equivalent). The index value, A_i, is the smaller of: 1) the maximum water equivalent since snow began to accumulate, or 2) a preset maximum (SI). SI is thus the mean areal water equivalent above which there is always 100 percent snow cover. A typical areal depletion curve is shown in Figure 3-3.

The one problem that remains is the case when new snow occurs over an area that is partially bare. In this case, the area reverts to 100 percent cover for a period of time, then returns to the point where it was on the areal depletion curve before the snowfall occurred. The method of modeling this situation also is shown on Figure 3-3. The variables are defined as follows:

- SBAESC = the areal extent of snow cover from the areal depletion curve just prior to the new snowfall;
- SB = the areal water equivalent just prior to the new snowfall;
- S = the amount of the new snowfall - inches water equivalent; and
- SBWS = the amount of water equivalent above which 100 percent areal snow cover temporarily exists.

SBWS is computed as:

$$SBWS = SB + 0.75 \cdot S. \tag{3.17}$$

Thus, the areal extent of snow cover remains at 100 percent until 25 percent of the new snow melts. In reality this 25 percent figure varies from area to area, but the magnitude of the variation and the effect on model results do not warrant the inclusion of another parameter.

3.3.4 SNOWPACK HEAT STORAGE

The model keeps a continuous accounting (on a six-hour basis) of the heat storage of the snowpack. The upper limit for heat storage computations is 32°F. Thus, when the snowpack is isothermal at 32°F, the snowpack heat storage is assumed to be zero. When heat is transferred from the snow to the air, heat storage becomes negative. This is called negative heat storage (NEGHS) in the model. Enough heat must be added to bring negative heat storage back to zero before surface melt water or rain water can contribute to liquid water storage or snowpack outflow. Negative heat storage can physically consist of snow at a temperature less than 32°F or refrozen liquid water or a combination of these. It makes no difference what the physical form of negative heat storage is, it is the total amount of the heat deficit that is important.

3.3.5 LIQUID-WATER RETENTION AND TRANSMISSION

Snow crystals retain liquid-water similar to soil particles. In the model the maximum amount of liquid-water (LIQWMX - inches) that the snowpack can hold is:

$$LIQWMX = PLWHC \cdot WE, \qquad (3.18)$$

where: PLWHC = percent (decimal) liquid-water holding capacity; and
WE = water equivalent of the solid portion of the snowpack in inches.

The model assumes PLWHC is a constant for all snowpack conditions, since variations of liquid-water holding capacity with regard to density and crystal structure are not well defined. The amount of liquid-water that exists within the snowpack at any time is LIQW (units are also inches).

Equations for the transmission of excess liquid-water through the snowpack were developed with data obtained from the Central Sierra Snow Laboratory Lysimeter during April and May of 1954. The equations apply to a "ripe" snowpack (well-aged snow with a spherical crystalline structure). However, they are used under all conditions since there is a lack of data and knowledge on the transmission of water through fresh snow. The excess liquid-water is first lagged and then attenuated. The equation for lag is (shown graphically on Figure 3-4):

$$LAG = 5.33 \cdot [1.0 - \exp(-0.03 \cdot WE/EXCESS)], \qquad (3.19)$$

where: LAG = lag in hours, and
EXCESS = excess liquid water in inches/six hours.

The equation for attenuation is (shown graphically on Figure 3-5):

$$PACKRO = (S + I_1)/[0.5 \cdot \exp(-83.5 \cdot I_1/WE^{1.3}) + 1.0], \quad (3.20)$$

where: PACKRO = snowpack outflow in inches/six hours;
S = the amount of excess liquid-water in storage in the snowpack at the beginning of the period - inches, and
I_1 = the amount of lagged inflow for the current period - inches/six hours.

The functional forms of Eqs. 3.19 and 3.20 were developed by plotting the experimental data. Final coefficient values were determined by minimizing the squared error between simulated and observed snowpack outflow from the lysimeter.

3.3.6 HEAT EXCHANGE AT THE SOIL-SNOW INTERFACE

Heat exchange at the soil-snow interface is usually negligible compared to heat exchange at the air-snow interface. In some watersheds a small amount of melt takes place continuously at the bottom of the snowpack and is enough to sustain base flow throughout the winter. The model assumes that a constant amount of melt takes place at the soil-snow interface. This constant rate of melt is defined by the parameter DAYGM which has units of inches of water equivalent/day.

3.3.7 COMPONENTS NOT INCLUDED

Neither snowpack sublimation or interception are explicitly included in the model for the following reasons.

a. To calculate snowpack sublimation with reasonable accuracy, dew point and wind data are needed. In this model, neither of those quantities are known. Snowpack sublimation is usually of the same order of magnitude from one snow season to the next for a given watershed. Thus, to some extent the value of SCF would reflect sublimation losses as well as precipitation gage catch deficiencies.

b. Interception of snow by vegetation and any subsequent loss are complex processes. During a storm, interception storage increases until some maximum is reached. After the storm, some of the intercepted snow falls to the ground, some melts and runs down the tree trunks, and some sublimates. Many studies have represented the seasonal loss by interception as a percentage of the total seasonal snowfall. If this is a valid assumption, which it seems to be, then it would be very difficult to separate interception effects from gage catch deficiency effects.

c. In most watersheds the magnitude of sublimation losses and interception losses are much less than the magnitude of precipitation gage catch deficiencies.

3.4 SUMMARY OF MODEL PARAMETERS

Following is a list of the parameters used in the snow accumulation and ablation model and their definitions for use as a reference:

a.	PXTEMP	Temperature above which precipitation is assumed to be rain (°F).
b.	SCF	Multiplying factor to correct for precipitation gage catch deficiency during periods of snowfall.
c.	MBASE	Base temperature for melt computations during non-rain periods (°F).
d.	UADJ	Average six-hour wind function during rain on snow events [inches/(in. H_g · 6 hr.)].
e.	MFMAX	Maximum non-rain melt factor which occurs on June 21 [inches/(6 hr.·°F)].
f.	MFMIN	Minimum non-rain melt factor which occurs on December 21 [inches/(6 hr.·°F)].
g.	TIPM	Antecedent temperature index parameter ($0.0 < TIPM \leq 1.0$).
h.	NMF	Maximum value of negative melt factor which occurs June 21 [inches/(6 hr.·°F)].
i.	SI	Mean areal water-equivalent above which 100 percent areal snow cover always exists (inches).
j.	PLWHC	Percent (decimal) liquid water holding capacity.
k.	DAYGM	Daily melt at the soil-snow interface (inches).
l.	EFC	Percent (decimal) of area over which evapotranspiration occurs when there is 100 percent snow cover. [Evapotranspiration is modified when snow is on the ground by:

$$EP = EFC \cdot P_e + (1.0 - EFC) \cdot (1.0 - AESC) \cdot P_e, \qquad (3.21)$$

where:

P_e is watershed potential evapotranspiration modified for snow cover (inches), and AESC is percent (decimal) areal extent of snow cover].

Reference:

Linsley, R. K., Kohler, M. A. and Paulhus, J. L. H., Hydrology for Engineers, McGraw-Hill, New York, 1958, 340 pp.

TABLE 3-1

SNOW-AIR INTERFACE HEAT EXCHANGE SUMMARY

A. AIR TEMPERATURE > 32 °F

1. No rain or light rain (< 0.1"/6 hr)

Heat Exchange = (T_a − MBASE) · Melt factor

2. Rain (≥ 0.1"/ 6 hr)

assume : no solar radiation
longwave equals blackbody radiation at air temperature
dew-point = air temperature
temp. of rain = air temperature

$$\text{Heat exchange} = 0.007 \cdot (T_a - 32) + 7.5 \cdot \gamma \cdot f(\mu) \cdot (T_a - 32) + 8.5 \cdot f(\mu) \cdot (e_a - 0.18) + 0.007 \cdot \text{Rain} \cdot (T_a - 32)$$

γ = psychrometric constant, e_a = vapor pressure
$f(\mu)$ = wind function

B. AIR TEMPERATURE ≤ 32 °F

$$\text{Heat Exchange} = (T_{a_2} - ATI_1) \cdot \text{Negative melt factor}$$

ATI is antecedent temperature index

$$ATI_2 = ATI_1 + TIPM \cdot (T_{a_2} - ATI_1)$$

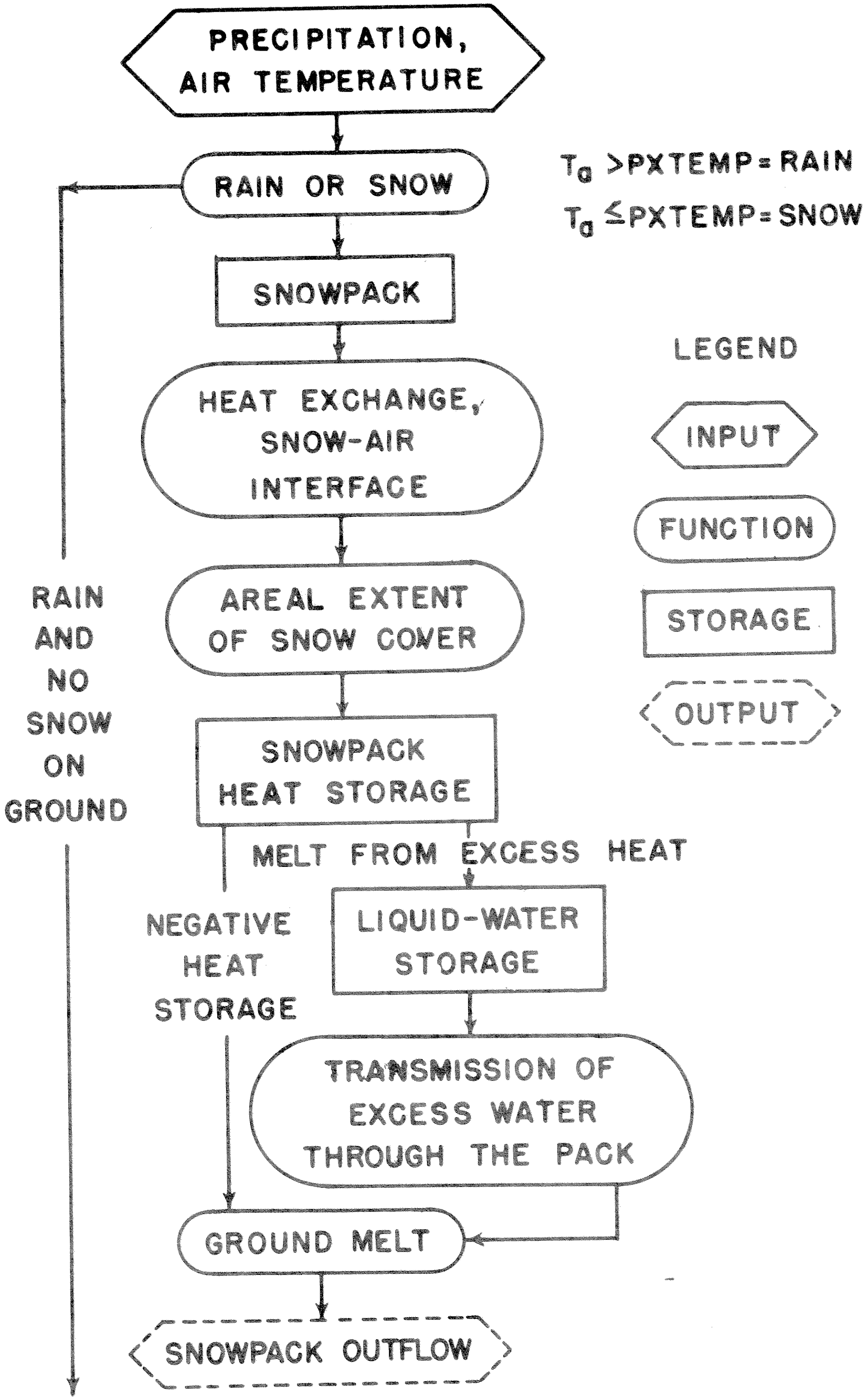


Figure 3-1. - Flow chart of snow accumulation and ablation model.

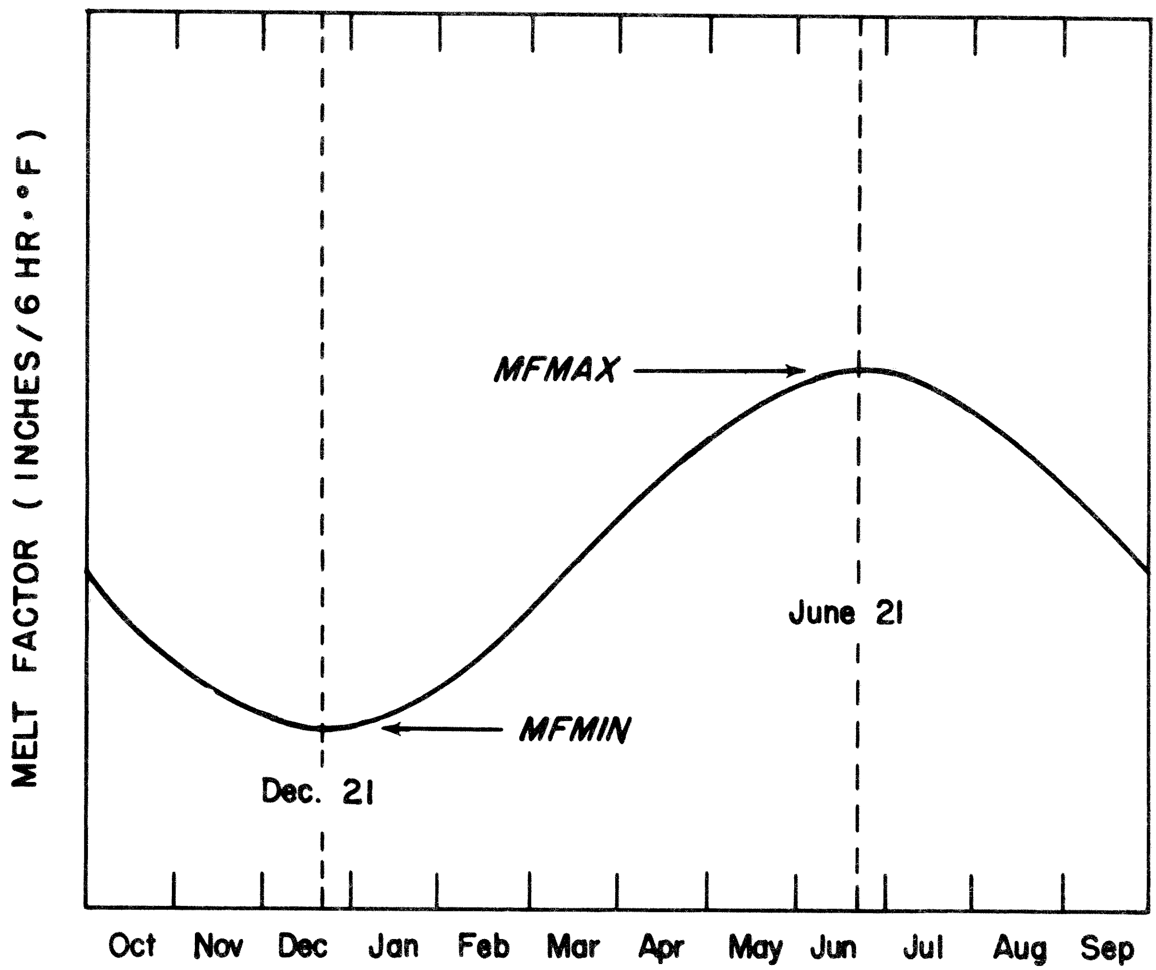


Figure 3-2. - Seasonal variation in melt factors.

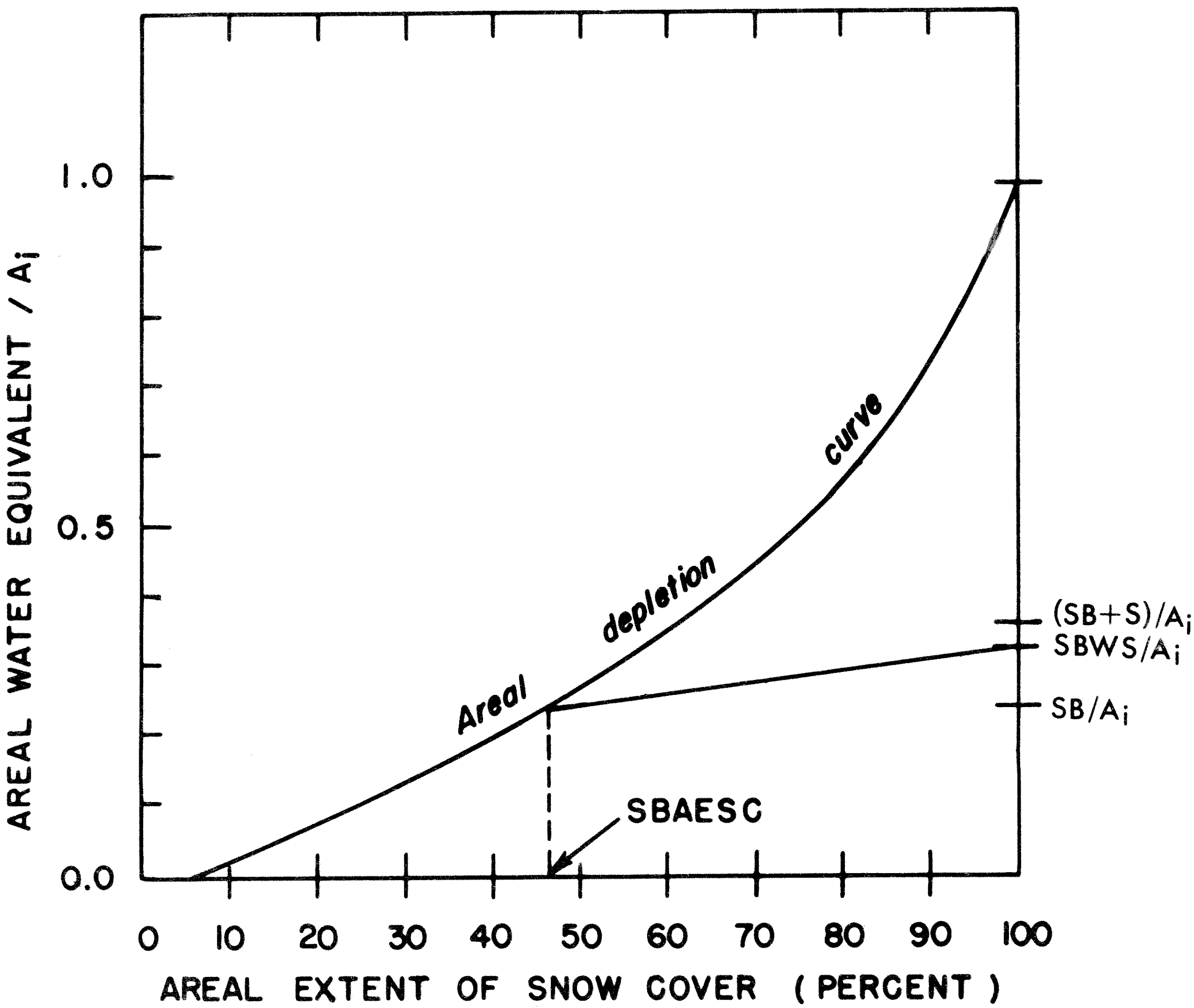


Figure 3-3. - Snow cover areal depletion curve.

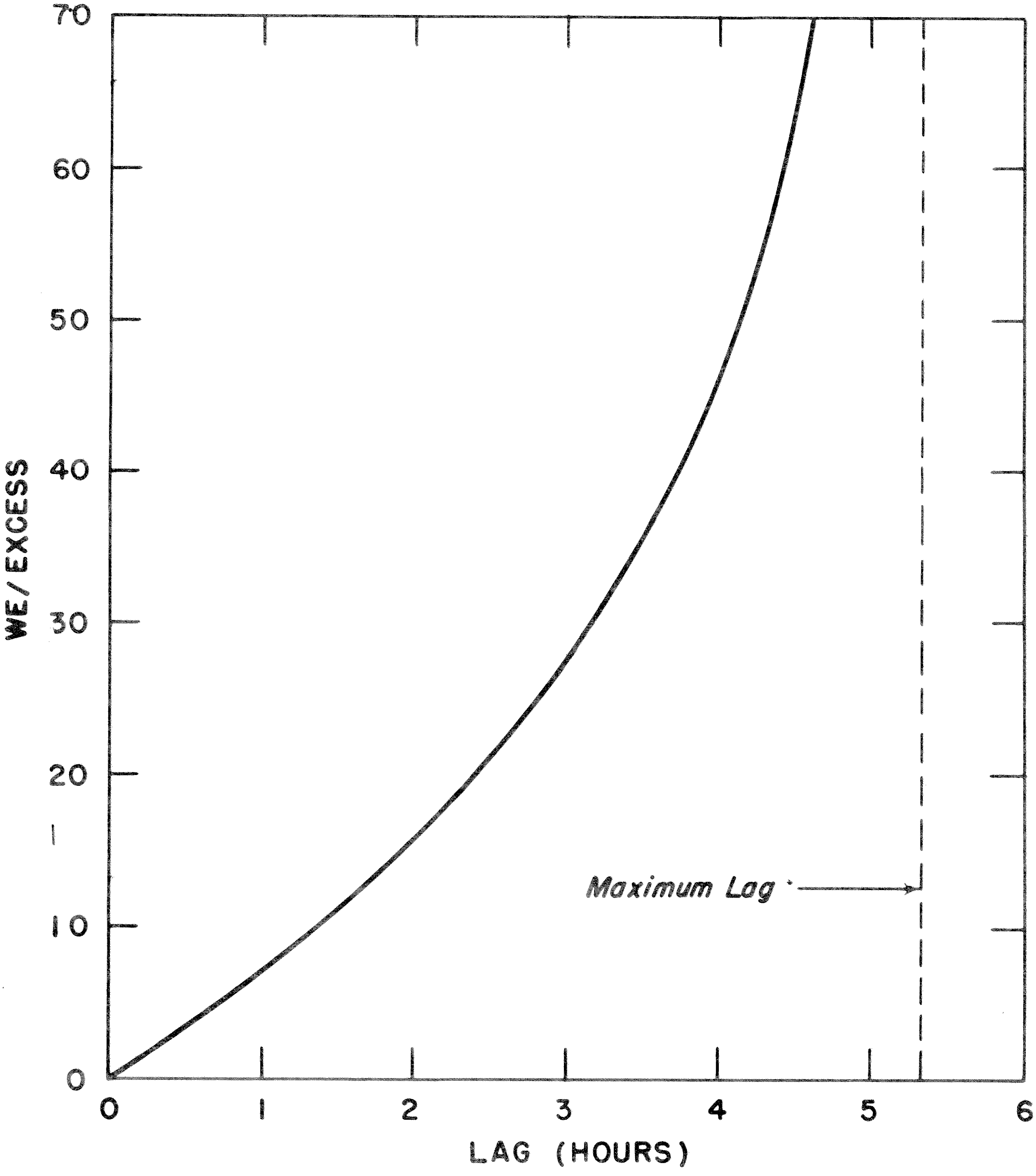


Figure 3-4. - Lag applied to excess liquid-water moving through a snowpack.

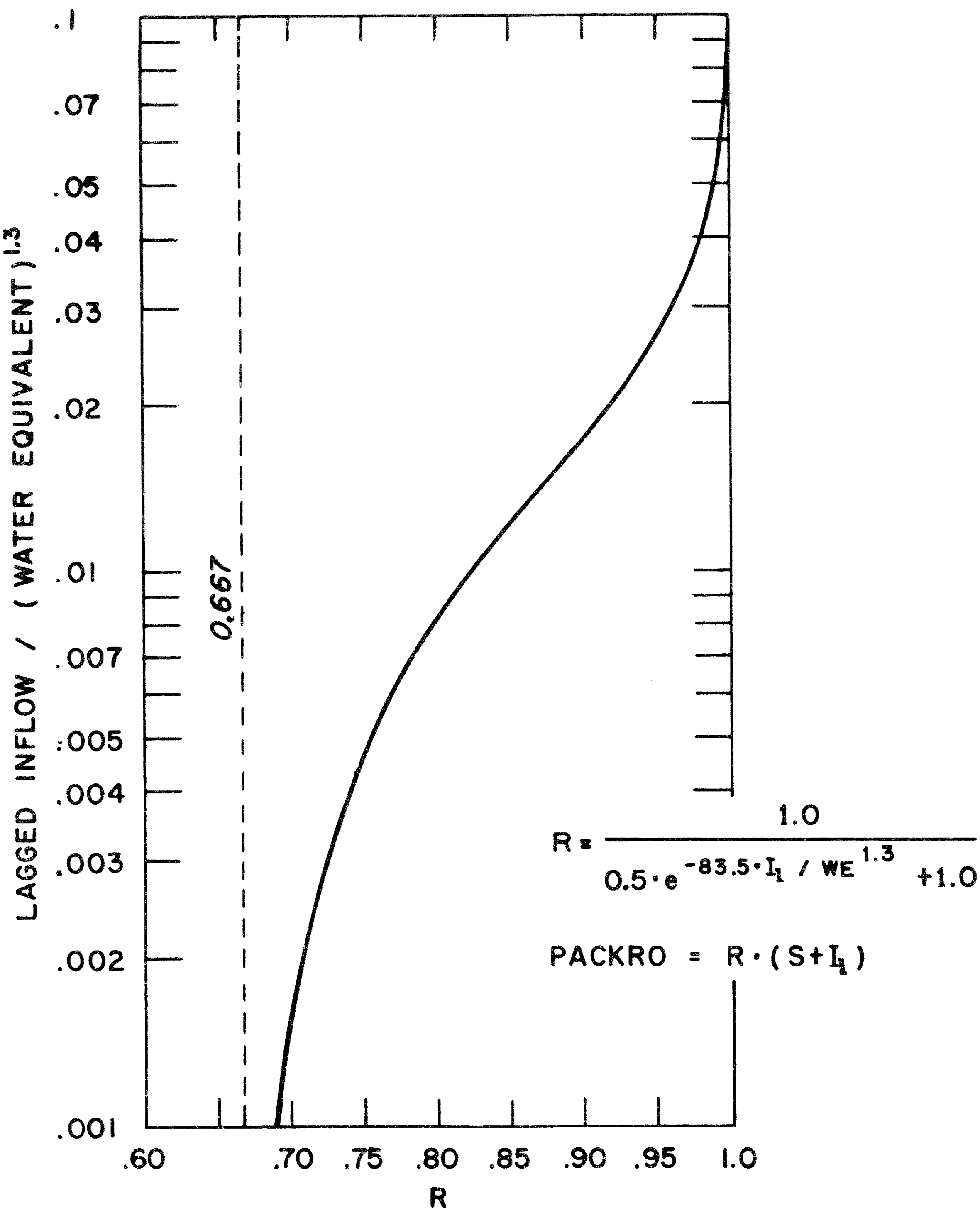


Figure 3-5. - Attenuation of excess liquid water moving through a snowpack.

CHAPTER 4. DESCRIPTION OF COMPUTER SUBROUTINES FOR THE SNOW ACCUMULATION AND ABLATION MODEL

4.1 INTRODUCTION

This chapter describes the computer subroutines which are needed to use the snow accumulation and ablation model in conjunction with the NWSRFS. The NWSRFS programs, as described in HYDRO-14, contain all the statements that are needed to communicate with the snow subroutines, i.e., subroutine CALL statements, COMMON blocks, and initialization of variables. Snow subroutines are provided for all three NWSRFS programs involving hydrograph simulation; the verification program (NWSRFS4), the optimization program (NWSRFS3), and the operational river forecasting program (NWSRFS5).

4.2 SUBROUTINES

There are four snow subroutines for the verification program, three for the optimization program, and three for the operational river forecasting program. Following is a brief description of the function of each subroutine:

a. Subroutines included in the verification, optimization, and operational programs.

   1) SNOWPM inputs snow parameters and initial values of snowpack storages and variables for each sub-area for which channel inflow is to be computed. Soil-moisture accounting sub-areas and snowpack accounting sub-areas are identical. The subroutine also outputs the parameters and initial values for future reference.

   2) PACK is the subroutine that simulates the accumulation and ablation of the snowpack, as described in Chapter 3. As a reference for those readers who are interested in the snow accumulation and ablation model, but do not want to obtain all the NWSRFS programs, a listing of subroutine PACK, from the verification program, is contained in appendix C.

b. Subroutine included in the verification and optimization programs.

   SNOWIN inputs six-hour air temperature data from tape. In addition, observed daily water-equivalent of the snowpack can be input from tape if such data are available. Observed water-equivalent data are not used in the computations, but are printed out so that a visual check between observed and computed water-equivalent can be made. (Note. In using the data processing programs from appendix E of HYDRO-14 to load observed water-equivalent data onto tape, observed water equivalent is treated as if it were mean daily flow data. For example, if two observed water equivalent stations and four mean daily flow stations were being loaded, the data processing programs would be instructed to load six mean daily flow stations. The observed water-equivalent stations must be placed before the mean daily flow stations in the input queue.) All data are input a month at a time. All snow data must be on the same tape. The subroutine contains the flexibility that if more stations or areas are on tape than are needed for a particular run, only that information that is requested is read. Thus, one data tape can be set up for a large river system and be used for running any segment of the system.

c. Subroutine included in the verification program only.

SNOWOT is a short subroutine which outputs total monthly snowfall, rain, and snowpack outflow, plus a water balance of the snowpack as a check on PACK subroutine computations.

d. Subroutine included in the operational program only.

UPSNOW allows for the input of adjustments to snowpack parameters and variables which may be needed operationally to adjust the snow model so that simulated conditions agree with observed conditions. A description of the adjustments is included later in this chapter under section 4.5.3.

4.3 VERIFICATION SNOW SUBROUTINES

This section describes the options, input required, and output produced by the snow subroutines which are used in conjunction with the verification program (NWSRFS4).

4.3.1 SUBROUTINE OPTIONS

There are three optional features in regard to data input and computer output with the verification snow subroutines.

a. As mentioned previously, observed daily water-equivalent data can be input and printed for comparative purposes. If observed water-equivalent data are not available, which is usually the case, the input of such data are eliminated.

b. The verification program contains the flexibility that the snow subroutines do not have to be used every month. Thus, during months when there is no snowfall and no snow on the ground, the program can bypass the snow subroutines. This feature eliminates the need for valid air temperature data during non-snow months. Thus, during non-snow months the air temperature records on the basic data tape can be loaded as missing data. Missing air temperature data are signified by 999.0.

c. During calibration it is important in many cases to monitor daily changes in snowpack conditions. This is necessary to answer questions such as: Was the runoff caused by melt, rain on snow, or just rain? What is the areal extent of snow cover during a certain period? What is the amount of negative heat storage and liquid-water retention before a certain event? Was the precipitation assumed to be rain or snow? When did melt occur? When did the snowpack disappear? To answer such questions the subroutines contain the option that snowpack variables can be output on a daily basis for each sub-area.

4.3.2 INPUT SUMMARY

Appendix D.1 contains a listing of the input needed to run the verification program with snow included.

4.3.3 SAMPLE INPUT

Appendix D.2 lists the input for an eight-year run of the verification program on the Passumpsic River at Passumpsic, Vermont.

4.3.4 SAMPLE OUTPUT

Appendix D.3 lists examples of the output from the run of the verification program which used the sample input data for the Passumpsic River. To conserve space, the entire output is not listed, but only examples of each type of printout.

4.4 OPTIMIZATION SNOW SUBROUTINES

This section describes the options, input required and output produced by the snow subroutines which are used in conjunction with the optimization program (NWSRFS3).

4.4.1 SUBROUTINE OPTIONS

There are two options in regard to snow computations included in the optimization program. The standard options of the optimization program are described in chapter 7 of HYDRO-14.

a. As in the verification program, the program can be instructed to bypass the snow subroutines during months with no snowfall and no snow on the ground.

b. The optimization program can be used for either one or two snow and soil-moisture accounting sub-areas (see section 7.4.3 of HYDRO-14). As the optimization program is currently written, soil-moisture accounting parameters are the same for each area when two sub-areas are used. In the snow subroutines different parameter values can be used for each sub-area. The use of different parameter values for each sub-area is intended for use during the optimization of a mountain watershed with two elevation zones. Care should be exercised for two reasons if this option is used: 1) geographical factors which would suggest the use of different snow parameters for each area also would generally suggest the use of different soil-moisture accounting parameters, and 2) unless variables such as water-equivalent and areal snow cover are available for each sub-area as a check on simulation results, the addition of twice as many snow parameters may allow for an improved hydrograph simulation, but at the expense of an unreasonable simulation of snow accumulation and ablation within each area. A further discussion of the use of elevation zones in mountainous areas is contained in section 5.8.1.

4.4.2 INPUT SUMMARY

Appendix E.1 contains a listing of the input needed to run the optimization program with snow included.

4.4.3 SAMPLE INPUT AND OUTPUT FOR OPTIMIZATION RUN

Appendix E.2 lists the input and the output for an optimization run on the Passumpsic River at Passumpsic, Vermont.

4.4.4 SAMPLE INPUT AND OUTPUT FOR SENSITIVITY RUN

As described in chapter 7 of HYDRO-14, the optimization program can also be operated in a sensitivity mode. Appendix E.3 lists the input and output for a sensitivity run on the Passumpsic River.

4.5 OPERATIONAL SNOW SUBROUTINES

This section describes program features, input required, and the output produced by the snow subroutines which are used in conjunction with the operational river forecasting program (NWSRFS5).

4.5.1 INPUT OF AIR TEMPERATURE DATA

In the operational program all data are input through subroutine DATAIN (see section 6.2 of HYDRO-14). This includes the input of six-hour air temperature data; both air temperatures that have been observed and those that are predicted to occur in the future. The determination of six-hour mean areal air temperature from point observations and possibly other meteorological data is left to the user. Since each river forecast office has different data networks, it would be extremely difficult to write a generalized operational data processing program that would fit the needs of all forecast offices. Thus, the task of writing an operational data processing program (i.e., a program to compute mean areal precipitation from point observations or other meteorological data, compute an estimate of evapotranspiration, compute mean areal air temperature from point values and other meteorological data, and compute discharge from river stage observations or reservoir levels) is left to the user.

In the case of air temperature, the point should be made that data other than maximum-minimum temperature observations will be available on an operational basis to compute six-hour mean areal air temperature. There will also be more data available to delineate whether precipitation is rainfall or snowfall. However the number of air temperature observation stations available operationally may be considerably less than the number used for model calibration. The effect of the operational temperature data network on simulation results should be random, as long as there is not a significant bias between the operational mean areal air temperature estimation procedure and the mean areal temperature procedure used in calibration.

4.5.2 INCLUSION OF SNOW IN AN OPERATIONAL RUN

On each run of the operational program the user must tell the program if snow is to be included. If there is no snowfall and no snow on the ground, the snow subroutines are not needed. This feature not only saves computer time during non-snow periods, but also eliminates the need for observed and predicted mean areal air temperature data. Snow parameters and initial values are retained on the carryover tape (see section 6.6 of HYDRO-14) so that they are available when the next snowfall occurs. However, the user must remember to input snow parameters on the initial run of the operational program or on another run subsequent to the first occurrence of snow. Once snow parameters are input they will be retained for use whenever snow occurs.

4.5.3 SNOWPACK ADJUSTMENTS

Several snowpack variables and parameters can be adjusted so that simulated conditions will agree with observed conditions. These adjustments fall into two categories: 1) adjustments to make snowpack variables such as water-equivalent and areal extent of snow cover agree with observed values, and 2) adjustments to correct for deviations between the simulated and observed hydrographs. In making hydrograph adjustments a major consideration is to determine the most likely cause of the error so that the correction will minimize future deviations of the hydrographs. A set of decision rules to accomplish this is an area for considerable future research. For the present, the program supplies only the methods of adjusting; the hydrologist must decide which adjustment to use. The following snowpack adjustments are available.

a. Adjustments to snowpack variables.

   1) Areal water-equivalent can be adjusted at any time by reading in a new areal water-equivalent value for those sub-areas which are in error. New areal water-equivalent values will usually be based on field measurements of water-equivalent. However, in some cases, water-equivalent adjustments may be based on deviations between simulated and observed hydrographs. In the operational program the following rules are used for adjusting areal water-equivalent:

      a) The new value is input in terms of total water-equivalent, i.e., solid plus liquid-water content of the snowpack.

      b) The percent liquid-water in the new snowpack is the same as in the old one.

      c) Areal extent of snow cover remains the same.

Subroutine UPSNOW changes the solid and liquid portions of the snowpack so that the percent liquid-water remains the same. Subroutine UPSNOW also computes an adjustment factor (AWEADJ) which keeps the areal extent of snow cover (AESC) the same:

$$AWEADJ = \frac{AESC_1}{AESC_2}, \qquad (4.1)$$

where: $AESC_1$ is the areal extent of snow cover computed from the basic areal depletion curve using the old value of areal water-equivalent, and $AESC_2$ is the areal extent of snow cover computed from the basic areal depletion curve using the new value of areal water-equivalent. (The basic areal depletion curve is the curve that was determined during model calibration.)

This adjustment factor remains in effect until the areal water-equivalent is adjusted again. The effect of AWEADJ is to temporarily shift the areal depletion curve. This effect is illustrated in figure 4.2.

2) Areal extent of snow cover can also be adjusted at any time by reading in a new value of areal snow cover for those sub-areas which are in error. Areal snow cover adjustments also will be based generally on observations of area snow cover, but could also be used to adjust the simulated hydrograph in some situations. Subroutine UPSNOW computes an adjustment factor (AEADJ) which temporarily shifts the areal depletion curve in a manner similar to AWEADJ:

$$AEADJ = \frac{AESC\ new}{AESC\ old} \qquad (4.2)$$

This adjustment factor remains in effect until the areal extent of snow cover is adjusted again. The effect of AEADJ on the areal depletion curve is illustrated in figure 4-2. It should be noted that to remain on the basic areal depletion curve that both areal water-equivalent and areal extent of snow cover must be adjusted.

3) The gage catch deficiency factor (SCF) for snowfall varies from storm to storm primarily as a function of wind. Operationally, wind data may be available and thus the user may want to estimate SCF for each storm rather than use a mean catch deficiency factor for all storms. An adjusted value of SCF can be input for any or all sub-areas. The adjusted value of SCF is not retained for future use, but is used only for the present storm. The mean snowfall correction factor is retained on the carryover tape.

b. Adjustments to correct hydrograph deviations.

1) The volume of snowmelt can be adjusted by applying a multiplying factor to the computation of melt. Since melt is computed differently during rain on snow and non-rain periods, two adjustments are needed:

   a) During non-rain periods the melt factor (M_f) can be multiplied by a correction factor.

   b) During rain on snow events, the average wind function (UADJ) can be multiplied by a correction factor.

   Both of these corrections are only applied to observed data. The corrections do not apply to the forecast period (future period for which predicted data are used). If several days of observed data are included in the computer run, the same multiplication factor applies to each day. The only method available to adjust different days by different amounts is to adjust the mean areal air temperature data.

2) The amount of negative heat storage can also be adjusted. This adjustment would probably not be used very often, but could be helpful during the early portion of snowmelt when the snowpack is becoming "ripe" and runoff is beginning to occur. The negative heat storage adjustment is also useful during mid-winter rain on snow events to partition the rain between that which is released and that which is retained within the snowpack. Even though negative heat storage is a snowpack variable, it is listed under hydrograph adjustments, since the adjustment to negative heat storage would almost always be based on deviations between observed and simulated hydrographs rather than on measurements of the variable itself.

4.5.4 INPUT SUMMARY

Appendix F.1 contains a listing of the input needed to run the operational river forecasting program with snow included.

4.5.5 SAMPLE INPUT AND OUTPUT FOR OPERATIONAL PROGRAM

Appendices F.2, F.3 and F.4 list the input and output for three runs of the operational program on the Rock River at Rock Rapids, Iowa. Appendix F.2 lists the initial run of the program to illustrate how to get the program started and how to create the initial carryover tape. Appendix F.3 shows the preliminary run on a major flood. Appendix F.4 illustrates the use of several adjustments to revise the preliminary run for the same major flood.

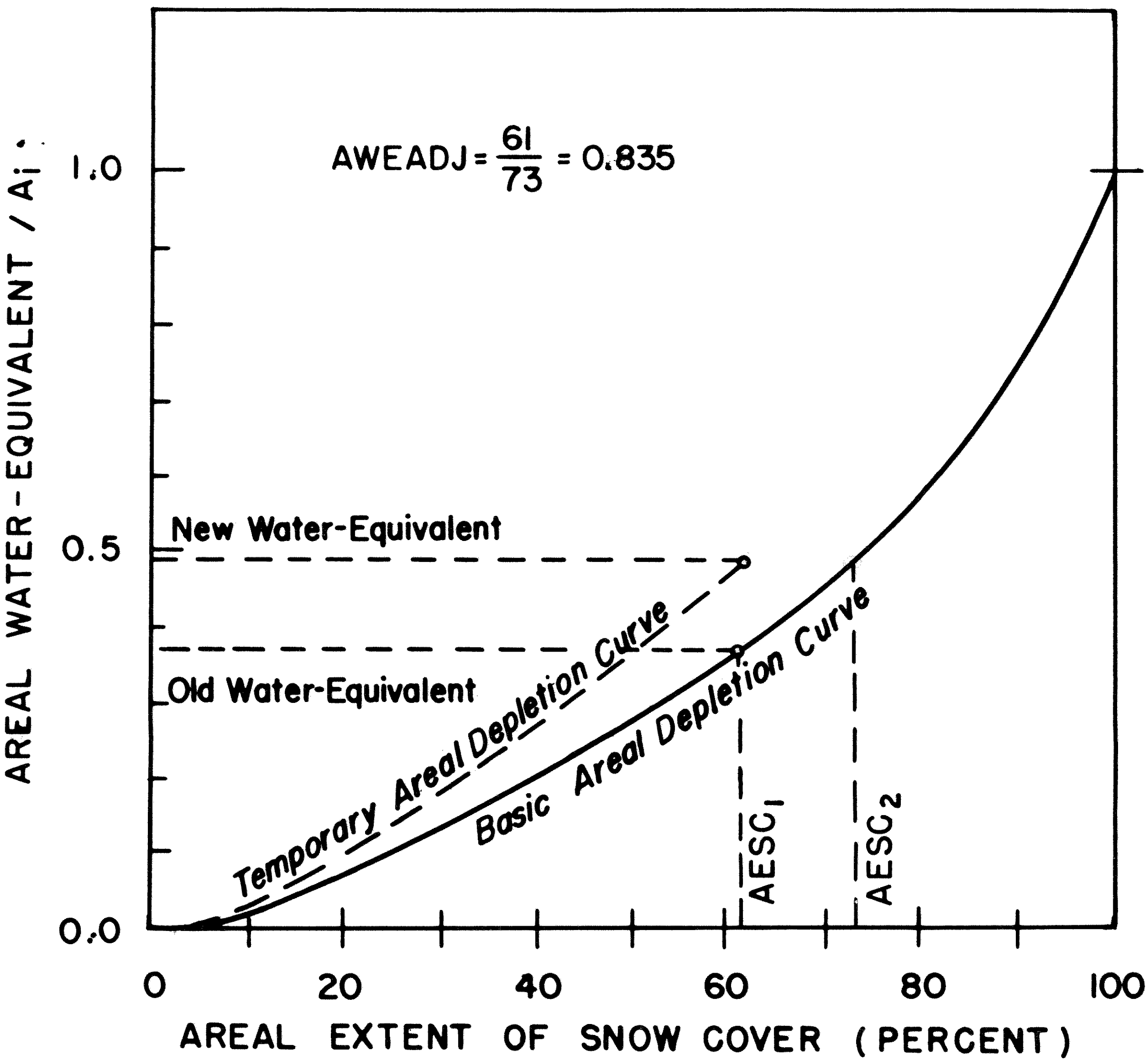


Figure 4-1. Effect of areal water-equivalent adjustment on the areal depletion curve.

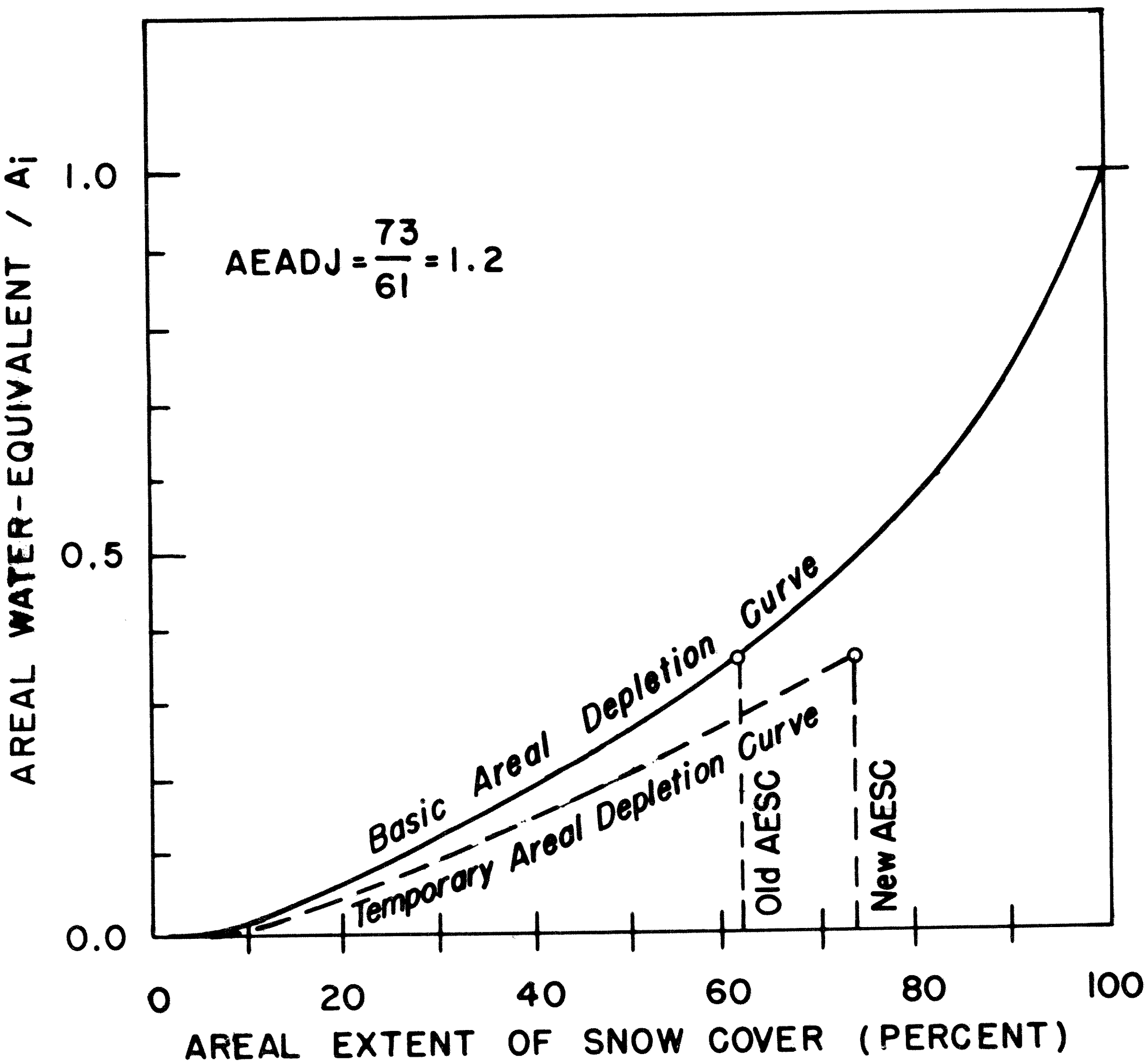


Figure 4-2. Effect of areal extent of snow cover adjustment on the areal depletion curve.

CHAPTER 5. CALIBRATION OF THE SNOW ACCUMULATION AND ABLATION MODEL

5.1 INTRODUCTION

In the application of a conceptual hydrologic model for river forecasting, the calibration process is extremely important. The calibration procedure used must not only result in realistic parameter values which produce reasonable simulation results, but also must be efficient so that a large number of river basins can be calibrated in a reasonable time. The procedure recommended is a combination of trial-and-error calibration and automatic parameter optimization. Trial-and-error calibration involves subjective manual adjustments to parameters based on an analysis of previous simulation results. In automatic parameter optimization, the computer adjusts parameters in a semi-random manner based on changes in the value of a single numerical evaluation criterion. The automatic technique used in the NWSRFS is the direct-search optimization technique, Pattern Search. A complete description of the Pattern Search algorithm is given by Monro (1971). The evaluation criterion which has been adopted is the sum of the squares of the errors between simulated and observed mean daily streamflow. Chapter 7 of HYDRO-14 describes the computational features and basic options of the computer program (NWSRFS3) which performs Pattern Search optimization.

This chapter outlines and discusses a recommended calibration procedure for river basins where the snow accumulation and ablation model is used. Only the snow model parameters are discussed in detail. The user should refer to chapter 7 of HYDRO-14 for suggestions regarding the determination of initial soil-moisture accounting and channel routing parameters and the optimization of those parameters.

In addition to calibrating the snow, soil-moisture accounting, and channel routing models on the basis of hydrograph simulation, the snow model can be calibrated by comparing the computed and observed water-equivalent of the snowpack. However, it is generally not feasible to calibrate the snow model using water-equivalent data because frequent representative water-equivalent measurements are not available for the large majority of watersheds.

5.2 OUTLINE OF STEPS IN THE RECOMMENDED CALIBRATION PROCEDURE

There are five basic steps in the recommended calibration procedure for the snow accumulation and ablation model. This section outlines the steps and the following sections discuss each step in detail.

a. Select initial values for each of the snow parameters (snow parameters are listed in section 3.4). Also select initial values for the soil-moisture accounting and channel routing parameters (see chapter 7 of HYDRO-14).

b. Simulate the entire calibration data period using the verification program. Check for periods when the form of the precipitation is in error, i.e., snow when rain actually occurred and vice versa. Adjust those periods that are determined to be in error. Also check for and correct any large data errors that can be substantiated.

Large errors should not be present if the data were properly checked for consistency at each stage of data preparation.

c. Perform trial-and-error calibration of the model parameters using the verification program (NWSRFS4).

d. Perform Pattern Search optimization on those parameters for which satisfactory values were not determined by trial-and-error calibration. The optimization program (NWSRFS3) is used for Pattern Search optimization.

e. Analyze calibration results. Repeat steps c and d if necessary.

5.3 INITIAL VALUES OF THE PARAMETERS FOR THE SNOW ACCUMULATION AND ABLATION MODEL

This section presents guidelines for determining initial values for each of the parameters included in the snow accumulation and ablation model. The definition of each parameter is listed in section 3.4. If other nearby watersheds have been calibrated, the parameter values from these watersheds should also be helpful in determining initial values. However, as mentioned in the following guidelines, certain snow parameters are influenced significantly by geographical conditions. Thus, values of these parameters from nearby watersheds should only be used to determine initial values if geographical conditions between the watershed being calibrated and the nearby watersheds are similar.

a. PXTEMP. Model calibration studies to date indicate that 33°F provides for the best delineation of rain from snow, i.e., 33°F and below, precipitation is snow - above 33°F, precipitation is rain. Some other investigators have found that 34°F or even 35°F gave the best results.

b. SCF. The gage catch deficiency correction factor during snowfall varies considerably depending on gage exposure, especially the effects of exposure on the wind velocity at the gage. Another important consideration is whether the gage has a windshield. Figure 5-1 shows typical gage catch deficiency correction factors during snowfall for shielded and unshielded gages as a function of wind speed. Although wind speed data at each precipitation gage are generally not available, Fig. 5-1 should be helpful in determining the initial value of SCF if some information on wind speeds over the area and on gage exposures is available.

c. MBASE. It is recommended that 32°F be used as the base temperature for melt computations during non-rain periods. In some studies other base temperatures have been used in an attempt to get a better linear relationship between snowmelt and air temperature. Results from the watersheds calibrated using this snow model indicate that 32°F is a completely adequate base temperature.

d. UADJ. Sublimation - condensation measurements during the Snow Investigations (1955) at the Central Sierra Snow Laboratory, and at the NOAA-ARS cooperative snow research station near Danville, Vermont resulted in nearly identical wind functions. The wind function computed from these measurements is:

$$f(u) = 0.006 \cdot u, \tag{5.1}$$

where: u is wind movement at 1/2 meter above the snow surface in miles, and
f(u) has units of inches/(in. Hg) ~~miles).~~

Thus, the initial value of UADJ would be 0.006 multiplied by the average six-hour wind movement in miles at the 1/2 meter level during rain on snow events.

e. MFMAX and MFMIN. As noted in Chapter 3, melt factors change as the relationship varies between air temperature and the meteorological variables affecting heat exchange. Therefore, climatological differences and differences in physiographic variables such as forest cover, slope, and aspect which affect radiation exchange and wind movement will cause one area to have a different melt factor than another area. With all other variables held constant, the following statements are generally true:

1. South facing slopes would have a higher melt factor than north facing slopes.

2. Areas where windy conditions prevail generally have a higher melt factor than areas where calm conditions prevail (however, under conditions of low humidity, sensible heat gain could be balanced or exceeded by latent heat loss).

3. The melt factor increases as forest cover decreases.

Most of the other variables are so interrelated that it is impossible to change one and hold all the others constant (e.g., solar radiation cannot be increased significantly without a decrease in atmospheric longwave radiation). Thus, it is difficult to make general statements about the effect of these variables on the melt factor.

A good initial value of MFMAX and MFMIN can be computed for a few areas based on snowpack water-equivalent and temperature data. When there is no snowfall during a snowmelt period, the amount of snowmelt can be approximated by the difference in water-equivalent measurements. The slope of a plot of the summation of snowmelt versus the summation of six-hourly air temperatures above MBASE is the melt factor for that snowmelt period. (It should be noted that when the area has less than 100 percent areal snow cover that the snowmelt values should be adjusted to represent the condition of 100 percent areal snow cover since the melt factor used in the model represents melt over the entire area.) A number of such plots from snowmelt periods occurring at different times during the year and from several snow seasons should define good initial values for

MFMAX and MFMIN. The main problem with using this method to estimate melt factors is that representative water-equivalent measurements, taken at frequent intervals, are made on only a very few areas.

Based on results from the areas tested on the model to date, forest cover seems to be the major factor affecting the variability of melt factors from one area to another area. Figures 5-2 and 5-3 show plots of maximum and minimum melt factors versus forest cover for the areas on which the model has been tested. These plots should be helpful in providing a reasonable initial value for parameters MFMAX and MFMIN when representative water-equivalent data are not available.

f. TIPM. The antecedent temperature index (ATI) is an index to the temperature of the surface layer of the snowpack, as discussed in section 3.3.2.2. The parameter TIPM indicates the thickness of the layer being considered. Values of TIPM less than 0.1 would give significant weight to temperatures over the past week or more and would thus indicate a deeper layer than TIPM values greater than 0.5 which would essentially only give weight to temperatures during the past day. A brief examination of snowpack temperature and air temperature data from the NOAA-ARS cooperative snow research site indicates that TIPM = 0.5 would correspond to a three- to six-inch surface layer while TIPM = 0.2 would correspond to approximately the top 12 inches of the snowpack.

It is felt that eventually the value of TIPM can be standardized. However, a complete analysis of the effect of different values of TIPM has not been completed. TIPM = 0.5 has given reasonable results on the watersheds tested though there is some indication that a lower value may be more appropriate.

g. NMF. The value of the negative melt factor is a function of the climatic conditions that occur over the snowpack when the air temperature is below 32°F. The value of NMF is also influenced by the density of the surface layer of the snowpack since the thermal conductivity of snow is a function of density. In addition, the value of the negative melt factor is dependent on the value of TIPM since TIPM controls the magnitude of ATI (ATI is an important quantity in Eq. 3.15 for calculating the change in heat storage during periods when the air temperature is below 32°F). Because of the interrelationship between NMF and TIPM it is recommended that a reasonable value of TIPM be established based on the guidelines suggested previously for parameter TIPM. Then, during model calibration only NMF would be allowed to vary. It should be noted that the optimization program does not allow TIPM to vary. Only parameter NMF can be included in automatic optimization.

The value of the maximum negative melt factor (NMF) has varied from 0.003 to 0.007 for the watersheds tested to date. An initial value of 0.005 should be satisfactory.

h. Areal depletion curve. There are a number of ways to determine the areal depletion curve for a given area. Several methods are listed below in order of the accuracy of the final product.

1. Determine the areal extent of snow cover over a number of years from aerial photographs and the areal water-equivalent from ground surveys on a number of days during the snowmelt period. An analysis of such measurements will result in the areal depletion curve. Except for a few watersheds, such information is not available nor is it generally practicable to obtain such measurements.

2. Measure the ablation of the snowpack by periodically making water-equivalent measurements at a representative site within each reasonably homogeneous geographical subarea. The subareas would be selected on the basis of elevation, vegetal cover, and aspect. As each subarea becomes bare, a point on the areal depletion curve could be established since the number of bare areas would be known and also the water-equivalent of those areas, where snow remains, would be known. Five to ten subareas should be adequate to obtain a reasonable estimate of the areal depletion curve.

3. In many areas the data necessary to use method number 2 for computing the areal depletion curve are not available and it would not be practicable to obtain water-equivalent data for each homogeneous subarea. However, in many areas some water-equivalent data are available. An approach similar to method 2 could be used in such areas by using the available water-equivalent data and by subjectively estimating accumulation and melt rates for the other subareas.

If data are not available to compute the shape of the areal depletion curve, then the shape of the curve must be arbitrarily selected. The same shaped areal depletion curve has been used for all of the watersheds tested to date. This curve (shown in Fig. 3-3) was originally computed for the Central Sierra Snow Laboratory using water-equivalent data from snow courses and areal snow cover determined from aerial photographs. Analysis of similar data indicates that the shape of the areal depletion curve for the Upper Columbia Snow Laboratory is essentially the same as that for Central Sierra. The same curve was also used for the Sleepers River watersheds and the Passumpsic River areas for which similar data were not available. Model calibration did not indicate that the shape of the areal depletion curve should be altered. All of these watersheds are similar with respect to elevation range and cover. In addition, the same curve was used successfully for the Rock River above Rock Rapids, Iowa. This watershed is an open agricultural area with little variation in elevation where during spring melt the period from complete snow cover to bare ground is normally only a few days. In this case, it was difficult to determine the shape of the areal depletion curve accurately by hydrograph simulation. While the same shaped curve gave good results on these watersheds, different shaped curves would probably be required on areas with different elevation ranges and cover configurations.

i. SI. The previously mentioned methods of determining the areal depletion curve would also indicate the areal water-equivalent above which 100 percent snow cover always exists. If one of these methods is not used, the following guidelines can be used to select an initial value for parameter SI.

1. If the area is very heterogeneous in regard to slope, aspect, and vegetal cover, then the initial value of SI should be about the same as the maximum water-equivalent that occurs. This is due to the fact that in very heterogeneous areas there are usually places where very little snow accumulates. Thus, these places will become bare soon after snowmelt begins.

2. If the area is more homogeneous, then the area would remain at 100 percent cover during the early portion of the snowmelt season, thus SI would be lower than the maximum water-equivalent that occurs. In the extreme case of a perfectly homogeneous area, such as a point study area, SI would be equal to zero.

j. PLWHC. Most measurements on "ripe" snow have indicated liquid-water retention capacities of less than 10 percent and in most cases on the order of two to five percent. Slush layers may be formed at the snow-soil interface or in conjunction with ice layers within the snowpack. These slush layers can hold a considerable amount of liquid-water. While slush layers form in deep snowpacks, their relative effect on the total liquid-water retained is usually small. However, in shallow snowpacks slush layers will increase the percent liquid-water holding capacity significantly. It is recommended that the initial value of PLWHC should be in the range 0.02 to 0.05 for areas which normally have deep snowpacks (approximately greater than 10 inches water-equivalent). The initial value of PLWHC should be greater for areas with normally shallow snowpacks, with a value of 0.25 not being unreasonable for an area such as the northcentral region of the United States.

k. DAYGM. The following guidelines, based on model testing to date, should be sufficient to obtain a reasonable estimate of the daily amount of melt at the snow-soil interface.

TABLE 5-1.--Guidelines for determining parameter DAYGM.

DAYGM (inches)	Climatic Conditions
0.0	Long cold winters (many days with air temperatures below 0°F), and shallow snowpacks
0.01	Long cold winters, and deep snowpacks
0.02	Moderate winters (temperatures above 0°F during most of the snow season), and deep snowpacks

1. EFC. A reasonable value for EFC can be obtained from a knowledge of the percent of the area covered by forests (usually available from topographic maps with a woodland overprint) and the type of forests. EFC is not an important parameter in most areas, but does influence the volume of snowmelt runoff from forested watersheds. The influence is greatest on forest watersheds where snowmelt occurs in late spring when evapotranspiration demand is increasing.

5.4 ADJUSTMENT OF AIR TEMPERATURE DATA WHEN FORM OF PRECIPITATION IS IN ERROR

The determination of model parameters can be severely affected when there are large errors in the data used for calibration. Errors in determining the form of precipitation can be classified under data errors. Ideally, the basic input data to the model would include the form of the precipitation. However, information on the form of precipitation for each six-hour period is not available. Therefore, since such input data are not available, it is necessary for the model to estimate the form of precipitation. As discussed in Chapter 3, the estimation of the form of precipitation is based on air temperature. The form of precipitation can be correctly estimated in most cases using air temperatures measured near the ground surface. However, ground level air temperatures are obviously not a perfect index to the form of precipitation, thus there will be times when the model estimation of the form of precipitation is in error. These cases should be corrected after the initial run of the verification program so that further parameter calibration is not affected.

An examination of the simulated versus observed discharge plot will indicate those periods during which an error in determining the form of precipitation might have a significant effect on model results (e.g., if the observed hydrograph shows a sizable response and the simulated hydrograph shows no response, this could be a case of rain occurring when the model determined that it was snowing). The next step is to examine the daily snow summary printout to determine if precipitation did occur, since the discrepancy could have been the result of an error in estimating the amount of snowmelt. In many cases, a significant deviation between model response and observed response is sufficient to verify that the form of the precipitation is in error. However, especially when the deviation is not great enough to make the cause obvious, it becomes necessary to examine other available data to determine if the form of precipitation is actually in error. Two types of data which are helpful in determining whether the form of precipitation is in error and which are usually readily available are:

a. Hourly or three hourly air temperature data from NWS first order stations or other recording temperature stations. Experience has shown that in most cases when the form of precipitation was in error, it was because maximum-minimum air temperature data were not sufficient to describe the daily variation in air temperature. The assumption of the maximum air temperature occurring in the afternoon and the minimum occurring near sunrise is more likely to be in error on days with precipitation than on days with no precipitation. For example, most of the periods when the form of precipitation was in error for the Passumpsic basin were nighttime periods when the model estimated that it was snowing when actually rain was occurring. An examination of hourly temperature records revealed that in almost all cases the nighttime temperatures had remained well above 33°F. Minimum temperatures below 33°F had occurred during daylight hours on the previous day and/or the following day.

b. Snowfall and snow on the ground data from daily observation stations. Program PRELIM2 (see section 2.4.2) will list snowfall and snow on the ground data for all daily observation stations that are selected for use in the basin analysis. This information is helpful in determining the actual form of the precipitation.

After determining which periods the form of precipitation is in error, the next step is to correct those periods. In some cases, it may be possible to correct most of the periods by changing the parameter PXTEMP. To correct the remaining periods it is necessary to change the six-hourly mean areal air temperature. On the watersheds tested to date, the number of periods for which air temperature was changed varied from zero on the Rock River at Rock Rapids, Iowa to 39 over an eight-year period on the Passumpsic River. Appendix G lists a computer program which will transfer data in NWSRFS standard tape format from one tape to another tape and change air temperature data for selected periods in the process.

5.5 TRIAL-AND-ERROR CALIBRATION

Trial-and-error calibration involves subjective manual adjustments to model parameters based on specific characteristics of previous simulation results. To perform trial-and-error calibration in an effective manner it is necessary to know: 1) which displays of simulation results should be examined and what to look for, 2) how different types of deviations between simulated and observed conditions indicate which parameters need to be changed, and 3) how large an adjustment should be made to a parameter to correct an observed deficiency in simulation results. Obviously, experience with using the model is very helpful in trial-and-error calibration. Even though there is no real substitute for experience, hopefully the following suggestions will improve the effectiveness of trial-and-error calibration for those who are using the model for the first time.

a. Which displays of simulation results to examine and what to look for. The most all inclusive display of simulation results is the plot of the simulated and observed mean daily discharge. This is the primary display to be analyzed. Displays such as the daily summary of snowpack conditions and the monthly summary of soil-moisture accounting volumes and variables are helpful in interpreting deviations between simulated and observed mean daily discharge. Portions of the statistical summary table should also be examined during trial-and-error calibration. The monthly, annual, and flow-interval percent bias columns are the most important statistics to examine in terms of determining simulation errors. In addition, RMS error, correlation coefficient, and the intercept and slope of the best fit linear regression line between simulated and observed daily discharge, give an indication as to whether a trial-and-error run was an improvement over previous runs.

The important thing to look for in examining these displays is consistent errors. Examples of consistent errors are:

1. The volume of flow during spring melt is always low.

2. Discharge is normally too low during the early portion of the spring melt period and too high during the later portion.

3. Mid-winter snowmelt rises are too high.

4. Low flows are simulated too high and high flows are too low.

5. Monthly flow volume is low in the spring, slightly high in the summer and winter, and quite high during the autumn.

6. Runoff volume is over-estimated during periods when soil-moisture is relatively low and under-estimated during periods when soil-moisture is high.

7. Peak discharge is low, but the recession limb of the storm hydrograph is high.

When the deviations between simulated and observed discharge are reasonably random, then parameter calibration is complete.

b. How to identify consistent deviations with model parameters. Once consistent model errors are identified, the next step is to determine which model parameter or parameters need to be changed to correct the error. Two suggestions which may be helpful in this regard are:

1. Try to relate the deviation in the hydrograph to the most likely physical cause. Then look at the structure of the model to determine which parameter or parameters control the physical process that is in error. For example, if the volume of spring runoff is low, it may be because the water-equivalent of the snowpack prior to melt is too low. An examination of the model structure reveals that the water-equivalent of the snowpack prior to spring melt is primarily a function of the gage catch deficiency correction factor and melt during the accumulation season. If there are no significant melt periods during the winter or if winter melt periods are simulated with reasonable accuracy, then parameter SCF is probably in error. On the other hand, if there are a number of mid-winter melt periods, the majority of which are simulated much too high, then MFMIN and MFMAX may be all or partly to blame for the error in the volume of spring snowmelt runoff.

2. Experiment with the model by varying the value of a single parameter and noting the effect on model response. Such experiments will indicate under what conditions each parameter affects model response and also the characteristics of the change in response. Figures 5-4, 5-5, and 5-6 show the effect of three of the most important snow parameters on model response. It should be noted that each of these parameters has a unique effect.

The complicating factor in determining which parameter values should be changed is that in most cases not one, but a number of parameters are in error simultaneously. In these situations, it is usually not possible to identify all the parameters that should be changed. It is recommended that the parameter which is felt to have the largest effect on the simulation error be changed first. A hydrologist with experience in using a model may change a large number of parameters on a single trial-and-error run. However, it is recommended for the beginner that the number of changes be kept small. Only the value of one parameter should be changed for each major simulation error that is identified (e.g., spring volume is too high or melt occurs too early in the spring).

In addition to experimenting with model parameters to determine their effect on hydrograph response, the sensitivity mode of the optimization program can be used to study the magnitude of the effect a given parameter has on simulation results. The sensitivity mode of the optimization program shows the effect that various values of different model parameters have on the evaluation criterion (sum of squares of the difference between simulated and observed mean daily discharge). This effect can be illustrated by a sensitivity plot. A sensitivity plot is made by establishing a parameter set and varying a single parameter holding all other parameters constant. Figures 5-7, 5-8, and 5-9 show sensitivity plots for the six major snow parameters on the Passumpsic River. Two different data periods were analyzed to show that the effect of parameter variation and the "optimum" magnitude of parameters can be different for different data periods. Several points should be noted regarding these plots:

1. The value of one parameter, especially an important parameter, can affect the sensitivity plot of other parameters. For example, the water-equivalent of the snowpack was underestimated for the earlier period (12/64 - 5/68). To compensate for this volume deficiency, the evaluation criterion could be improved by retarding melt during the winter, thus holding the water in the snowpack until spring. This is why low values of parameter MFMIN and high values of parameter NMF caused an improvement in the evaluation criterion. This helps show why an examination of the plots of mean daily discharge is essential in trial-and-error calibration. The output of the 12/64 - 5/68 sensitivity run might suggest that SCF, MFMIN, and NMF should be changed when in reality the values of MFMIN and NMF are quite reasonable and only SCF is in error.

2. The snow correction factor, SCF, and the non-rain melt factor are the most sensitive and the most important snow parameters. SCF is the only snow parameter which has a significant effect on the volume of runoff from the snowpack (EFC affects volume to a small degree). All the other snow parameters affect the timing of the snowpack runoff. Of these, the non-rain melt factor is the most important. MFMAX is generally more important than MFMIN since most of the snowpack runoff occurs after March 21 in areas where there is a significant snowmelt contribution to runoff.

3. Some parameters are more sensitive to changes in one direction than to changes in the other direction. This can be noted in the sensitivity plot for parameter SI.

c. <u>How to determine the magnitude by which to change parameter values</u>. There are two basic methods of determining how the magnitude of a change in the value of a parameter will affect simulation results. These have been mentioned previously since the methods also aid in determining which parameters should be changed. The two methods are: 1) experimentation with the model parameters to determine their effect on hydrograph response, and 2) evaluation of sensitivity plots. Experience has shown that in the early stages of trial-and-error calibration reasonably large changes in parameter values are better than small changes. The determination of the optimum value of a parameter seems easier if the optimum value is bracketed than if the optimum value is approached from one direction.

Trial-and-error calibration should be applied to the entire data period used for the calibration analysis. Initially, one or two water years may be sufficient to determine parameter changes. However, as the simulation results begin to look reasonable, the entire data period should be included in the analysis. Trial-and-error calibration should be continued until the purpose for which trial-and-error calibration is being used is accomplished. This purpose may be to obtain reasonable initial parameter values for Pattern Search optimization or the purpose may be the complete calibration of the watershed. Sections 5.6 and 5.7 include a discussion of the uses of trial-and-error calibration in conjunction with Pattern Search optimization for determining model parameter values for a given watershed.

5.6 PATTERN SEARCH OPTIMIZATION

5.6.1 INTRODUCTION

It is obvious that a conceptual hydrologic model can be calibrated solely by a trial-and-error procedure. However, there are two disadvantages of trial-and-error calibration: 1) the effectiveness of the procedure is largely determined by the amount of experience that the person who is performing the calibration has with the model, and 2) the number of man-hours needed to analyze simulation results to determine parameter changes is generally large. An automatic optimization technique would overcome these disadvantages. However, besides requiring relatively large amounts of computer time as compared to trial-and-error calibration, automatic optimization techniques have disadvantages of their own. These include:

a. Parameter adjustments are based on a single criterion of model performance.

b. A sub-optimum set of parameter values can be calculated as a result of poorly selected starting values.

c. Interrelationships between model parameters can cause: 1) the solution to converge slowly to the optimum, 2) parameter values to be distorted, and 3) optimum parameter combinations, but unrealistic values of individual parameters to be calculated.

In addition, because of the computer time necessary, there is usually a practical limit on the period that can be analyzed by automatic optimization techniques. The procedure recommended for use with the NWSRFS uses trial-and-error in the initial stages of calibration to minimize most of the disadvantages of automatic optimization. Automatic optimization using the direct search technique, Pattern Search, is then used to minimize the disadvantages of trial-and-error calibration.

5.6.2 MINIMIZING THE DISADVANTAGES OF PATTERN SEARCH

The following disadvantages of Pattern Search optimization can be minimized by the proper use of trial-and-error calibration.

a. Poor selection of starting values. The main reason for using trial-and-error calibration prior to Pattern Search optimization is to insure a reasonable set of starting parameter values. Trial-and-error calibration should always be continued until a set of parameter values is obtained which will produce a simulated mean daily discharge plot which resembles the actual mean daily discharge plot.

b. Effect of interrelationships between parameters. There are several difficulties that can arise during Pattern Search optimization because of interrelationships between parameters. These difficulties include:

    1. When one parameter is not at its optimum value, other parameter values can be distorted. This is especially true when the parameter, which is not at the optimum, is a very important parameter. Table 5-2 illustrates how Pattern Search optimization can distort parameter values. The final parameter values based on eight years of data are: SCF = 1.1, MFMAX = 0.022, and NMF = 0.003. When SCF is set to 1.4 and not included in the optimization, the values of MFMAX and NMF are distorted. When all three parameters are optimized, the value of NMF is still distorted because NMF has only a minor effect on the evaluation criterion compared to SCF and MFMAX.

2. The solution may converge slowly to the optimum. This effect is also illustrated by Table 5-2. The value of SCF converges slowly to the optimum when all three parameters are included, partly because of the interrelationship between SCF and MFMAX. The value of MFMAX increases at first to compensate for the high starting value of SCF. As SCF approaches its optimum value, the value of MFMAX reverses direction and returns to its optimum. The value of SCF converges more rapidly to the optimum when only SCF is included in the optimization.

3. If several parameters have much the same effect upon the transformation of the input data into the output hydrograph, Pattern Search will seek the optimum parameter combination. This can lead to satisfactory model performance, but physically unrealistic parameter values. Examples of this case are the parameters CC and LIRC6, which control the volume and timing of interflow, and the time-delay histogram and the parameter KS1, which determine the channel response function in the NWSRFS (these parameters are defined in chapter 4 and chapter 5 of HYDRO-14). A large volume of interflow and significant attenuation within the channel system have a similar effect on the output hydrograph.

Table 5-2.--Effect of including different parameter combinations in Pattern Search optimization. Passumpsic River, 12/69 - 6/71.

Case	Run No.	Parameter Value			Evaluation Criterion x 10^8
		SCF	MFMAX	NMF	
All three parameters included	1	1.40	0.022	0.0030	2.20
	15	1.27	0.028	0.0017	.87
	30	1.02	0.027	0.0004	.63
	47	1.11	0.022	0.0009	.34
MFMAX and NMF optimized	1	1.40	0.022	0.0030	2.20
	31		0.026	0.0003	1.54
Only SCF optimized	1	1.40	0.022	0.0030	2.20
	13	1.11			.38

To avoid some of the difficulties caused by interrelationships between parameters, the number of parameters which are included in Pattern Search optimization should be kept to a minimum. Especially those parameters which have only a minor effect on the evaluation criterion should not be included in Pattern Search optimization. To keep the number of parameters which are included in Pattern Search optimization to a minimum, the value of as many parameters as possible should be determined in advance. Parameter values can be determined by:

1. An analysis of the observed discharge hydrograph. Soil-moisture accounting parameters LKK6, A, EPXM, LIRC6, and KGS, plus the

channel response function can generally be determined by hydrograph analysis.

2. The value of a number of parameters can be determined adequately by physical considerations. This includes snow parameters PXTEMP, MBASE, TIPM, EFC, and the shape of the areal depletion curve plus soil-moisture accounting parameters K1, GAGEPE, K24EL, and SRC1.

3. The value of parameters which have a minor effect on the evaluation criterion can be determined through trial-and-error calibration by examining only those periods when the parameter is important. The evaluation criteria used in Pattern Search optimization is affected mainly by parameters which control high flow periods and parameters which control the majority of the events.

A number of snow model parameters have been purposely excluded from Pattern Search optimization because of the difficulties caused by interrelationships between parameters. The parameters PXTEMP, MBASE, TIPM, EFC, and the shape of the areal depletion curve must be determined prior to Pattern Search optimization. In addition, adequate final values for parameters NMF, PLWHC, and DAYGM should be able to be obtained from trial-and-error calibration. This leaves five snow model parameters which could be included in Pattern Search optimization. These parameters are SCF, MFMAX, MFMIN, UADJ, and SI.

c. Analysis of a limited data period. In order to get realistic and stable parameter values, the data period being analyzed by Pattern Search optimization should contain a variety of typical hydrologic conditions which can occur over the watershed (e.g., periods of high soil-moisture and periods of low soil-moisture, high flows and low flows, relatively large snowpacks and relatively small snowpacks, mid-winter melt events and rain on snow events, as well as spring snowmelt). In addition, there should be a reasonably large number of events so that plus-and-minus data errors would tend to balance each other. Also in regard to the snow model, it is important to include many days of snowmelt so that the melt factors will not be based on a limited number of climatic conditions. The optimization computer program (NWSRFS) limits the period that can be analyzed by Pattern Search optimization to 50 months. A 50-month period can generally be found which contains sufficient hydrologic variety plus reasonably unbiased data errors and climatic conditions. Trial-and-error calibration should be quite helpful in the selection of a data period for Pattern Search optimization. This is true, since many of the factors which determine period selection are examined closely when analyzing the hydrograph to determine parameter changes during trial-and-error calibration.

It should be noted that in some watersheds it is impossible to find a 50-month period which has enough hydrologic variety plus unbiased data errors and climatic conditions. An example of such a watershed is the Rock River at Rock Rapids, Iowa. There were four significant snowmelt rises, each of short duration, in the ten-year period being analyzed. In addition, there were two significant rises caused by rain. Only three of the significant rises in the hydrograph occurred in any 50-month period. In this case, Pattern Search optimization was not an effective tool for parameter calibration, thus the calibration was performed solely by trial-and-error.

5.6.3 ADDITIONAL COMMENTS OF THE USE OF PATTERN SEARCH OPTIMIZATION

The previous section discussed several things that could be done to improve the effectiveness of Pattern Search optimization for use in the calibration of a conceptual hydrologic model. The three major recommendations were:

a. Reasonable starting values should be determined for all model parameters that are to be included in Pattern Search optimization.

b. The number of parameters included in Pattern Search optimization should be kept to a minimum. Parameters which have a small effect on the evaluation criterion should not be included. As many parameters as possible should be determined by physical considerations, by hydrograph analysis, and by trial-and-error calibration before using Pattern Search optimization.

c. The data period selected for analysis with Pattern Search optimization should contain as much hydrologic variety as possible. The period should also contain reasonably unbiased data errors and climatic conditions.

Several other comments regarding the use of Pattern Search optimization and the optimization computer program (NWSRFS3) which may be helpful are:

a. The optimization program contains a provision that selected periods can be removed from the calculation of the evaluation criterion. Thus, the parameter values will be based only on the remaining periods. This provision can be used to an advantage in some watersheds where snow is included. Soil-moisture accounting and channel routing parameters could first be optimized by removing all periods when snow is a factor. Then the snow parameters could be optimized by using only those periods when snow influenced the hydrograph. Obviously, this procedure is of no value in areas where snow is a factor in almost all significant rises of the hydrograph. The procedure of optimizing soil-moisture accounting and channel routing parameters on one run and snow parameters on the next run is ideally suited to the transitional zones where snowmelt is not the major source of runoff.

b. The input for the optimization program specifies that upper and lower constraints be provided for each parameter. The purpose of having constraints is to insure that physically unrealistic parameter values are not calculated by Pattern Search optimization.

c. The purpose of Pattern Search optimization is to assist in the determination of realistic parameter values which produce reasonable simulation results. These parameter values will then be used to predict hydrographs in the future. It is not the purpose of Pattern Search optimization to make slight adjustments to parameter values in order to get the best possible RMS error. The future is not going to be exactly like the past. Figs. 5-7, 5-8, and 5-9 indicate that the analysis of different periods will give different parameter values. Therefore, there is no reason to expect that after reasonable simulation results have been obtained that further slight adjustments to parameter values will improve future streamflow forecasts.

d. It is suggested that the maximum number of runs (MAXN, see card 21 of input summary - appendix E) of the optimization program be set equal to approximately ten times the number of parameters that are included in Pattern Search optimization.

e. The "best" parameter values as determined by Pattern Search optimization are not necessarily those which give the lowest value of the evaluation criterion. The mean discharge column also should be examined. In some cases, a large flow bias can exist when the evaluation criterion is at its lowest value. A large bias is not desirable.

5.7 ANALYSIS OF THE CALIBRATION RESULTS

After finishing the initial trial-and-error calibration and the first use of Pattern Search optimization, the results need to be analyzed to determine if parameter calibration is complete or if further trial-and-error calibration and possibly further Pattern Search optimization are necessary. The first step is to run the entire data period, using the verification program, with the parameter changes determined by Pattern Search optimization. If an analysis of the estimated and observed mean daily flow plots and an examination of the statistical summary indicates that the errors seem to be reasonably random, then the calibration is complete. If consistent errors still remain, then further trial-and-error calibration and possibly further Pattern Search optimization are needed to try to eliminate or reduce these errors.

Listed below are some possible reasons for consistent errors still remaining after the initial trial-and-error calibration and the first use of Pattern Search optimization:

a. Important model parameter or parameters may not have been corrected properly during trial-and-error calibration nor included in Pattern Search optimization.

b. The period used for Pattern Search optimization may not be representative of the entire data period.

c. The channel response function may not be adequate to describe properly the response of the channel over the entire range of discharge. Variable Lag and/or variable K may need to be included.

d. There may be deficiencies in the conceptual model. For example, the effect of frozen ground and other temperature related phénomena which affect the movement and retention of water in soil are not included in the soil-moisture accounting model. Consistent errors will result when phenomena occur which are not included in the conceptual model or which are not modeled satisfactorily. Further calibration will not correct these deficiencies.

5.8 OTHER CALIBRATION CONSIDERATIONS

5.8.1 USE OF ELEVATION ZONES

The computation of snowmelt and the form of precipitation is based on mean areal temperature in the snow accumulation and ablation model. Snowmelt is either assumed to be occurring over the entire area or no snowmelt is assumed to be occurring anywhere in the area. Also, either all the precipitation is assumed to be rain or it is all assumed to be snow. In addition, as the areal extent of the snowpack is depleted in a mountainous area, the mean areal temperature is no longer the same as the mean temperature over the snow covered area. The use of mean areal temperature to estimate snowmelt and the form of precipitation can result in errors. Simulation errors in the computation of snowmelt will occur primarily during the early portion of the snowmelt season when melt occurs only at low elevations and late in the snowmelt season when only the high elevations are covered with snow. The estimation of the form of precipitation will cause simulation errors during periods when rain is occurring at low elevations and snow is occurring at high elevations. Such simulation errors will be unimportant when the elevation range of the area is small, but increase in importance as the elevation range increases. To reduce these simulation errors, the elevation range needs to be reduced. The elevation range can be reduced by dividing the watershed into subareas based on elevation (elevation zones). Based on the watersheds tested to date with the snow model, it is not possible to give specific guidelines as to when elevation zones should be used. For the Passumpsic River, the RMS error was improved by about six percent and the correlation coefficient by about one percent when two elevation zones were used. The Passumpsic River has an elevation range of 1500 feet over 90 percent of the area (discounting the lower and upper five percent of the area - elevation range is 2900 feet for the entire area). The same parameter values that were used for the total area were used for each subarea except for SI (SI varied between areas since the amount of water equivalent varies). None of the other watersheds were modeled using elevation zones.

In addition to improving simulation results because of more representative air temperature data, improvements also may be possible through the use of different parameter values for each elevation zone. Since physiographic and climatic conditions vary with elevation, it would seem logical that model parameters also should vary. Simulation results can be improved by varying parameter values between elevation zones. However, unless care is exercised, the improvements may be at the expense of unrealistic parameter values. As mentioned previously, a slight improvement in simulation results does not insure that the future can be predicted with greater accuracy. Several suggestions which may be helpful if parameter values are varied between elevation zones are:

a. In a large watershed with several elevation zones, it may be possible that there are some small gaged areas which lie within a single elevation zone. Calibration of these small areas will provide a good estimate of the parameter values for the elevation zone, as long as physiographic conditions are similar between the small gaged area and the rest of the elevation zone.

b. The simulated snowpack water-equivalent for each elevation zone should be compared with available water-equivalent measurements to insure that the simulation of the snowpack is reasonable.

c. Differences in parameter values between elevation zones should be physically realistic.

5.8.2 EFFECT OF THE PRECIPITATION NETWORK ON THE SNOW CORRECTION FACTOR

In many cases, the precipitation network used in model calibration is different from the network used for operational river forecasting. Many stations are included in the published climatological network which do not report to a River Forecast Center. On the other hand, stations report to a River Forecast Center, but their precipitation data are not published as part of the climatological network. Results to date indicate that the most stable and realistic parameter values can be obtained when as much data as possible are included in the parameter calibration analysis. Because of data retrieval problems, it is generally not feasible to include stations which are not part of the published climatological network in the calibration analysis. Parameter values obtained during the calibration analysis are applicable to the operational data network as long as there is no bias between the data values obtained from the two networks. If there is no bias, the differences in simulation results from the two networks will be random.

The snow correction factor is an indication of the catch deficiencies during snowfall of the individual gages which makeup the precipitation data network. Thus, the snow correction factor for one precipitation data network probably will be different than that for another. Two possible methods for determining the snow correction factor for the operational precipitation network are:

a. The snow correction factor, SCF, could be determined for the operational precipitation network by trial-and-error calibration and Pattern Search optimization if all the stations included in the operational network are also part of the climatological network. In this case, mean areal precipitation would be recomputed using only those stations which are in the operational network.

b. The snow correction factor for the operational precipitation network (SCF_H) could be computed as

$$SCF_H = R_{C/H} \cdot SCF_C \quad , \tag{5.2}$$

where: $R_{C/H}$ is the ratio of mean areal precipitation during snowfall of the climatological network compared to the operational network, and
SCF_C is the snow correction factor for the climatological precipitation network.

In this case, all the stations in the operational hydrologic network do not have to be part of the climatological network.

The number of stations actually reporting during any time period would not affect the value of the snow correction factor. Missing precipitation data would be estimated from those stations which do report based on predetermined inter-station relationships. These relationships might include storm type, form of precipitation, and wind speed.

It should be noted that in addition to adjusting the snow correction factor, network effects on rainfall amounts and air temperature also must be considered so that the operational data network will not bias the simulation results.

References:

Monro, John C., "Direct Search Optimization in Mathematical Modeling and a Watershed Model Application," NOAA Technical Memorandum NWS HYDRO-12, U. S. Department of Commerce, Washington, D.C., April 1971, 52 pp.

Larson, Lee W., "An Application of the Dual-Gage Approach for Calculating "True" Solid Precipitation," National Weather Service, NOAA, Silver Spring, Md., presented at the 53rd Annual Meeting of the American Geophysical Union, Washington, D.C., April 17-21, 1972, 18 pp.

"Lysimeter Studies of Snow Melt," Snow Investigations Research Note No. 25, U. S. Army Corps of Engineers, North Pacific Division, Portland, Oregon, 1955, 41 pp.

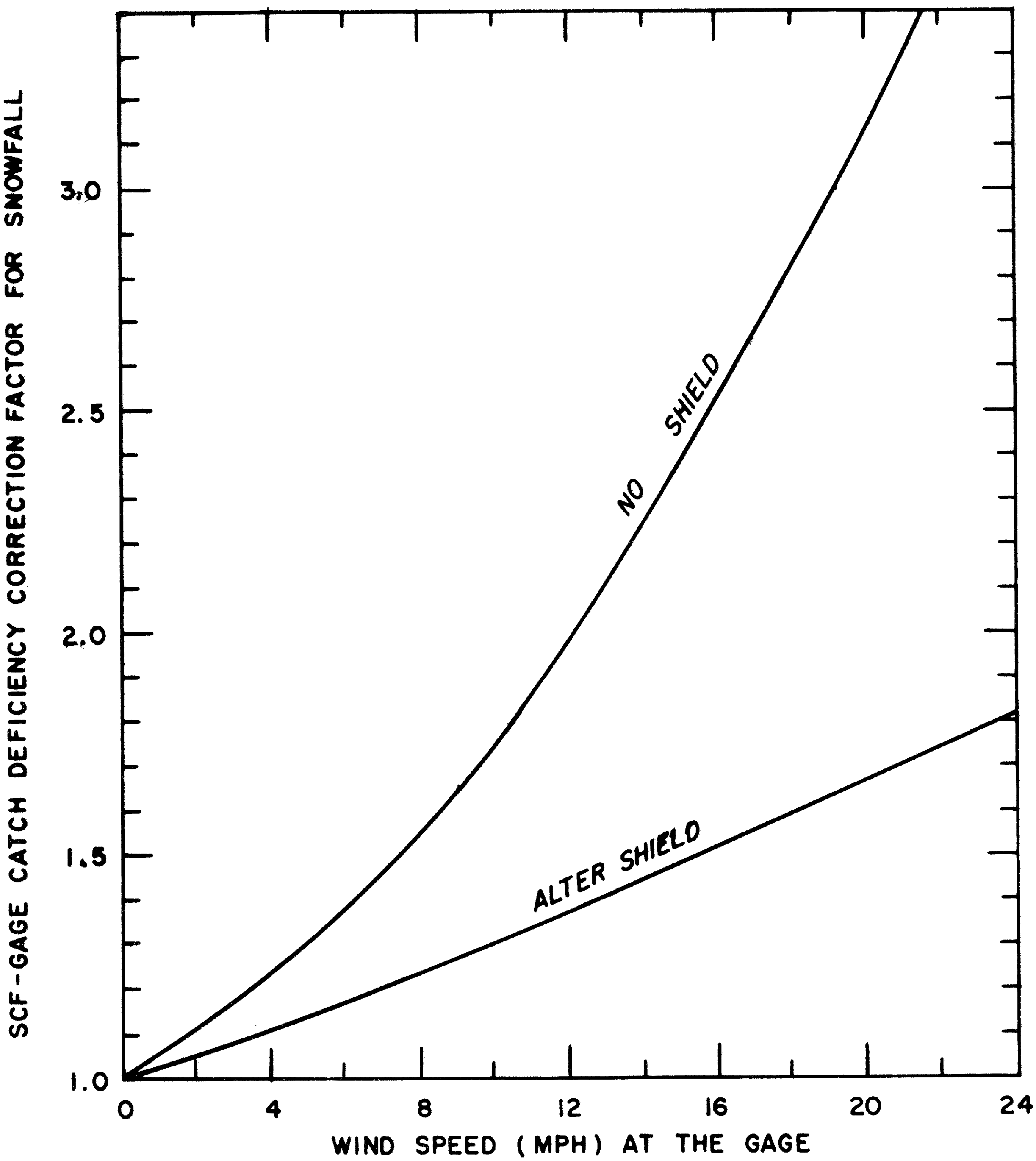


Figure 5-1. Typical gage catch deficiency correction factors during snowfall for shielded and unshielded gages (Larson 1972).

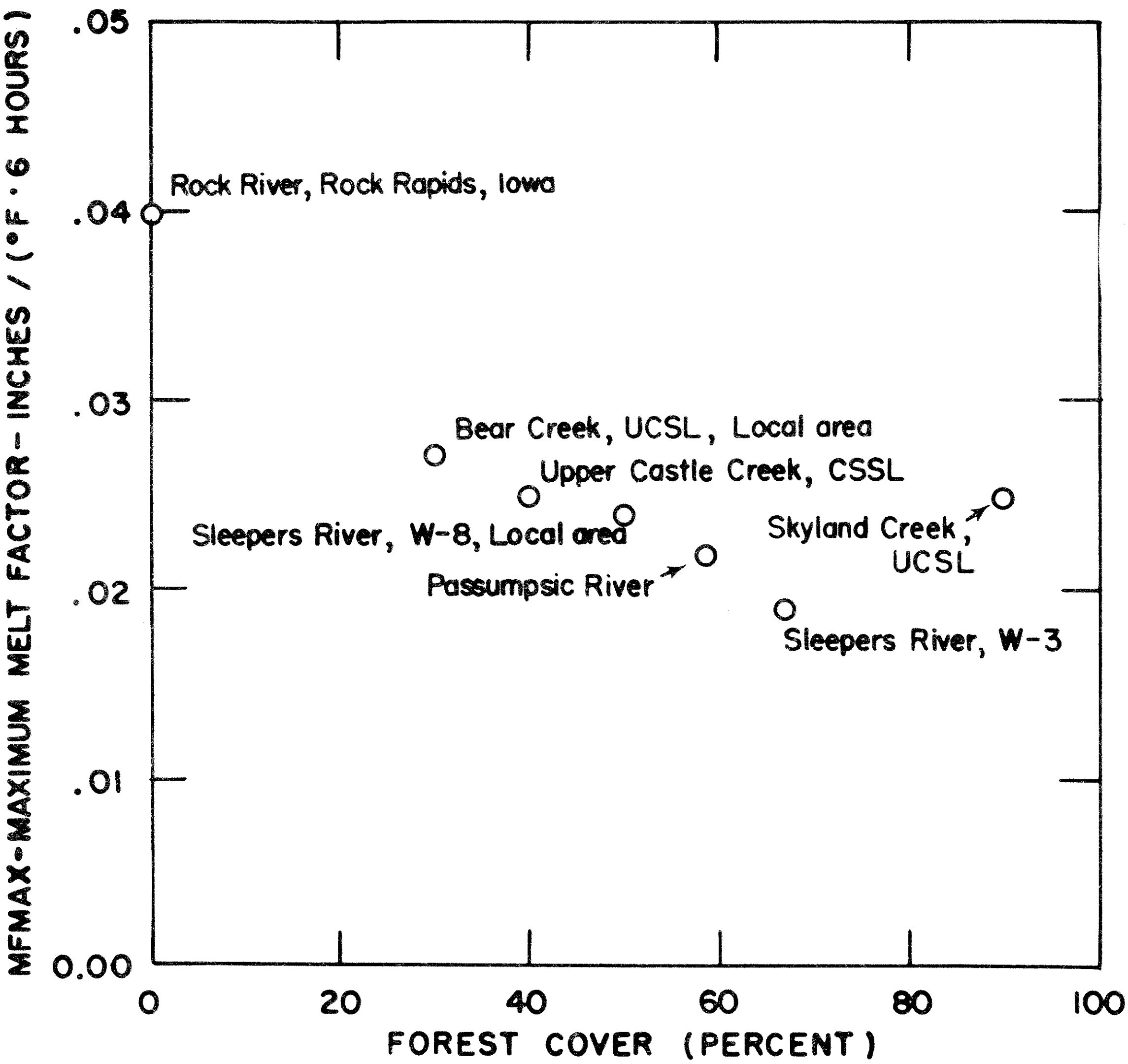


Figure 5-2. Maximum melt factor versus forest cover for areas tested on snow model.

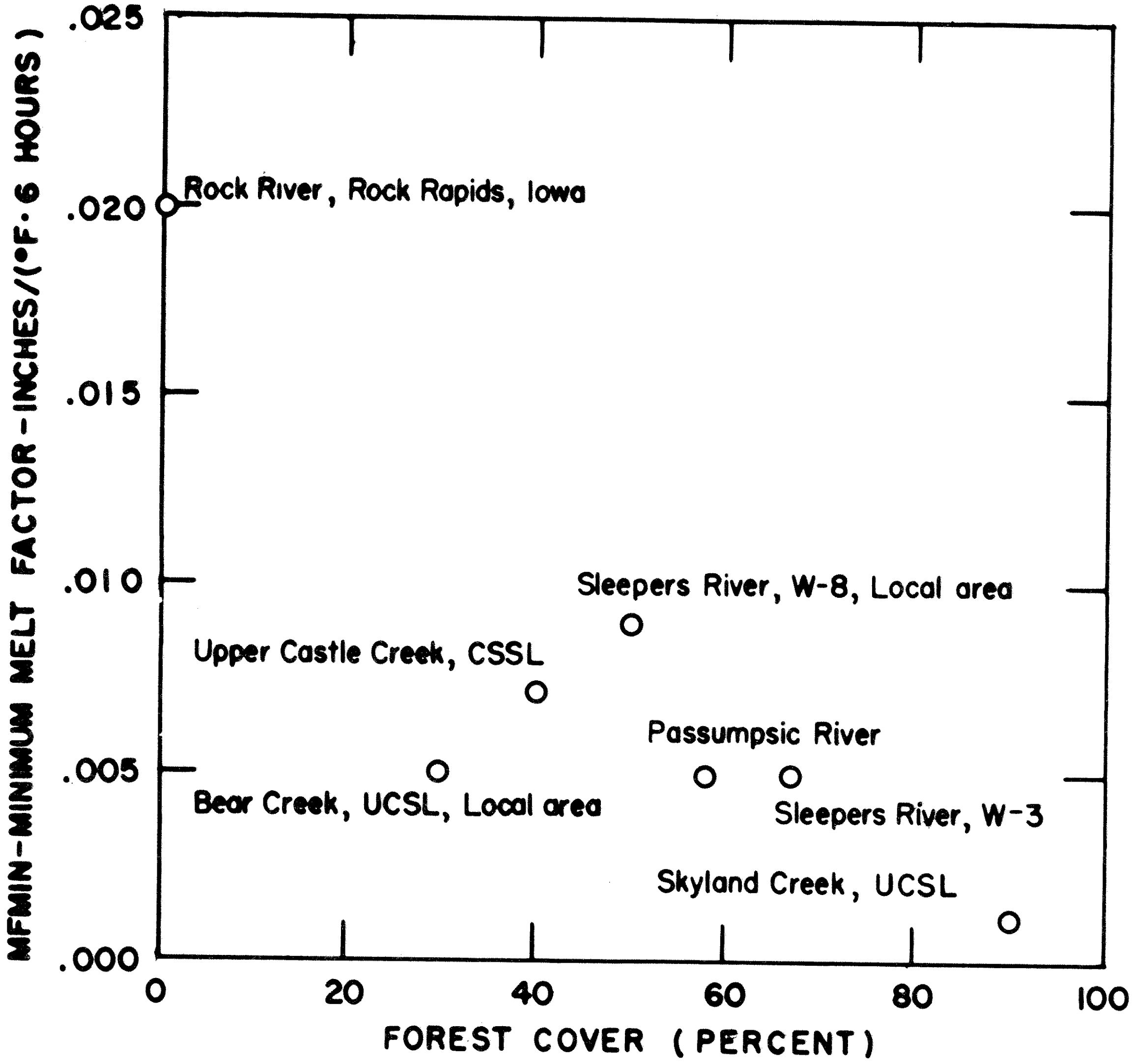


Figure 5-3. Minimum melt factor versus forest cover for areas tested on snow model.

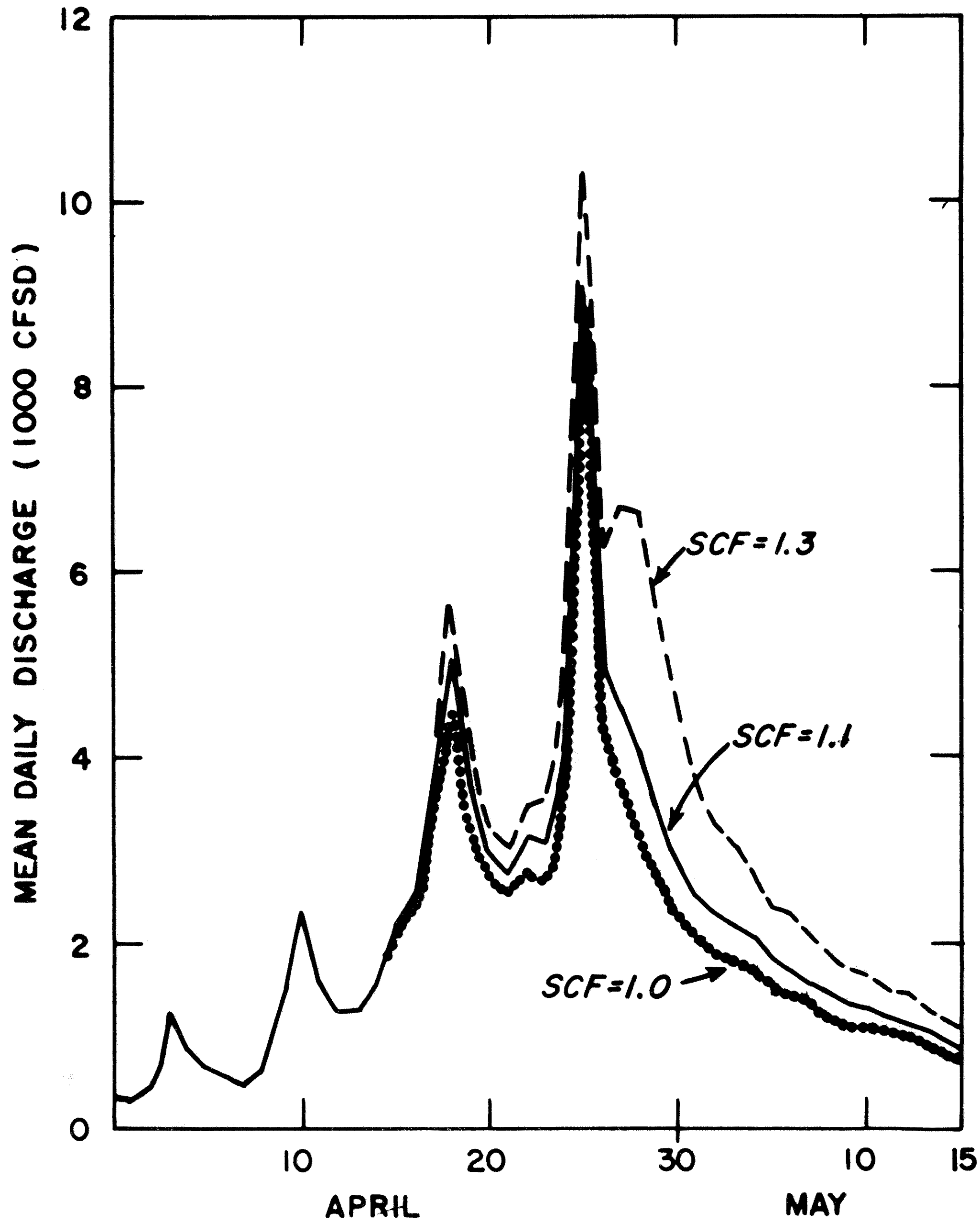


Figure 5-4. Effect of parameter SCF on spring snowmelt hydrograph. Passumpsic River at Passumpsic, Vermont, 1970.

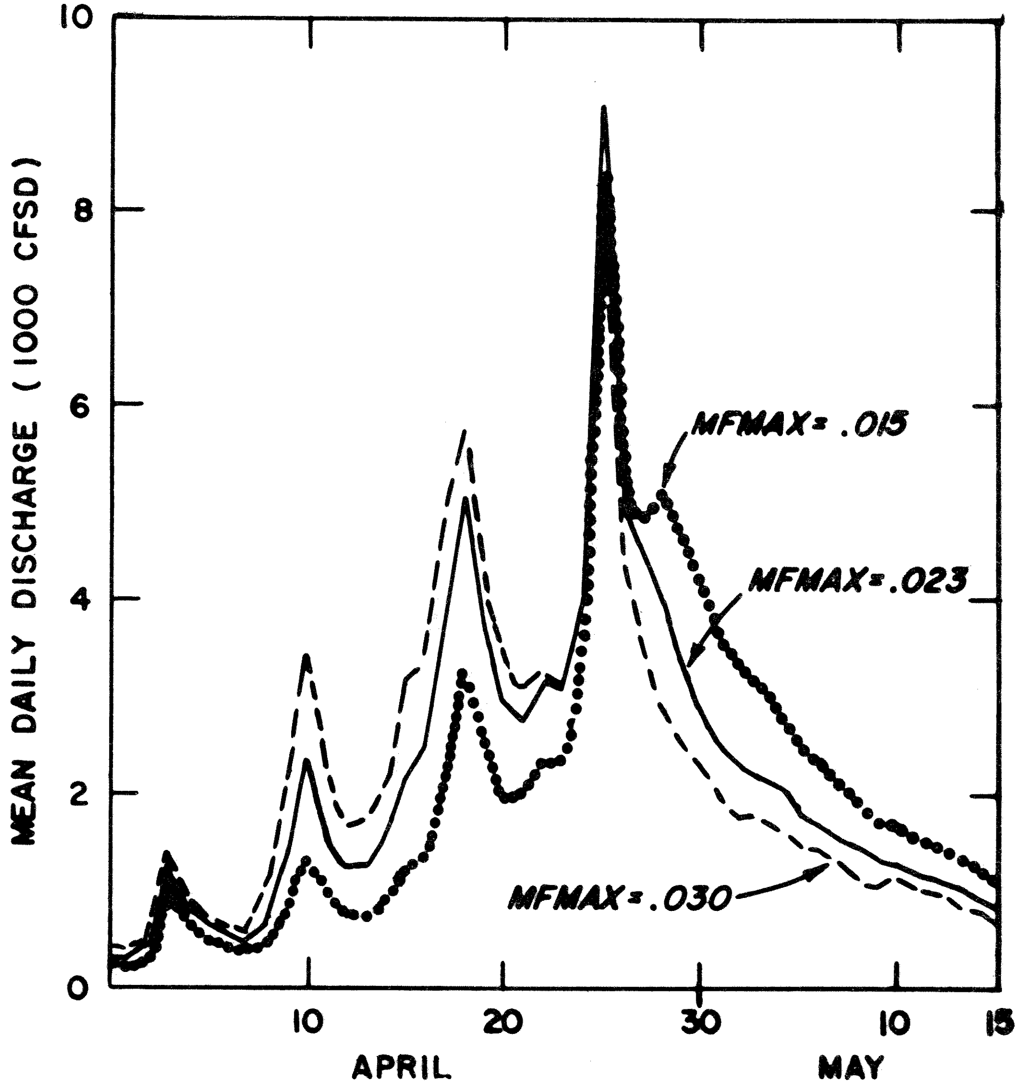


Figure 5-5. Effect of parameter MFMAX on spring snowmelt hydrograph. Passumpsic River at Passumpsic, Vermont, 1970.

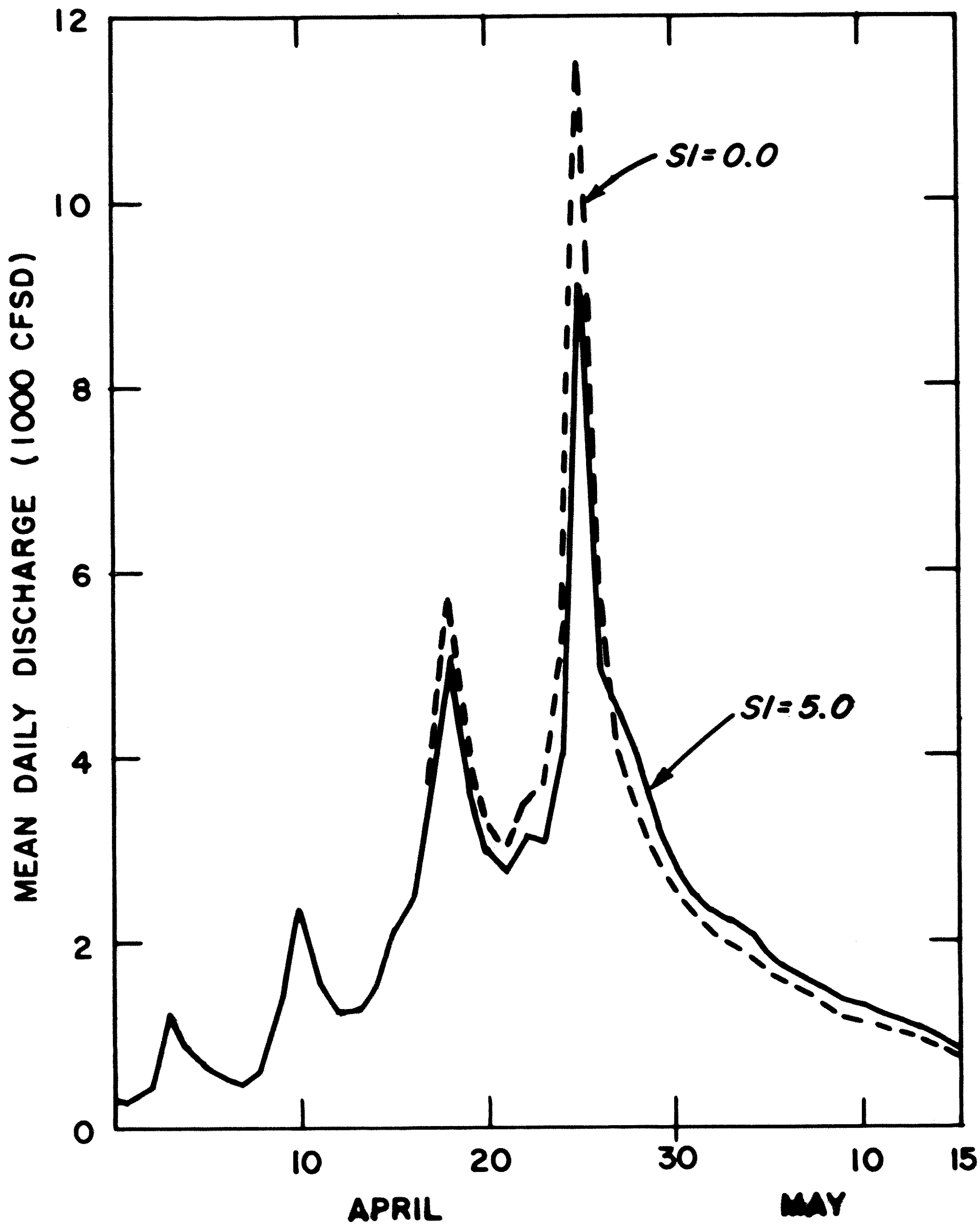


Figure 5-6. Effect of parameter SI on spring snowmelt hydrograph. Passumpsic River at Passumpsic, Vermont, 1970.

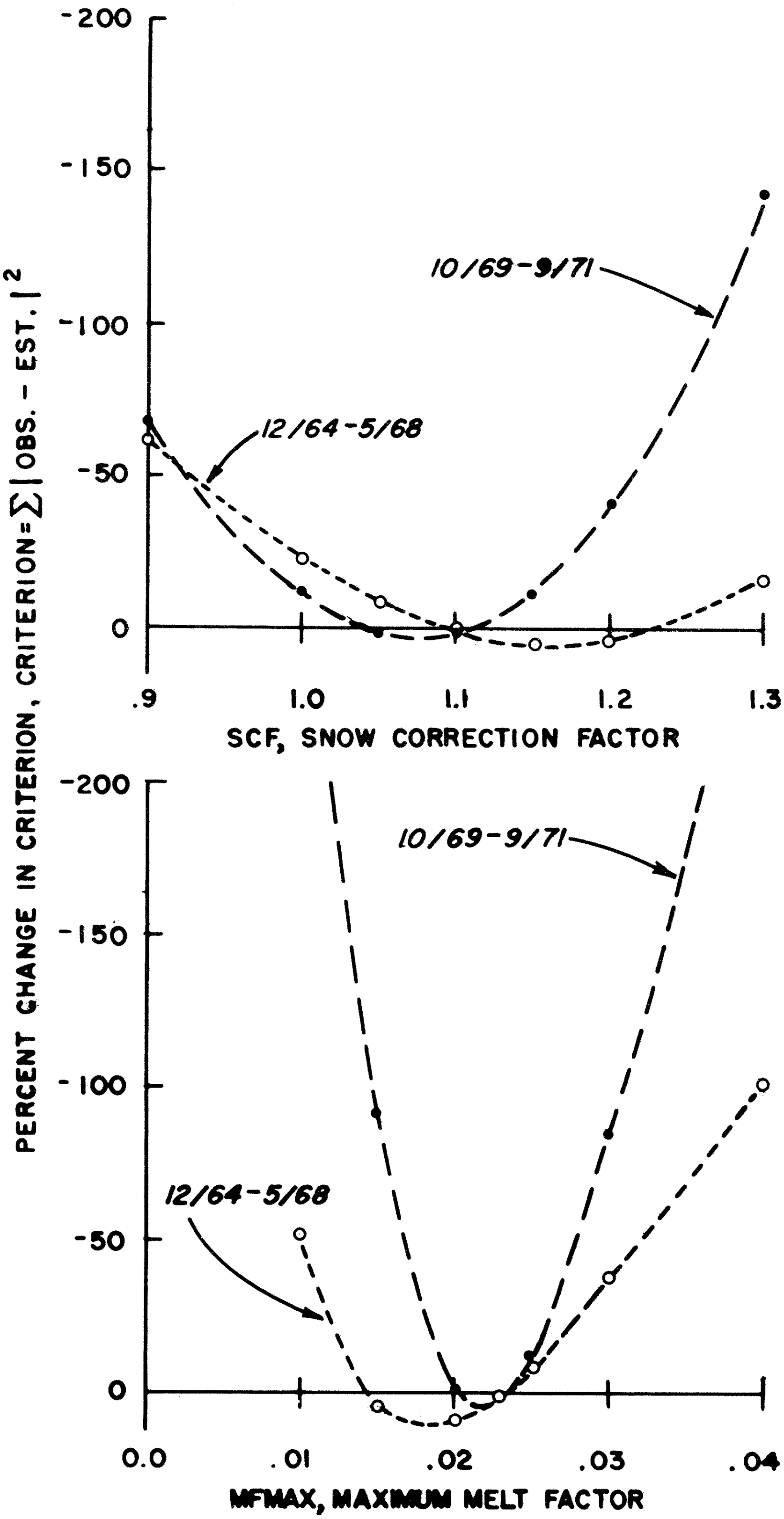


Figure 5-7. Sensitivity plots for parameters SCF and MFMAX. Passumpsic River at Passumpsic, Vermont, 1970.

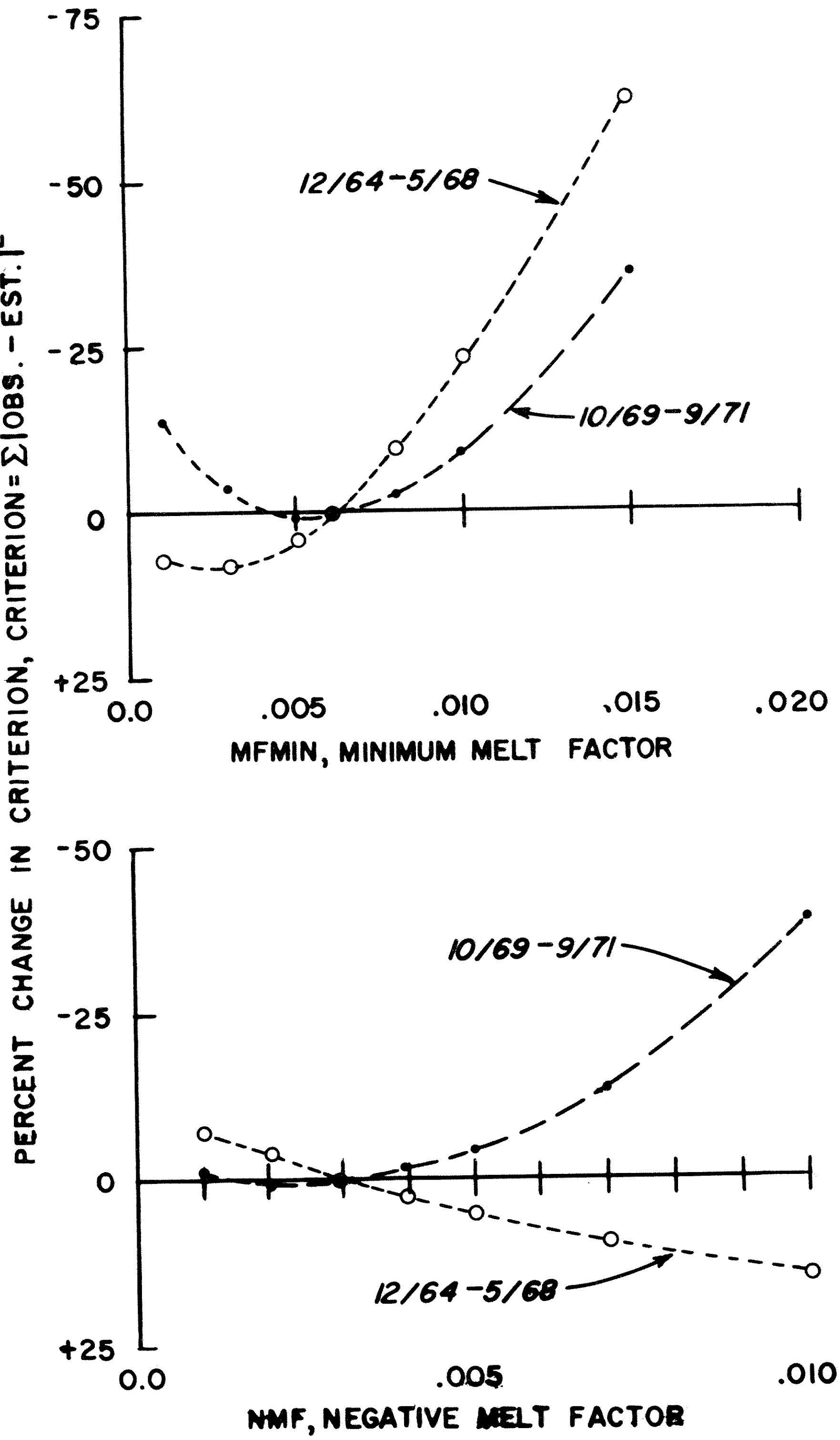


Figure 5-8. Sensitivity plots for parameters MFMIN and NMF. Passumpsic River at Passumpsic, Vermont, 1970.

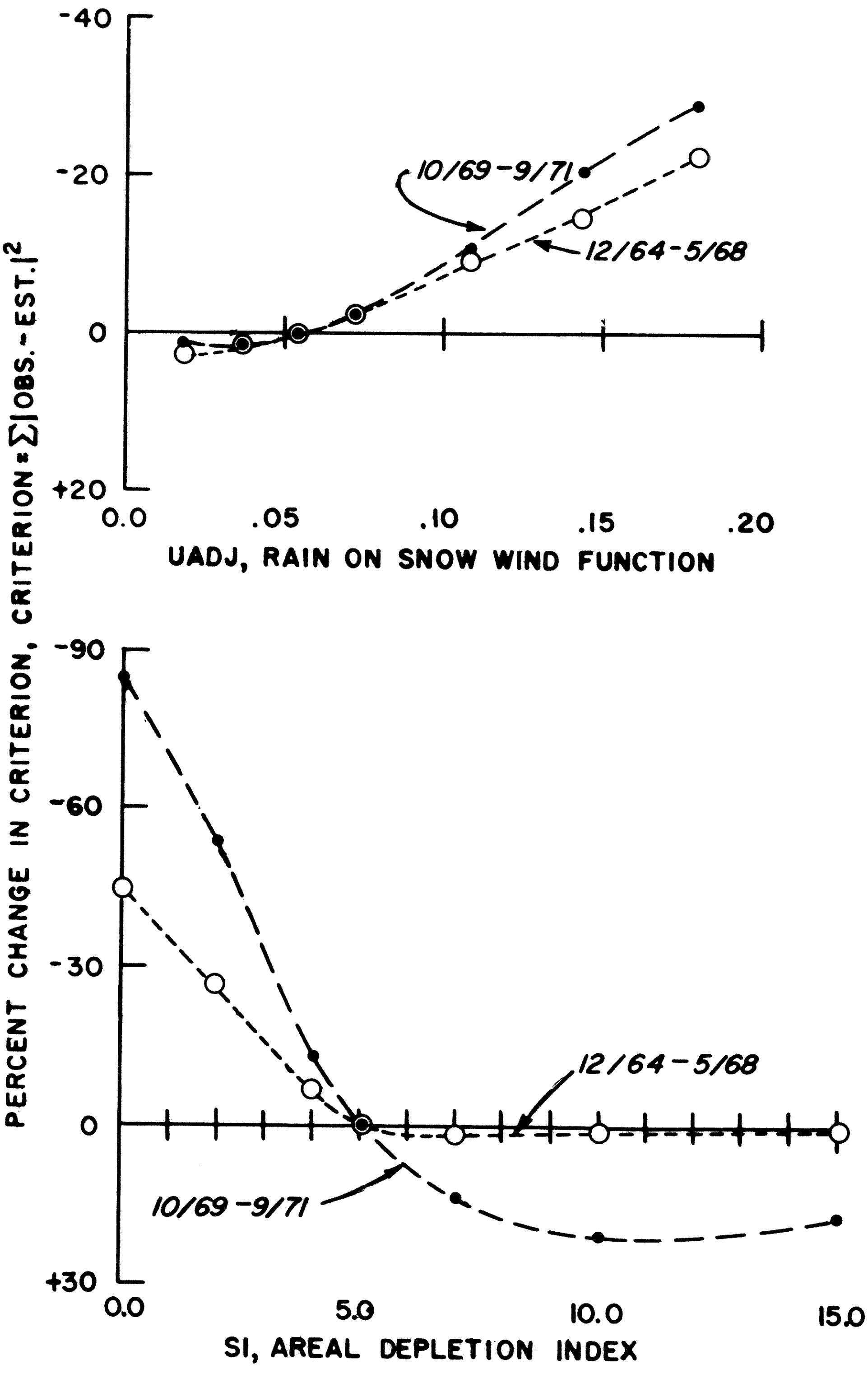


Figure 5-9. Sensitivity plots for parameters UADJ and SI. Passumpsic River at Passumpsic, Vermont, 1970.

APPENDIX A

PRELIMINARY DATA PROCESSING PROGRAMS

A.1 PROGRAM PRELIM1 - HOURLY PRECIPITATION DATA

A.2 PROGRAM PRELIM2 - DAILY OBSERVATIONS

A.1 PROGRAM PRELIM1 - HOURLY PRECIPITATION DATA

```
      PROGRAM PRELIM1(INPUT,OUTPUT,TAPE1,TAPE2)
************************************************************************
C     PROGRAM TO PERFORM PRELIMINARY DATA PROCESSING OF HOURLY
C          PRECIPITATION FOR MBP PROGRAM. FOR USE IN MOUNTAIN AREAS.
************************************************************************
************************************************************************
C CARD NO.     FORMAT      CONTENTS
************************************************************************
C    1           I5        NUMBER OF STATIONS    (75 MAX)
C                I5        INITIAL MONTH
C                I5        INITIAL YEAR (2 DIGITS)
C                I5        FINAL MONTH
C                I5        FINAL YEAR
C                I5        NUMBER OF INPUT NCC-NWSRFS TAPES
************************************************************************
C    2         8A10        TAPE LABELS OF EACH NCC-NWSRFS INPUT TAPE. (16 MAX)
************************************************************************
C ***NOTE*** REPEAT CARD 3 FOR EACH STATION
C    3          5A4        STATION NAME
C                I5        NWS STATE NUMBER
C                I5        NWS STATION NUMBER
************************************************************************
************************************************************************
      DIMENSION LASTDA(2,12),HTAPE(16),PXNAME(75,5),NWSST(75),NWSSTA
     1(75),E(240),DATA(31),ND(12),DSUM(12),PX(50,12)
      DATA LASTDA/31,31,28,29,31,31,30,30,31,31,30,30,31,31,31,31,30,30
     1,31,31,30,30,31,31/
      LFTD=5LTAPE2
      READ 1000,NSTA,IMO,IYR,LMO,LYR,NT
 1000 FORMAT (16I5)
      READ 1003,(HTAPE(I),I=1,NT)
 1003 FORMAT(8A10)
      DO 100 IRG=1,NSTA
      READ 1001,(PXNAME(IRG,I),I=1,5),NWSST(IRG),NWSSTA(IRG)
 1001 FORMAT(5A4,2I5)
  100 CONTINUE
      IRG=1
      NBMO=IYR*12+IMO
      NEMO=LYR*12+LMO
      NYRS=LYR-IYR+1
      NTAPE=1
      REWIND 1
      REWIND 2
************************************************************************
  105 DO 101 MO=1,12
      ND(MO)=0
      DSUM(MO)=0.0
  101 CONTINUE
```

```
      DO 102 I=1,NYRS
      DO 102 MO=1,12
      PX(I,MO)=999.99
  102 CONTINUE
      PRINT 1002,(PXNAME(IRG,I),I=1,5),NWSST(IRG),NWSSTA(IRG),IMO,IYR,
     1LMO,LYR
 1002 FORMAT(1H1,10X,16HDATA SUMMARY FOR,1X,5A4,3X,I2,1H-,I4,1X,
     114HFOR THE PERIOD,I3,1H/,I2,1X,7HTHROUGH,I3,1H/,I2)
      IDSTA=NWSSTA(IRG)
      ISTATE=NWSST(IRG)
      MONUM=1
      MTDB=0
      IF(IRG.GT.1) GO TO 113
  110 BUFFER IN(2,0)(E(1),E(240))
      IF (UNIT(2))112,111,112
  111 IF (NTAPE.EQ.NT) GO TO 200
      CALL CHANGER (LFTD,HTAPE(NTAPE),HTAPE(NTAPE+1),1)
      NTAPE=NTAPE+1
      REWIND 2
      GO TO 110
  112 DECODE(10,1004,E(1))IST,ICS,ICYR,ICMO
 1004 FORMAT (I2,I4,2I2)
113   IF ((ICS.EQ.IDSTA).AND.(IST.EQ.ISTATE)) GO TO 120
      IF (MONUM.EQ.1) GO TO 110
      GO TO 200
  120 NCMO=ICYR*12+ICMO
      IF ((NCMO.LT.NBMO).OR.(NCMO.GT.NEMO)) GO TO 110
C     FOUND MONTH AT STATION WITHIN SELECTED PERIOD
      MONUM=MONUM+1
      NYR=ICYR-IYR+1
      LY=0
      IF ((ICYR-4*(ICYR/4)).EQ.0) LY=1
      LAST=LASTDA((LY+1),ICMO)
      BUFFER OUT (1,0)(E(1),E(240))
      IF(UNIT(1)) 121,121,121
C     PRECIPITATION
  121 DECODE(127,1005,E(225))(DATA(I),I=1,31)
 1005 FORMAT (2X,31F4.2)
      MTDE=0
      SUM=0.0
      DO 122 ID=1,LAST
      IF (DATA(ID).GT.99.985) GO TO 130
      IF (DATA(ID).GT.99.975) GO TO 123
      SUM=SUM+DATA(ID)
      MTDE=0
      GO TO 122
  123 MTDE=1
  122 CONTINUE
      IF ((MTDB.EQ.1).OR.(MTDE.EQ.1)) GO TO 124
      PX(NYR,ICMO)=SUM
      DSUM(ICMO)=DSUM(ICMO)+SUM
      ND(ICMO)=ND(ICMO)+1
  124 MTDB=MTDE
      GO TO 110
```

```
  130 IF (DATA(LAST).EQ.99.98) MTDB=1
      GO TO 110
C     END OF MONTHLY COMPUTATIONS
********************************************************************************
********************************************************************************
C     PRINT STATION SUMMARY
  200 YSUM=0.0
      DO 201 MO=1,12
      IF (ND(MO).EQ.0) GO TO 201
      DSUM(MO)=DSUM(MO)/ND(MO)
      YSUM=YSUM+DSUM(MO)
  201 CONTINUE
      PRINT 2000
 2000 FORMAT (1H0,40X,26HSTATION SUMMARY FOR PERIOD)
      PRINT 2009,(MO,MO=1,12)
 2009 FORMAT (1H0,25HPRECIPITATION  YEAR/MONTH,5X,12I7,11X,5HTOTAL)
      DO 210 I=1,NYRS
      SUM=0.0
      DO 211 MO=1,12
  211 SUM=SUM+PX(I,MO)
      IF (SUM.GT.900.0) SUM=999.99
      NYR=IYR+I-1
      PRINT 2010,NYR,(PX(I,MO),MO=1,12),SUM
 2010 FORMAT (1H ,18X,2H19,I2,8X,12F7.2,8X,F8.2)
  210 CONTINUE
      PRINT 2001,(MO,MO=1,12)
 2001 FORMAT (1H0,20X,5HMONTH,5X,12I7,2X,16HANNUAL AVE/TOTAL)
      PRINT 2002,(ND(MO),MO=1,12)
 2002 FORMAT (1H ,16HNUMBER OF MONTHS,14X,12I7)
      PRINT 2003,(DSUM(MO),MO=1,12),YSUM
 2003 FORMAT (1H ,29HAVERAGE MONTHLY PRECIPITATION,1X,12F7.2,8X,F8.2)
      IF (IRG.EQ.NSTA) GO TO 299
      IRG=IRG+1
      GO TO 105
********************************************************************************
  299 CONTINUE
      STOP
      END
```

A.2 PROGRAM PRELIM2 - DAILY OBSERVATIONS

```
      PROGRAM PRELIM2(INPUT,OUTPUT,TAPE1,TAPE2)
*****************************************************************************
C     PROGRAM TO PERFORM PRELIMINARY DATA PROCESSING OF DAILY OBSERVATIONS
C           FOR MBP AND MBT PROGRAMS. FOR USE IN
C           MOUNTAIN AREAS OR AREAS WHERE SNOW IS
C           TO BE INCLUDED.
*****************************************************************************
*****************************************************************************
C CARD NO.     FORMAT      CONTENTS
*****************************************************************************
C   1            I5          NUMBER OF STATIONS    (75 MAX)
C                I5          INITIAL MONTH
C                I5          INITIAL YEAR (2 DIGITS)
C                I5          FINAL MONTH
C                I5          FINAL YEAR
C                I5          NUMBER OF INPUT NCC-NWSRFS TAPES
*****************************************************************************
C   2           8A10         TAPE LABELS OF EACH NCC-NWSRFS INPUT TAPE. (16 MAX)
*****************************************************************************
C ***NOTE*** REPEAT CARD 3 FOR EACH STATION
C   3            5A4         STATION NAME
C                I5          NWS STATE NUMBER
C                I5          NWS STATION NUMBER
C                I5          =1 TEMPERATURE AVAILABLE, =0 NO
C                I5          =1 WATER EQUIVALENT OF SNOW AVAILABLE, =0 NO
C                I5          =1 EVAPORATION DATA AVAILABLE, =0 NO
*****************************************************************************
*****************************************************************************
      DIMENSION LASTDA(2,12),DTAPE(16),PXNAME(75,5),NWSST(75),NWSSTA
     1(75),IT(75),IWE(75),IE(75),ND(5,12),DSUM(5,12),E(96),DATA(31),
     2SF(31),SOG(31),WE(31),YSUM(5),PX(50,12)
      DATA LASTDA/31,31,28,29,31,31,30,30,31,31,30,30,31,31,31,31,30,30
     1,31,31,30,30,31,31/
      LFTD=5LTAPE2
      READ 1000,NSTA,IMO,IYR,LMO,LYR,NT
 1000 FORMAT(16I5)
      READ 1003,(DTAPE(I),I=1,NT)
 1003 FORMAT(8A10)
      DO 100 IRG=1,NSTA
      READ 1001,(PXNAME(IRG,I),I=1,5),NWSST(IRG),NWSSTA(IRG),IT(IRG),
     1IWE(IRG),IE(IRG)
 1001 FORMAT(5A4,5I5)
  100 CONTINUE
      IRG=1
      NBMO=IYR*12+IMO
      NEMO=LYR*12+LMO
      NYRS=LYR-IYR+1
      NTAPE=1
      REWIND 1
      REWIND 2
*****************************************************************************
```

```
  105 DO 101 I=1,5
      DO 101 MO=1,12
      ND(I,MO)=0
      DSUM(I,MO)=0.0
  101 CONTINUE
      DO 102 I=1,NYRS
      DO 102 MO=1,12
      PX(I,MO)=999.99
  102 CONTINUE
      PRINT 1002,(PXNAME(IRG,I),I=1,5),NWSST(IRG),NWSSTA(IRG),IMO,IYR,
     1LMO,LYR
 1002 FORMAT(1H1,10X,16HDATA SUMMARY FOR,1X,5A4,3X,I2,1H-,I4,1X,
     114HFOR THE PERIOD,I3,1H/,I2,1X,7HTHROUGH,I3,1H/,I2)
      IDSTA=NWSSTA(IRG)
      ISTATE=NWSST(IRG)
      MONUM=1
      MTDB=0
      NEDW=0
      NEDE=0
      IF(IRG.GT.1) GO TO 113
  110 BUFFER IN(2,0)(E(1),E(96))
      IF (UNIT(2))112,111,112
  111 IF (NTAPE.EQ.NT) GO TO 200
      CALL CHANGER (LFTD,DTAPE(NTAPE),DTAPE(NTAPE+1),1)
      NTAPE=NTAPE+1
      REWIND 2
      GO TO 110
  112 DECODE(10,1004,E(1))IST,ICS,ICYR,ICMO
 1004 FORMAT (I2,I4,2I2)
 113  IF ((ICS.EQ.IDSTA).AND.(IST.EQ.ISTATE)) GO TO 120
      IF (MONUM.EQ.1) GO TO 110
      GO TO 200
  120 NCMO=ICYR*12+ICMO
      IF ((NCMO.LT.NBMO).OR.(NCMO.GT.NEMO)) GO TO 110
C     FOUND MONTH AT STATION WITHIN SELECTED PERIOD
      MONUM=MONUM+1
      NYR=ICYR-IYR+1
      LY=0
      IF ((ICYR-4*(ICYR/4)).EQ.0) LY=1
      LAST=LASTDA((LY+1),ICMO)
      BUFFER OUT (1,0)(E(1),E(96))
      IF(UNIT(1)) 121,121,121
C     PRECIPITATION
  121 DECODE(124,1005,E(2))(DATA(I),I=1,31)
 1005 FORMAT (31F4.2)
      MTDE=0
      SUM=0.0
      DO 122 ID=1,LAST
      IF (DATA(ID).GT.99.985) GO TO 129
      IF (DATA(ID).GT.99.975) GO TO 123
      SUM=SUM+DATA(ID)
      MTDE=0
      GO TO 122
  123 MTDE=1
```

```
  122 CONTINUE
      IF ((MTDB.EQ.1).OR.(MTDE.EQ.1)) GO TO 124
      PX(NYR,ICMO)=SUM
      DSUM(1,ICMO)=DSUM(1,ICMO)+SUM
      ND(1,ICMO)=ND(1,ICMO)+1
  124 MTDB=MTDE
      GO TO 130
129   IF (DATA(LAST).EQ.99.98) MTDB=1
  130 IF (IT(IRG).EQ.0) GO TO 140
C     MAXIMUM TEMPERATURE
      DECODE (97,1006,E(14))(DATA(I),I=1,31)
 1006 FORMAT(4X,31F3.0)
      DO 131 ID=1,LAST
      IF (DATA(ID).GT.300.0) GO TO 131
      DSUM(2,ICMO)=DSUM(2,ICMO)+DATA(ID)-100.0
      ND(2,ICMO)=ND(2,ICMO)+1
  131 CONTINUE
C     MINIMUM TEMPERATURE
      DECODE (100,1007,E(23))(DATA(I),I=1,31)
 1007 FORMAT (7X,31F3.0)
      DO 132 ID=1,LAST
      IF (DATA(ID).GT.300.0) GO TO 132
      DSUM(3,ICMO)=DSUM(3,ICMO)+DATA(ID)-100.0
      ND(3,ICMO)=ND(3,ICMO)+1
  132 CONTINUE
C     SNOWFALL
  140 DECODE (65,1008,E(42))(DATA(I),I=1,31)
 1008 FORMAT (3X,31F2.0)
      NS=1
      DO 141 ID=1,LAST
      SF(ID)=DATA(ID)
      IF (NS.EQ.0) GO TO 141
      IF (DATA(ID).GT.97.5) GO TO 141
      IF (DATA(ID).LT.0.5) GO TO 141
      NS=0
  141 CONTINUE
C     SNOW ON GROUND
      DECODE (98,1009,E(48))(DATA(I),I=1,31)
 1009 FORMAT (5X,31F3.0)
      DO 142 ID=1,LAST
      SOG(ID)=DATA(ID)
      IF (NS.EQ.0) GO TO 142
      IF (DATA(ID).GT.998.5) GO TO 142
      IF (DATA(ID).LT.0.5) GO TO 142
      NS=0
  142 CONTINUE
      IF (NS.EQ.1) GO TO 150
      IF (IWE(IRG).EQ.0) GO TO 145
C     WATER EQUIVALENT
      DECODE(101,1010,E(57))(WE(I),I=1,31)
 1010 FORMAT (8X,31F3.1)
C     PRINT OUT SNOW DATA FOR MONTH IF ANY AVAILABLE
  145 PRINT 1011,ICMO,ICYR,(ID,ID=1,16)
 1011 FORMAT (1H0,I2,1H/,I2,20X,16I6)
```

```
      PRINT 1012,(SF(ID),ID=1,16)
 1012 FORMAT (1H ,5X,8HSNOWFALL,12X,16F6.0)
      PRINT 1013,(SOG(ID),ID=1,16)
 1013 FORMAT (1H ,5X,14HSNOW ON GROUND,6X,16F6.0)
      IF(IWE(IRG).EQ.1)PRINT 1014,(WE(ID),ID=1,16)
 1014 FORMAT (1H ,5X,16HWATER EQUIVALENT,4X,16F6.1)
      PRINT 1015,(ID,ID=17,LAST)
 1015 FORMAT (1H ,25X,15I6)
      PRINT 1012,(SF(ID),ID=17,LAST)
      PRINT 1013,(SOG(ID),ID=17,LAST)
      IF (IWE(IRG).EQ.1) PRINT 1014,(WE(ID),ID=17,LAST)
  150 IF (IE(IRG).EQ.0) GO TO 110
C     WIND MOVEMENT
      DECODE (125,1016,E(67))(DATA(I),I=1,31)
 1016 FORMAT(1X,31F4.0)
      DAYSW=0.0
      SUM=0.0
      DO 151 ID=1,LAST
      IF(DATA(ID).GT.9998.5) GO TO 153
      IF (DATA(ID).GT.9997.5) GO TO 152
      SUM=SUM+DATA(ID)
      DAYSW=DAYSW+NEDW+1.0
  153 NEDW=0
      GO TO 151
  152 NEDW=NEDW+1
  151 CONTINUE
      TW=0.0
      IF (DAYSW.LT.0.5) GO TO 155
      TW=SUM*(LAST/DAYSW)
      DSUM(5,ICMO)=DSUM(5,ICMO)+SUM
      NDAYS=DAYSW+0.5
      ND(5,ICMO)=ND(5,ICMO)+NDAYS
C     EVAPORATION
  155 DECODE (98,1017,E(79))(DATA(I),I=1,31)
 1017 FORMAT (5X,31F3.2)
      DAYSE=0.0
      SUM=0.0
      DO 156 ID=1,LAST
      IF (DATA(ID).GT.9.985) GO TO 158
      IF (DATA(ID).GT.9.975) GO TO 157
      SUM=SUM+DATA(ID)
      DAYSE=DAYSE+NEDE+1.0
  158 NEDE=0
      GO TO 156
  157 NEDE=NEDE+1
  156 CONTINUE
      AVE=0.0
      TE=0.0
      IF (DAYSE.LT.0.5) GO TO 110
      AVE=SUM/DAYSE
      TE=SUM*(LAST/DAYSE)
      DSUM (4,ICMO)=DSUM(4,ICMO)+SUM
      NDAYS=DAYSE+0.5
      ND (4,ICMO)=ND(4,ICMO)+NDAYS
```

```
  160 PRINT 1018,ICMO,ICYR,NDAYS,AVE,TE
 1018 FORMAT(1H ,I2,1H/,I2,3X,14HEVAPORATION---,5HDAYS=,I2,3X,
     111HAVE. DAILY=,F5.3,3X,27HTOTAL(BASED ON FULL MONTH)=,F5.2)
      IF (DAYSW.LT.0.5) GO TO 110
      NDAYS=DAYSW+0.5
      PRINT 1019,NDAYS,TW
 1019 FORMAT(1H+,88X,12HWIND---DAYS=,I2,3X,18HTOTAL(FULL MONTH)=,F6.0)
      GO TO 110
C     END OF MONTHLY COMPUTATIONS
****************************************************************************
****************************************************************************
C     PRINT STATION SUMMARY
  200 DO 201 I=1,5
      YSUM(I)=0.0
      DO 201 MO=1,12
      IF (ND(I,MO).EQ.0) GO TO 204
      DSUM(I,MO)=DSUM(I,MO)/ND(I,MO)
      YSUM(I)=YSUM(I)+DSUM(I,MO)
204   IF (MO.NE.12) GO TO 201
      IF (I.EQ.1) GO TO 201
      IF (I.EQ.4) GO TO 203
      YSUM(I)=YSUM(I)*0.083333
      GO TO 201
203   YSUM(I)=YSUM(I)*30.417
  201 CONTINUE
      PRINT 2000
 2000 FORMAT (1H0,40X,26HSTATION SUMMARY FOR PERIOD)
      PRINT 2009,(MO,MO=1,12)
 2009 FORMAT (1H0,25HPRECIPITATION  YEAR/MONTH,5X,12I7,11X,5HTOTAL)
      DO 210 I=1,NYRS
      SUM=0.0
      DO 211 MO=1,12
  211 SUM=SUM+PX(I,MO)
      IF (SUM.GT.900.0) SUM=999.99
      NYR=IYR+I-1
      PRINT 2010,NYR,(PX(I,MO),MO=1,12),SUM
 2010 FORMAT (1H ,18X,2H19,I2,8X,12F7.2,8X,F8.2)
  210 CONTINUE
      PRINT 2001,(MO,MO=1,12)
 2001 FORMAT (1H0,20X,5HMONTH,5X,12I7,2X,16HANNUAL AVE/TOTAL)
      PRINT 2002,(ND(1,MO),MO=1,12)
 2002 FORMAT (1H ,16HNUMBER OF MONTHS,14X,12I7)
      PRINT 2003,(DSUM(1,MO),MO=1,12),YSUM(1)
 2003 FORMAT (1H ,29HAVERAGE MONTHLY PRECIPITATION,1X,12F7.2,8X,F8.2)
      IF (IT(IRG).EQ.0) GO TO 202
      PRINT 2001,(MO,MO=1,12)
      PRINT 2004,(ND(2,MO),MO=1,12)
 2004 FORMAT (1H ,14HNUMBER OF DAYS,16X,12I7)
      PRINT 2005,(DSUM(2,MO),MO=1,12),YSUM(2)
 2005 FORMAT (1H ,30HAVERAGE DAILY MAX. TEMPERATURE,12F7.1,8X,F8.1)
      PRINT 2001,(MO,MO=1,12)
      PRINT 2004,(ND(3,MO),MO=1,12)
      PRINT 2006,(DSUM(3,MO),MO=1,12),YSUM(3)
 2006 FORMAT (1H ,30HAVERAGE DAILY MIN. TEMPERATURE,12F7.1,8X,F8.1)
```

```
  202 IF (IE(IRG).EQ.0) GO TO 205
      PRINT 2001,(MO,MO=1,12)
      PRINT 2004,(ND(4,MO),MO=1,12)
      PRINT 2007,(DSUM(4,MO),MO=1,12),YSUM(4)
 2007 FORMAT (1H ,25HAVERAGE DAILY EVAPORATION,5X,12F7.3,8X,F8.1)
      PRINT 2001,(MO,MO=1,12)
      PRINT 2004,(ND(5,MO),MO=1,12)
      PRINT 2008,(DSUM(5,MO),MO=1,12),YSUM(5)
 2008 FORMAT (1H ,27HAVERAGE DAILY WIND MOVEMENT,3X,12F7.0,8X,F8.0)
  205 IF (IRG.EQ.NSTA) GO TO 299
      IRG=IRG+1
      GO TO 105
********************************************************************************
  299 CONTINUE
      STOP
      END
```

APPENDIX B

MEAN AREAL TEMPERATURE PROGRAM

B.1 MAT PROGRAM INPUT SUMMARY

B.2 SAMPLE INPUT FOR MAT PROGRAM

B.3 EXAMPLES OF OUTPUT FROM MAT PROGRAM

B.4 SAMPLE INPUT WHEN PROGRAM TEMPCK IS USED IN CONJUNCTION WITH THE MAT PROGRAM

B.5 OUTPUT FROM PROGRAM TEMPCK

B.1 MAT PROGRAM INPUT SUMMARY

```
C      THIS PROGRAM COMPUTES SIX-HOURLY MEAN AREAL TEMPERATURE(MAT) AND
C           IS CURRENTLY DIMENSIONED FOR THE FOLLOWING.
C      10  BASINS
C      40  MAXIMUM-MINIMUM TEMPERATURE STATIONS
C      10  CHANGES IN OBSERVATION TIME PER STATION
C      10  CORRECTIONS TO MAX.-MIN. TEMPERATURE PER STATION
C
C      MEAN AREAL TEMPERATURE CONSISTENCY PROGRAM GOES WITH THIS PROGRAM.
C      INPUT FOR MAT CONSISTENCY IS IN THIS PROGRAM.  THIS PROGRAM WRITES
C      ALL THE INFORMATION NEEDED BY MAT CONSISTENCY ON SCRATCH DISK OR
C      TAPE.  THE TWO PROGRAMS ARE EXECUTED CONSECUTIVELY.
C          MAT CONSISTENCY IS DIMENSIONED FOR THE FOLLOWING.
C       5  GROUPS OF STATIONS
C      25  YEARS OF DATA.
**************************************************************************
**************************************************************************
C      INPUT SUMMARY FOR MEAN AREAL TEMPERATURE(MAT) COMPUTATIONS.
**************************************************************************
*CARD NO. FORMAT           COMMENTS
**************************************************************************
C    1          I5      NUMBER OF INITIAL MONTH
C               I5      INITIAL YEAR (LAST TWO DIGITS)
C               I5      NUMBER OF LAST MONTH
C               I5      LAST YEAR (LAST TWO DIGITS)
C               I5      NUMBER OF MAX-MIN TEMPERATURE STATIONS IN THIS RUN
C               I5      NUMBER OF AREAS WHERE MAT IS TO BE COMPUTED.
C               I5      =1  MOUNTAINOUS AREA-USE MEAN MONTHLY TEMPERATURE AND
C                             ELEVATION TO ESTIMATE MISSING DATA.
C                       =0  NON-MOUNTANOUS AREA - MEANS AND ELEVATION NOT NEEDED.
C               I5      =1  PUT MEAN AREAL TEMPERATURES ON TAPE IN NWSRFS FORM
                                  (OUTPUT TAPE IS DESIGNATED AS TAPE1)
C                       =0  PUT MAT ON O/H STANDARD FORMAT CARDS (FIELD LENGTH=3)
C               I5      =1  INPUT DATA AND PUT INFORMATION ON DISK OR TAPE SO THAT
C                             MAT CONSISTENCY CHECK PROGRAM CAN BE RUN.
C                       =0  CONSISTENCY CHECK IS NOT TO BE RUN.
C               I5      =1  PRINT MAX-MIN TEMPERATURE DATA FOR EACH STATION AS IT IS
C                             READ FROM NCC-NWSRFS TAPE.
C                       =0  DO NOT PRINT MAX-MIN DATA FOR EACH STATION.
C               I5      =1  INPUT CORRECTIONS TO MAX-MIN TEMPERATURE DATA
C                       =0  NO CORRECTIONS NEEDED.
C               I5      =0  PUNCH A ZERO IN COLUMN 60
**************************************************************************
C***NOTE*** CARD 2 ONLY NEEDED FOR MOUNTAINOUS AREAS.
C    2       F5.3     DISTANCE BETWEEN MAP GRID COORDINATES IN MILES.
**************************************************************************
**************************************************************************
C***NOTE*** REPEAT CARDS 3 THROUGH 5 FOR EACH MAX-MIN TEMPERATURE STATION.
C             STATIONS MUST BE IN THE ORDER THAT THEY APPEAR ON THE INPUT
C             DATA TAPE.  (INPUT TAPE IS DESIGNATED TAPE2)
```

```
              DUMMY STATIONS CAN BE PLACED ANYWHERE.
              INPUT ORDER DETERMINES STATION RUN NUMBER.
**********************************************************************
C   3       5A4     STATION NAME
C          F5.0     X GRID COORDINATE        NOTE.. SQUARE GRID SYSTEM OF ANY
C          F5.0     Y GRID COORDINATE             ORIENTATION IS USED.
C                                             BASINS MUST FALL WITHIN BASIC
C                                       80 X 80 GRID.  STATIONS CAN BE ANYWHERE.
C             I5     NATIONAL WEATHER SERVICE STATE NUMBER
C             I5     NATIONAL WEATHER SERVICE STATION INDEX NUMBER
C                        FOR A DUMMY STATION (HYPOTHETICAL STATION WITH ALL
C                             MISSING DATA) USE AN INDEX NUMBER GREATER THAN
C                             9999.
C           F5.0     OBSERVATION TIME  (HOUR 1 THROUGH 24) FOR INITIAL MONTH
C          F10.0     STATION ELEVATION IN FEET
**********************************************************************
C      ***NOTE*** CARDS 4 AND 5 ONLY NEEDED IF RUN IS FOR A MOUNTAINOUS AREA.
**********************************************************************
C   4  15X,F5.0     ELEVATION WEIGHTING FACTOR(FE) FOR MAXIMUM TEMPERATURE.
C        12F5.0     MEAN MAXIMUM TEMPERATURE (DEGREES F) FOR EACH MONTH.
C                        IN ORDER JANUARY THROUGH DECEMBER.
**********************************************************************
C   5  15X,F5.0     ELEVATION WEIGHTING FACTOR(FE) FOR MINIMUM TEMPERATURE.
C        12F5.0     MEAN MINIMUM TEMPERATURE  (DEGREES F) FOR EACH MONTH.
C                        IN ORDER  JANUARY THROUGH DECEMBER.
**********************************************************************
**********************************************************************
C***NOTE***  REPEAT CARDS 6 THROUGH 8 FOR EACH AREA FOR WHICH MAT IS TO BE
C                                                               COMPUTED.
**********************************************************************
C   6      10A4     AREA NAME
C          1X,A9     AREA IDENTIFICATION NUMBER
C             I5     =1 STATION WEIGHTS DETERMINED BY GRID POINT WEIGHTING
C                        METHOD.  STATION WEIGHTS FOR EACH GRID POINT WITHIN
C                        THE AREA ARE A FUNCTION OF ONE OVER THE DISTANCE FROM
C                        THE GRID POINT TO THE NEAREST STATION IN EACH
C                        QUADRANT.
C                   =0 USE PREDETERMINED STATION WEIGHTS. PREDETERMINED
C                        WEIGHTS ARE RECOMMENDED FOR MOST MOUNTAIN AREAS.
**********************************************************************
C        ***NOTE***  CARD 7 ONLY USED FOR PREDETERMINED STATION WEIGHTS.
**********************************************************************
C    7   16F5.2     PREDETERMINED WEIGHT FOR EACH STATION. STATION ORDER
C                        IS DETERMINED FROM CARD 3. REPEAT CARD 7 IF MORE
C                        THAN 16 STATIONS.
**********************************************************************
C        ***NOTE***  CARD GROUP 8 IS ONLY USED IF GRID POINT WEIGHTS ARE USED.
C                        EIGHTY(80) CARDS ARE NEEDED IN GROUP 8.  THIS IS THE
C                        GRID MAP OF THE AREAS. ALL GRID POINTS IN THE AREA
C                        ARE DESIGNATED WITH A ONE(1). GRID POINTS OUTSIDE
C                        THE AREA ARE LEFT BLANK.
**********************************************************************
C   8      80I1     AREA GRID MAP.  ONE Y ORDINATE PER CARD.  FIRST CARD IS
C                        FOR Y=80, SECOND CARD Y=79, ETC.--80TH CARD Y=1.
```

```
C                       THUS IF CARDS ARE LISTED, THE LISTING WILL LOOK
C                       SIMILAR TO THE SHAPE OF THE AREA.
************************************************************************
************************************************************************
C         ***NOTE*** CARD 9 GROUP MUST ALWAYS BE INCLUDED.
C                       CARD 9 GROUP DESIGNATES CHANGES IN OBSERVATION TIME FOR
C                       EACH STATION.  STATION CHANGES MUST BE IN ORDER BY DATE
C                       (EARLIEST FIRST). OTHER THAN THAT REQUIREMENT,ORDER
C                       DOES NOT MATTER.  THUS ALL CHANGES FOR ONE STATION
C                       CAN BE FIRST, FOLLOWED BY THE NEXT STATION, ETC. OR
C                       ALL THE CHANGES FOR THE FIRST MONTH AT ALL STATIONS
C                       CAN BE FOLLOWED BY CHANGES IN SUBSEQUENT MONTHS.
************************************************************************
C    9          I5     STATION RUN NUMBER(FROM CARD 3)
C               I5     MONTH NUMBER OF TIME CHANGE
C               I5     YEAR (LAST 2 DIGITS)
C             F5.0     NEW OBSERVATION TIME (HOUR 1 THROUGH 24)
C
C      ***NOTE***  CARD GROUP 9 ENDS WITH A CARD WITH 99 IN COLUMNS 4-5.
************************************************************************
************************************************************************
C         ***NOTE***  CARD GROUP 10 IS ONLY NEEDED IF CORRECTIONS ARE TO BE
C                       MADE TO MAX-MIN TEMPERATURE DATA.
C                       CORRECTIONS TO EACH STATION MUST BE IN ORDER BY DATE
C                       (EARLIEST FIRST) AS WITH CARD GROUP 9.
C                       CORRECTION REMAINS IF EFFECT UNTIL THE DATE OF THE
C                           NEXT CORRECTION.
************************************************************************
C   10          I5     STATION RUN NUMBER (FROM CARD 3)
C               I5     MONTH NUMBER WHEN CORRECTION STARTS.
C               I5     YEAR (LAST 2 DIGITS)
C             F5.0     CORRECTION TO MAXIMUM TEMPERATURE (DEGREES F)
C             F5.0     CORRECTION TO MINIMUM TEMPERATURE (DEGREES F)
C
C      ***NOTE*** CARD GROUP 10 ENDS WITH A CARD WITH 99 IN COLUMNS 4-5.
************************************************************************
************************************************************************
C   11        8A10     REEL NUMBER OF EACH INPUT DATA TAPE USED. (SEQUENTIAL)
C                    *NOTE* CHECK STATEMENTS USED TO CHANGE TAPES. OTHER
C                           SYSTEMS MAY USE DIFFERENT PROCEDURE.
************************************************************************
************************************************************************
C      ***NOTE*** CARDS 12 AND 13 ONLY NEEDED IF CONSISTENCY CHECK IS TO BE MADE.
************************************************************************
C   12          I5     NUMBER OF GROUPS TO MAKE CONSISTENCY CHECKS ON. (5 MAXIMUM)
C              5I5     NUMBER OF STATIONS IN EACH GROUP.  (40 MAXIMUM)
************************************************************************
C   **NOTE** REPEAT CARD 13 FOR EACH GROUP
C   13        16I5     RUN NUMBER OF EACH STATION IN THE GROUP. (16 PER CARD)
C                       GET RUN NUMBERS FROM CARD 3 ORDER.  ASSIGN PLUS AND
C                       MINUS TO RUN NUMBERS AS DISCUSSED BELOW.
C                       NOTE...EVERY STATION MUST BE IN A GROUP. HOWEVER, NO
C                       STATION CAN BE IN MORE THAN ONE GROUP.  STATIONS
C                       WITH POSITIVE RUN NUMBERS MAKE UP THE GROUP BASE AND
```

```
C                             ARE PLOTTED AGAINST THE OTHER STATIONS IN THE GROUP
C                             BASE. STATIONS WITH NEGATIVE RUN NUMBERS ARE PLOTTED
C                             AGAINST THE GROUP BASE, STATION ORDER DOES NOT MATTER.
C
C                             (E.G. GROUP ONE CONTAINS 5 STATIONS.  THEIR RUN NUMBERS
C                             ARE 3,5,6,9 AND 12. CARD NO. 13 INPUT FOR GROUP
C                             ONE IS...6,5,9,-12,-3. THEN STATION 6 IS PLOTTED
C                             AGAINST THE AVERAGE OF STATIONS 5 AND 9.  STATION
C                             12 IS PLOTTED AGAINST THE AVERAGE OF THE GROUP BASE.
C                             THE GROUP BASE CONSISTS OF STATIONS 6,5, AND 9.)
**********************************************************************************
**********************************************************************************
```

B.2 SAMPLE INPUT FOR MAT PROGRAM

```
   10    63     9    71     7     3     1     1     1     1     1     0
1.133
MC INDOE FALLS,VT.        46    37    43 5044     8         480.
MAX. 43-5044        0.0 24.6 28.4 38.9 52.0 65.6 75.7 79.9 77.3 69.6 59.2 44.1 29.4
MIN. 43-5044        0.0  2.0  4.1 16.9 28.7 39.2 49.4 55.0 53.3 46.8 36.0 27.8 11.9
MT. MANSFIELD,VT.         13    53    43 5416    17        3950.
MAX. 43-5416        0.0 15.6 18.1 25.5 38.3 51.7 62.1 65.5 62.7 56.4 46.4 32.9 20.4
MIN. 43-5416        0.0  -.9  2.1 11.8 23.2 34.5 45.4 49.7 48.0 41.9 31.2 19.4  5.5
NEWPORT,VERMONT           40    78    43 5542    24         766.
MAX. 43-5542        0.0 23.0 27.3 37.2 51.2 64.5 75.5 79.5 76.3 69.3 57.9 41.8 26.8
MIN. 43-5542        0.0  1.0  3.0 15.5 28.0 39.4 49.7 54.7 52.5 45.4 36.7 26.4 10.0
NORTH DANVILLE,VT.        44    50    43 5632    24        1140.
MAX. 43-5632        0.0 21.3 24.8 34.5 48.0 61.4 71.9 75.6 72.5 64.9 54.6 39.0 24.9
MIN. 43-5632        0.0  1.7  4.0 16.2 28.1 37.9 47.2 52.5 50.2 43.1 34.4 24.6 10.2
ST. JOHNSBURY,VT.         48    47    43 7054    16         699.
MAX. 43-7054        0.0 23.4 28.1 37.7 52.1 66.0 76.1 79.5 76.9 69.4 58.8 41.9 26.6
MIN. 43-7054        0.0  2.5  5.1 16.8 27.7 38.8 49.2 54.1 52.5 45.5 34.9 26.1 11.0
WEST BURKE,VERMONT        50    60    43 9099     8         900.
MAX. 43-9099        0.0 22.8 26.6 36.8 49.7 64.3 74.6 79.1 76.2 68.5 57.1 41.5 26.3
MIN. 43-9099        0.0  -.2  0.9 14.5 28.2 38.5 48.8 53.8 51.7 45.0 35.1 27.0 10.4
WEST RIDGE-DUMMY          42    51   4310000    24        1740.
MAX. W. RIDGE       0.0 19.8 23.1 32.3 45.6 58.9 69.7 73.1 69.8 62.7 52.4 37.3 23.6
MIN. W. RIDGE       0.0  1.1  3.6 15.2 27.1 37.0 46.6 51.5 49.3 42.3 33.6 23.2  9.2
PASSUMPSIC RIVER AT PASSUMPSIC,VERMONT     01135500     0
  0.0  0.0  0.0  .29  .06  .15  .50
PASSUMPSIC RIVER BELOW 1330 FEET ELEV.   L01135500     0
  0.0  0.0  0.0  .58  .12  .30  0.0
PASSUMPSIC RIVER ABOVE 1330 FEET ELEV.   H01135500     0
  0.0  0.0  0.0  0.0  0.0  0.0  1.0
    6     2    67     7                                                    43-9099
   99
    5    10    63 -2.5 -1.5                                                43-7054
    6    10    63  0.0  6.0                                                43-9099
    6    10    67  0.0  4.0                                                43-9099
   99
E07527 P
    1     7
    1     3     5     6    -4    -2    -7
```

B.3 EXAMPLES OF OUTPUT FROM MAT PROGRAM

MEAN AREAL TEMPERATURE FROM 10/53 THROUGH 9/71

STATION MEANS ARE USED TO ESTIMATE MISSING DATA GRID LENGTH= 1.1330 MILES

RESULTS OUTPUT ON TAPE1.

STA. RUN NO.	STATION NAME	X	Y	NWS STA. NO.	ELEVATION-FT.	FE MAX.	FE MIN.
1	MC INDOE FALLS,VT.	46.	37.	43- 5044	480.	0.0	0.0
2	MT. MANSFIELD,VT.	13.	53.	43- 5416	3950.	0.0	0.0
3	NEWPORT,VERMONT	40.	73.	43- 5542	766.	0.0	0.0
4	NORTH DANVILLE,VT.	44.	53.	43- 5632	1140.	0.0	0.0
5	ST. JOHNSBURY,VT.	48.	47.	43- 7054	699.	0.0	0.0
6	WEST BURKE,VERMONT	50.	60.	43- 9099	900.	0.0	0.0
7	WEST RIDGE-DUMMY	42.	51.	43-10000	1740.	0.0	0.0

STA. RUN NO.	MEANS JAN-DEC												
1	MAX	24.6	28.4	38.9	52.0	65.6	75.7	79.9	77.3	69.6	59.2	44.1	29.4
1	MIN	2.0	4.1	16.9	28.7	39.2	49.4	55.0	53.3	46.8	36.0	27.8	11.9
2	MAX	15.6	18.1	25.5	38.3	51.7	62.1	65.5	62.7	56.4	46.4	32.9	20.4
2	MIN	-.9	2.1	11.8	23.2	34.5	45.4	49.7	48.0	41.9	31.2	13.4	5.5
3	MAX	23.0	27.3	37.2	51.2	64.5	75.5	79.5	76.3	69.3	57.9	41.8	26.8
3	MIN	1.0	3.0	15.5	28.0	39.4	49.7	54.7	52.5	45.4	36.7	26.4	10.0
4	MAX	21.3	24.8	34.5	48.0	61.4	71.9	75.6	72.5	64.9	54.6	39.0	24.9
4	MIN	1.7	4.0	16.2	28.1	37.9	47.2	52.5	50.2	43.1	34.4	24.6	10.2
5	MAX	23.4	28.1	37.7	52.1	66.0	76.1	79.5	76.9	69.4	58.8	41.9	26.6
5	MIN	2.5	5.1	16.8	27.7	38.8	49.2	54.1	52.5	45.5	34.9	26.1	11.0
6	MAX	22.8	26.6	36.8	49.7	64.3	74.6	79.1	76.2	68.5	57.1	41.5	26.3
6	MIN	-.2	.9	14.5	28.2	38.5	48.8	53.8	51.7	45.0	35.1	27.0	10.4
7	MAX	19.8	23.1	32.3	45.6	58.9	69.7	73.1	69.8	62.7	52.4	37.3	23.6
7	MIN	1.1	3.5	15.2	27.1	37.0	46.6	51.5	49.3	42.3	33.6	23.2	9.2

STATION WEIGHTS FOR PASSUMPSIC RIVER AT PASSUMPSIC,VERMONT ID= 01135500

MC INDOE FALLS,VT.	0.000
MT. MANSFIELD,VT.	0.000
NEWPORT,VERMONT	0.000
NORTH DANVILLE,VT.	.290
ST. JOHNSBURY,VT.	.060
WEST BURKE,VERMONT	.150
WEST RIDGE-DUMMY	.500

STATION WEIGHTS FOR PASSUMPSIC RIVER BELOW 1330 FEET ELEV. ID=L01135500

MC INDOE FALLS,VT.	0.000
MT. MANSFIELD,VT.	0.000
NEWPORT,VERMONT	0.000
NORTH DANVILLE,VT.	.580
ST. JOHNSBURY,VT.	.120
WEST BURKE,VERMONT	.300
WEST RIDGE-DUMMY	0.000

STATION WEIGHTS FOR PASSUMPSIC RIVER ABOVE 1330 FEET ELEV. ID=H01135500

MC INDOE FALLS,VT.	0.000
MT. MANSFIELD,VT.	0.000
NEWPORT,VERMONT	0.000
NORTH DANVILLE,VT.	0.000
ST. JOHNSBURY,VT.	0.000
WEST BURKE,VERMONT	0.000
WEST RIDGE-DUMMY	1.000

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MAX-MIN TEMPERATURE DATA FROM NCC-NWSRFS TAPE FOR WEST BURKE,VERMONT
 NWS STA. 43-9099      10/63     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  50. 63. 75. 67. 47. 71. 74. 83. 57. 49. 64. 53. 51. 55. 70. 75. 74. 68. 75. 76. 76. 55. 55. 65. 77. 78. 71. 67. 59. 44. 40.
 MIN  26. 26. 35. 45. 30. 30. 36. 43. 26. 27. 31. 34. 26. 27. 29. 37. 37. 38. 43. 38. 38. 26. 26. 36. 38. 41. 45. 44. 40. 36. 34.
 NWS STA. 43-9099      11/63     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  48. 46. 40. 35. 42. 42. 43. 58. 57. 50. 46. 40. 42. 41. 40. 40. 37. 43. 50. 39. 48. 44. 54. 52. 34. 29. 42. 49. 35. 53.
 MIN  34. 40. 35. 21. 22. 30. 40. 47. 49. 43. 41. 41. 36. 34. 32. 35. 25. 30. 41. 33. 34. 45. 47. 34. 26. 18. 24. 20. 20. 38.
 NWS STA. 43-9099      12/63     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  50. 19. 27. 26. 25. 25. 23. 27. 40. 40. 32. 20. 16. 26. 25. 10.  8.  9. 15. 10.  5.  8. 18. 15. 26. 26. 10. 10. 10. 21. -2.
 MIN  11.  5.  7. 22.  6. -2. -1. 16. 16. 30. 16. -2.  8.  8. 13. -2.-11.-12. -2. -2. -9. -2. -8. -8. 17.  3.-13.-16. -9. -5.-22.
 NWS STA. 43-9099       1/64     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  11. 22. 34. 38. 34. 20. 27. 35. 28. 35. 34. 12.  6.  4.  8. 22. 25. 23. 33. 40. 43. 38. 35. 34. 36. 42. 35. 29. 18. 24. 26.
 MIN -22.-16. 24. 30. 16. -7. -4. -3. -2. -2. 10.-12.-12. -4.-19.-14. 10.  1. 16. 19. 29. 36. 10. 10. 34. 24. 18. 10.  5.  1.  7.
 NWS STA. 43-9099       2/64     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  33. 34. 28. 15. 33. 35. 35. 35. 31. 17. 19. 25. 35. 35. 30. 30. 25. 20. 34. 34. 27. 24. 18. 35. 34. 24. 31. 15. 34.
 MIN   5. 31.  6.  5.  7.  5.  5. 31. -1.-18.-19.-19.-10.  9. -6. -5.  6. -5. -5.  7. 20.  6. -9. -4.-12.-12.  6.-15.-15.
 NWS STA. 43-9099       3/64     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  31. 42. 45. 56. 54. 50. 32. 48. 38. 36. 28. 30. 35. 34. 44. 43. 29. 38. 18. 28. 38. 45. 45. 34. 45. 43. 35. 30. 40. 43. 34.
 MIN   6. 14. 24. 24. 26. 26. 14. 17. 32. 24. 24. 15. 20. 10. 19. 27.  6.  8.  9. 11. 17. 22. 26. 14. 14. 30. 29. 21. 21. 22. 11.
 NWS STA. 43-9099       4/64     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  26. 30. 40. 39. 28. 41. 47. 55. 50. 37. 53. 51. 63. 66. 52. 56. 51. 43. 59. 47. 44. 60. 41. 46. 44. 50. 65. 72. 70. 68.
 MIN  -2. -5.  4. 24.  0. 11. 11. 38. 36. 28. 28. 25. 31. 31. 45. 39. 27. 27. 36. 31. 32. 36. 42. 40. 40. 34. 32. 32. 33. 31.
 NWS STA. 43-9099       5/64     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  75. 73. 72. 76. 78. 78. 78. 85. 81. 73. 56. 50. 73. 71. 54. 70. 79. 70. 67. 78. 52. 64. 78. 82. 89. 64. 70. 65. 55. 53. 62.
 MIN  30. 34. 31. 34. 34. 36. 39. 47. 51. 54. 50. 42. 45. 46. 35. 35. 50. 43. 43. 45. 30. 30. 46. 59. 68. 45. 45. 45. 39. 38. 38.
 NWS STA. 43-9099       6/64     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  68. 66. 68. 70. 58. 61. 78. 75. 78. 61. 80. 70. 78. 78. 69. 67. 55. 66. 75. 88. 89. 84. 80. 88. 83. 72. 78. 70. 74. 80.
 MIN  40. 43. 36. 36. 44. 34. 40. 61. 51. 57. 45. 44. 43. 49. 44. 44. 46. 38. 38. 54. 60. 60. 46. 46. 62. 43. 43. 41. 43. 43.
 NWS STA. 43-9099       7/64     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  90. 84. 80. 79. 79. 70. 73. 73. 78. 80. 80. 85. 84. 76. 78. 81. 81. 87. 92. 80. 78. 90. 84. 86. 72. 75. 79. 84. 91. 88. 70.
 MIN  62. 52. 52. 62. 59. 60. 57. 58. 53. 53. 60. 61. 61. 62. 66. 55. 55. 56. 68. 51. 51. 66. 65. 65. 64. 60. 63. 61. 63. 50. 41.
 NWS STA. 43-9099       8/64     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  69. 59. 69. 73. 74. 65. 67. 81. 79. 69. 69. 80. 75. 64. 64. 62. 76. 75. 70. 67. 67. 68. 64. 63. 74. 79. 69. 74. 79. 84. 85.
 MIN  40. 45. 44. 41. 41. 55. 39. 39. 53. 48. 47. 53. 59. 42. 48. 47. 50. 58. 46. 46. 46. 51. 53. 58. 51. 52. 44. 43. 43. 57. 62.
 NWS STA. 43-9099       9/64     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  81. 63. 68. 68. 51. 67. 58. 75. 80. 65. 67. 67. 58. 65. 69. 56. 58. 60. 59. 65. 68. 69. 68. 78. 72. 55. 67. 69. 53. 54.
 MIN  60. 40. 39. 39. 53. 56. 45. 45. 45. 55. 60. 45. 31. 33. 28. 32. 32. 40. 31. 30. 33. 35. 38. 51. 48. 36. 36. 35. 30. 30.
 NWS STA. 43-9099      10/64     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  60. 61. 60. 64. 72. 46. 55. 42. 56. 60. 54. 41. 52. 46. 49. 72. 75. 68. 66. 47. 47. 44. 42. 40. 40. 54. 59. 65. 61. 57. 42.
 MIN  31. 31. 43. 35. 39. 24. 24. 18. 18. 33. 32. 22. 22. 42. 32. 32. 34. 34. 44. 42. 37. 34. 26. 27. 33. 29. 29. 36. 37. 39. 32.
 NWS STA. 43-9099      11/64     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  42. 51. 48. 51. 50. 39. 44. 45. 54. 49. 40. 35. 34. 56. 40. 34. 35. 35. 30. 35. 41. 40. 28. 32. 35. 52. 52. 34. 36. 38.
 MIN  21. 25. 23. 22. 22. 26. 42. 28. 27. 31. 25. 25. 38. 35. 22. 21. 28. 29.  8.  8. 18. 18. -1.  2. 16. 37. 37. 16. 16. 22.
 NWS STA. 43-9099      12/64     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  25. 15. 22. 29. 25. 28. 18. 17. 18. 15. 23. 35. 35. 40. 35. 24. 19. 36. 19. 20. 27. 25. 28. 36. 48. 31. 50. 35. 25. 19. 32.
 MIN  18.  7.  5. 19. 24. 21.  2.-11. -8. -1. -3.  3. 35. 35. 16. -8.-10. 22. -7.  5. 14.  1. 14. 31. 38. 41. 38. 26.  5.  2. 22.
 NWS STA. 43-9099       1/65     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  32. 24. 11. 25. 24. 34. 30. 20. 38. 43. 21. 25. 36. 30. 15. -4. -2.  4. 12. 18. 24. 19. 30. 10. 24. 28. 36. 33. 24.  9. 17.
 MIN  12.-13. -5. 14. -1. 11. -2. -7. 16. 15.  1.  1. 15. 16.-28.-29. -9.-16.-12. -9.  4. -1. -2.  3. 13.  6. 14. -6.-15.-18.-16.
 NWS STA. 43-9099       2/65     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  21. 17. 22. 18. 18. 13. 30. 43. 42. 25. 29. 40. 35. 24. 16. 33. 40. 29. 24.  8. 10. 25. 20. 12. 33. 42. 32. 25.
 MIN -15.-15.-12.-12.-12.-14. 16. 33. 21.  5. 13. 17. 17. -8. -7. -6. -4. -4. 11. -2.-12.  5.-14.-12.-11. 24.  7. -1.
 NWS STA. 43-9099       3/65     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  28. 34. 45. 50. 51. 52. 43. 45. 45. 48. 40. 25. 29. 32. 32. 32. 37. 35. 36. 39. 28. 30. 29. 31. 30. 36. 34. 28. 32. 30. 31.
 MIN   5. 13. 21. 25. 25. 31. 38. 35. 20. 20. 24.  3.  3.  9.  9.  4.  4. 11. 26. 10.  9.  5.  6.  1.  2.  4. 30.  2.  4.  8. 12.
 NWS STA. 43-9099       4/65     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  25. 28. 38. 38. 44. 49. 53. 46. 41. 44. 50. 35. 39. 45. 54. 59. 45. 42. 46. 54. 60. 60. 51. 40. 46. 57. 40. 45. 60. 65.
 MIN   2. -1. 15. 16. 18. 16. 24. 26. 36. 38. 23. 35. 36. 26. 26. 27. 36. 30. 26. 26. 28. 30. 25. 28. 20. 32. 35. 34. 27. 28.
 NWS STA. 43-9099       5/65     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  70. 58. 59. 73. 60. 64. 66. 64. 73. 78. 72. 76. 75. 57. 63. 78. 79. 68. 58. 65. 70. 74. 75. 60. 68. 77. 79. 77. 74. 65. 61.
 MIN  28. 31. 26. 27. 26. 26. 32. 32. 47. 58. 58. 45. 44. 28. 29. 35. 56. 56. 53. 48. 31. 32. 37. 30. 30. 35. 57. 52. 42. 40. 44.
 NWS STA. 43-9099       6/65     OB. TIME= 800.      TEMP. CORRECTION      MAX=  0.0      MIN=  6.0
 MAX  65. 64. 72. 60. 74. 79. 84. 86. 81. 84. 77. 68. 77. 49. 55. 70. 69. 76. 78. 78. 84. 84. 80. 85. 70. 64. 72. 72. 89. 82.
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MIN  36. 37. 33. 33. 36. 41. 54. 58. 54. 56. 41. 40. 47. 46. 39. 40. 40. 43. 55. 49. 56. 55. 50. 48. 40. 36. 42. 50. 51. 58.
NWS STA. 43-9099      7/65     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  68. 71. 81. 70. 75. 79. 65. 76. 78. 84. 79. 78. 74. 84. 83. 78. 83. 75. 76. 72. 61. 74. 78. 76. 84. 76. 74. 78. 72. 72. 74.
MIN  41. 40. 40. 48. 45. 48. 37. 38. 51. 50. 47. 45. 44. 44. 61. 45. 45. 63. 60. 47. 45. 42. 42. 55. 58. 47. 46. 46. 54. 43. 43.
NWS STA. 43-9099      8/65     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  78. 80. 72. 70. 75. 81. 88. 90. 81. 82. 83. 74. 81. 79. 86. 92. 86. 88. 85. 72. 70. 71. 76. 61. 72. 68. 62. 77. 78. 55. 55.
MIN  45. 56. 61. 44. 41. 40. 48. 62. 71. 58. 58. 45. 45. 55. 59. 66. 62. 62. 66. 60. 45. 50. 58. 45. 47. 57. 59. 61. 45. 40. 32.
NWS STA. 43-9099      9/65     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  58. 62. 68. 75. 77. 75. 76. 78. 65. 72. 82. 64. 68. 63. 60. 65. 60. 61. 65. 56. 76. 86. 89. 85. 62. 61. 68. 45. 57. 50.
MIN  34. 53. 40. 41. 40. 46. 48. 49. 43. 43. 59. 35. 35. 36. 50. 57. 36. 36. 55. 56. 60. 62. 62. 64. 55. 38. 37. 27. 26. 31.
NWS STA. 43-9099     10/65     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  59. 60. 53. 46. 36. 34. 43. 59. 55. 59. 62. 53. 57. 51. 55. 58. 47. 56. 56. 75. 75. 73. 49. 59. 58. 46. 56. 39. 35. 33. 50.
MIN  31. 47. 31. 31. 30. 30. 24. 33. 41. 40. 48. 44. 38. 34. 32. 33. 26. 27. 27. 47. 45. 44. 47. 45. 37. 35. 37. 31. 28. 24. 24.
NWS STA. 43-9099     11/65     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  52. 36. 28. 38. 33. 36. 48. 46. 43. 34. 38. 44. 45. 49. 38. 31. 38. 42. 25. 31. 31. 34. 39. 33. 35. 33. 35. 36. 37. 31.
MIN  35. 20. 21. 23. 22. 21. 37. 31. 29. 17. 15. 30. 35. 37. 24. 24. 33. 25. 24. 10. 17. 31. 34. 32. 15. 18. 31. 32. 23. 21.
NWS STA. 43-9099     12/65     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  28. 34. 36. 40. 38. 35. 34. 21. 29. 32. 37. 31. 35. 32. 35. 36. 37. 34. 31. 23. 10. 22. 28. 34. 35. 36. 10. 15. 24. 31. 35.
MIN  15. 17. 32. 33. 35. 30. 21.  4.  8.  7. 14. 14. 24. 28. 36. 35. 31. 25. 17. -9.-11. -2.  6. 20. 28. 11. -4. -7.  2. 11. 23.
NWS STA. 43-9099      1/66     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX 999. 50. 26. 35. 28. 33. 32. 27. 12. 10. 26. 22.  0. 12. 21. 18. 12. 20. 25. 20. 34. 32. 34. 29. 20. 20. 15. 22.  8. 18. 35.
MIN 999. 16. 17. 15.  6.  9. 16. 14.  0. -7.  5. -5.-19.-19.  2.-16. -4. 16. 21.  6. 10. 14. 11. 26.  2.-14.-14. -9. -9. -9.  6.
NWS STA. 43-9099      2/66     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  18. 25. 36. 34. 35. 28. 22. 24. 28. 32. 46. 52. 42. 34. 35. 28. 29. 24. 16.  6.  5. 12. 22. 32. 38. 29. 35. 43.
MIN   5.  7. 10.  8. 17.  5.-15.-13.-12.  5. 17. 28. 20. 21. 11.  1.  2.  2. -8.-24.-17. -4. 16. -4. -2. 23.  1. 12.
NWS STA. 43-9099      3/66     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  44. 45. 35. 43. 47. 41. 40. 35. 28. 38. 44. 28. 31. 32. 44. 20. 35. 45. 56. 47. 44. 45.999. 47. 52. 39. 38. 25. 22. 31. 34.
MIN  16. 35. 29. 22. 26. 37. 26.  8.  0.  0.  9.  2.  5.  5.  5. -2. -2.  1. 33. 35. 36. 24. 25. 38. 41. 15. 16.  7.  6.  6. 13.
NWS STA. 43-9099      4/66     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  49. 35. 42. 41. 40. 47. 48. 50. 40. 40. 44. 41. 46. 47. 54. 58. 58. 47. 55. 63. 47. 60. 55. 63. 43. 45. 38. 42. 40. 54.
MIN  30. 28. 29. 26. 30. 31. 25. 25. 36. 30. 33. 32. 32. 31. 24. 24. 27. 24. 25. 26. 40. 40. 30. 34. 41. 30. 23. 22. 27. 26.
NWS STA. 43-9099      5/66     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  66. 60. 48. 59. 46. 61. 53. 42. 48. 39. 41. 50. 54. 48. 70. 75. 58. 62. 63. 58. 74. 71. 71. 80. 85. 80. 80. 84. 66. 72. 69.
MIN  29. 30. 21. 22. 25. 25. 26. 25. 31. 31. 30. 27. 31. 30. 34. 49. 47. 46. 47. 54. 44. 39. 37. 37. 37. 39. 39. 43. 56. 39. 32.
NWS STA. 43-9099      6/66     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  58. 62. 68. 78. 79. 77. 85. 75. 74. 58. 54. 65. 75. 81. 86. 76. 60. 75. 75. 79. 82. 70. 80. 85. 84. 64. 80. 85. 82. 85.
MIN  33. 33. 33. 36. 60. 63. 63. 54. 41. 41. 46. 35. 41. 42. 57. 52. 53. 45. 45. 53. 53. 42. 43. 52. 66. 58. 60. 55. 56. 51.
NWS STA. 43-9099      7/66     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  75. 82. 86. 93. 79. 82. 78. 82. 75. 82. 85. 82. 78. 83. 76. 71. 78. 84. 81. 80. 70. 70. 76. 86. 87. 89. 75. 75. 62. 72. 75.
MIN  46. 47. 64. 67. 46. 46. 61. 53. 45. 51. 62. 59. 50. 55. 45. 41. 42. 54. 55. 54. 41. 41. 47. 56. 61. 64. 45. 46. 56. 57. 43.
NWS STA. 43-9099      8/66     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  83. 83. 78. 64. 79. 81. 82. 87. 88. 88. 82. 83. 74. 70. 75. 78. 80. 74. 82. 80. 74. 75. 65. 69. 64. 72. 72. 73. 70. 78. 82.
MIN  46. 46. 56. 43. 43. 49. 54. 62. 59. 61. 55. 55. 59. 43. 43. 53. 64. 55. 58. 45. 45. 50. 59. 61. 47. 49. 48. 50. 40. 40. 56.
NWS STA. 43-9099      9/66     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  76. 80. 79. 67. 56. 72. 74. 68. 74. 77. 78. 64. 71. 72. 68. 62. 61. 70. 75. 60. 64. 61. 62. 56. 50. 56. 56. 58. 60. 62.
MIN  42. 44. 56. 56. 51. 46. 45. 45. 42. 42. 51. 34. 34. 38. 48. 34. 34. 38. 48. 35. 30. 30. 53. 33. 35. 33. 31. 30. 35. 34.
NWS STA. 43-9099     10/66     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  60. 54. 55. 60. 62. 58. 48. 67. 75. 77. 64. 61. 42. 50. 58. 68. 57. 40. 44. 45. 45. 57. 63. 62. 61. 58. 52. 59. 66. 55. 32.
MIN  45. 34. 30. 31. 38. 40. 32. 34. 37. 34. 33. 31. 29. 28. 36. 38. 41. 38. 38. 40. 33. 27. 27. 35. 26. 23. 22. 24. 28. 26. 15.
NWS STA. 43-9099     11/66     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  44. 58. 65. 65. 41. 42. 40. 45. 46. 53. 62. 50. 48. 32. 29. 31. 30. 38. 48. 27. 38. 41. 45. 48. 40. 50. 53. 52. 60. 55.
MIN  21. 33. 50. 30. 23. 23. 35. 36. 41. 47. 50. 44. 31. 18. 18. 14. 19. 33. 30. 12. 10. 10. 11. 14. 30. 38. 34. 37. 43. 32.
NWS STA. 43-9099     12/66     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  35. 35. 22. 15. 18. 22. 28. 34. 36. 48. 56. 41. 25. 29. 26. 28. 29. 41. 41. 15. 23. 29. 26. 20. 25. 24. 22. 20. 21. 30. 22.
MIN  35. 23.  6.  0.  0.  1. 20. 29. 36. 37. 40. 25. 11. 11. 29.  8. 14. 31. 10.  2.  6. 16. 18.  0.  4. 14. -1. -4.  0. 18. -2.
NWS STA. 43-9099      1/67     OB. TIME= 800.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  22. 28. 33. 32. 36. 35. 10. 29. 38. 31. 29. 25. 24. 39. 37. 38. 18. 35.  2. 10. 23. 40. 42. 40. 50. 37. 36. 32. 32. 20. 15.
MIN  -2. 17. 22. 18. 30.  1.-14. -4. 30.  1.  4.  3.  3. 15. 26.  7. -4.  1.-25.-20.  5.  6. 29. 35. 30. 34. 27. 25. 21. 10. -6.
NWS STA. 43-9099      2/67     OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  23. 32. 31. 17. 28. 29.  5.  2. 18. 30. 34. 38.-10. 12. 31. 41. 38. 10. 12. 16. 22. 28. 31. 35. 21.  9. 19. 24.
MIN  -7. 19.  3.-13. -4. -3.-19.-24.-24. -2.  7.-14.-31.-31.-13. 25. -9.-12.-16.-13. -5. -9. -9. 16.  2. -4.-14.-11.
NWS STA. 43-9099      3/67     OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  38. 12. 22. 42. 24. 28.999. 36. 28. 40. 55. 52. 27. 36. 36. 38. 28. 12. 20. 30. 34. 38. 34. 46. 40. 42. 43. 50. 51. 44. 47.
MIN  12.-16.-12. 16.-12. 10.999.  2.-11.-11. 11. 18.  4.  9. 18. 18. -9.-12.-20. -9. -2. -3. 20. 20. 21. 26. 28. 24. 24. 37. 28.
NWS STA. 43-9099      4/67     OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  55. 69. 57. 52. 40. 56. 38. 36. 46. 58. 45. 32. 34. 62. 61. 38. 35. 43. 46. 44. 47. 55. 44. 42. 43. 44. 56. 59. 58. 56.
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MIN  32. 34. 45. 19. 19. 32. 34. 34. 22. 36. 19. 17. 16. 17. 28. 36. 36. 36. 36. 36. 26. 28. 36. 38. 26. 24. 25. 30. 27. 29.
NWS STA. 43-9099      5/67      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  65. 78. 71. 48. 58. 54. 54. 56. 43. 55. 43. 53. 49. 55. 60. 45. 57. 62. 56. 70. 63. 55. 54. 64. 70. 48. 48. 59. 61. 61. 59.
MIN  32. 31. 36. 31. 31. 27. 24. 31. 37. 38. 31. 32. 31. 34. 43. 44. 30. 30. 39. 48. 35. 33. 33. 32. 32. 37. 41. 44. 32. 31. 37.
NWS STA. 43-9099      6/67      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  62. 75. 81. 88. 89. 89. 85. 84. 69. 85. 80. 83. 72. 78. 62. 78. 88. 82. 72. 73. 69. 78. 78. 82. 85. 83. 75. 81. 85. 80.
MIN  32. 34. 44. 48. 54. 51. 54. 56. 54. 55. 54. 61. 60. 60. 59. 59. 66. 61. 46. 45. 46. 61. 64. 54. 59. 55. 46. 46. 47. 46.
NWS STA. 43-9099      7/67      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  68. 85. 86. 76. 75. 70. 71. 80. 83. 78. 79. 84. 82. 81. 83. 71. 75. 78. 80. 84. 88. 88. 84. 84. 86. 83. 87. 83. 70. 84. 84.
MIN  46. 60. 66. 48. 52. 48. 43. 43. 56. 66. 51. 51. 55. 54. 54. 61. 56. 55. 56. 57. 59. 62. 61. 65. 67. 59. 53. 53. 64. 57. 56.
NWS STA. 43-9099      8/67      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  80. 78. 80. 75. 78. 78. 78. 79. 81. 78. 76. 55. 75. 75. 78. 82. 82. 85. 84. 74. 78. 78. 74. 70. 77. 78. 84. 75. 78. 78. 78.
MIN  56. 46. 46. 66. 60. 52. 46. 46. 48. 68. 59. 43. 50. 52. 51. 53. 53. 55. 55. 66. 60. 52. 41. 38. 43. 48. 51. 64. 56. 56. 56.
NWS STA. 43-9099      9/67      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  6.0
MAX  56. 65. 56. 59. 71. 75. 68. 69. 80. 77. 53. 55. 74. 78. 78. 81. 79. 89. 78. 69. 75. 69. 59. 52. 58. 46. 67. 76. 73. 73.
MIN  37. 36. 41. 41. 44. 51. 33. 33. 47. 51. 31. 31. 33. 35. 38. 42. 48. 51. 47. 35. 35. 60. 48. 40. 41. 34. 37. 46. 65. 66.
NWS STA. 43-9099      10/67     OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  77. 58. 64. 80. 66. 61. 47. 48. 52. 59. 62. 55. 49. 48. 48. 61. 60. 68. 67. 56. 44. 53. 46. 58. 64. 58. 50. 53. 51. 38. 38.
MIN  45. 42. 43. 40. 46. 49. 34. 27. 32. 54. 44. 44. 32. 29. 29. 46. 53. 51. 55. 37. 30. 35. 30. 29. 29. 32. 42. 39. 30. 26. 26.
NWS STA. 43-9099      11/67     OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  50. 63. 56. 57. 53. 43. 39. 39. 38. 36. 35. 45. 48. 42. 28. 28. 24. 29. 35. 34. 32. 39. 31. 36. 37. 33. 28. 42. 30. 24.
MIN  27. 38. 49. 35. 26. 22. 21. 22. 16. 13. 14. 14. 40. 21. 20. 18.  6. 14. 30. 26.  8.  8. 18. 29. 15. 24. 24. 23. 13.  4.
NWS STA. 43-9099      12/67     OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  24. 21. 30. 34. 28. 26. 34. 32. 34. 29. 24. 33. 43. 45. 33. 25. 20. 30. 34. 42. 40. 40. 42. 23. 16. 34. 33. 18. 28. 22. 22.
MIN  -1. -3. -3. 22. 22.  4.  6. 24. 32. 16. 11. 12. 38. 34. 23. 13. 13. 15. 23. 36. 17. 17. 27.  8.  4.  6.-10.-10. 16. -4. -7.
NWS STA. 43-9099      1/68      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  21.  8.  8. 15. 22.  8. 16. 10.-16. -8. -2. -2. 10. 22. 33. 33. -1. 12. 26. 35. 35. 35. 37. 32. 17. 12. 21. 33. 31. 32. 35.
MIN  -6.-27.-27.  3. 11.-18. -3.-16.-30.-28.-28.-30.-30.-16.-11. -4.-26.-26. -5. 14. 24. -3. -5. 13.-10. -5.  1. 10. 24. 21. 24.
NWS STA. 43-9099      2/68      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  34. 35. 44. 39. 24. 18. 22. 23. 18. 22. 18.  5. 19.  5. 20. 18. 19. 25. 12.  8. 10. -1. 19. 15. 26. 27. 30. 35. 42.
MIN  10. 10. 37. 23. 13.  7. 13. -2.-12.-12.  4.-14.-14.-13.  3. -8. -8. -1. -5. -7.-21.-19. -8.-18.-17.-13.-14.-11. 10.
NWS STA. 43-9099      3/68      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  42. 30. 28.  9. 28. 26. 30. 23. 37. 53. 40. 35. 32. 30. 26. 42. 54. 43. 51. 62. 50. 42. 38. 41. 30. 36. 53. 55. 55. 61. 48.
MIN  30. 21.  5.  0.  5. -6.-16.-16.  4. 21. 32.  1.  0.  4. -6. -4. 37. 38. 35. 37. 38. 39. 36. 28. 15. 15. 24. 29. 29. 35. 25.
NWS STA. 43-9099      4/68      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  64. 48. 45. 52. 56. 50. 45. 59. 58. 46. 51. 54. 70. 80. 83. 59. 57. 56. 68. 69. 56. 72. 68. 67. 51. 45. 48. 44. 52. 58.
MIN  37. 20. 20. 27. 36. 18. 21. 28. 32. 35. 32. 25. 29. 34. 31. 32. 29. 31. 32. 34. 38. 47. 40. 37. 43. 39. 34. 33. 26. 26.
NWS STA. 43-9099      5/68      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  68. 60. 58. 64. 54. 53. 53. 50. 69. 71. 65. 70. 60. 60. 75. 78. 81. 56. 59. 52. 46. 62. 64. 65. 68. 58. 58. 71. 78. 67. 70.
MIN  32. 38. 30. 30. 36. 41. 25. 24. 24. 49. 33. 33. 38. 32. 32. 38. 39. 49. 48. 46. 44. 38. 37. 33. 34. 35. 32. 32. 34. 37. 54.
NWS STA. 43-9099      6/68      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  69. 76. 65. 71. 72. 81. 81. 78. 78. 67. 64. 60. 72. 72. 78. 82. 62. 59. 59. 60. 58. 66. 68. 63. 62. 71. 70. 63. 58. 76.
MIN  55. 55. 58. 52. 46. 50. 57. 49. 52. 55. 54. 55. 59. 49. 50. 52. 54. 52. 47. 46. 45. 44. 47. 53. 54. 56. 54. 52. 52. 54.
NWS STA. 43-9099      7/68      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  82. 90. 83. 74. 78. 76. 72. 75. 85. 88. 70. 83. 82. 82. 82. 89. 89. 88. 92. 90. 74. 79. 88. 76. 68. 76. 78. 88. 78. 66. 70.
MIN  60. 62. 55. 52. 53. 54. 46. 52. 53. 64. 48. 49. 58. 58. 65. 66. 66. 68. 71. 62. 48. 55. 58. 51. 53. 48. 48. 48. 47. 46. 41.
NWS STA. 43-9099      8/68      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  80. 76. 78. 81. 82. 88. 78. 78. 79. 78. 72. 64. 74. 81. 84. 67. 72. 79. 66. 78. 70. 71. 59. 78. 78. 88. 68. 60. 60. 65. 70.
MIN  46. 57. 48. 51. 56. 56. 61. 52. 52. 56. 50. 43. 41. 48. 45. 39. 39. 43. 37. 38. 58. 47. 38. 38. 63. 58. 42. 42. 42. 42. 43.
NWS STA. 43-9099      9/68      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  74. 81. 81. 74. 74. 74. 64. 76. 75. 78. 76. 63. 65. 52. 62. 72. 79. 80. 79. 82. 85. 84. 75. 76. 74. 72. 69. 67. 61. 53.
MIN  44. 49. 56. 49. 49. 51. 59. 40. 41. 43. 56. 50. 47. 48. 37. 38. 41. 55. 47. 48. 50. 52. 51. 47. 50. 57. 52. 45. 45. 33.
NWS STA. 43-9099      10/68     OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  51. 78. 76. 68. 57. 47. 52. 47. 44. 59. 54. 58. 63. 61. 65. 72. 78. 78. 78. 65. 62. 49. 68. 58. 59. 52. 43. 48. 46. 44. 40.
MIN  36. 45. 48. 43. 38. 31. 31. 44. 36. 32. 32. 40. 33. 32. 31. 42. 42. 43. 48. 49. 42. 42. 34. 31. 31. 44. 36. 37. 36. 36. 35.
NWS STA. 43-9099      11/68     OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  34. 45. 48. 49. 50. 51. 48. 43. 38. 39. 36. 39. 35. 35. 28. 33. 32. 29. 39. 40. 29. 30. 38. 35. 42. 36. 29. 31. 34. 39.
MIN  24. 24. 38. 28. 24. 25. 26. 36. 34. 34. 34. 23. 32. 30. 18. 27. 18. 23. 31. 26. 18. 16. 14. 14. 35. 26. 14. 18. 19. 24.
NWS STA. 43-9099      12/68     OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  26. 29. 34. 38. 37. 38. 30. 29. 24.  5.  6. 12. 36. 43. 36. 16. 12. 15. 28. 28. 31. 32. 32. 35. 25. -8. -8.  4. 34. 30. 15.
MIN   8. 13. 29. 28. 29. 29. 15.  6.  7. -1.-16.-16.  9. 34. 18.  9.  9.  9.  6.  4. 24. 27. 27. 28. -4.-17.-26.-25.  7. -4.-11.
NWS STA. 43-9099      1/69      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  23. 20. 15. 21. 20. 18. 32. 34. 20. 16. 22. 15. 22. 24. 22. 24. 28. 27. 38. 35. 31. 34. 41. 41. 45. 32. 18.  8. 18. 24. 33.
MIN  -2.  8. -5. -5. -8.-11.-11. 22. -6. -1. -6. -2.  5. 15. 19. -8. -8. 12. 28.  5. -4. -4.  3.  3. 24. 15.  2.-16.-16.  9. 26.
NWS STA. 43-9099      2/69      OB. TIME= 700.     TEMP. CORRECTION     MAX=  0.0     MIN=  4.0
MAX  35. 29. 39. 30. 12.  5. 20. 22. 29. 30. 22. 31. 36. 30. 10. 18. 23. 32. 38. 36. 43. 39. 46. 44. 35. 28. 34. 29.
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MIN  22. 21. 22. 14.  0. -6. -8. -7. -7. 15.  3.  3. 16.  9.  6. -6.-11.-11. -2. 27. 15. 12. 15. 21. 27. 27. 22.  7.
NWS STA. 43-9099        3/69       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  36. 43. 41. 34. 29. 15. 20. 23. 27. 30. 28. 24. 20. 35. 37. 37. 34. 36. 46. 45. 42. 36. 37. 50. 53. 41. 44. 31. 45. 39. 28.
MIN  -3. -1. 16. 17.-10.-19.-16. -4.  5. 16. 19. 12. 16. 24. 31. 21. 10. 17. 29. 34. 36. 33. 16. 19. 26. 36. 28. 12. 19. 18.  7.
NWS STA. 43-9099        4/69       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  31. 41. 38. 37. 52. 44. 44. 55. 43. 53. 48. 42. 45. 51. 65. 71. 41. 56. 43. 40. 42. 54. 41. 50. 44. 54. 51. 70. 73. 44.
MIN   1. 10.  1. 10. 25. 34. 18. 26. 16. 20. 35. 20. 21. 31. 30. 32. 40. 40. 34. 23. 22. 28. 42. 35. 35. 28. 38. 40. 38. 39.
NWS STA. 43-9099        5/69       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  58. 58. 67. 63. 58. 51. 58. 56. 59. 64. 53. 55. 58. 54. 54. 60. 78. 84. 55. 64. 67. 56. 65. 60. 55. 66. 51. 64. 75. 75. 74.
MIN  28. 27. 33. 32. 27. 29. 28. 32. 42. 41. 33. 40. 39. 38. 34. 39. 47. 50. 50. 58. 46. 35. 42. 48. 49. 35. 27. 33. 46. 49. 44.
NWS STA. 43-9099        6/69       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  64. 78. 85. 74. 62. 73. 66. 72. 69. 72. 83. 82. 88. 89. 84. 66. 64. 75. 79. 78. 68. 70. 76. 61. 68. 64. 79. 91. 88. 75.
MIN  36. 46. 63. 43. 37. 43. 50. 49. 38. 41. 42. 54. 59. 65. 64. 59. 43. 45. 49. 60. 43. 43. 54. 54. 55. 44. 49. 67. 61. 49.
NWS STA. 43-9099        7/69       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  80. 78. 72. 75. 80. 76. 64. 68. 74. 75. 66. 78. 75. 71. 75. 88. 92. 87. 85. 76. 78. 77. 78. 82. 80. 76. 63. 75. 75. 80. 80.
MIN  53. 44. 46. 44. 52. 52. 39. 37. 39. 45. 54. 62. 60. 63. 52. 57. 67. 64. 49. 51. 61. 62. 46. 47. 47. 48. 60. 62. 66. 71. 66.
NWS STA. 43-9099        8/69       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  84. 84. 82. 82. 75. 75. 83. 83. 82. 77. 70. 73. 79. 80. 83. 85. 87. 78. 80. 75. 66. 64. 69. 80. 84. 79. 64. 70. 78. 78. 81.
MIN  60. 62. 65. 59. 62. 61. 63. 60. 62. 58. 59. 52. 49. 54. 63. 63. 65. 63. 63. 43. 43. 37. 40. 49. 55. 48. 38. 39. 56. 48. 49.
NWS STA. 43-9099        9/69       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  87. 87. 72. 74. 80. 80. 79. 78. 63. 61. 58. 55. 68. 67. 74. 78. 76. 63. 58. 62. 66. 68. 72. 73. 71. 59. 55. 65. 57. 51.
MIN  60. 61. 50. 51. 51. 52. 67. 61. 56. 53. 38. 42. 52. 44. 46. 57. 57. 37. 31. 31. 32. 36. 39. 44. 46. 51. 52. 43. 47. 32.
NWS STA. 43-9099       10/69       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  57. 61. 63. 60. 50. 61. 71. 69. 71. 62. 69. 66. 69. 59. 62. 51. 58. 52. 52. 56. 56. 42. 36. 29. 40. 35. 48. 48. 39. 40. 49.
MIN  37. 38. 42. 46. 29. 29. 32. 43. 38. 31. 31. 34. 44. 46. 28. 24. 24. 34. 30. 32. 42. 34. 26. 14. 14. 36. 35. 25. 20. 20. 20.
NWS STA. 43-9099       11/69       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  51. 48. 52. 61. 61. 51. 50. 57. 61. 59. 51. 46. 48. 45. 44. 42. 34. 40. 48. 50. 38. 23. 27. 30. 32. 31. 38. 27. 30. 37.
MIN  21. 36. 43. 48. 46. 44. 43. 48. 49. 44. 44. 44. 39. 28. 32. 22. 24. 23. 34. 34. 21.  8.  8. 30.  4.  4. 23.  0.  0. 27.
NWS STA. 43-9099       12/69       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  31. 33. 18. 25. 20. 23. 23. 28. 38. 38. 43. 52. 40. 35. 32. 28. 23. 22. 22. 28. 24. 26. 28.  5. 10. 12. 31. 31. 24. 24. 18.
MIN  16. 13.  4. 12. 16. 13. -2.  0. 27. 36. 36. 41. 32. 14. 16. 22. 19. 18. 17. 22. 11. 16.  2. -1.-20.-20. 13. 24. 16. -1. -1.
NWS STA. 43-9099        1/70       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  18. 14. 18. 18. 13. 18. 21. 16. 12. 15. 10.  9. 10. 11.  5.  5. 18. 29. 17.  5. 11.  3.  5.  9. 14. 20. 29. 28. 35. 38. 21.
MIN -13.-12.-15.-16.-18.-18. -6.-16.-15. -3.  3.-17.-16.  0. -6.-16.-14. 14.-22.-24.-24.-13.-21.-17.-16.  4. 12.  6. 12. 24.-11.
NWS STA. 43-9099        2/70       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  25. 42. 45. 42.  5. 16. 32. 36. 41. 41. 44. 46. 18. 10. 16. 21. 21. 24. 39. 30. 21. 24. 31.  8. 22. 29.  7. 27.
MIN -11. 18. 22.  9.-18. -8.  6.  4.  2.  3. 33. 12.  0.-19.-19.  2. -2.  2.  8.-12. -5.  3.  8. -6.  3.-14.-14.-11.
NWS STA. 43-9099        3/70       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  34. 28. 37. 33. 40. 35. 28. 37. 26. 21. 22. 30. 36. 31. 35. 31. 31. 37. 47. 51. 51. 38. 49. 40. 43. 40. 42. 38. 40. 27. 35.
MIN  19. 20.  2. -4. -4. 27. 19. 19. -5. -5. 15. 22. 20. 19. 22. -4. -4.  4.  6.  9. 11. 34. 36. 34. 36. 18. 22. 20. 22.  8. 10.
NWS STA. 43-9099        4/70       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  42. 45. 38. 32. 38. 38. 45. 45. 55. 64. 41. 34. 46. 50. 59. 55. 62. 64. 47. 45. 44. 48. 51. 53. 49. 58. 71. 78. 73. 71.
MIN  14. 18. 34. 26. 13.  8. 12. 24. 31. 31. 28. 29. 31. 24. 26. 26. 34. 40. 30. 24. 29. 40. 34. 41. 43. 31. 34. 36. 39. 34.
NWS STA. 43-9099        5/70       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  78. 87. 74. 52. 69. 69. 45. 45. 60. 66. 83. 75. 67. 65. 67. 70. 65. 55. 58. 75. 58. 77. 73. 68. 60. 51. 63. 58. 58. 72. 77.
MIN  39. 58. 46. 33. 34. 45. 35. 36. 41. 42. 52. 50. 46. 49. 34. 33. 52. 50. 44. 46. 38. 41. 47. 39. 37. 45. 47. 37. 31. 34. 43.
NWS STA. 43-9099        6/70       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  85. 84. 88. 72. 72. 75. 66. 69. 88. 84. 85. 82. 74. 64. 75. 81. 80. 81. 80. 80. 58. 72. 74. 78. 85. 64. 72. 56. 70. 76.
MIN  53. 63. 64. 52. 52. 54. 56. 51. 53. 52. 54. 48. 39. 35. 39. 43. 52. 60. 62. 53. 51. 49. 46. 44. 48. 36. 42. 44. 40. 44.
NWS STA. 43-9099        7/70       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  63. 78. 68. 80. 80. 74. 78. 81. 85. 87. 85. 82. 76. 73. 79. 74. 78. 82. 80. 78. 82. 73. 76. 85. 89. 90. 88. 90. 91. 89. 92.
MIN  54. 58. 61. 62. 59. 60. 48. 50. 57. 60. 63. 53. 47. 46. 48. 67. 59. 56. 45. 50. 65. 45. 48. 51. 55. 61. 60. 60. 61. 62. 64.
NWS STA. 43-9099        8/70       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  86. 83. 82. 78. 70. 77. 79. 82. 85. 88. 88. 83. 78. 88. 88. 89. 89. 80. 75. 81. 76. 72. 70. 61. 79. 75. 82. 70. 75. 70. 68.
MIN  72. 66. 58. 56. 45. 47. 48. 49. 51. 54. 55. 50. 55. 57. 58. 59. 63. 48. 39. 44. 63. 45. 49. 58. 48. 52. 57. 45. 46. 41. 47.
NWS STA. 43-9099        9/70       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  64. 59. 65. 65. 77. 64. 58. 63. 66. 64. 70. 67. 75. 73. 63. 52. 68. 61. 59. 58. 74. 71. 88. 70. 75. 78. 78. 59. 61. 53.
MIN  43. 40. 35. 37. 62. 56. 54. 53. 51. 57. 48. 38. 38. 44. 45. 49. 44. 44. 52. 44. 42. 42. 66. 48. 48. 56. 58. 36. 38. 45.
NWS STA. 43-9099       10/70       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  55. 58. 55. 63. 53. 51. 63. 74. 76. 80. 75. 60. 65. 66. 70. 61. 45. 39. 54. 46. 55. 53. 60. 61. 53. 52. 58. 52. 55. 56. 57.
MIN  39. 39. 42. 37. 38. 30. 32. 49. 47. 44. 44. 59. 62. 61. 63. 44. 32. 26. 26. 21. 21. 32. 46. 56. 49. 48. 42. 21. 22. 21. 21.
NWS STA. 43-9099       11/70       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  55. 60. 65. 51. 53. 42. 44. 51. 44. 51. 50. 55. 53. 52. 44. 37. 35. 32. 41. 41. 46. 41. 45. 35. 26. 28. 30. 34. 35. 36.
MIN  21. 34. 36. 26. 28. 33. 36. 22. 18. 18. 34. 44. 39. 44. 39. 38. 24. 24. 24. 36. 39. 31. 35. 14. 13.  9. 13. 32. 36. 35.
NWS STA. 43-9099       12/70       OB. TIME= 700.       TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  38. 40. 51. 45. 30. 23. 24. 14. 10. 28. 20. 13. 12. 20. 24. 18. 21. 30. 23. 29. 29. 10.  6. 22. 24. 15. 19. 20. 11. 16.  9.
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MIN  24. 24. 24. 30. 16. 14. 13.-12. -5.  9.  9. -9. -9. 15. -4.-14.-14. 19. 19. 21.  4.-24.-21.  9.-10.-10. 13. 13.  9.-10. -1.
NWS STA. 43-9099      1/71      OB. TIME= 700.      TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  20. 16. 26. 29. 33. 35. 26. 22.  5. 12. 20. 32. 20.  5. 18. 21.  1.  2.  2.  1.  5. 26. 30. 31. 35. 40. 35.  9.  2. 23. 28.
MIN  -5.  0. 15. -1.  9. 26. 21.-11.-24.-24. -2. 20.-27.-26.  0. -6.-27.-27.-28.-30.-28.-18. -2.  1.  8. 19. 11.-10.-16. -9. -9.
NWS STA. 43-9099      2/71      OB. TIME= 700.      TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  18.  9. -4.  8. 18. 29. 37. 32. 41. 34. 20. 25. 38. 44. 35. 26. 25. 31. 42. 32. 31. 30. 32. 30. 31. 34. 44. 38.
MIN -27.-27.-22.-25.-24. 13.  7.  6. 30. -5. -5. -1. 29. 33.  0. -4. -8. -8. 29. 14. 22. 21.  6. 20.  5. 17. 23. 36.
NWS STA. 43-9099      3/71      OB. TIME= 700.      TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  41. 34. 32. 32. 29. 25. 36. 34. 31. 18. 34. 33. 34. 44. 48. 47. 45. 31. 30. 38. 40. 34. 36. 34. 28. 27. 33. 41. 41. 43. 39.
MIN  29. 12.  5.  9. 21.  4.  7. 19. 16. -2. -1. 25. -4. -2. 32. 31. 26.  6.  4.  6. 29. 26.  0.  2. 14. -3. -1.  3. 23. 29. 21.
NWS STA. 43-9099      4/71      OB. TIME= 700.      TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  35. 46. 48. 49. 38. 42. 48. 38. 33. 52. 49. 52. 61. 54. 34. 36. 41. 44. 48. 56. 56. 46. 40. 39. 56. 49. 45. 49. 58. 45.
MIN   8. 18. 35. 29. 15. 13. 21. 18.  9. 15. 36. 25. 30. 36. 24. 24. 19. 28. 36. 31. 35. 36. 35. 26. 34. 36. 35. 31. 34. 39.
NWS STA. 43-9099      5/71      OB. TIME= 700.      TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  55. 53. 53. 47. 44. 55. 54. 63. 70. 64. 75. 80. 78. 50. 52. 75. 68. 63. 81. 89. 84. 59. 54. 53. 65. 64. 62. 56. 63. 79. 79.
MIN  34. 35. 38. 42. 40. 31. 33. 29. 32. 34. 36. 38. 44. 38. 28. 31. 44. 42. 45. 54. 60. 51. 33. 30. 33. 52. 50. 49. 35. 38. 45.
NWS STA. 43-9099      6/71      OB. TIME= 700.      TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  63. 68. 78. 71. 71. 63. 72. 89. 79. 68. 64. 73. 78. 76. 76. 73. 80. 82. 87. 86. 89. 70. 79. 82. 76. 78. 72. 75. 80. 84.
MIN  33. 33. 38. 53. 34. 34. 42. 51. 54. 37. 34. 35. 48. 47. 51. 46. 52. 49. 53. 56. 63. 53. 55. 51. 48. 52. 46. 45. 49. 57.
NWS STA. 43-9099      7/71      OB. TIME= 700.      TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  92. 82. 73. 69. 80. 86. 78. 79. 82. 86. 81. 71. 72. 78. 70. 78. 80. 82. 70. 74. 70. 79. 82. 86. 83. 82. 87. 78. 80. 72. 80.
MIN  66. 57. 43. 41. 48. 54. 59. 53. 54. 51. 50. 41. 40. 44. 52. 49. 53. 53. 52. 53. 48. 47. 49. 59. 63. 61. 64. 47. 48. 59. 62.
NWS STA. 43-9099      8/71      OB. TIME= 700.      TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  82. 81. 82. 70. 70. 71. 80. 71. 84. 85. 88. 81. 70. 81. 85. 62. 73. 82. 84. 89. 79. 73. 78. 55. 63. 70. 78. 70. 67. 75. 75.
MIN  62. 62. 67. 62. 47. 51. 56. 48. 54. 58. 63. 55. 45. 47. 55. 56. 43. 44. 53. 54. 57. 55. 58. 47. 38. 41. 54. 54. 59. 55. 42.
NWS STA. 43-9099      9/71      OB. TIME= 700.      TEMP. CORRECTION      MAX=  0.0      MIN=  4.0
MAX  68. 70. 76. 80. 85. 82. 70. 81. 84. 74. 77. 77. 70. 72. 68. 78. 73. 63. 65. 69. 65. 61. 69. 69. 54. 60. 65. 68. 64. 70.
MIN  39. 40. 42. 56. 62. 64. 53. 63. 64. 42. 44. 48. 68. 64. 64. 61. 53. 54. 40. 43. 53. 40. 38. 41. 32. 33. 34. 36. 53. 46.
```

```
MAT FOR AREA= 01135500        3/70
16.  21.  25.  18. /  15.  25.  30.  13. /   6.  19.  27.   8. /  -1.  19.  32.  23. /  18.  26.  30.  25. /
22.  23.  24.  19. /  16.  26.  31.  18. /  12.  19.  23.  10. /   3.  12.  18.  10. /   6.  14.  20.  17. /
16.  21.  25.  22. /  20.  28.  32.  24. /  20.  25.  29.  23. /  20.  26.  29.  17. /  11.  21.  27.   8. /
-1.  15.  25.  16. /  12.  24.  30.  15. /   8.  29.  41.  20. /  10.  32.  45.  24. /  14.  33.  44.  32. /
27.  31.  34.  31. /  29.  39.  44.  35. /  30.  33.  35.  31. /  29.  34.  37.  30. /  27.  32.  35.  23. /
17.  29.  37.  30. /  27.  32.  34.  23. /  18.  29.  36.  21. /  14.  20.  23.  12. /   7.  22.  30.  16. /
 9.  25.  34.  21. /

MAT FOR AREA=L01135500        3/70
16.  23.  26.  20. /  17.  27.  32.  14. /   5.  20.  29.   9. /  -1.  21.  34.  23. /  17.  26.  32.  26. /
23.  25.  26.  20. /  17.  27.  32.  19. /  13.  21.  25.  10. /   3.  13.  20.  10. /   5.  15.  21.  18. /
16.  23.  26.  23. /  21.  29.  33.  25. /  21.  27.  30.  23. /  20.  27.  31.  19. /  14.  23.  28.   9. /
-0.  16.  26.  16. /  11.  24.  32.  15. /   8.  30.  42.  21. /  10.  33.  46.  24. /  14.  34.  46.  32. /
26.  32.  36.  32. /  30.  40.  45.  36. /  32.  35.  37.  32. /  30.  36.  39.  32. /  28.  34.  36.  24. /
18.  30.  38.  31. /  27.  33.  36.  24. /  18.  30.  37.  23. /  16.  22.  25.  13. /   8.  23.  32.  17. /
10.  26.  36.  22. /

MAT FOR AREA=H01135500        3/70
15.  20.  23.  17. /  14.  24.  28.  13. /   5.  18.  26.   7. /  -2.  18.  31.  24. /  20.  25.  28.  23. /
21.  21.  22.  17. /  15.  24.  29.  16. /  10.  17.  22.   9. /   4.  12.  17.  10. /   6.  14.  13.  17. /
15.  20.  23.  20. /  19.  26.  30.  23. /  19.  24.  27.  22. /  19.  25.  27.  14. /   9.  20.  25.   7. /
-1.  13.  23.  16. /  13.  23.  29.  15. /   8.  28.  40.  20. /  10.  31.  43.  24. /  14.  32.  43.  33. /
28.  30.  32.  30. /  29.  37.  42.  33. /  29.  31.  33.  30. /  29.  33.  36.  29. /  25.  30.  33.  22. /
16.  28.  35.  30. /  27.  31.  33.  22. /  17.  28.  34.  19. /  12.  18.  21.  11. /   6.  20.  29.  15. /
 9.  24.  33.  20. /
```

```
            MAT FOR AREA= 01135500      4/70
 15.  29.  39.  29. /   25.  30.  33.  29. /   26.  30.  31.  24. /   20.  28.  32.  19. /   12.  24.  31.  14. /
  6.  25.  37.  27. /   23.  34.  40.  29. /   24.  40.  50.  38. /   33.  48.  56.  38. /   29.  34.  37.  27. /
 22.  27.  30.  28. /   28.  36.  40.  31. /   27.  38.  44.  29. /   22.  42.  53.  34. /   25.  41.  50.  33. /
 25.  44.  56.  43. /   37.  50.  58.  40. /   32.  38.  41.  30. /   25.  34.  39.  27. /   21.  31.  37.  32. /
 30.  37.  41.  36. /   34.  41.  45.  35. /   30.  38.  43.  39. /   37.  41.  43.  37. /   34.  44.  49.  35. /
 28.  51.  65.  45. /   35.  59.  72.  49. /   38.  57.  69.  50. /   41.  57.  66.  46. /   37.  57.  70.  56. /

            MAT FOR AREA=L01135500      4/70
 15.  31.  40.  30. /   25.  31.  35.  30. /   28.  31.  33.  25. /   22.  30.  34.  20. /   13.  26.  33.  15. /
  7.  27.  39.  28. /   22.  35.  42.  30. /   25.  42.  52.  39. /   33.  49.  58.  39. /   30.  36.  40.  29. /
 24.  28.  32.  29. /   28.  37.  42.  33. /   28.  39.  45.  30. /   23.  43.  55.  35. /   26.  42.  51.  34. /
 26.  46.  58.  44. /   37.  51.  59.  42. /   34.  40.  44.  32. /   26.  35.  41.  28. /   22.  32.  39.  33. /
 30.  38.  43.  38. /   35.  43.  47.  36. /   31.  40.  45.  41. /   38.  43.  45.  39. /   36.  46.  51.  36. /
 29.  53.  66.  45. /   35.  60.  74.  49. /   38.  58.  71.  51. /   42.  58.  58.  47. /   37.  58.  72.  56. /

            MAT FOR AREA=H01135500      4/70
 14.  28.  37.  28. /   24.  29.  31.  27. /   25.  28.  30.  22. /   19.  26.  31.  18. /   12.  23.  29.  13. /
  5.  24.  35.  27. /   23.  33.  39.  29. /   24.  39.  48.  38. /   33.  47.  54.  36. /   28.  32.  35.  25. /
 21.  25.  28.  27. /   27.  34.  38.  30. /   26.  36.  42.  28. /   21.  40.  51.  33. /   25.  39.  48.  32. /
 25.  43.  54.  43. /   37.  49.  56.  39. /   30.  35.  38.  28. /   23.  32.  37.  26. /   20.  29.  35.  31. /
 29.  35.  39.  35. /   33.  39.  43.  33. /   23.  36.  41.  38. /   36.  40.  41.  35. /   32.  42.  47.  33. /
 27.  50.  63.  44. /   35.  58.  71.  48. /   37.  56.  67.  49. /   40.  56.  65.  45. /   36.  56.  68.  56. /
```

CONSISTENCY CHECK FOR MAT PROGRAM

STATIONS WITH POSITIVE RUN NUMBERS CONSTITUTE GROUP BASE AND ARE PLOTTED AGAINST THE OTHER STATIONS IN THE GROUP BASE

STATIONS WITH NEGATIVE RUN NUMBERS ARE PLOTTED AGAINST THE GROUP BASE

STATIONS IN GROUP 1

STA. RUN NO.	STATION NAME
1	MC INDOE FALLS,VT.
3	NEWPORT,VERMONT
5	ST. JOHNSBURY,VT.
6	WEST BURKE,VERMONT
-4	NORTH DANVILLE,VT.
-2	MT. MANSFIELD,VT.
-7	WEST RIDGE-DUMMY

DEVIATION OF STATION ACCUMULATED MEAN FROM GROUP ACCUMULATED MEAN-----GROUP=1   TEMP=MAX

STA. RUN NO.	STA. PLOT NO.	STATION NAME
1	1	MC INDOE FALLS,VT.
3	2	NEWPORT,VERMONT
5	3	ST. JOHNSBURY,VT.
6	4	WEST BURKE,VERMONT
-4	5	NORTH DANVILLE,VT.

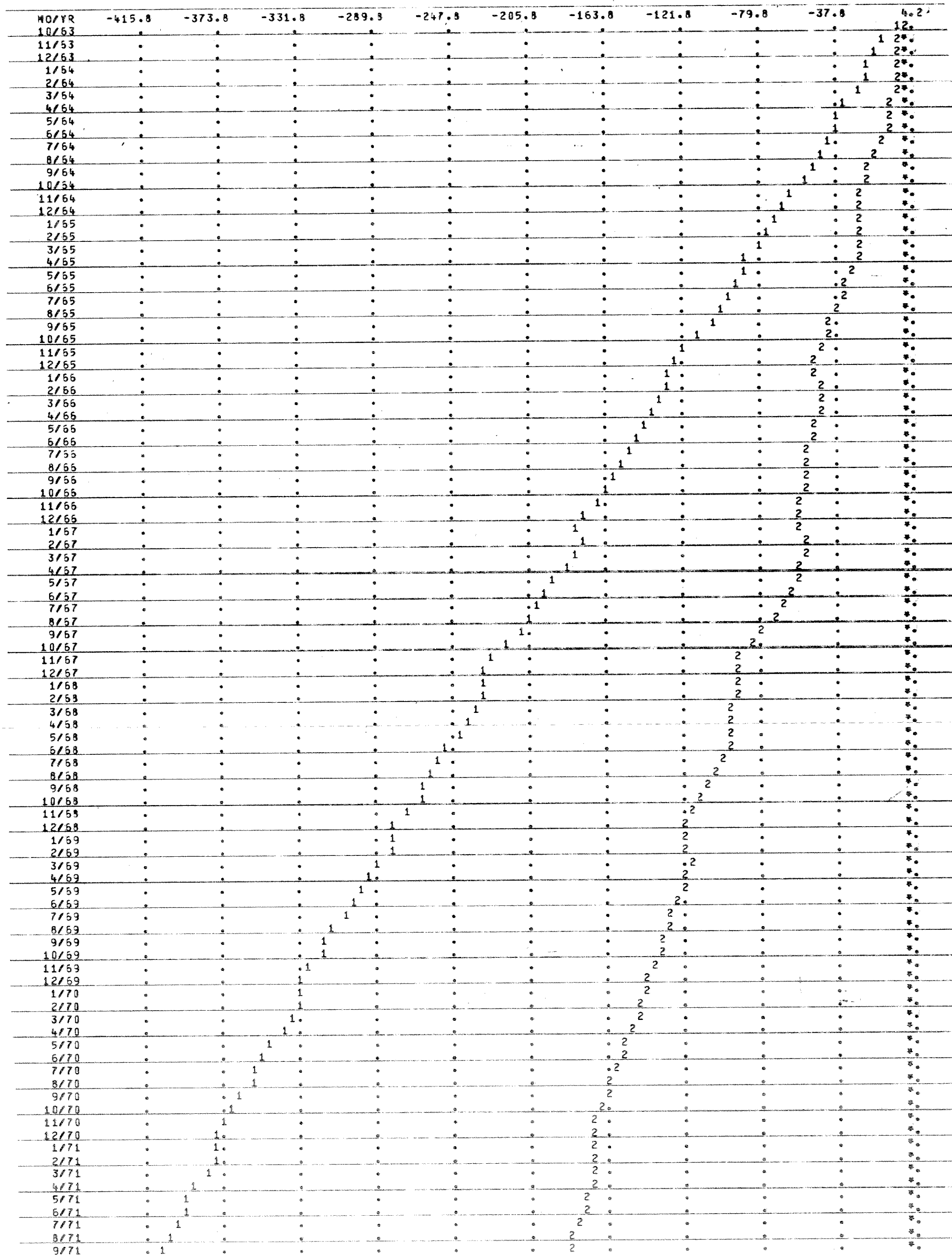
ASTERICKS INDICATE ZERO DEVIATION   UNITS ARE DEGREES F

```
MO/YR -333.0    -288.0    -243.0    -198.0    -153.0    -108.0     -63.0     -18.0      27.0      72.0     117.0
10/63  .         .         .         .         .         .         .         .   5     .         .         .
11/63  .         .         .         .         .         .         .         . 523     .         .         .
12/63  .         .         .         .         .         .         .         . 523     .         .         .
 1/64  .         .         .         .         .         .         .         .5431     .         .         .
 2/64  .         .         .         .         .         .         .         . 5 31    .         .         .
 3/64  .         .         .         .         .         .         .         .54 231   .         .         .
 4/64  .         .         .         .         .         .         .         5 4 231   .         .         .
 5/64  .         .         .         .         .         .         .         5 42*31   .         .         .
 6/64  .         .         .         .         .         .         .        5.4 2*31   .         .         .
 7/64  .         .         .         .         .         .         .        5.4 2*31   .         .         .
 8/64  .         .         .         .         .         .         .      5  .4 2* 3   .         .         .
 9/64  .         .         .         .         .         .         .     5   .4 2* 3   .         .         .
10/64  .         .         .         .         .         .         .    5    4  2* 3   .         .         .
11/64  .         .         .         .         .         .         .   5     4  2* 31  .         .         .
12/64  .         .         .         .         .         .         .    5    4. 2* 31  .         .         .
 1/65  .         .         .         .         .         .         .   5     4. 2* 3 1 .         .         .
 2/65  .         .         .         .         .         .         .   5     4. 2* 3 1 .         .         .
 3/65  .         .         .         .         .         .         .  5      4. 2* 3 1 .         .         .
 4/65  .         .         .         .         .         .         .  5      4. 2 * 3 1.         .         .
 5/65  .         .         .         .         .         .         .  5      4. 2 * 3 1.         .         .
 6/65  .         .         .         .         .         .         . 5     4 . 2  * 3 1.         .         .
 7/65  .         .         .         .         .         .         .5      4 . 2  * 3 1.         .         .
 8/65  .         .         .         .         .         .         5       4 .2   * 3 1.         .         .
 9/65  .         .         .         .         .         .         5       4 . 2  * 3 1.         .         .
10/65  .         .         .         .         .         .        5.       4 .2   *  3 1         .         .
11/65  .         .         .         .         .         .       5 .      4  .2   *  3 1         .         .
12/65  .         .         .         .         .         .       5 .      4  .2   * 3  1         .         .
 1/66  .         .         .         .         .         .      5  .      4  .2   *  3 .1        .         .
 2/66  .         .         .         .         .         .      5  .     4   .2   *  3 .1        .         .
 3/66  .         .         .         .         .         .     5   .     4   .2   *  3 . 1       .         .
 4/66  .         .         .         .         .         .    5    .    4      2  * 3  .  1      .         .
 5/66  .         .         .         .         .         .   5     .    4      2  * 3  .   1     .         .
 6/66  .         .         .         .         .         .  5      .     4     2  *  3 .   1     .         .
 7/66  .         .         .         .         .         . 5       .   4       2  *  3 .   1     .         .
 8/66  .         .         .         .         .         5         .   4    2.    *  3 .    1    .         .
 9/66  .         .         .         .         .        5.         .   4    2.    *  3 .    1    .         .
10/66  .         .         .         .         .       5 .         .  4     2.    *  3 .     1   .         .
11/66  .         .         .         .         .      5. .         .  4     2.    *  3 .     1   .         .
12/66  .         .         .         .         .     5   .         . 4      2.    * 3  .      1  .         .
 1/67  .         .         .         .         .     5   .         . 4      2.    * 3  .       1 .         .
 2/67  .         .         .         .         .    5    .         .4      2 .    *  3 .       1 .         .
 3/67  .         .         .         .         .    5    .         .4      2 .    *  3 .        1.         .
 4/67  .         .         .         .         .    5    .         .4      2 .    *  3 .        1.         .
 5/67  .         .         .         .         .   5     .         .4      2 .    *  3 .        1.         .
 6/67  .         .         .         .         .   5     .         .4      2 .    *  3 .         1         .
 7/67  .         .         .         .         .   5     .         .4      2 .    *  3 .         1         .
 8/67  .         .         .         .         .  5      .         .4      2 .    * 3  .         1         .
 9/67  .         .         .         .         .  5      .         .4      2 .    * 3  .         1         .
10/67  .         .         .         .         . 5       .         4       2 .    *  3 .         1         .
11/67  .         .         .         .         .5        .         4       2 .    * 3  .         .1        .
12/67  .         .         .         .         5         .         4      2  .    * 3  .         .1        .
 1/68  .         .         .         .         5         .         4      2  .    * 3  .         . 1       .
 2/68  .         .         .         .       5 .         .         4      2  .    * 3  .         . 1       .
 3/68  .         .         .         .       5 .         .        4.      2  .    *  3 .         . 1       .
 4/68  .         .         .         .     5   .         .        4.      2  .    *  3 .         . 1       .
 5/68  .         .         .         .    5    .         .        4.      2  .    *  3 .         . 1       .
 6/68  .         .         .         .    5    .         .       4 .       2 .    *  3 .         .  1      .
 7/68  .         .         .         .  5      .         .       4 .      2  .    *  3 .         .  1      .
 8/68  .         .         .         . 5       .         .       4 .      2  .    *  3 .         .  1      .
 9/68  .         .         .         .5        .         .       4 .      2  .    *  3 .         .  1      .
10/68  .         .         .         5         .         .       4 .      2  .    *  3 .         .  1      .
11/68  .         .         .        5.         .         .      4  .      2  .    *  3 .         .  1      .
12/68  .         .         .       5 .         .         .      4  .      2  .    *  3 .         .   1     .
 1/69  .         .         .       5 .         .         .      4  .       2 .    *  3 .         .   1     .
 2/69  .         .         .      5  .         .         .      4  .      2  .    *  3 .         .   1     .
 3/69  .         .         .     5   .         .         .      4  .      2  .    *  3 .         .   1     .
 4/69  .         .         .   5     .         .         .     4   .      2  .    *  3 .         .    1    .
 5/69  .         .         .  5      .         .         .     4   .      2  .    *  3 .         .    1    .
 6/69  .         .         . 5       .         .         .     4   .      2  .    *  3 .         .    1    .
 7/69  .         .         5         .         .         .     4   .      2  .    *  3 .         .    1    .
 8/69  .         .        5.         .         .         .    4    .      2  .    *  3 .         .    1    .
 9/69  .         .       5 .         .         .         .    4    .      2  .    *   3.         .    1    .
10/69  .         .       5 .         .         .         .    4    .      2  .    *   3.         .     1   .
11/69  .         .      5  .         .         .         .   4     .      2  .    *   3.         .     1   .
12/69  .         .     5   .         .         .         .   4     .      2  .    *   3.         .      1  .
 1/70  .         .     5   .         .         .         .   4     .     2   .    *  3 .         .      1  .
 2/70  .         .    5    .         .         .         .   4     .     2   .    *   3.         .      1  .
 3/70  .         .   5     .         .         .         .   4     .     2   .    *   3.         .      1  .
 4/70  .         .  5      .         .         .         .   4     .     2   .    *   3.         .      1  .
 5/70  .         . 5       .         .         .         .  4      .     2   .    *    3         .      1  .
 6/70  .         .5        .         .         .         .  4      .     2   .    *    3         .      1  .
 7/70  .         5         .         .         .         .  4      .     2   .    *    3         .     1   .
 8/70  .         5         .         .         .         .  4      .      2  .    *    3         .     1   .
 9/70  .        5.         .         .         .         .  4      .      2  .    *    3         .     1   .
10/70  .       5 .         .         .         .         . 4       .      2  .    *    3         .     1   .
11/70  .       5 .         .         .         .         . 4       .      2  .    *    3         .      1  .
12/70  .       5 .         .         .         .         . 4       .      2  .    *    3         .       1 .
 1/71  .      5  .         .         .         .         . 4       .     2   .    *    3         .       1 .
 2/71  .      5  .         .         .         .         . 4       .     2   .    *    3         .       1 .
 3/71  .     5   .         .         .         .         . 4       .     2   .    *    3         .        1.
 4/71  .     5   .         .         .         .         .4        .     2   .    *    3         .        1.
 5/71  .    5    .         .         .         .         .4        .     2   .    *    3         .        1.
 6/71  .   5     .         .         .         .         .4        .     2   .    *    3         .        1.
 7/71  .   5     .         .         .         .         .4        .     2   .    *    3         .        1.
 8/71  .  5      .         .         .         .         4         .     2   .    *    .3        .        1.
 9/71  . 5       .         .         .         .         4         .     2   .    *    .3        .        1.
```

DEVIATION OF STATION ACCUMULATED MEAN FROM GROUP ACCUMULATED MEAN-----GROUP=1 TEMP=MIN

STA. RUN NO.	STA. PLOT NO.	STATION NAME
-2	1	MT. MANSFIELD,VT.
-7	2	WEST RIDGE-DUMMY

ASTERISKS INDICATE ZERO DEVIATION UNITS ARE DEGREES F



B.4 SAMPLE INPUT WHEN PROGRAM TEMPCK IS USED IN CONJUNCTION WITH THE MAT PROGRAM

```
* MAT PROGRAM INPUT ***********************************************************
   10    63     9    71    13     0     1     0     1     0     0     1
 2.44
CHEVELON RS,ARIZONA      40    40     2 1574    17       7006.
MAX.  2-1574       24.0 43.8 46.5 51.4 58.4 68.8 77.4 82.2 78.6 73.2 66.3 53.1 43.6
MIN.  2-1574       24.0 18.5 20.8 25.1 30.5 38.9 47.2 56.5 53.7 46.8 37.1 28.3 20.5
CHEVELON RS,ARIZ-EST     40    40     210000    17       7006.
MAX.  2-1574       24.0 43.8 46.5 51.4 58.4 68.8 77.4 82.2 78.6 73.2 66.3 53.1 43.6
MIN.  2-1574       24.0 18.5 20.8 25.1 30.5 38.9 47.2 56.5 53.7 46.8 37.1 28.3 20.5
CHILDS,ARIZONA           27    24     2 1614    10       2650.
MAX.  2-1614        0.0 59.7 64.6 69.6 76.2 87.8 96.1102.3 99.2 93.0 85.0 70.5 58.4
MIN.  2-1614        0.0 31.9 34.2 38.2 43.6 51.3 59.2 69.5 67.0 58.7 48.1 39.1 32.9
FLAGSTAFF WSO,ARIZ.      16    43     2 3010    24       7006.
MAX.  2-3010        0.0 42.3 44.5 48.7 55.5 67.0 75.6 81.3 78.2 71.7 64.4 51.5 42.2
MIN.  2-3010        0.0 14.3 17.0 19.9 25.1 33.1 39.9 51.5 49.6 40.3 30.2 22.9 15.4
FORESTDALE,ARIZONA       62    38     2 3082    19       6100.
MAX.  2-3082        0.0 45.9 49.9 54.4 62.9 73.9 81.5 86.8 82.5 76.5 72.4 57.0 47.4
MIN.  2-3082        0.0 15.4 16.3 20.7 24.0 30.7 38.7 51.1 49.8 41.5 30.2 23.8 16.9
JUNIPINE,ARIZONA         15    38     2 4508    18       5134.
MAX.  2-4508        0.0 51.3 53.9 59.0 65.2 75.7 83.7 88.8 86.2 80.7 73.4 60.3 50.9
MIN.  2-4508        0.0 27.6 28.0 31.3 36.4 44.5 51.5 60.1 58.5 52.1 43.3 35.6 28.1
MCNARY,ARIZONA           68    39     2 5412     8       7320.
MAX.  2-5412        0.0 45.0 46.1 50.6 58.3 68.9 77.4 81.0 77.8 72.8 66.7 54.5 45.9
MIN.  2-5412        0.0 16.2 17.9 21.7 27.3 34.9 41.6 50.2 48.2 41.8 32.4 25.3 18.4
PLEASANT VALLEY RS       45    28     2 6653    17       5050.
MAX.  2-6653        0.0 53.3 56.5 60.8 67.1 77.1 85.9 90.1 86.8 81.6 74.7 62.7 52.2
MIN.  2-6653        0.0 18.8 21.5 23.0 27.4 34.5 41.1 54.8 53.5 44.7 32.6 24.9 18.4
SEDONA RS,ARIZONA        18    33     2 7708    17       4320.
MAX.  2-7708        0.0 56.5 60.2 64.9 71.0 81.8 90.2 96.0 93.0 87.2 79.2 66.2 55.5
MIN.  2-7708        0.0 28.0 30.2 32.6 38.4 45.4 52.7 63.6 61.7 54.0 45.5 35.9 28.0
SNOWFLAKE,ARIZONA        58    47     2 8012    19       5642.
MAX.  2-8012        0.0 48.1 54.6 60.7 66.6 76.8 84.9 90.1 87.1 80.9 72.8 59.7 48.7
MIN.  2-8012        0.0 15.0 18.3 23.2 28.2 37.1 44.6 56.0 54.1 44.9 32.7 23.9 16.4
SPRINGERVILLE,ARIZ.      79    48     2 8162    17       7060.
MAX.  2-8162        0.0 47.7 49.7 55.5 62.7 71.3 79.0 82.0 79.5 74.2 68.5 57.6 48.1
MIN.  2-8162        0.0 15.3 17.3 21.9 27.2 34.9 42.9 52.5 49.9 42.7 30.9 23.3 16.1
WILLIAMS,ARIZONA          3    39     2 9359    17       6750.
MAX.  2-9359        0.0 45.5 46.8 51.0 57.5 67.5 76.2 81.7 78.9 73.2 66.1 53.8 45.3
MIN.  2-9359        0.0 21.8 22.1 26.0 30.9 39.4 47.1 54.9 53.1 46.6 38.9 29.7 22.6
WINSLOW WSO,ARIZONA      37    54     2 9439    24       4895.
MAX.  2-9439        0.0 44.0 52.4 60.8 68.7 79.9 89.4 94.6 91.2 83.9 73.8 59.5 45.1
MIN.  2-9439        0.0 16.1 22.8 28.2 34.9 44.4 52.8 63.7 61.7 52.3 39.5 29.0 18.7
  99
E05820 P
    2     8     5
    5     7     8    10    11    13    -1    -2
    3     4     6     9    12
* PROGRAM TEMPCK INPUT CARD ***************************************************
   -9   -29   10.
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B.5 OUTPUT FROM PROGRAM TEMPCK

MOUNTAIN TEMPERATURE ESTIMATION CHECK FOR CHEVELON RS,ARIZONA

```
ROOT MEAN SQUARE FOR 10/63          MAX=   2.1      MIN=   3.0
ROOT MEAN SQUARE FOR 11/63          MAX=   1.4      MIN=   3.2
ROOT MEAN SQUARE FOR 12/63          MAX=   2.3      MIN=   2.8
ROOT MEAN SQUARE FOR  1/64          MAX=   2.8      MIN=   3.4
          MAX. ERROR EXCEEDED--MAX TEMP.    2/20/64    OBS=  50.0    EST=  38.2
ROOT MEAN SQUARE FOR  2/64          MAX=   3.9      MIN=   2.7
ROOT MEAN SQUARE FOR  3/64          MAX=   2.5      MIN=   4.4
ROOT MEAN SQUARE FOR  4/64          MAX=   2.0      MIN=   3.5
ROOT MEAN SQUARE FOR  5/64          MAX=   2.6      MIN=   3.5
          MAX. ERROR EXCEEDED--MIN TEMP.    6/10/64    OBS=  34.0    EST=  46.0
          MAX. ERROR EXCEEDED--MIN TEMP.    6/23/64    OBS=  39.0    EST=  49.3
ROOT MEAN SQUARE FOR  6/64          MAX=   1.7      MIN=   4.8
          MAX. ERROR EXCEEDED--MAX TEMP.    7/28/64    OBS=  70.0    EST=  83.9
          MAX. ERROR EXCEEDED--MAX TEMP.    7/30/64    OBS=  64.0    EST=  77.1
          MAX. ERROR EXCEEDED--MAX TEMP.    7/31/64    OBS=  62.0    EST=  73.3
          MAX. ERROR EXCEEDED--MIN TEMP.    7/19/64    OBS=  49.0    EST=  60.9
ROOT MEAN SQUARE FOR  7/64          MAX=   5.4      MIN=   4.3
          MAX. ERROR EXCEEDED--MAX TEMP.    8/ 4/64    OBS=  65.0    EST=  78.7
          MAX. ERROR EXCEEDED--MAX TEMP.    8/ 5/64    OBS=  64.0    EST=  79.8
          MAX. ERROR EXCEEDED--MAX TEMP.    8/ 8/64    OBS=  72.0    EST=  82.8
          MAX. ERROR EXCEEDED--MAX TEMP.    8/10/64    OBS=  72.0    EST=  82.3
          MAX. ERROR EXCEEDED--MIN TEMP.    8/ 1/64    OBS=  38.0    EST=  57.6
          MAX. ERROR EXCEEDED--MIN TEMP.    8/ 2/64    OBS=  41.0    EST=  58.3
ROOT MEAN SQUARE FOR  8/64          MAX=   6.2      MIN=   5.3
ROOT MEAN SQUARE FOR  9/64          MAX=   2.8      MIN=   2.8
          MAX. ERROR EXCEEDED--MIN TEMP.   10/31/64    OBS=  41.0    EST=  29.0
ROOT MEAN SQUARE FOR 10/64          MAX=   2.5      MIN=   4.4
          MAX. ERROR EXCEEDED--MAX TEMP.   11/30/64    OBS=  74.0    EST=  55.0
          MAX. ERROR EXCEEDED--MIN TEMP.   11/ 3/64    OBS=  10.0    EST=  28.5
          MAX. ERROR EXCEEDED--MIN TEMP.   11/18/64    OBS=   1.0    EST=  16.3
          MAX. ERROR EXCEEDED--MIN TEMP.   11/21/64    OBS=   5.0    EST=  15.6
          MAX. ERROR EXCEEDED--MIN TEMP.   11/23/64    OBS=   8.0    EST=  21.2
          MAX. ERROR EXCEEDED--MIN TEMP.   11/24/64    OBS=   6.0    EST=  19.4
ROOT MEAN SQUARE FOR 11/64          MAX=   4.4      MIN=   7.4
          MAX. ERROR EXCEEDED--MAX TEMP.   12/14/64    OBS=  33.0    EST=  50.0
ROOT MEAN SQUARE FOR 12/64          MAX=   3.6      MIN=   3.5
ROOT MEAN SQUARE FOR  1/65          MAX=   3.0      MIN=   3.7
ROOT MEAN SQUARE FOR  2/65          MAX=   2.1      MIN=   4.0
ROOT MEAN SQUARE FOR  3/65          MAX=   2.5      MIN=   3.1
          MAX. ERROR EXCEEDED--MIN TEMP.    4/22/65    OBS=  49.0    EST=  36.1
ROOT MEAN SQUARE FOR  4/65          MAX=   2.2      MIN=   4.4
          MAX. ERROR EXCEEDED--MIN TEMP.    5/27/65    OBS=  47.0    EST=  34.7
ROOT MEAN SQUARE FOR  5/65          MAX=   2.6      MIN=   4.4
ROOT MEAN SQUARE FOR  6/65          MAX=   1.7      MIN=   3.6
ROOT MEAN SQUARE FOR  7/65          MAX=   2.6      MIN=   3.1
          MAX. ERROR EXCEEDED--MAX TEMP.    8/ 9/65    OBS=  72.0    EST=  83.3
ROOT MEAN SQUARE FOR  8/65          MAX=   2.8      MIN=   3.5
ROOT MEAN SQUARE FOR  9/65          MAX=   2.4      MIN=   2.6
ROOT MEAN SQUARE FOR 10/65          MAX=   2.7      MIN=   4.2
          MAX. ERROR EXCEEDED--MIN TEMP.   11/11/65    OBS=  38.0    EST=  25.3
          MAX. ERROR EXCEEDED--MIN TEMP.   11/12/65    OBS=  36.0    EST=  24.4
          MAX. ERROR EXCEEDED--MIN TEMP.   11/23/65    OBS=  35.0    EST=  45.7
ROOT MEAN SQUARE FOR 11/65          MAX=   2.0      MIN=   5.5
          MAX. ERROR EXCEEDED--MAX TEMP.   12/ 5/65    OBS=  69.0    EST=  58.7
          MAX. ERROR EXCEEDED--MIN TEMP.   12/16/65    OBS=   8.0    EST=  18.9
ROOT MEAN SQUARE FOR 12/65          MAX=   3.5      MIN=   4.4
          MAX. ERROR EXCEEDED--MAX TEMP.    1/16/66    OBS=  45.0    EST=  31.9
          MAX. ERROR EXCEEDED--MIN TEMP.    1/11/66    OBS=  34.0    EST=  23.8
          MAX. ERROR EXCEEDED--MIN TEMP.    1/16/66    OBS=  12.0    EST=  22.6
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ROOT MEAN SQUARE FOR  1/66                  3.8      MIN=    4.4
ROOT MEAN SQUARE FOR  2/66            MAX=  3.0      MIN=    3.8
     MAX. ERROR EXCEEDED--MIN TEMP.           3/24/66        OBS=  24.0      EST=  35.7
ROOT MEAN SQUARE FOR  3/66            MAX=  2.9      MIN=    4.8
     MAX. ERROR EXCEEDED--MIN TEMP.           4/27/66        OBS=  46.0      EST=  35.2
ROOT MEAN SQUARE FOR  4/66            MAX=  2.5      MIN=    5.2
     MAX. ERROR EXCEEDED--MIN TEMP.           5/17/66        OBS=  49.0      EST=  38.3
     MAX. ERROR EXCEEDED--MIN TEMP.           5/28/66        OBS=  51.0      EST=  40.5
ROOT MEAN SQUARE FOR  5/66            MAX=  1.7      MIN=    4.4
     MAX. ERROR EXCEEDED--MIN TEMP.           6/29/66        OBS=  41.0      EST=  62.1
ROOT MEAN SQUARE FOR  6/66            MAX=  1.8      MIN=    6.0
ROOT MEAN SQUARE FOR  7/66            MAX=  2.6      MIN=    3.8
ROOT MEAN SQUARE FOR  8/66            MAX=  1.6      MIN=    4.4
ROOT MEAN SQUARE FOR  9/66            MAX=  2.7      MIN=    3.7
ROOT MEAN SQUARE FOR 10/66            MAX=  3.5      MIN=    3.1
     MAX. ERROR EXCEEDED--MIN TEMP.          11/11/66        OBS=  15.0      EST=  25.3
     MAX. ERROR EXCEEDED--MIN TEMP.          11/21/66        OBS=  26.0      EST=  42.0
     MAX. ERROR EXCEEDED--MIN TEMP.          11/24/66        OBS=  35.0      EST=  24.8
     MAX. ERROR EXCEEDED--MIN TEMP.          11/25/66        OBS=  37.0      EST=  26.0
ROOT MEAN SQUARE FOR 11/66            MAX=  2.4      MIN=    5.6
     MAX. ERROR EXCEEDED--MIN TEMP.          12/31/66        OBS=  11.0      EST=  -1.1
ROOT MEAN SQUARE FOR 12/66            MAX=  3.0      MIN=    4.4
ROOT MEAN SQUARE FOR  1/67            MAX=  3.3      MIN=    5.2
ROOT MEAN SQUARE FOR  2/67            MAX=  2.8      MIN=    4.6
     MAX. ERROR EXCEEDED--MIN TEMP.           3/ 2/67        OBS=  41.0      EST=  26.9
ROOT MEAN SQUARE FOR  3/67            MAX=  2.0      MIN=    4.2
     MAX. ERROR EXCEEDED--MIN TEMP.           4/27/67        OBS=  43.0      EST=  32.1
ROOT MEAN SQUARE FOR  4/67            MAX=  2.9      MIN=    5.8
     MAX. ERROR EXCEEDED--MIN TEMP.           5/ 9/67        OBS=  52.0      EST=  37.4
ROOT MEAN SQUARE FOR  5/67            MAX=  1.6      MIN=    4.2
ROOT MEAN SQUARE FOR  6/67            MAX=  1.7      MIN=    3.8
ROOT MEAN SQUARE FOR  7/67            MAX=  3.7      MIN=    4.0
     MAX. ERROR EXCEEDED--MAX TEMP.           8/ 6/67        OBS=  84.0      EST=  73.9
ROOT MEAN SQUARE FOR  8/67            MAX=  3.4      MIN=    3.0
     MAX. ERROR EXCEEDED--MIN TEMP.           9/13/67        OBS=  37.0      EST=  50.7
     MAX. ERROR EXCEEDED--MIN TEMP.           9/29/67        OBS=  52.0      EST=  41.2
     MAX. ERROR EXCEEDED--MIN TEMP.           9/30/67        OBS=  57.0      EST=  42.7
ROOT MEAN SQUARE FOR  9/67            MAX=  3.3      MIN=    5.3
     MAX. ERROR EXCEEDED--MAX TEMP.          10/15/67        OBS=  77.0      EST=  66.7
     MAX. ERROR EXCEEDED--MIN TEMP.          10/ 1/67        OBS=  60.0      EST=  45.9
     MAX. ERROR EXCEEDED--MIN TEMP.          10/19/67        OBS=  45.0      EST=  33.9
     MAX. ERROR EXCEEDED--MIN TEMP.          10/24/67        OBS=  44.0      EST=  33.9
     MAX. ERROR EXCEEDED--MIN TEMP.          10/27/67        OBS=  44.0      EST=  30.6
ROOT MEAN SQUARE FOR 10/67            MAX=  3.3      MIN=    6.0
     MAX. ERROR EXCEEDED--MAX TEMP.          11/27/67        OBS=  55.0      EST=  42.3
     MAX. ERROR EXCEEDED--MIN TEMP.          11/ 1/67        OBS=  38.0      EST=  28.0
     MAX. ERROR EXCEEDED--MIN TEMP.          11/ 2/67        OBS=  44.0      EST=  30.7
ROOT MEAN SQUARE FOR 11/67            MAX=  3.5      MIN=    5.3
     MAX. ERROR EXCEEDED--MAX TEMP.          12/12/67        OBS=  52.0      EST=  41.4
     MAX. ERROR EXCEEDED--MAX TEMP.          12/22/67        OBS=  24.0      EST=  34.4
     MAX. ERROR EXCEEDED--MAX TEMP.          12/23/67        OBS=  29.0      EST=  39.8
     MAX. ERROR EXCEEDED--MIN TEMP.          12/15/67        OBS=  10.0      EST=  22.5
ROOT MEAN SQUARE FOR 12/67            MAX=  4.6      MIN=    4.9
     MAX. ERROR EXCEEDED--MIN TEMP.           1/ 1/68        OBS=  23.0      EST=   4.8
     MAX. ERROR EXCEEDED--MIN TEMP.           1/ 3/68        OBS=  25.0      EST=  13.2
ROOT MEAN SQUARE FOR  1/68            MAX=  3.7      MIN=    6.3
     MAX. ERROR EXCEEDED--MAX TEMP.           2/ 4/68        OBS=  55.0      EST=  43.1
ROOT MEAN SQUARE FOR  2/68            MAX=  3.6      MIN=    3.4
     MAX. ERROR EXCEEDED--MIN TEMP.           3/16/68        OBS=  20.0      EST=  35.1
     MAX. ERROR EXCEEDED--MIN TEMP.           3/17/68        OBS=  19.0      EST=  33.8
ROOT MEAN SQUARE FOR  3/68            MAX=  3.5      MIN=    5.0
     MAX. ERROR EXCEEDED--MIN TEMP.           4/13/68        OBS=  24.0      EST=  39.4
     MAX. ERROR EXCEEDED--MIN TEMP.           4/26/68        OBS=  41.0      EST=  30.7
ROOT MEAN SQUARE FOR  4/68            MAX=  3.1      MIN=    4.9
     MAX. ERROR EXCEEDED--MIN TEMP.           5/21/68        OBS=  55.0      EST=  43.6
     MAX. ERROR EXCEEDED--MIN TEMP.           5/29/68        OBS=  57.0      EST=  45.0
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ROOT MEAN SQUARE FOR  5/68        MAX=   2.0      MIN=    4.8
          MAX. ERROR EXCEEDED--MIN TEMP.     6/16/68     OBS=  30.0     EST=  46.9
          MAX. ERROR EXCEEDED--MIN TEMP.     6/29/68     OBS=  68.0     EST=  54.6
          MAX. ERROR EXCEEDED--MIN TEMP.     6/30/68     OBS=  66.0     EST=  42.5
ROOT MEAN SQUARE FOR  6/68        MAX=   1.4      MIN=    7.8
          MAX. ERROR EXCEEDED--MIN TEMP.     7/ 4/68     OBS=  40.0     EST=  52.2
          MAX. ERROR EXCEEDED--MIN TEMP.     7/14/68     OBS=  42.0     EST=  52.1
          MAX. ERROR EXCEEDED--MIN TEMP.     7/20/68     OBS=  64.0     EST=  53.6
ROOT MEAN SQUARE FOR  7/68        MAX=   2.0      MIN=    6.0
          MAX. ERROR EXCEEDED--MIN TEMP.     8/26/68     OBS=  41.0     EST=  51.9
ROOT MEAN SQUARE FOR  8/68        MAX=   2.1      MIN=    4.0
ROOT MEAN SQUARE FOR  9/68        MAX=   1.6      MIN=    5.1
          MAX. ERROR EXCEEDED--MIN TEMP.    10/ 6/68     OBS=  50.0     EST=  39.4
ROOT MEAN SQUARE FOR 10/68        MAX=   2.7      MIN=    4.0
          MAX. ERROR EXCEEDED--MAX TEMP.    11/ 9/68     OBS=  44.0     EST=  60.8
          MAX. ERROR EXCEEDED--MAX TEMP.    11/11/68     OBS=  48.0     EST=  63.4
          MAX. ERROR EXCEEDED--MIN TEMP.    11/25/68     OBS=  24.0     EST=  34.8
ROOT MEAN SQUARE FOR 11/68        MAX=   5.6      MIN=    3.1
          MAX. ERROR EXCEEDED--MAX TEMP.    12/ 2/68     OBS=  42.0     EST=  31.2
          MAX. ERROR EXCEEDED--MAX TEMP.    12/16/68     OBS=  55.0     EST=  44.0
          MAX. ERROR EXCEEDED--MIN TEMP.    12/ 9/68     OBS=  37.0     EST=  20.6
          MAX. ERROR EXCEEDED--MIN TEMP.    12/11/68     OBS=  39.0     EST=  24.5
          MAX. ERROR EXCEEDED--MIN TEMP.    12/22/68     OBS=  12.0     EST= -13.2
          MAX. ERROR EXCEEDED--MIN TEMP.    12/23/68     OBS=  17.0     EST=   -.7
          MAX. ERROR EXCEEDED--MIN TEMP.    12/24/68     OBS=  36.0     EST=  12.8
ROOT MEAN SQUARE FOR 12/68        MAX=   4.1      MIN=    8.7
          MAX. ERROR EXCEEDED--MAX TEMP.     1/ 4/69     OBS=  67.0     EST=  43.0
          MAX. ERROR EXCEEDED--MAX TEMP.     1/ 8/69     OBS=  66.0     EST=  51.5
          MAX. ERROR EXCEEDED--MAX TEMP.     1/ 9/69     OBS=  66.0     EST=  47.1
          MAX. ERROR EXCEEDED--MIN TEMP.     1/ 7/69     OBS=  14.0     EST=  27.7
          MAX. ERROR EXCEEDED--MIN TEMP.     1/ 8/69     OBS=  13.0     EST=  31.4
          MAX. ERROR EXCEEDED--MIN TEMP.     1/20/69     OBS=  21.0     EST=  35.8
ROOT MEAN SQUARE FOR  1/69        MAX=   6.8      MIN=    5.7
          MAX. ERROR EXCEEDED--MIN TEMP.     2/15/69     OBS=  15.0     EST=  28.4
          MAX. ERROR EXCEEDED--MIN TEMP.     2/16/69     OBS=  12.0     EST=  26.9
          MAX. ERROR EXCEEDED--MIN TEMP.     2/24/69     OBS=  10.0     EST=  22.0
          MAX. ERROR EXCEEDED--MIN TEMP.     2/25/69     OBS=  33.0     EST=  22.3
ROOT MEAN SQUARE FOR  2/69        MAX=   2.1      MIN=    6.3
          MAX. ERROR EXCEEDED--MIN TEMP.     3/21/69     OBS=  37.0     EST=  22.1
ROOT MEAN SQUARE FOR  3/69        MAX=   2.7      MIN=    4.6
          MAX. ERROR EXCEEDED--MIN TEMP.     4/ 3/69     OBS=  39.0     EST=  28.1
ROOT MEAN SQUARE FOR  4/69        MAX=   3.1      MIN=    4.4
          MAX. ERROR EXCEEDED--MIN TEMP.     5/ 6/69     OBS=  21.0     EST=  35.5
          MAX. ERROR EXCEEDED--MIN TEMP.     5/14/69     OBS=  54.0     EST=  41.1
ROOT MEAN SQUARE FOR  5/69        MAX=   2.3      MIN=    4.9
          MAX. ERROR EXCEEDED--MIN TEMP.     6/29/69     OBS=  55.0     EST=  44.5
ROOT MEAN SQUARE FOR  6/69        MAX=   1.8      MIN=    4.0
ROOT MEAN SQUARE FOR  7/69        MAX=   1.7      MIN=    3.9
          MAX. ERROR EXCEEDED--MAX TEMP.     8/25/69     OBS=  89.0     EST=  78.9
ROOT MEAN SQUARE FOR  8/69        MAX=   2.8      MIN=    3.3
          MAX. ERROR EXCEEDED--MIN TEMP.     9/ 5/69     OBS=  46.0     EST=  56.1
ROOT MEAN SQUARE FOR  9/69        MAX=   3.8      MIN=    3.7
          MAX. ERROR EXCEEDED--MAX TEMP.    10/12/69     OBS=  73.0     EST=  55.3
          MAX. ERROR EXCEEDED--MAX TEMP.    10/21/69     OBS=  63.0     EST=  44.5
          MAX. ERROR EXCEEDED--MIN TEMP.    10/ 2/69     OBS=  53.0     EST=  42.2
          MAX. ERROR EXCEEDED--MIN TEMP.    10/ 3/69     OBS=  48.0     EST=  37.5
ROOT MEAN SQUARE FOR 10/69        MAX=   5.3      MIN=    4.7
          MAX. ERROR EXCEEDED--MAX TEMP.    11/17/69     OBS=  53.0     EST=  41.6
          MAX. ERROR EXCEEDED--MIN TEMP.    11/10/69     OBS=  26.0     EST=  38.2
ROOT MEAN SQUARE FOR 11/69        MAX=   3.2      MIN=    3.7
          MAX. ERROR EXCEEDED--MIN TEMP.    12/ 3/69     OBS=  11.0     EST=  32.3
          MAX. ERROR EXCEEDED--MIN TEMP.    12/ 4/69     OBS=  20.0     EST=  34.3
ROOT MEAN SQUARE FOR 12/69        MAX=   2.8      MIN=    5.0
          MAX. ERROR EXCEEDED--MIN TEMP.     1/28/70     OBS=  12.0     EST=  24.0
ROOT MEAN SQUARE FOR  1/70        MAX=   2.7      MIN=    4.1
          MAX. ERROR EXCEEDED--MAX TEMP.     2/ 2/70     OBS=  51.0     EST=  37.8
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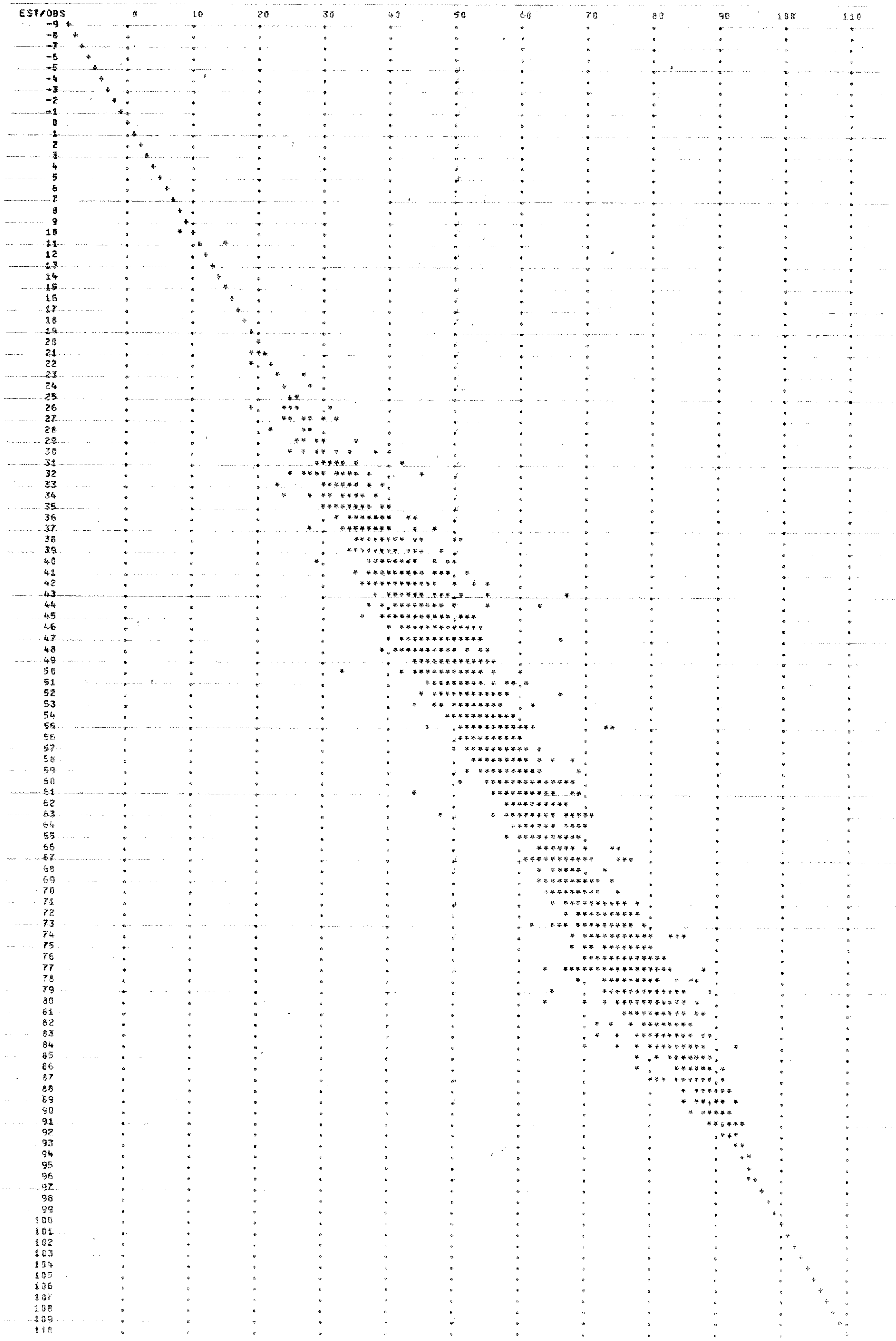
ROOT MEAN SQUARE FOR  2/70           MAX=   3.1     MIN=    3.4
          MAX. ERROR EXCEEDED--MAX TEMP.     3/ 2/70        OBS=  50.0      EST=  39.8
          MAX. ERROR EXCEEDED--MIN TEMP.     3/29/70        OBS=  13.0      EST=  28.8
ROOT MEAN SQUARE FOR  3/70           MAX=   3.2     MIN=    4.1
          MAX. ERROR EXCEEDED--MAX TEMP.     4/ 4/70        OBS=  61.0      EST=  50.8
          MAX. ERROR EXCEEDED--MIN TEMP.     4/16/70        OBS=  15.0      EST=  26.1
ROOT MEAN SQUARE FOR  4/70           MAX=   2.8     MIN=    4.3
          MAX. ERROR EXCEEDED--MIN TEMP.     5/23/70        OBS=  51.0      EST=  39.3
ROOT MEAN SQUARE FOR  5/70           MAX=   2.1     MIN=    5.0
          MAX. ERROR EXCEEDED--MIN TEMP.     6/ 1/70        OBS=  37.0      EST=  48.0
ROOT MEAN SQUARE FOR  6/70           MAX=   2.2     MIN=    4.3
ROOT MEAN SQUARE FOR  7/70           MAX=   2.4     MIN=    4.0
ROOT MEAN SQUARE FOR  8/70           MAX=   2.5     MIN=    3.5
          MAX. ERROR EXCEEDED--MIN TEMP.     9/28/70        OBS=  30.0      EST=  42.0
ROOT MEAN SQUARE FOR  9/70           MAX=   3.6     MIN=    3.5
          MAX. ERROR EXCEEDED--MIN TEMP.    10/10/70        OBS=  24.0      EST=  37.2
          MAX. ERROR EXCEEDED--MIN TEMP.    10/12/70        OBS=  22.0      EST=  34.6
          MAX. ERROR EXCEEDED--MIN TEMP.    10/19/70        OBS=  26.0      EST=  36.2
ROOT MEAN SQUARE FOR 10/70           MAX=   3.0     MIN=    5.3
ROOT MEAN SQUARE FOR 11/70           MAX=   0.0     MIN=    0.0
          MAX. ERROR EXCEEDED--MIN TEMP.    12/ 4/70        OBS=  33.0      EST=  22.4
          MAX. ERROR EXCEEDED--MIN TEMP.    12/ 8/70        OBS=  36.0      EST=  25.7
          MAX. ERROR EXCEEDED--MIN TEMP.    12/19/70        OBS=   5.0      EST=  16.3
ROOT MEAN SQUARE FOR 12/70           MAX=   2.8     MIN=    5.2
ROOT MEAN SQUARE FOR  1/71           MAX=   2.7     MIN=    4.5
          MAX. ERROR EXCEEDED--MIN TEMP.     2/ 8/71        OBS=  27.0      EST=  15.5
ROOT MEAN SQUARE FOR  2/71           MAX=   2.2     MIN=    5.0
          MAX. ERROR EXCEEDED--MIN TEMP.     3/25/71        OBS=  42.0      EST=  29.9
ROOT MEAN SQUARE FOR  3/71           MAX=   3.2     MIN=    4.3
          MAX. ERROR EXCEEDED--MIN TEMP.     4/ 8/71        OBS=  13.0      EST=  30.2
          MAX. ERROR EXCEEDED--MIN TEMP.     4/12/71        OBS=  45.0      EST=  33.0
          MAX. ERROR EXCEEDED--MIN TEMP.     4/22/71        OBS=  16.0      EST=  27.7
ROOT MEAN SQUARE FOR  4/71           MAX=   2.1     MIN=    6.0
          MAX. ERROR EXCEEDED--MIN TEMP.     5/ 3/71        OBS=  44.0      EST=  33.3
          MAX. ERROR EXCEEDED--MIN TEMP.     5/ 8/71        OBS=  23.0      EST=  36.4
          MAX. ERROR EXCEEDED--MIN TEMP.     5/13/71        OBS=  19.0      EST=  38.5
          MAX. ERROR EXCEEDED--MIN TEMP.     5/31/71        OBS=  20.0      EST=  38.8
ROOT MEAN SQUARE FOR  5/71           MAX=   2.8     MIN=    7.3
          MAX. ERROR EXCEEDED--MIN TEMP.     6/18/71        OBS=  45.0      EST=  55.5
ROOT MEAN SQUARE FOR  6/71           MAX=   2.9     MIN=    4.5
          MAX. ERROR EXCEEDED--MAX TEMP.     7/ 6/71        OBS=  85.0      EST=  73.6
          MAX. ERROR EXCEEDED--MIN TEMP.     7/ 6/71        OBS=  44.0      EST=  57.3
          MAX. ERROR EXCEEDED--MIN TEMP.     7/21/71        OBS=  45.0      EST=  56.3
ROOT MEAN SQUARE FOR  7/71           MAX=   3.0     MIN=    5.4
          MAX. ERROR EXCEEDED--MAX TEMP.     8/ 5/71        OBS=  88.0      EST=  77.4
ROOT MEAN SQUARE FOR  8/71           MAX=   3.0     MIN=    4.1
ROOT MEAN SQUARE FOR  9/71           MAX=   1.9     MIN=    3.1
```

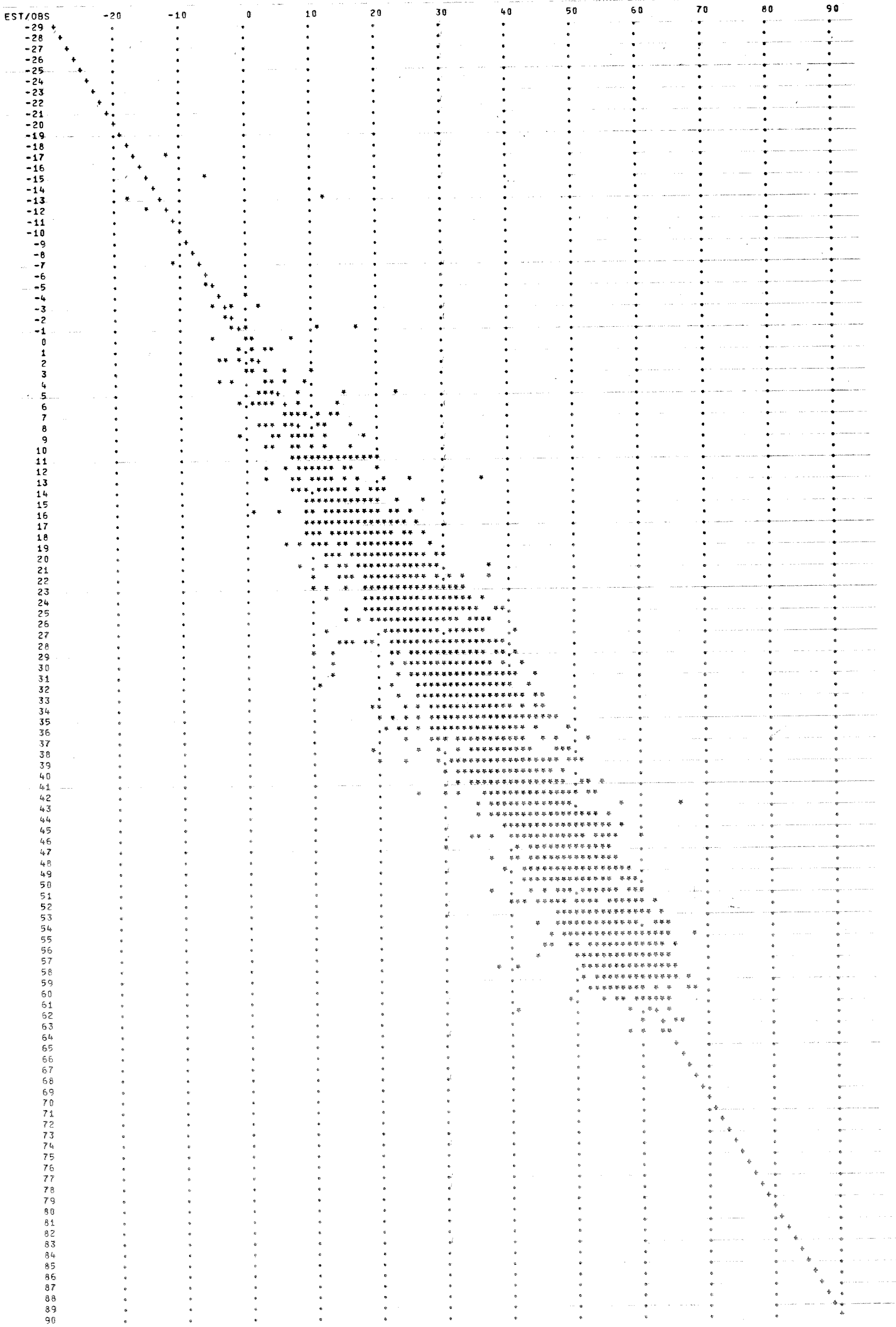
SUMMARY OF ROOT MEAN SQUARE OF OBS. AND EST.--PLUS STANDARD DEVIATION OF OBS. AND MEAN

MONTH	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
RMS MAX	3.8	2.9	2.9	2.6	2.3	1.9	3.1	3.3	2.9	3.3	3.2	3.4	3.0
S.D. MAX	9.5	8.2	9.9	8.4	8.3	7.3	5.6	5.2	5.9	7.1	7.4	9.1	7.8
RMS MIN	4.8	4.3	4.3	4.9	4.9	5.0	4.4	4.0	3.8	4.4	4.7	5.1	4.6
S.D. MIN	10.5	8.2	8.5	7.0	7.6	7.8	4.9	4.9	6.5	7.2	7.6	9.0	7.6

OBSERVED VS. ESTIMATED MAX TEMPERATURE FOR CHEVELON RS,ARIZONA + IS 45 DEGREE LINE



OBSERVED VS. ESTIMATED MIN TEMPERATURE FOR CHEVELON RS,ARIZONA + IS 45 DEGREE LINE



APPENDIX C

LISTING OF SUBROUTINE PACK FROM THE VERIFICATION PROGRAM

```
      SUBROUTINE PACK(DA1,P61,DA2,P62,K1,COVER,EFC,PX,PE,MONTH,YEAR,IRG)
      INTEGER ANGLE(12),TG,TITLE,DA1,P61,DA2,P62,YEAR
      REAL MFMAXT,MFMINT,NMFT,LIQW,NEGHS,LAGRO,MELT,K1,MF,MINDEX,NMINDEX
     1,NMRATE,LIQWMX
      DIMENSION LAGRO(2),K1(5),EFC(5),COVER(5,31),PX(5,31,4),PE(2,31),
     1AESCA(11)
C     SNOW VARIABLES
      INTEGER CASE,SNOWOPT,WEIN,TAGIN,TAG,WEGIN,WEG,OSPRO,TSPRO
      REAL MFMAX,MFMIN,NMF,MBASE,LIQWI,NEGHSI,LAGROI
      COMMON/S/CASE,SNOWOPT,NTAG,NWEG,WEIN,TAELEV(3),TALR(3,4),TAGIN(3),
     1TAG(5),WEGIN(5),WEG(5),ELEV(5),SCF(5),MFMAX(5),MFMIN(5),NMF(5),
     2UADJ(5),SI(5),DAYGM(5),      STOREI(5),SBI(5),SBAESCI(5),SBWSI(5),
     3WEI(5),NEGHSI(5),LIQWI(5),LAGROI(5,2),COEFAD(5,10),     OWE(5,31),
     4SSFALL(5),SRAIN(5),SUMPRO(5),        SBAL(5),TINDXI(5),      CSI(5),
     5OSPRO,TSPRO,MBASE(5),PLWHC(5),TIPM(5),PXTEMP(5)
C     SNOW AND INPUT COMMON BLOCK
      COMMON/SI/TA(3,31,4)
      DATA ANGLE/285,316,345,10,40,71,101,132,163,193,224,254/
*****************************************************************************
C BEGIN INITIAL VALUES
      NOSNOW=1
      SSFALLT=0.0
      SRAINT=0.0
      SUMPROT=0.0
      SBALT=0.0
      TG=TAG(IRG)
      IGWE=WEG(IRG)
C INITIAL PARAMETER VALUES
      ELEVT=ELEV(IRG)*0.001
      PA=29.9-1.02*ELEVT+0.0032*(ELEVT**2.4)
      EDIFF=ELEVT-TAELEV(TG)*0.001
      UADJT=UADJ(IRG)
      SCFT=SCF(IRG)
      GM=DAYGM(IRG)*0.25
      MFMAXT=MFMAX(IRG)
      MFMINT=MFMIN(IRG)
      NMFT=NMF(IRG)
      BASEM=MBASE(IRG)
      RASNOW=PXTEMP(IRG)
      WCPLW=PLWHC(IRG)
      TSPM=TIPM(IRG)
      AESCA(1)=0.05
      DO 76 I=2,11
 76   AESCA(I)=COEFAD(IRG,(I-1))
C INITIAL SNOWPACK CONDITIONS
      SIT=SI(IRG)
      CSIT=CSI(IPG)
      WE=WEI(IRG)
```

```
      NEGHS=NEGHSI(IRG)
      LIQW=LIQWI(IRG)
      SBWS=SBWSI(IRG)
      TINDEX=TINDXI(IRG)
      SB=SBI(IRG)
      SBAESC=SBAESCI(IRG)
      STORAGE=STORFI(IRG)
      DO 74 I=1,2
74    LAGRO(I)=LAGROI(IRG,I)
C COMPUTE TOTAL PACK VALUES
      PWE=WE
      PLIQW=LIQW
      PNEGHS=NEGHS
C PWATER1=INITIAL TOTAL WATER IN SNOWPACK
      PWATER1=PWE+PLIQW+LAGRO(1)+STORAGE
      PWATER=PWATER1
      IF (WE.GT.0.0) NOSNOW=0
      TITLE=0
      IP=P61
      IDA=DA1
      GO TO 101
C END INITIAL VALUES
*****************************************************************************
C     BEGINNING OF 6 HOUR AND DAY LOOP
100   IF (IP.NE.1) GO TO 105
C INITIAL DAILY VALUES
101   DSFALL=0.0
      DRAIN=0.0
      DQNET=0.0
C INITIAL SIX HOUR VALUES
105   MELT=0.0
      RAINM=0.0
      CNHS=0.0
      SFALL=0.0
      PX6=PX(IRG,IDA,IP)*K1(IRG)
      PX(IRG,IDA,IP)=PX6
C TEST IF A SNOWPACK EXISTS OR IF THERE IS NEW PRECIPITATION
      IF ((WE.EQ.0.0).AND.(PX6.EQ.0.0)) GO TO 180
*****************************************************************************
C     PERIOD VALUES OF INPUT VARIABLES
      PTA=TA(TG,IDA,IP)+EDIFF*TALR(TG,IP)
C END OF PERIOD INPUT
*****************************************************************************
C     ESTIMATION OF FORM AND TEMPERATURE OF PRECIPITATION
      IF (PX6.LT.0.0001) GO TO 121
      TPX=PTA
C TPX=TEMPERATURE OF PRECIPITATION
      IF (TPX.GT.RASNOW) GO TO 322
C     SNOWFALL
      IF(TPX.GT.32.0) TPX=32.0
      PX6=PX6*SCFT
      SFALL=PX6
      DSFALL=DSFALL+SFALL
      SSFALLT=SSFALLT+SFALL
```

```
      SBWS=PWE+PLIQW+0.75*PX6
      WE=WE+PX6
      NEGHS=NEGHS+(32.0-TPX)*PX6/287.0
      IF (PX6.GT.0.2) TINDEX=TPX
      PWE=PWE+PX6
      PX6=0.0
      GO TO 121
C     RAIN
322   IF (WE.EQ.0.0) GO TO 180
      RAINM=0.007*PX6*(TPX-32.0)
      DRAIN=DRAIN+PX6
      SRAINT=SRAINT+PX6
**********************************************************************
**********************************************************************
C SNOWPACK COMPUTATIONS
C     GROUNDMELT
121   IF (WE.GT.GM) GO TO 125
      GMRO=WE+LIQW
      GO TO 175
125   WLOS=(GM/WE)*LIQW
      WE=WE-GM
      PWE=PWE-GM
      LIQW=LIQW-WLOS
      GMRO=GM+WLOS
**********************************************************************
C     SNOWPACK ENERGY EXCHANGE COMPUTATIONS
      IF (NOSNOW.EQ.1) GO TO 124
      IF (IP.NE.1) GO TO 127
124   IDN=ANGLE(MONTH)+IDA
      DIFF=MFMAXT-MFMINT
      DAYN=IDN
      MF=(SIN(DAYN*2.0*3.1416/366.0)*DIFF*0.5)+
     1(MFMAXT+MFMINT)*0.5
      RATIO=MF/MFMAXT
C     MF=BASIC MELT FACTOR FOR CURRENT DAY
127   MINDEX=PTA-BASEM
      IF (MINDEX.LT.0.0) MINDEX=0.0
      IF (PTA.LE.32.0) MINDEX=0.0
C     EMPIRICAL EXCHANGE COMPUTATIONS
      NMINDEX=TINDEX-PTA
      IF (PTA.GT.32.0) NMINDEX=0.0
C     NEGATIVE EXCHANGE
      NMRATE=RATIO*NMFT
      CNHS=NMRATE*NMINDEX
      TINDEX=TINDEX+TSPM*(PTA-TINDEX)
      IF (PX6.GT.0.10) GO TO 130
C MELT DURING NON-RAIN OR LIGHT RAIN PERIODS
      MELT=MF*MINDEX+RAINM
      GO TO 160
C     MELT DURING RAIN.GT.0.10 INCH IN SIX HOURS
130   MINDEX=PTA-32.0
      EA=8.1175E6*EXP(-7701.544/(PTA+405.0265))
      MELT=0.007*MINDEX+(0.000359*1517.1*PA*UADJT/202.4)*MINDEX+
     1(EA-0.18)*8.5*UADJT+RAINM
```

```
      IF (MELT.LT.0.0) MELT=0.0
C END OF SNOWPACK ENERGY EXCHANGE COMPUTATIONS
***************************************************************************
C     AREAL EXTENT OF SNOW COVER
160   TWE=PWE+PLIQW
      IF (TWE.GT.CSIT) CSIT=TWE
      VSIT=CSIT
      IF(CSIT.GT.SIT) VSIT=SIT
      IF (TWE.GE.VSIT) GO TO 162
      IF (TWE.LE.SB) GO TO 163
      IF (TWE.GE.SBWS) GO TO 161
      AESC=SBAESC+((1.0-SBAESC)*((TWE-SB)/(SBWS-SB)))
      GO TO 164
163   FI=(TWE/VSIT)*10.0+1.0
      I=FI
      FF=I
      FI=FI-FF
      AESC=AESCA(I)+(AESCA(I+1)-AESCA(I))*FI
      IF (AESC.GT.1.0) AESC=1.0
      SB=TWE+0.05
      SBWS=TWE
      SBAESC=AESC
      GO TO 164
162   SB=TWE
161   AESC=1.0
164   IF (AESC.LT.0.05)AESC=0.05
***************************************************************************
C     ADJUSTMENT OF PERIOD VALUES FOR AESC
      IF (AESC.EQ.1.0) GO TO 1651
      MELT=MELT*AESC
      CNHS=CNHS*AESC
      RAINM=RAINM*AESC
1651  CONTINUE
      IF ((CNHS+NEGHS).LT.0.0) CHNS=-1.0*NEGHS
***************************************************************************
C SURFACE MELT COMPUTATIONS
      IF (MELT.LE.0.0) GO TO 165
      IF (MELT.LT.WE) GO TO 1601
      MELT=WE
      MELT=MELT+LIQW
      GO TO 175
1601  WE=WE-MELT
C     QNET=NET SURFACE ENERGY EXCHANGE EXCLUDING PRECIP. IN INCHES WE
165   QNET=MELT-CNHS
      DQNET=DQNET+QNET
***************************************************************************
C HEAT AND WATER BALANCE FOR SNOWPACK
      WATER=MELT+PX6
      HEAT=CNHS
      LIQWMX=WCPLW*WE
      NEGHS=NEGHS+HEAT
      IF (ABS(NEGHS).GT.(0.33*WE)) NEGHS=(NEGHS/ABS(NEGHS))*0.33*WE
      IF ((WATER+LIQW).LT.(LIQWMX+NEGHS)) GO TO 233
      EXCESS=WATER+LIQW-LIQWMX-NEGHS
```

```
      LIQW=LIQWMX
      WE=WE+NEGHS
      NEGHS=0.0
      GO TO 235
233   IF (WATER.LT.NEGHS) GO TO 234
      LIQW=LIQW+WATER-NEGHS
      WE=WE+NEGHS
      NEGHS=0.0
      EXCESS=0.0
      GO TO 235
234   WE=WE+WATER
      NEGHS=NEGHS-WATER
      EXCESS=0.0
235   CONTINUE
*******************************************************************************
      PWE=WE
      PNEGHS=NEGHS
      PLIQW=LIQW
      IF (TINDEX.GT.32.0) TINDEX=32.0
      IF (NEGHS.EQ.0.0) TINDEX=32.0
*******************************************************************************
C     ROUTE EXCESS WATER THROUGH THE PACK
C     LAG -- FUNCTION OF INFLOW AND PACK WE
      PACKRO=0.0
      IF (EXCESS.EQ.0.0) GO TO 26
      IF (PWE.LT.1.0) GO TO 28
      NI=((EXCESS*100.0)**0.3)+0.5
      IF (NI.EQ.0) NI=1
      FN=NI
      DO 25 JJ=1,NI
      FJ=JJ
      FLAG=5.33*(1.0-EXP(-0.03*PWE*FN/(EXCESS*(FJ-0.5))))
      POR2=FLAG/6.0
      POR1=1-POR2
      LAGRO(2)=LAGRO(2)+POR2*EXCESS/FN
      LAGRO(1)=LAGRO(1)+POR1*EXCESS/FN
25    CONTINUE
      GO TO 26
28    LAGRO(2)=0.0
      LAGRO(1)=EXCESS+LAGRO(1)
      GO TO 29
C ATTENUATION -- FUNCTION OF STORAGE AND PACK WE
26    IF ((STORAGE+LAGRO(1)).EQ.0.0) GO TO 27
      PACKRO=(STORAGE+LAGRO(1))/(0.5*EXP(-83.5*LAGRO(1)/(PWE**1.3))+1.0)
      STORAGE=STORAGE+LAGRO(1)-PACKRO
      IF (STORAGE.GT.0.001) GO TO 27
      PACKRO=PACKRO+STORAGE
      STORAGE=0.0
      GO TO 27
29    PACKRO=STORAGE+LAGRO(1)
      STORAGE=0.0
27    PACKRO=PACKRO+GMRO
      PX (IRG,IDA,IP)=PACKRO
      LAGRO(1)=LAGRO(2)
```

```
      LAGRO(2)=0.0
      NOSNOW=0
      GO TO 400
*****************************************************************************
C     SNOW GONE -- LAYER OR TOTAL PACK
175   WE=0.0
      NEGHS=0.0
      LIQW=0.0
C     INITIALIZE ALL VARIABLES FOR NO SNOW
      PACKRO=GMRO+MELT+LAGRO(1)+STORAGE+PX6
      PX(IRG,IDA,IP)=PACKRO
      SB=0.0
      SBAESC=0.0
      SBWS=0.0
      CSIT=0.0
      AESC=0.0
      TINDEX=32.0
      LAGRO(1)=0.0
      LAGRO(2)=0.0
      STORAGE=0.0
      PWE=0.0
      PNEGHS=0.0
      PLIQW=0.0
      PWATER=0.0
      NOSNOW=1
C END OF SNOWPACK COMPUTATIONS
*****************************************************************************
*****************************************************************************
400   SUMPROT=SUMPROT+PACKRO
      IF (TITLE.EQ.1) GO TO 405
C OUTPUT SNOWOPT.EQ.1(DAILY ONLY) SNOWOPT=0(NONE)
      IF (SNOWOPT.EQ.0) GO TO 403
      PRINT 900,IRG,MONTH,YEAR
      PRINT 901
403   TITLE=1
405   IF (IP.NE.4) GO TO 406
      PWATER=PWE+PLIQW+LAGRO(1)+STORAGE
      IF (SNOWOPT.EQ.0) GO TO 406
      PRINT 902,IDA,DSFALL,DRAIN,DQNET,AESC,PWE,PLIQW,PNEGHS,PWATER,
     1OWE(IGWE,IDA)
*****************************************************************************
406   COVER(IRG,IDA)=AESC
      GO TO 190
C NO SNOWPACK -- NO SNOWFALL
180   COVER(IRG,IDA)=0.0
C INCREMENT TO NEXT PERIOD
190   IF((IDA.EQ.DA2).AND.(IP.EQ.P62)) GO TO 195
      IP=IP+1
      IF (IP.LE.4) GO TO 100
      IP=1
      IDA=IDA+1
      GO TO 100
C     END OF SIX HOUR AND DAY LOOP
*****************************************************************************
```

```
C       SNOW CARRYOVER VALUES
195     WEI(IRG)=WE
        NEGHSI(IRG)=NEGHS
        LIQWI(IRG)=LIQW
        SSFALL(IRG)=SSFALLT
        SRAIN(IRG)=SRAINT
        SUMPRO(IRG)=SUMPROT
        SBALT=PWATER-PWATER1-SSFALLT-SRAINT+SUMPROT
        SBAL(IRG)=SBALT
        SBWSI(IRG)=SBWS
        CSI(IRG)=CSIT
        TINDXI(IRG)=TINDEX
        SBI(IRG)=SB
        SBAESCI(IRG)=SBAESC
        STOREI(IRG)=STORAGE
        DO 197 I=1,2
        LAGROI(IRG,I)=LAGRO(I)
197     CONTINUE
********************************************************************************
C FORMAT STATEMENTS
900     FORMAT (1H1,24HSNOW SUMMARY FOR STATION,I3,5X,I2,1H/,I2)
901     FORMAT (1H0,2X,3HDAY,2X,8HSNOWFALL,6X,4HRAIN,2X, 8HHEAT-EXQ,5X,
       15HCOVER,3X,7HPACK WE,4X,6HLIQUID,2X,8HNEG-HEAT,2X,11HTOTAL WATER,
       22X,15HOBS WATER EQUIV)
902     FORMAT (1H ,I5,3F10.3,2F10.2,2F10.3,F10.2,5X,F10.2)
        RETURN
        END
```

APPENDIX D

VERIFICATION PROGRAM WITH SNOW -- INPUT AND OUTPUT SAMPLES

D.1 VERIFICATION PROGRAM WITH SNOW - INPUT SUMMARY

D.2 SAMPLE INPUT FOR VERIFICATION PROGRAM WITH SNOW

D.3 EXAMPLES OF OUTPUT FROM VERIFICATION PROGRAM WITH SNOW

D.1 VERIFICATION PROGRAM WITH SNOW - INPUT SUMMARY

```
C          INPUT SUMMARY FOR VERIFICATION
*******************************************************************************
*CARD NO. FORMAT    CONTENTS
*******************************************************************************
C   1       20A4    BASIC RUN INFORMATION SUCH AS DATE,ETC.
*******************************************************************************
C   2       20A4    BASIN NAME
*******************************************************************************
C   3         I5    NO. OF MBP AREAS USED IN RUN (NGAGES)
C             I5    NO. OF PE STATIONS USED (NPEGS)
C             I5    NO. OF STREAM-FLOW-POINTS USED (NPTS)
C             I5    NO. OF UPSTREAM INFLOW POINTS NEEDED FROM OUTSIDE
C                       AREA BEING RUN (NPTSUP)
*******************************************************************************
C   4         I5    NO. OF MBP AREAS ON INPUT TAPE
C             I5    NO. OF PE STATIONS ON TAPE
C             I5    NO. OF MEAN DAILY FLOW-POINTS ON TAPE
C             I5    NO. OF POINTS WITH OBSERVED SIX-HOUR DISCHARGE
C                       THAT ARE ON TAPE
C             I5    NO. OF UPSTREAM INFLOWS FROM OUTSIDE RUN AREA
C                       ON TAPE
*******************************************************************************
C   5         I5    FIRST MONTH OF RUN
C             I5    FIRST YEAR OF RUN (LAST 2 DIGITS ONLY)
C             I5    LAST MONTH
C             I5    LAST YEAR
*******************************************************************************
C   6       16I5    IDENTIFIES THE MBP AREAS ON TAPE TO BE USED IN THE RUN.
C                        ALSO DEFINES THE PRECIP. AREA ORDER FOR THE RUN.
C                        1 TO (NGAGES) VALUES ARE NEEDED.
C                   E.G.    5 MBP AREAS ON TAPE,(NGAGES)=3, CARD 6=4,1,5
C                               THEN THE 4 TH GAGE ON TAPE WILL BE GAGE 1 FOR RUN.
C                                        1 ST GAGE ON TAPE WILL BE GAGE 2 FOR RUN.
C                                        5 TH GAGE ON TAPE WILL BE GAGE 3 FOR RUN.
*******************************************************************************
C   7       10A4    NAME OF PE STATION
C             I5    NEP
C             I5    NDUR
C    (REPEAT CARD 7 FOR EACH PE STATION(1 TO NPEGS))--ORDER OF READ DETERMINES
C                        PE STATION NUMBER FOR THE RUN)
*******************************************************************************
C   8       16I5    SAME AS CARD 6 ONLY FOR PE STATIONS.
*******************************************************************************
C   9       16I5    ASSOCIATES PE STATIONS TO MBP AREAS
C                        1 TO (NGAGES) VALUES ARE NEEDED
C                   E.G. (NGAGES)=3,(NPEGS)=2, CARD  9=2,1,2
C                               THEN THE 1ST PRECIP AREA WILL USE PE FROM NO.2
C                                                                   PE STATION
C                                    THE 2ND PRECIP AREA WILL USE PE FROM NO.1
```

```
C                                                                    PE STATION
C                                            THE 3RD PRECIP AREA WILL USE PE FROM NO.2
C                                                                    PE STATION
*********************************************************************************
C  10       16I5      SAME AS CARD 6 ONLY FOR MEAN DAILY FLOW STATIONS
C                          (VALUE =0 IF NO M.D.F. FOR A PARTICULAR FLOW-POINT)
*********************************************************************************
C  11       16I5      SAME AS CARD 6 ONLY FOR SIX HOUR OBSERVED DISCHARGE
C                          (VALUE =0 IF NO DISCHARGE FOR A PARTICULAR FLOW-POINT)
*********************************************************************************
C  11A      16I5      SAME AS CARD 6 ONLY FOR UPSTREAM INFLOW STATIONS
C                         FROM OUTSIDE CURRENT RUN AREA
C                          (ONLY NEEDED IF NO. OF UPSTREAM INFLOWS ON TAPE.GT.0)
*********************************************************************************
C  12       16I5      TYPE OF ROUTING TO BE APPLIED TO REACH ABOVE FLOW-
C                          POINT (1 TO NPTS) EQUAL TO 1 FOR NOW
C                     1 IS FOR LAG AND K ROUTING INCLUDING VARIABLE
C                     SEE CHAPTER 6 OF HYDRO-14 FOR ADDING OTHER ROUTING
C                          PROCEDURES.
*********************************************************************************
C  13       16I5      FLOW TO ROUTE DOWNSTREAM (1 TO NPTS)
C                     =1 ROUTE OBSERVED OR BEST ESTIMATE OF OBSERVED
C                     =0 ROUTE SIMULATED
*********************************************************************************
C  14         I5      =1 STORE CHANNEL INFLOW ON TAPE     =0 NO
C             I5      =1 DO ROUTING ONLY USING CHANNEL INFLOWS PREVIOUSLY STORED
C                               ON TAPE    =0 NO
C             I5      =1 SAVE 6 HOUR FLOW AT EACH FLOW POINT ON TAPE FOR USE
C                          AS  UPSTREAM INFLOWS LATER      =0 NO
C             I5      =1 PLOT SIX HOUR FLOW FOR ALL PERIODS WHEN OBSERVED IS
C                               READ IN.         =0 NO
C             I5      =1 PLOT MEAN DAILY FLOWS BY WATER YEAR FOR FLOW-POINTS
C                          WHERE OBSERVED DATA IS READ IN AND PLOT IS WANTED.
C                          THIS IS A PRINTER PLOT.  =0 FOR CARD OUTPUT FOR
C                      CAL-COMP PLOT PROGRAM
C             I5      TAPE NO. OF CHANNEL INFLOW TAPE
C             I5      TAPE NO. OF PRECIPITATION TAPE
C             I5      TAPE NO. OF MEAN DAILY FLOW TAPE
C             I5      TAPE NO. OF SIX HOUR OBSERVED DISCHARGE TAPE
C             I5      TAPE NO. OF PE TAPE
C             I5      TAPE NO. OF SNOW DATA (TEMPERATURE-WATER EQUIVALENT)
C             I5      TAPE NO. FOR SAVING SIX HOUR FLOWS AS FUTURE
C                                    UPSTREAM INFLOWS
C             I5      TAPE NO. FOR UPSTREAM INFLOWS FROM OUTSIDE RUN AREA
C             I5      =0    NO  STATISTICAL SUMMARY
C                     =1    MULTIYEAR STATISTICAL SUMMARY PLUS PUNCH M.D.F. IN
C                                                STANDARD FORMAT
C                     =2    MULTIYEAR SUMMARY ONLY
C                     =3    YEARLY AND MULTIYEAR SUMMARY
C                     =4    YEARLY PLUS MULTIYEAR PLUS PUNCH M.D.F. CARDS
C             I5      =1 OUTPUT MONTHLY FLOW VOLUMES AND MOISTURE STORAGES, =0 NO
*********************************************************************************
C  15         I5      =1 SNOW IS INCLUDED,  =0 NO SNOW
C             I5      =1 OUTPUT WATER YEAR MEAN DAILY FLOW SUMMARY TABLES,
```

```
C                              =0 NO TABLE OUTPUT
C                   I5    =1 OUTPUT DETAILED SOIL MOISTURE OUTPUT FOR SELECTED MONTHS,
C                              =0 NO DETAILED OUTPUT
************************************************************************
C  15A        16I5    MONTH AND YEAR (2 DIGITS) FOR WHICH DETAILED SOIL MOISTURE
C                              OUTPUT IS WANTED.  (UP TO 8 MONTHS CAN BE OBTAINED)
C                     (THIS CARD ONLY NEEDED IF DETAILED SOIL MOISTURE OUTPUT
C                              IS ASKED FOR)
************************************************************************
************************************************************************
C**NOTE**  REPEAT CARDS 16 THROUGH 19 FOR EACH MBP AREA (NGAGES)
C  16         5A4     NAME OF MBP AREA
C           4F5.2     SOIL-MOISTURE VOLUME PARAMETERS
C           ,F5.1,         MOD. STANFORD WATERSHED MODEL
C            F5.2,         ORDER OF PARAMETERS IS --
C           2F5.1,              K1,A,EPXM,UZSN,LZSN,CB,POWER,CC,K24L
C             F5.2         (PARAMETERS DEFINED IN SECTION 4.3 OF HYDRO-14
************************************************************************
C  17         20X,    EVAPOTRANSPIRATION PARAMETERS FOR SOIL MOISTURE
C           5F5.2          ORDER IS  K3,GAGEPE,EHIGH,ELOW,K24EL
************************************************************************
C  18         20X,    SOIL MOISTURE  TIMING PARAMETERS
C           2F5.2,         ORDER IS---
C            F5.4,          SRC1,LIRC6,LKK6,KV,KGS
C           2F5.2
************************************************************************
C  19         20X,    SOIL MOISTURE INITIAL CONDITIONS
C           7F5.1          ORDER IS---UZSI,LZSI,SGWI,GWSI,RESI,SRGXI,SCEPI
C                               UZS=UPPER ZONE STORAGE
C                               LZS=LOWER ZONE STORAGE
C                               SGW=GROUNDWATER STORAGE
C                               GWS=ANTECEDENT GW INFLOW INDEX
C                               RES=SURFACE DETENTION
C                               SRGX=INTERFLOW DETENTION
C                               SCEP=INTERCEPTION STORAGE
************************************************************************
************************************************************************
************************************************************************
*********NOTE***********  THE FOLLOWING 200 SERIES CARDS ARE ONLY NEEDED
***    IF SNOW IS INCLUDED.     DO NOT PUT IN OTHERWISE.    ******************
************************************************************************
C 201           I5    PUNCH 1 IN COLUMN 5
C               I5    =1 OUTPUT DAILY SNOW QUANTITIES SUCH AS WATER-EQUIVALENT,
C                          SNOWFALL,HEAT EXCHANGE,ETC.
C                     =0 NO DAILY SNOW OUTPUT
C               I5    =1  OUTPUT SNOWPACK OUTFLOW ON TO TAPE.
C                     =0  DO NOT OUTPUT ON TO TAPE
C               I5    TAPE NUMBER TO WHICH SNOWPACK OUTFLOW IS TO BE WRITTEN
************************************************************************
C 202           I5    NUMBER OF MAT AREAS USED IN THIS RUN (NTAG)
C               I5    NUMBER OF AREAS WITH OBSERVED WATER-EQUIVALENT  (NWEG)
************************************************************************
C 203           I5    NUMBER OF MAT AREAS ON INPUT TAPE
C               I5    NUMBER OF OBS. AREAL WATER-EQUIVALENTS ON INPUT TAPE
```

```
************************************************************************
C 204        5A4      NAME OF MAT AREA
C          F10.0      MEAN ELEVATION OF MAT AREA IN FEET
C          4F5.1      AIR TEMPERATURE LAPSE RATES FOR MID-6AM,6AM-NOON,
C                           NOON-6PM,6PM-MID.   DEG. F/1000 FT. ELEV. CHANGE
C              NOTE..REPEAT THIS CARD FOR EACH MAT AREA. CARD ORDER
C                     DEFINES MAT ORDER NUMBER FOR THIS RUN.
************************************************************************
C 205        16I5     IDENTIFIES THE MAT AREAS ON TAPE TO BE USED IN THIS RUN.
C                           1 TO (NTAG) VALUES ARE NEEDED.
C                     E.G. 5 MAT AREAS ON TAPE, NTAG=2 , CARD 205 = 4,2
C                           THEN THE 4 TH MAT RECORD ON TAPE IS THE TEMPERATURE
C                                        DATA FOR THE 1 ST MAT AREA.
C                                2 ND MAT RECORD ON TAPE IS THE TEMPERATURE
C                                        DATA FOR THE 2 ND MAT AREA.
************************************************************************
C 206        16I5     ASSOCIATES MAT AREAS TO MBP AREAS
C                           1 TO (NGAGES) VALUES ARE NEEDED
C                     E.G. (NGAGES)=3, (NTAG)=2,  CARD 206=2,1,1
C                           THEN THE 1 ST PRECIP AREA WILL USE AIR TEMPERATURE
C                                            FROM MAT AREA NO.2
C                                2 ND PRECIP AREA WILL USE AIR TEMPERATURE
C                                            FROM MAT AREA NO.1
C                                3 RD PRECIP AREA WILL USE AIR TEMPERATURE
C                                            FROM MAT AREA NO.1
************************************************************************
C NOTE..CARDS 207 THROUGH 209 ONLY NEEDED IF (NWEG.GT.0)
************************************************************************
C 207        5A4      NAME OF OBSERVED WATER-EQUIVALENT MEASUREMENT AREA
C              NOTE..REPEAT THIS CARD FOR EACH OBS. WATER-EQUIVALENT AREA
C                     USED IN THIS RUN.  CARD ORDER DEFINES ORDER NO. FOR RUN.
************************************************************************
C 208        16I5     SAME AS CARD 205 ONLY FOR OBS. WATER-EQUIVALENT AREAS.
************************************************************************
C 209        16I5     SAME AS CARD 206 ONLY FOR OBS. WATER-EQUIVALENT AREAS.
************************************************************************
************************************************************************
C NOTE..REPEAT CARDS 210,211,212,213,214 FOR EACH MEAN BASIN PRECIPITATION AREA
C              USED IN THIS RUN (NGAGES)
************************************************************************
C 210 20X,F10.0       MEAN AREA ELEVATION IN FEET
C            F5.2     PERCENT/100 OF AREA OVER WHICH EVAPOTRANSPIRATION CAN TAKE
C                           PLACE WHEN THERE IS COMPLETE AREAL SNOW COVER (EFC)
C            F5.2     MULTIPLYING FACTOR TO CORRECT FOR GAGE CATCH DEFICIENCY
C                           IN THE CASE OF SNOWFALL. (SCF)
C            F5.4     MAXIMUM NON-RAIN MELT FACTOR -- OCCURS ON JUNE 21. (MFMAX)
C            F5.4     MINIMUM NON-RAIN MELT FACTOR -- OCCURS ON DEC. 21. (MFMIN)
C            F5.4     MAXIMUM NEGATIVE MELT FACTOR -- (NMF)
C              NOTE..UNITS FOR MELT FACTORS ARE INCHES/DEG.F/SIX HOURS
C            F5.4     MEAN WIND FUNCTION VALUE DURING RAIN ON SNOW PERIODS
C                           UNITS ARE INCHES/INCH OF MERCURY  (UADJ)
C            F5.1     AREAL WATER-EQUIVALENT (INCHES) ABOVE WHICH THERE IS
C                           ALWAYS COMPLETE AREAL SNOW COVER.  (SI)
C            F5.2     DAILY MELT AT THE SNOW-SOIL INTERFACE IN INCHES. (DAYGM)
```

```
****************************************************************************************
C 211            INITIAL VALUES OF SOME SNOW COVER VARIABLES.
C      20X,F5.0      ANTECEDENT SNOW TEMP. INDEX  (DEG. F)  (ATI)
C          F5.2      FREE WATER IN SNOW IN EXCESS OF THAT HELD AGAINST GRAVITY
C                          DRAINAGE  (INCHES)
C          F5.2      POINT SB ON AREAL DEPLETION CURVE  (INCHES)
C          F5.2      PERCENT/100 AREAL SNOW COVER AT POINT SB.
C          F5.2      POINT SBWS ON AREAL DEPLETION CURVE (INCHES)
C    NOTE..SEE CHAP. 3  FOR FURTHER EXPLANATION OF THESE INITIAL VALUES.
****************************************************************************************
C 212            INITIAL VALUES OF MAJOR SNOW COVER VARIABLES
C      20X,F5.2      INITIAL WATER-EQUIVALENT OF SOLID PORTION OF THE
C                          SNOWPACK.   (INCHES)
C          F5.2      INITIAL NEGATIVE HEAT STORAGE  (INCHES)
C          F5.2      INITIAL AMOUNT OF FREE WATER HELD AGAINST GRAVITY
C                          DRAINAGE (INCHES).  MAXIMUM EQUALS PERCENT LIQUID
C                          WATER HOLDING CAPACITY TIMES INITIAL WATER-EQUIVALENT.
****************************************************************************************
****************************************************************************************
C 213            ADDITIONAL SNOW PARAMETERS
C      20X,F5.0      MELT FACTOR BASE TEMPERATURE  (DEG. F) (MBASE)
C          F5.0      TEMPERATURE (DEG. F) TO DIVIDE RAIN FROM SNOW  (PXTEMP)
C                          IF AIR TEMPERATURE GREATER,THEN RAIN
C                          IF AIR TEMPERATURE LESS THAN OR EQUAL,THEN SNOW
C          F5.2      PERCENT/100 LIQUID WATER HOLDING CAPACITY  (PLWHC)
C                          MAXIMUM AMOUNT OF FREE WATER HELD AGAINST GRAVITY.
C          F5.2      ANTECEDENT SNOW TEMP. INDEX PARAMETER  (TIPM)
C                          (.GE.0.0 --.LE.1.0)
****************************************************************************************
C 214 20X,9F5.2      AREAL SNOW COVER DEPLETION CURVE
C                          PERCENT/100 AREAL EXTENT OF SNOW COVER AT
C                          WATER EQUIVALENT/AI RATIOS OF  0.1,0.2,0.3,0.4,0.5,
C                                0.6,0.7,0.8,0.9  (SEE SECTION 3.3.3 FOR DEFINITION
C                                OF AI)    FOR RATIO=0.0  AREAL COVER=0.05
C                                              RATIO=1.0  AREAL COVER=1.00
****************************************************************************************
****************************************************************************************
****************************************************************************************
C**NOTE**CARD 20A IS ONLY NEEDED WHEN THE NUMBER OF UPSTREAM INFLOWS
C        FROM OUTSIDE THE AREA BEING RUN IS.GT.0 (NPTSUP.GT.0)
C  20A      7A4      NAME OF UPSTREAM INFLOW POINT
C      2X,F10.0      AREA OF UPSTREAM INFLOW POINT  (TOTAL AREA ABOVE GAGE SQ.MI)
C        REPEAT CARD 20A FOR EACH UPSTREAM INFLOW POINT (1 TO NPTSUP))
C              ORDER OF CARDS DETERMINES FLOW-POINT NUMBER FOR RUN
C              FIRST UPSTREAM INFLOW POINT IS ASSIGNED FLOW-POINT NUMBER
C                    EQUAL TO (NPTS+1) ETC. E.G. IF NPTS=3 THEN THE FIRST
C                    UPSTREAM INFLOW POINT BECOMES FLOW-POINT 4 FOR
C                    THE RUN.
****************************************************************************************
****************************************************************************************
C**NOTE** REPEAT CARDS 20 THROUGH 23 (IF ALL NEEDED) FOR EACH FLOW-POINT
C         WITHIN RUN AREA (NPTS)
C        ORDER OF CARDS DETERMINES FLOW-POINT NUMBER FOR THE RUN.
C        NOTE...ALL FLOW-POINTS UPSTREAM FROM GAGE MUST HAVE A SMALLER RUN
```

```
C            NUMBER THAN THE GIVEN GAGE--EXCEPT FOR UPSTREAM INFLOW-POINTS
C            FROM OUTSIDE THE AREA BEING RUN(SEE CARD 20A)
C  20      7A4      NAME OF FLOW-POINT
C      2X,F10.0     TOTAL AREA ABOVE FLOW-POINT IN SQUARE MILES
C         ,F5.2,    CONSTANT K ROUTING FACTOR IN HOURS   =0.0 IF VAR. K USED
C          I5       =1 USE VARIABLE K   =0 NO
C          I5       =1 USE VARIABLE LAG =0 NO
C          I5       ROUTING INTERVAL IN HOURS  (MUST=6 FOR NOW)
C          I5       NO. OF VALUES  IN TIME-DELAY HISTOGRAM FOR LOCAL AREA
C          I5       NO. OF UPSTREAM  INFLOW POINTS TO LOCAL AREA (NUPIN)
C                        THESE CAN BE UPSTREAM INFLOWS FROM OUTSIDE OR
C                        INSIDE THE RUN AREA
C          I5       NO.OF POINTS TO DEFINE VARIABLE K VS OUTFLOW CURVE
C          I5       NO. OF POINTS TO DEFINE VARIABLE LAG VS INFLOW CURVE
********************************************************************************
C  20B   8F10.0     VARIABLE K VS.OUTFLOW CURVE IF NEEDED    K IN HOURS
C                        MAXIMUM POINTS TO DEFINE CURVE IS 10 (THUS 3 CARDS)
C                        VALUES READ IN PAIRS  (FLOW,K)
C                             SO 4 PAIRS OF (FLOW,K) CAN GO ON A CARD
C                        K AT ZERO FLOW MUST BE FIRST POINT
C                        CALCULATIONS USING K ARE BASED ON A LINEAR
C                             INTERPOLATION BETWEEN POINTS
C                        K VALUE FOR HIGHEST DEFINED FLOW IS USED FOR
C                             ALL FLOWS ABOVE THAT DISCHARGE
********************************************************************************
C  20C   8F10.0     VARIABLE LAG VS. INFLOW CURVE IF NEEDED   LAG IN HOURS
C                        MAX.PTS=10, VALUES IN PAIRS(FLOW,LAG), 4 PAIRS PER CARD
C                        LAG AT ZERO FLOW MUST BE FIRST POINT
C                        CALCULATIONS USING VARIABLE LAG ARE BASE ON
C                             LAGGING THE VOLUME OF FLOW IN THE INTERVAL
C                             FLOW(N) TO FLOW(N+1) BY THE AVERAGE LAG FOR
C                             THAT INTERVAL (LAG(N)+LAG(N+1))*0.5
C                        LAG VALUE FOR HIGHEST DEFINED FLOW IS USED FOR
C                             ALL FLOW ABOVE THAT DISCHARGE
********************************************************************************
C  21    40X,I5     =1 IF M.D.F. PLOT WANTED FOR THE FLOW-POINT  =0 NO PLOT
C                        M.D. OBSERVED FLOW MUST BE READ IN TO GET PLOT
C         F10.0     MAXIMUM PLOT ORDINATE FOR M.D.F. PLOT
C         F10.0     BASE FOR FLOW INTERVAL CALCULATIONS IN STATISTICAL
C                        SUBROUTINE   (GUIDE--FLOW THAT IS EXCEEDED 25 PER
C                                                  CENT OF THE TIME)
C         1X,A9     USGS STATION IDENTICATION NUMBER  (NEEDED IF STD. FMT CARDS
C                                  ARE TO BE PUNCHED)
********************************************************************************
C  22      30X,     TIME DELAY HISTOGRAM (MAX.NO OF POINTS=30)
C        10F5.2          HISTOGRAM IS FOR LOCAL AREA   SUMMATION OF VALUES=1.0
********************************************************************************
C  23      30X,     MBP AREAS TO BE ASSIGNED TO EACH ELEMENT OF THE TIME-DELAY
C          10I5          HISTOGRAM ---  MBP AREAS DESIGNATED BY RUN NO. WHICH
C                        IS DETERMINED BY THE ORDER CARDS 16 TO 19 WERE READ.
********************************************************************************
C  20D     30X,     RUN NO. OF EACH UPSTREAM INFLOW POINT TO LOCAL AREA
C          5I5                NEEDED IF (NUPIN.GT.0)
********************************************************************************
```

```
C  20E      30X,      CONSTANT LAG FOR EACH UPSTREAM INFLOW POINT
C          5F5.1           (LAG IN HOURS)     NEEDED IF (NUPIN.GT.0)
C                **NOTE** TOTAL LAG CONSISTS OF CONSTANT PLUS VARIABLE COMPONENT
*****************************************************************************
*****************************************************************************
C  24        4I5      NUMBER OF RECORDS TO SKIP ON TAPES 1 TO 4 TO POSITION
C                          THE TAPE CORRECTLY FOR THE INITIAL MONTH
*****************************************************************************
*****************************************************************************
*****************************************************************************
C    THE FOLLOWING SNOW INPUT  CARD  TELLS THE PROGRAM FOR WHICH MONTHS VALID
C         AIR TEMPERATURE DATA ARE AVAILABLE AND THUS WHICH MONTHS SNOW
C         COMPUTATIONS ARE TO BE MADE.     =1 VALID DATA AVAILABLE
C                                          =0 AIR TEMPERATURE DATA IS MISSING
******NOTE********  CARD 241 ONLY NEEDED IF SNOW IS INCLUDED.  ****************
*****************************************************************************
C 241       12I5      VALID AIR TEMP. DATA INDICATOR-- MONTHS 1-12 (JAN-DEC)
C                          REPEAT CARD 241 FOR EACH WATER YEAR
*****************************************************************************
*****************************************************************************
*****************************************************************************
*****************************************************************************
C      DATA INPUT DESCRIPTION --------- SNOW NOT INCLUDED.
C
C          A.    BASIC DATA  CAN BE ON MORE THAN ONE TAPE  (IN ORDER BY MONTHS)
C                          IF ON ONE TAPE MUST BE IN FOLLOWING ORDER
C                1.    MBP AREAS  RECORD SIZE=124     SIX HOUR PCPN IN SEQUENTIAL
C                                                    ORDER FOR THE MONTH
C                2.    PE STATION RECORD SIZE=31      DAILY PE
C                3.    M.D.F STREAMGAGES  RECORD SIZE=31  DAILY FLOWS FROM
C                                                     USGS WATER SUPPLY PAPERS
C                          MISSING DATA IS READ IN AS NEGATIVE NUMBER
C                          ENTIRE MONTH MUST EITHER BE ALL VALID DATA OR
C                               ALL MISSING DATA.
C                4.    SIX HOUR DISCHARGES RECORD SIZE=124
C                          DISCHARGE AT 6 A.M.,NOON,6 P.M.,MID. FOR EACH DAY
C                               IN SEQ. ORDER FOR THE MONTH
C                          MISSING DATA IS READ IN AS NEGATIVE NUMBER
C
C          B.  OTHER DATA IS EITHER GENERATED BY THE PROGRAM IN A PREVIOUS
C                RUN OR IN THE CASE OF UPSTREAM INFLOWS, THESE CAN BE GENERATED
C                BY A PREVIOUS RUN OR THE TAPE COULD BE PREPARED.
C                     IF PREPARED IT IS THE SAME FORMAT AS SIX HOUR DISCHARGES
C                          EXCEPT NO MISSING DATA IS ALLOWED.
*****************************************************************************
*****************************************************************************
*****************************************************************************
C      DATA INPUT DESCRIPTION ------- SNOW INCLUDED.
C
C          BASIC DATA CAN BE ON MORE THAN ONE TAPE  (IN ORDER BY MONTHS)
C                IF ON ONE TAPE,MUST BE IN THE FOLLOWING ORDER
C
C          1. MBP AREA DATA -- RECORD SIZE 124
C          2. PE DATA -- RECORD SIZE 31
```

```
C          3. MAT AREA DATA -- RECORD SIZE 124
C             (NOTE..AIR TEMPERATURE CAN BE LOADED ON TO TAPE USING
C              O/H STANDARD FORMAT CARDS WITH PROGRAM NWSRFS2. (SEE NWSRFS
C              TECH. MEMO APPENDIX E ) NOTE THAT AIR TEMPERATURE MUST BE
C              PUNCHED WITH FIELD LENGTH .EQ.3 ON O/H STD. FMT. CARDS.
C          4. OBSERVED AREAL WATER EQUIVALENT -- RECORD SIZE 31
C             (NOTE..OBSERVED WATER EQUIVALENT DATA CAN BE LOADED ON TO TAPE
C            BY PROGRAM NWSRFS2, BY TREATING IT AS IF IT WAS MEAN DAILY FLOW.)
C          5. MEAN DAILY FLOW DATA -- RECORD SIZE 31
C          6. SIX HOUR DISCHARGE DATA -- RECORD SIZE 124
************************************************************************
************************************************************************
************************************************************************
************************************************************************
```

D.2 SAMPLE INPUT FOR VERIFICATION PROGRAM WITH SNOW

```
NORTHERN NEW ENGLAND SNOW BASIN--TEMPERATURE INDEX MODEL--FINAL TRIAL,ERROR RUN
PASSUMPSIC RIVER AT PASSUMPSIC,VERMONT  --  TWO SUB-AREAS
   2    1    1    0
   3    1    1    0    0
  10   63    9   71
   2    3
NORTHERN NEW ENGLAND PE ESTIMATE          166   92
   1
   1    1
   1
   0
   1
   0
   0    0    0    0    1    0    1    1    0    1    1    0    0    3    1
   1    1    1
   4   70    5   70    4   71    5   71
PASSUMPSIC RIVER-L    1.0  .05  .20  .25  5.0  .30  3.0  .90  0.0       VOL PARM
PASSUMPSIC RIVER-L    .30  1.0  1.0  0.0  .25                           ET  PARM
PASSUMPSIC RIVER-L     .9  .10 .004  .55  .99                          TIME PARM
PASSUMPSIC RIVER-L    0.0  5.5  1.1  .12  0.0  0.0  .10                 INITIAL
PASSUMPSIC RIVER-H    1.0  .05  .20  .25  5.0  .30  3.0  .90  0.0       VOL PARM
PASSUMPSIC RIVER-H    .30  1.0  1.0  0.0  .25                           ET  PARM
PASSUMPSIC RIVER-H     .9  .10 .004  .55  .99                          TIME PARM
PASSUMPSIC RIVER-H    0.0  5.5  1.1  .12  0.0  0.0  .10                 INITIAL
   1    1    0    0
   2    0
   3    0
PASSUMPSIC R. MAT-L       1060. -1.5 -2.7 -3.9 -2.7
PASSUMPSIC R. MAT-H       1740. -1.5 -2.7 -3.9 -2.7
   2    3
   1    2
PASSUMPSIC RIVER-L        1060.  .50 1.17 .022 .005 .003 .054  4.5  .01
PASSUMPSIC RIVER-L    32.  0.0  0.0  0.0  0.0
PASSUMPSIC RIVER-L    0.0  0.0  0.0
PASSUMPSIC RIVER-L    32.  33.  .03   .5
AREAL DEPLETION LOW   .24  .39  .52  .64  .75  .82  .88  .92  .96
PASSUMPSIC RIVER-H        1740.  .90 1.13 .022 .005 .003 .054  6.0  .01
PASSUMPSIC RIVER-H    32.  0.0  0.0  0.0  0.0
PASSUMPSIC RIVER-H    0.0  0.0  0.0
PASSUMPSIC RIVER-H    32.  33.  .03   .5
AREAL DEPLETION HIGH  .24  .39  .52  .64  .75  .82  .88  .92  .96
PASSUMPSIC R. AT PASSUMPSIC          436.  9.0    0    0    6    3    0    0    0
PASSUMPSIC R. AT PASSUMPSIC                  1   10000.     1000.  01135500
TIME-DELAY,PASSUMPSIC          .10  .40  .50
GAGE-AREA ,PASSUMPSIC            1    1    2
   0    0    0    0                                                SKIP TAPE RECDS
   1    1    1    1    1    0    0    0    0    0    0    1        WATER YEAR  64
   1    1    1    1    1    0    0    0    0    1    1    1        WATER YEAR  65
   1    1    1    1    1    0    0    0    0    0    1    1        WATER YEAR  66
   1    1    1    1    1    0    0    0    0    0    1    1        WATER YEAR  67
   1    1    1    1    1    0    0    0    0    0    1    1        WATER YEAR  68
   1    1    1    1    1    0    0    0    0    0    1    1        WATER YEAR  69
   1    1    1    1    1    0    0    0    0    1    1    1        WATER YEAR  70
   1    1    1    1    1    0    0    0    0    0    1    1        WATER YEAR  71
```

D.3 EXAMPLES OF OUTPUT FROM VERIFICATION PROGRAM WITH SNOW

```
                PASSUMPSIC RIVER AT PASSUMPSIC,VERMONT  --  TWO SUB-AREAS

NORTHERN NEW ENGLAND SNOW BASIN--TEMPERATURE INDEX MODEL--FINAL TRIAL,ERROR RUN

                                               BASIC RUN INFORMATION

RUN BEGINS OCT 1963     RUN ENDS SEPT 1971

NUMBER OF PRECIPITATION GAGES= 2     NUMBER OF FLOW-POINTS= 1     NUMBER OF POTENTIAL ET STATIONS= 1
            EVAPORATION PARAMETERS ARE     NORTHERN NEW ENGLAND PE ESTIMATE          NEP=166     NDUR= 92

                  SNOW IS INCLUDED
```

PASSUMPSIC RIVER AT PASSUMPSIC,VERMONT -- TWO SUB-AREAS

NORTHERN NEW ENGLAND SNOW BASIN--TEMPERATURE INDEX MODEL--FINAL TRIAL,ERROR RUN

SOIL MOISTURE VOLUME PARAMETERS

RG	PRECIP. GAGE NAME	K1	A	EPXM	UZSN	LZSN	CB	POWER	CC	K24L	K3	GAGEPE	EHIGH	ELOW	K24EL
1	PASSUMPSIC RIVER-L	1.000	.050	.200	.250	5.000	.300	3.000	.900	0.000	.300	1.000	1.000	0.000	.250
2	PASSUMPSIC RIVER-H	1.000	.050	.200	.250	5.000	.300	3.000	.900	0.000	.300	1.000	1.000	0.000	.250

SOIL MOISTURE TIMING PARAMETERS

RG	SRC1	LIRC6	LKK6	KV	KGS
1	.900	.100	.0040	.550	.9900
2	.900	.100	.0040	.550	.9900

SOIL MOISTURE INITIAL VALUES

RG	UZS	LZS	SGW	GWS	RES	SRGX	SCEP
1	0.00	5.50	1.10	.12	0.00	0.00	.10
2	0.00	5.50	1.10	.12	0.00	0.00	.10

SNOW PARAMETERS--CASE=1

INPUT GAGES USED

RG	TA GAGE	WE GAGE
1	PASSUMPSIC R. MAT-L	
2	PASSUMPSIC R. MAT-H	

TA GAGE	ELEV.	PERIOD TA LAPSE RATES			
PASSUMPSIC R. MAT-L	1060.	-1.5	-2.7	-3.9	-2.7
PASSUMPSIC R. MAT-H	1740.	-1.5	-2.7	-3.9	-2.7

AREA SNOW PARAMETERS

RG	ELEV	EFC	SCF	MFMAX	MFMIN	NMF	UADJ	SI	DAYGM	MBASE	PXTEMP	PLWHC	TIPM
1	1060.	.50	1.17	.0220	.0050	.0030	.0540	4.50	.010	32.0	33.0	.030	.500
2	1740.	.90	1.13	.0220	.0050	.0030	.0540	6.00	.010	32.0	33.0	.030	.500

INTIAL SNOW VALUES

RG	WE	NEGHS	LIQW	STORAGE	SB	SBAESC	SBWS	TINDEX
1	0.00	0.000	0.000	0.000	0.000	0.000	0.000	32.
2	0.00	0.000	0.000	0.000	0.000	0.000	0.000	32.

AREAL DEPLETION CURVE FOR AREA 1

WE/AI	0.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
AESC	.05	.24	.39	.52	.64	.75	.82	.88	.92	.96	1.00

AREAL DEPLETION CURVE FOR AREA 2

WE/AI	0.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
AESC	.05	.24	.39	.52	.64	.75	.82	.88	.92	.96	1.00

PASSUMPSIC RIVER AT PASSUMPSIC,VERMONT -- TWO SUB-AREAS

NORTHERN NEW ENGLAND SNOW BASIN--TEMPERATURE INDEX MODEL--FINAL TRIAL,ERROR RUN

FLOW-POINT PARAMETERS

FP	FLOW-POINT NAME	AREA	KS1	OBSER	COMPAR	CHECK	SIXIN	HISTOGRAMS			
1	PASSUMPSIC R. AT PASSUMPSIC	436.00	9.00	0	1	1	0	TIME-DELAY	.100	.400	.500
								GAGE AREA	1	1	2

SNOW SUMMARY FOR STATION 1 4/70

DAY	SNOWFALL	RAIN	HEAT-EXQ	COVER	PACK WE	LIQUID	NEG-HEAT	TOTAL WATER	OBS WATER EQUIV
1	0.000	0.000	.118	1.00	6.48	.194	.005	6.70	I
2	.427	.740	.080	1.00	6.83	.205	0.000	7.26	I
3	.244	0.000	-.004	1.00	7.05	.211	.014	7.26	I
4	0.000	0.000	.002	1.00	7.03	.210	.026	7.24	I
5	0.000	0.000	-.025	1.00	7.02	.210	.051	7.23	I
6	.001	0.000	.093	1.00	6.96	.207	.009	7.18	I
7	0.000	.021	.176	1.00	6.78	.203	.004	7.00	I
8	0.000	0.000	.580	1.00	6.19	.186	0.000	6.49	I
9	0.000	.020	.836	1.00	5.34	.160	0.000	5.61	I
10	0.000	.001	.194	1.00	5.13	.154	.007	5.31	I
11	0.000	0.000	-.004	1.00	5.12	.154	.011	5.28	I
12	0.000	.000	.255	1.00	4.87	.146	0.000	5.04	I
13	0.000	0.000	.335	1.00	4.52	.136	.005	4.67	I
14	0.000	0.000	.600	.96	3.91	.117	0.000	4.09	I
15	0.000	0.000	.488	.92	3.42	.102	0.000	3.55	I
16	0.000	0.000	.769	.85	2.64	.079	0.000	2.82	I
17	0.000	.234	.831	.68	1.80	.054	0.000	1.96	I
18	0.000	.028	.248	.58	1.54	.046	.000	1.59	I
19	0.000	0.000	.106	.55	1.42	.043	.006	1.46	I
20	.014	.195	.061	.54	1.37	.041	0.000	1.45	I
21	0.000	.207	.200	.49	1.16	.035	0.000	1.25	I
22	0.000	0.000	.260	.40	.89	.027	0.000	.91	I
23	.010	0.000	.198	.34	.69	.021	0.000	.71	I
24	0.000	1.178	.200	.26	.48	.014	0.000	.49	I
25	0.000	0.000	.170	.19	.30	.009	0.000	.31	I
26	0.000	.002	.186	.11	.10	.003	0.000	.11	I

SIX-HOUR SOIL MOISTURE OUTPUT FOR 4/70 PASSUMPSIC RIVER-L   ELKK6=LKK6*(1.0+KV*GWS)   GWIN=INFLOW TO GROUNDWATER STORAGE

IDA	IP6	SCEP	UZS	LZS	SGW	RES	SRGX	ELKK6	INFIL	GWIN	IMPV-RO	SUR-RO	INTERFW	GW-FLOW	TOTAL-RO	PRECIP
1	1	.200	.537	7.776	1.474	0.0000	.0010	.0060	.0047	.0040	.0002	.0000	.0001	.0090	.0093	.005
1	2	.197	.537	7.776	1.468	0.0000	.0009	.0060	.0036	.0030	.0002	.0000	.0001	.0087	.0090	.004
1	3	.193	.536	7.778	1.468	0.0000	.0009	.0060	.0107	.0091	.0007	.0000	.0001	.0086	.0094	.013
1	4	.200	.538	7.788	1.512	0.0000	.0028	.0061	.0624	.0531	.0039	.0011	.0003	.0093	.0146	.078
2	1	.200	.538	7.790	1.515	0.0000	.0026	.0061	.0145	.0124	.0008	.0001	.0003	.0094	.0105	.016
2	2	.199	.538	7.791	1.511	0.0000	.0023	.0061	.0065	.0055	.0003	.0000	.0002	.0093	.0099	.007
2	3	.199	.548	7.814	1.623	0.0000	.0160	.0064	.1430	.1221	.0093	.0080	.0017	.0103	.0293	.186
2	4	.200	.588	7.852	1.796	0.0000	.0840	.0068	.2166	.1853	.0196	.0397	.0089	.0122	.0804	.393
3	1	.200	.596	7.876	1.914	0.0000	.0975	.0070	.1537	.1318	.0104	.0124	.0103	.0135	.0467	.209
3	2	.198	.596	7.879	1.916	0.0000	.0879	.0070	.0172	.0148	.0009	.0001	.0093	.0134	.0237	.019
3	3	.195	.594	7.880	1.909	0.0000	.0791	.0070	.0082	.0070	.0004	.0000	.0084	.0132	.0220	.008
3	4	.200	.594	7.880	1.897	0.0000	.0712	.0070	.0015	.0013	.0003	.0000	.0075	.0133	.0212	.006
4	1	.200	.594	7.881	1.887	0.0000	.0641	.0070	.0041	.0035	.0002	.0000	.0068	.0132	.0202	.004
4	2	.196	.594	7.881	1.876	0.0000	.0577	.0069	.0024	.0021	.0001	.0000	.0061	.0129	.0191	.003
4	3	.191	.591	7.881	1.866	0.0000	.0519	.0069	.0025	.0022	.0002	0.0000	.0055	.0125	.0182	.004
4	4	.200	.591	7.882	1.855	0.0000	.0467	.0069	.0020	.0017	.0006	.0000	.0049	.0129	.0184	.011
5	1	.200	.591	7.882	1.846	0.0000	.0421	.0069	.0049	.0043	.0003	.0000	.0044	.0128	.0175	.005
5	2	.196	.591	7.883	1.837	0.0000	.0379	.0068	.0037	.0032	.0002	.0000	.0040	.0125	.0167	.004
5	3	.191	.588	7.883	1.826	0.0000	.0341	.0068	.0024	.0021	.0001	0.0000	.0036	.0121	.0159	.003
5	4	.194	.588	7.883	1.814	0.0000	.0307	.0068	0.0000	0.0000	.0001	0.0000	.0032	.0124	.0158	.003
6	1	.196	.588	7.883	1.801	0.0000	.0276	.0068	0.0000	0.0000	.0001	0.0000	.0029	.0123	.0153	.003
6	2	.195	.588	7.883	1.789	0.0000	.0248	.0067	0.0000	0.0000	.0001	0.0000	.0026	.0119	.0147	.003
6	3	.192	.586	7.884	1.781	0.0000	.0224	.0067	.0040	.0035	.0003	.0000	.0024	.0116	.0143	.007
6	4	.200	.586	7.888	1.793	0.0000	.0206	.0067	.0290	.0249	.0020	.0003	.0022	.0122	.0166	.039
7	1	.200	.586	7.893	1.791	0.0000	.0186	.0067	.0108	.0093	.0006	.0000	.0020	.0121	.0147	.011
7	2	.196	.586	7.891	1.785	0.0000	.0168	.0067	.0077	.0066	.0004	.0000	.0018	.0119	.0141	.008
7	3	.193	.584	7.898	1.812	0.0000	.0163	.0068	.0456	.0392	.0026	.0007	.0017	.0120	.0169	.052
7	4	.200	.587	7.912	1.881	0.0000	.0214	.0069	.0958	.0825	.0061	.0033	.0023	.0131	.0253	.123
8	1	.200	.587	7.915	1.883	0.0000	.0194	.0069	.0176	.0152	.0009	.0001	.0020	.0132	.0163	.019
8	2	.196	.587	7.918	1.892	0.0000	.0178	.0070	.0251	.0217	.0014	.0002	.0019	.0131	.0165	.027
8	3	.192	.595	7.944	2.019	0.0000	.0431	.0072	.1646	.1421	.0116	.0151	.0045	.0143	.0455	.232
8	4	.200	.604	7.968	2.141	0.0000	.0656	.0075	.1595	.1379	.0116	.0149	.0069	.0162	.0496	.232
9	1	.200	.605	7.981	2.197	0.0000	.0645	.0076	.0846	.0733	.0050	.0030	.0068	.0169	.0318	.100
9	2	.194	.608	7.996	2.268	0.0000	.0668	.0078	.1026	.0889	.0063	.0048	.0071	.0175	.0357	.126
9	3	.187	.629	8.025	2.432	.0011	.1629	.0082	.2119	.1840	.0212	.0564	.0172	.0193	.1141	.425
9	4	.200	.635	8.050	2.554	0.0000	.1807	.0084	.1649	.1435	.0126	.0186	.0191	.0217	.0720	.251
10	1	.200	.636	8.061	2.599	0.0000	.1677	.0085	.0778	.0678	.0046	.0027	.0177	.0224	.0474	.092
10	2	.195	.636	8.063	2.594	0.0000	.1512	.0085	.0196	.0171	.0011	.0001	.0160	.0221	.0393	.021
10	3	.191	.633	8.073	2.635	0.0000	.1399	.0086	.0726	.0633	.0042	.0021	.0148	.0224	.0435	.084
10	4	.200	.634	8.085	2.684	0.0000	.1320	.0087	.0839	.0733	.0055	.0033	.0139	.0237	.0464	.109
11	1	.200	.634	8.087	2.673	0.0000	.1189	.0087	.0137	.0120	.0007	.0001	.0126	.0235	.0369	.015
11	2	.194	.634	8.088	2.655	0.0000	.1071	.0087	.0062	.0054	.0003	.0000	.0113	.0229	.0346	.007
11	3	.185	.630	8.088	2.635	0.0000	.0963	.0086	.0039	.0034	.0002	0.0000	.0102	.0223	.0327	.005
11	4	.188	.630	8.088	2.613	0.0000	.0867	.0086	0.0000	0.0000	.0001	0.0000	.0092	.0227	.0320	.003
12	1	.190	.630	8.088	2.590	0.0000	.0780	.0086	0.0000	0.0000	.0001	0.0000	.0082	.0224	.0307	.003
12	2	.194	.630	8.088	2.568	0.0000	.0702	.0085	0.0000	0.0000	.0005	0.0000	.0074	.0217	.0296	.010
12	3	.187	.627	8.099	2.617	0.0000	.0684	.0086	.0817	.0714	.0049	.0028	.0072	.0221	.0370	.099
12	4	.200	.629	8.112	2.675	0.0000	.0694	.0088	.0935	.0817	.0063	.0042	.0073	.0236	.0415	.127
13	1	.200	.629	8.114	2.667	0.0000	.0627	.0087	.0178	.0156	.0010	.0001	.0066	.0235	.0312	.019
13	2	.195	.629	8.117	2.664	0.0000	.0568	.0087	.0233	.0204	.0013	.0002	.0060	.0233	.0307	.025
13	3	.191	.629	8.136	2.757	0.0000	.0695	.0089	.1341	.1175	.0089	.0099	.0073	.0244	.0505	.178
13	4	.200	.631	8.151	2.828	0.0000	.0748	.0091	.1108	.0972	.0075	.0065	.0079	.0260	.0479	.150
14	1	.200	.631	8.153	2.811	0.0000	.0674	.0091	.0104	.0091	.0006	.0000	.0071	.0258	.0335	.011
14	2	.195	.631	8.158	2.819	0.0000	.0618	.0091	.0386	.0339	.0021	.0006	.0065	.0256	.0349	.043
14	3	.189	.640	8.186	2.960	0.0000	.1256	.0094	.1927	.1693	.0169	.0371	.0133	.0276	.0948	.338
14	4	.200	.643	8.205	3.048	0.0000	.1341	.0096	.1337	.1177	.0096	.0111	.0142	.0297	.0645	.192
15	1	.200	.643	8.210	3.054	0.0000	.1219	.0097	.0402	.0354	.0022	.0007	.0129	.0298	.0456	.045
15	2	.191	.644	8.215	3.062	0.0000	.1112	.0097	.0425	.0375	.0024	.0008	.0117	.0295	.0444	.048
15	3	.182	.646	8.243	3.185	0.0000	.1491	.0100	.1760	.1553	.0141	.0256	.0157	.0311	.0866	.281
15	4	.200	.648	8.254	3.249	0.0000	.1475	.0101	.1107	.0979	.0080	.0069	.0156	.0332	.0637	.159
16	1	.200	.648	8.257	3.239	0.0000	.1333	.0101	.0259	.0229	.0014	.0003	.0141	.0331	.0489	.028

16	2	.192	.649	8.267	3.272	0.0000	.1252	.0102	.0746	.0660	.0044	.0027	.0132	.0333	.0536	.088
16	3	.183	.657	8.296	3.406	0.0000	.2087	.0105	.1926	.1706	.0192	.0497	.0220	.0352	.1261	.384
16	4	.200	.661	8.316	3.500	0.0000	.2203	.0107	.1491	.1322	.0117	.0167	.0233	.0380	.0897	.234
17	1	.200	.662	8.328	3.547	0.0000	.2085	.0109	.0968	.0860	.0060	.0052	.0220	.0389	.0722	.121
17	2	.186	.666	8.348	3.643	0.0000	.2245	.0111	.1533	.1363	.0114	.0189	.0237	.0402	.0942	.229
17	3	.172	.671	8.375	3.767	0.0000	.2978	.0114	.1880	.1674	.0190	.0487	.0314	.0419	.1410	.379
17	4	.200	.679	8.400	3.881	0.0000	.3510	.0117	.1788	.1595	.0183	.0420	.0370	.0458	.1431	.366
18	1	.200	.680	8.412	3.922	0.0000	.3272	.0118	.0985	.0879	.0062	.0057	.0345	.0467	.0932	.124
18	2	.195	.680	8.420	3.935	0.0000	.2992	.0118	.0679	.0607	.0040	.0024	.0316	.0469	.0849	.080
18	3	.190	.675	8.432	3.980	0.0000	.2808	.0120	.1041	.0931	.0065	.0058	.0296	.0476	.0894	.129
18	4	.200	.675	8.438	3.977	0.0000	.2552	.0120	.0504	.0450	.0034	.0012	.0269	.0482	.0798	.067
19	1	.200	.675	8.438	3.933	0.0000	.2296	.0119	.0037	.0033	.0002	.0000	.0242	.0474	.0718	.004
19	2	.187	.675	8.439	3.891	0.0000	.2067	.0118	.0048	.0043	.0003	.0000	.0218	.0460	.0681	.005
19	3	.174	.670	8.444	3.887	0.0000	.1877	.0118	.0477	.0427	.0030	.0009	.0198	.0452	.0689	.061
19	4	.200	.670	8.447	3.864	0.0000	.1696	.0118	.0258	.0231	.0027	.0003	.0179	.0462	.0672	.054
20	1	.200	.670	8.448	3.822	0.0000	.1526	.0118	.0040	.0036	.0002	.0000	.0161	.0455	.0618	.004
20	2	.196	.670	8.448	3.779	0.0000	.1374	.0117	.0024	.0022	.0001	.0000	.0145	.0445	.0591	.003
20	3	.193	.666	8.460	3.825	0.0000	.1347	.0118	.1017	.0911	.0063	.0055	.0142	.0452	.0713	.125
20	4	.200	.667	8.468	3.842	0.0000	.1266	.0119	.0710	.0637	.0046	.0026	.0134	.0462	.0667	.092
21	1	.200	.667	8.472	3.829	0.0000	.1151	.0119	.0366	.0328	.0020	.0006	.0122	.0460	.0608	.041
21	2	.197	.667	8.474	3.803	0.0000	.1040	.0118	.0216	.0193	.0012	.0002	.0110	.0454	.0577	.023
21	3	.195	.665	8.491	3.880	0.0000	.1208	.0120	.1386	.1244	.0096	.0135	.0128	.0469	.0827	.192
21	4	.200	.667	8.503	3.932	0.0000	.1248	.0122	.1110	.0997	.0075	.0080	.0132	.0484	.0771	.151
22	1	.200	.667	8.510	3.933	0.0000	.1154	.0122	.0550	.0495	.0032	.0015	.0122	.0485	.0654	.063
22	2	.194	.667	8.516	3.939	0.0000	.1077	.0122	.0611	.0549	.0036	.0019	.0114	.0485	.0653	.071
22	3	.188	.665	8.530	3.999	0.0000	.1167	.0124	.1233	.1109	.0083	.0097	.0123	.0495	.0798	.166
22	4	.200	.665	8.532	3.967	0.0000	.1053	.0123	.0188	.0169	.0016	.0002	.0111	.0496	.0625	.033
23	1	.200	.665	8.533	3.920	0.0000	.0948	.0123	.0024	.0022	.0001	.0000	.0100	.0487	.0588	.003
23	2	.193	.665	8.538	3.917	0.0000	.0879	.0123	.0509	.0458	.0029	.0013	.0093	.0483	.0618	.058
23	3	.185	.661	8.547	3.938	0.0000	.0851	.0123	.0778	.0700	.0048	.0029	.0090	.0484	.0651	.095
23	4	.200	.661	8.551	3.924	0.0000	.0780	.0123	.0382	.0344	.0029	.0007	.0082	.0490	.0609	.058
24	1	.200	.661	8.555	3.908	0.0000	.0715	.0123	.0368	.0332	.0021	.0006	.0076	.0488	.0591	.041
24	2	.197	.664	8.569	3.974	0.0000	.0902	.0125	.1292	.1164	.0091	.0126	.0095	.0502	.0814	.182
24	3	.193	.697	8.588	4.080	.0077	.3786	.0128	.1760	.1588	.0482	.3856	.0400	.0523	.5261	.965
24	4	.200	.699	8.604	4.151	0.0000	.3758	.0130	.1390	.1256	.0103	.0170	.0397	.0545	.1215	.206
25	1	.200	.699	8.606	4.114	0.0000	.3385	.0129	.0181	.0164	.0010	.0002	.0357	.0538	.0907	.020
25	2	.186	.699	8.612	4.112	0.0000	.3083	.0129	.0573	.0518	.0033	.0017	.0325	.0532	.0908	.067
25	3	.172	.693	8.618	4.117	0.0000	.2813	.0130	.0651	.0589	.0041	.0019	.0297	.0526	.0883	.082
25	4	.189	.693	8.618	4.064	0.0000	.2532	.0129	0.0000	0.0000	.0008	0.0000	.0267	.0530	.0806	.017
26	1	.191	.693	8.618	4.012	0.0000	.2279	.0128	0.0000	0.0000	.0001	0.0000	.0241	.0520	.0762	.003
26	2	.175	.693	8.624	4.008	0.0000	.2082	.0128	.0536	.0485	.0035	.0015	.0220	.0508	.0778	.070
26	3	.150	.687	8.631	4.020	0.0000	.1922	.0129	.0704	.0637	.0050	.0023	.0203	.0498	.0774	.101
26	4	.180	.687	8.631	3.968	0.0000	.1730	.0128	0.0000	0.0000	.0015	0.0000	.0183	.0514	.0711	.030
27	1	.183	.687	8.631	3.918	0.0000	.1557	.0127	0.0000	0.0000	.0004	0.0000	.0164	.0504	.0672	.009
27	2	.167	.687	8.635	3.899	0.0000	.1413	.0127	.0342	.0310	.0025	.0006	.0149	.0484	.0664	.050
27	3	.133	.682	8.636	3.866	0.0000	.1273	.0126	.0181	.0164	.0023	.0001	.0134	.0460	.0618	.047
27	4	.133	.682	8.636	3.818	0.0000	.1146	.0125	0.0000	0.0000	0.0000	0.0000	.0121	.0485	.0605	0.000
28	1	.133	.682	8.636	3.770	0.0000	.1031	.0124	0.0000	0.0000	0.0000	0.0000	.0109	.0475	.0584	0.000
28	2	.104	.682	8.636	3.723	0.0000	.0928	.0124	0.0000	0.0000	0.0000	0.0000	.0098	.0451	.0549	.001
28	3	.042	.677	8.637	3.682	0.0000	.0835	.0123	.0050	.0045	.0000	0.0000	.0088	.0427	.0515	0.000
28	4	.042	.677	8.637	3.637	0.0000	.0752	.0122	0.0000	0.0000	0.0000	0.0000	.0079	.0449	.0529	0.000
29	1	.042	.677	8.637	3.593	0.0000	.0677	.0121	0.0000	0.0000	0.0000	0.0000	.0071	.0441	.0512	0.000
29	2	.015	.677	8.637	3.550	0.0000	.0609	.0120	0.0000	0.0000	0.0000	0.0000	.0064	.0419	.0483	0.000
29	3	0.000	.633	8.637	3.510	0.0000	.0548	.0120	.0027	.0025	0.0000	0.0000	.0058	.0397	.0455	0.000
29	4	0.000	.633	8.637	3.468	0.0000	.0493	.0119	0.0000	0.0000	0.0000	0.0000	.0052	.0417	.0469	0.000
30	1	0.000	.633	8.637	3.427	0.0000	.0444	.0118	0.0000	0.0000	0.0000	0.0000	.0047	.0410	.0456	0.000
30	2	0.000	.592	8.637	3.387	0.0000	.0400	.0117	0.0000	0.0000	0.0000	0.0000	.0042	.0381	.0424	0.000
30	3	0.000	.568	8.637	3.348	0.0000	.0360	.0117	.0001	.0001	0.0000	0.0000	.0038	.0353	.0391	0.000
30	4	0.000	.508	8.637	3.309	0.0000	.0324	.0116	0.0000	0.0000	0.0000	0.0000	.0034	.0388	.0422	0.000

SNOW SUMMARY FOR STATION 2 4/78

DAY	SNOWFALL	RAIN	HEAT-EXO	COVER	PACK WE	LIQUID	NEG-HEAT	TOTAL WATER	OBS WATER EQUIV
1	0.000	0.000	.065	1.00	9.93	.297	.007	10.23	I
2	.635	.197	.020	1.00	10.55	.316	0.000	11.03	I
3	.308	0.000	-.017	1.00	10.85	.316	.020	11.17	I
4	0.000	0.000	-.019	1.00	10.84	.316	.040	11.16	I
5	0.000	0.000	-.016	1.00	10.83	.316	.056	11.14	I
6	0.000	0.000	.048	1.00	10.82	.315	.008	11.13	I
7	.013	0.000	.101	1.00	10.72	.321	.008	11.07	I
8	0.000	0.000	.447	1.00	10.27	.308	0.000	10.71	I
9	0.000	.007	.684	1.00	9.58	.287	0.000	9.97	I
10	0.000	0.000	.023	1.00	9.53	.286	.015	9.83	I
11	0.000	0.000	-.008	1.00	9.52	.285	.023	9.81	I
12	0.000	0.000	.139	1.00	9.39	.282	.005	9.70	I
13	0.000	0.000	.213	1.00	9.16	.275	.010	9.47	I
14	0.000	0.000	.467	1.00	8.70	.261	0.000	9.01	I
15	0.000	0.000	.377	1.00	8.31	.249	0.000	8.59	I
16	0.000	0.000	.734	1.00	7.57	.227	0.000	7.97	I
17	0.000	.276	.915	1.00	6.64	.199	0.000	7.09	I
18	.038	0.006	.151	1.00	6.51	.195	.009	6.73	I
19	0.000	0.000	.068	1.00	6.42	.192	.015	6.63	I
20	.098	.171	.033	1.00	6.49	.192	.002	6.71	I
21	0.000	.202	.218	1.00	6.27	.188	0.000	6.58	I
22	0.000	0.000	.371	1.00	5.89	.177	0.000	6.11	I
23	.004	0.000	.331	.99	5.55	.167	0.000	5.83	I
24	0.000	1.466	.447	.95	5.09	.153	0.000	5.41	I
25	0.000	0.000	.450	.92	4.63	.139	0.000	4.81	I
26	0.000	0.000	.998	.85	3.63	.109	0.000	3.86	I
27	0.000	0.000	1.209	.69	2.41	.072	0.000	2.58	I
28	0.000	0.000	.893	.50	1.50	.045	0.000	1.62	I
29	0.000	0.000	.608	.34	.88	.027	0.000	.91	I
30	0.000	0.000	.454	.22	.42	.013	0.000	.43	I

SIX-HOUR SOIL MOISTURE OUTPUT FOR 4/70 PASSUMPSIC RIVER-H   ELKK6=LKK6*(1.0+KV*GWS)   GWIN=INFLOW TO GROUNDWATER STORAGE

IDA	IP6	SCEP	UZS	LZS	SGW	RES	SRGX	ELKK6	INFIL	GWIN	IMPV-RO	SUR-RO	INTERFW	GW-FLOW	TOTAL-RO	PRECIP
1	1	.192	.524	7.901	.940	0.0000	.0002	.0050	0.0000	0.0000	.0001	0.0000	.0000	.0047	.0049	.003
1	2	.189	.524	7.901	.935	0.0000	.0002	.0050	0.0000	0.0000	.0001	0.0000	.0000	.0044	.0045	.003
1	3	.181	.524	7.901	.931	0.0000	.0001	.0050	.0007	.0006	.0002	0.0000	.0000	.0040	.0043	.004
1	4	.192	.524	7.901	.926	0.0000	.0001	.0050	0.0000	0.0000	.0005	0.0000	.0000	.0046	.0051	.010
2	1	.197	.524	7.901	.922	0.0000	.0001	.0049	0.0000	0.0000	.0003	0.0000	.0000	.0046	.0048	.005
2	2	.199	.524	7.901	.917	0.0000	.0001	.0049	.0005	.0004	.0002	.0000	.0000	.0045	.0047	.004
2	3	.197	.523	7.901	.915	0.0000	0.0000	.0049	.0019	.0017	.0001	.0000	.0000	.0044	.0045	.003
2	4	.200	.523	7.904	.926	0.0000	.0002	.0050	.0189	.0163	.0011	.0001	.0000	.0046	.0059	.023
3	1	.200	.531	7.920	1.014	0.0000	.0069	.0052	.1076	.0927	.0066	.0038	.0007	.0052	.0164	.133
3	2	.196	.531 ,	7.924	1.029	0.0000	.0065	.0052	.0242	.0209	.0013	.0002	.0007	.0052	.0073	.026
3	3	.192	.530	7.925	1.030	0.0000	.0059	.0052	.0068	.0059	.0065	.0000	.0006	.0050	.0061	.010
3	4	.197	.530	7.925	1.025	0.0000	.0053	.0052	0.0000	0.0000	.0003	0.0000	.0006	.0053	.0061	.005
4	1	.200	.530	7.925	1.020	0.0000	.0047	.0052	.0008	.0007	.0002	.0000	.0005	.0053	.0060	.004
4	2	.192	.530	7.925	1.017	0.0000	.0043	.0052	.0024	.0021	.0001	.0000	.0005	.0049	.0055	.003
4	3	.179	.529	7.925	1.012	0.0000	.0038	.0051	.0008	.0007	.0001	0.0000	.0004	.0044	.0050	.003
4	4	.181	.529	7.925	1.007	0.0000	.0035	.0051	0.0000	0.0000	.0001	0.0000	.0004	.0052	.0057	.003
5	1	.184	.529	7.925	1.002	0.0000	.0031	.0051	0.0000	0.0000	.0001	0.0000	.0003	.0052	.0056	.003
5	2	.180	.529	7.925	.997	0.0000	.0028	.0051	0.0000	0.0000	.0001	0.0000	.0003	.0048	.0052	.003
5	3	.168	.529	7.926	.992	0.0000	.0025	.0051	.0008	.0006	.0001	0.0000	.0003	.0044	.0048	.003
5	4	.171	.529	7.926	.987	0.0000	.0023	.0051	0.0000	0.0000	.0001	0.0000	.0002	.0051	.0054	.003
6	1	.173	.529	7.926	.982	0.0000	.0020	.0051	0.0000	0.0000	.0001	0.0000	.0002	.0050	.0054	.003
6	2	.169	.529	7.926	.977	0.0000	.0018	.0051	0.0000	0.0000	.0001	0.0000	.0002	.0046	.0050	.003
6	3	.158	.528	7.926	.973	0.0000	.0017	.0051	.0007	.0006	.0001	0.0000	.0002	.0042	.0045	.003
6	4	.160	.528	7.926	.968	0.0000	.0015	.0051	0.0000	0.0000	.0001	0.0000	.0002	.0049	.0052	.003
7	1	.163	.528	7.926	.963	0.0000	.0013	.0050	0.0000	0.0000	.0001	0.0000	.0001	.0049	.0051	.003
7	2	.159	.528	7.926	.958	0.0000	.0012	.0050	0.0000	0.0000	.0001	0.0000	.0001	.0045	.0048	.003
7	3	.156	.527	7.926	.954	0.0000	.0011	.0050	.0007	.0006	.0005	0.0000	.0001	.0042	.0048	.010
7	4	.200	.527	7.929	.967	0.0000	.0012	.0050	.0203	.0176	.0033	.0001	.0001	.0049	.0084	.066
8	1	.200	.527	7.931	.976	0.0000	.0012	.0051	.0167	.0144	.0009	.0001	.0001	.0050	.0061	.018
8	2	.193	.527	7.933	.983	0.0000	.0011	.0051	.0141	.0122	.0008	.0000	.0001	.0047	.0056	.015
8	3	.185	.531	7.947	1.056	0.0000	.0056	.0052	.0908	.0784	.0057	.0026	.0006	.0048	.0137	.115
8	4	.200	.546	7.968	1.176	0.0000	.0213	.0055	.1456	.1259	.0106	.0090	.0022	.0065	.0283	.211
9	1	.200	.549	7.980	1.240	0.0000	.0234	.0057	.0821	.0711	.0049	.0023	.0025	.0070	.0167	.097
9	2	.189	.551	7.989	1.286	0.0000	.0233	.0058	.0619	.0536	.0035	.0013	.0025	.0069	.0141	.071
9	3	.177	.573	8.017	1.438	0.0000	.0605	.0061	.1851	.1606	.0149	.0217	.0064	.0077	.0507	.298
9	4	.200	.588	8.043	1.576	0.0000	.0880	.0064	.1706	.1483	.0138	.0183	.0093	.0101	.0516	.276
10	1	.200	.590	8.053	1.625	0.0000	.0827	.0065	.0693	.0603	.0040	.0019	.0087	.0106	.0253	.080
10	2	.192	.590	8.055	1.632	0.0000	.0747	.0065	.0203	.0177	.0011	.0001	.0079	.0103	.0194	.022
10	3	.183	.587	8.056	1.627	0.0000	.0672	.0065	.0056	.0049	.0006	.0000	.0071	.0098	.0175	.012
10	4	.200	.587	8.058	1.627	0.0000	.0606	.0065	.0125	.0109	.0015	.0001	.0064	.0107	.0186	.030
11	1	.200	.588	8.059	1.625	0.0000	.0546	.0065	.0098	.0085	.0005	.0000	.0058	.0106	.0169	.010
11	2	.188	.588	8.060	1.619	0.0000	.0492	.0065	.0049	.0043	.0003	.0000	.0052	.0100	.0154	.005
11	3	.169	.585	8.060	1.610	0.0000	.0442	.0065	.0020	.0017	.0002	0.0000	.0047	.0093	.0141	.004
11	4	.171	.585	8.060	1.599	0.0000	.0398	.0064	0.0000	0.0000	.0001	0.0000	.0042	.0104	.0147	.003
12	1	.174	.585	8.060	1.589	0.0000	.0358	.0064	0.0000	0.0000	.0001	0.0000	.0038	.0103	.0142	.003
12	2	.167	.585	8.060	1.579	0.0000	.0323	.0064	0.0000	0.0000	.0002	0.0000	.0034	.0096	.0132	.005
12	3	.167	.583	8.060	1.571	0.0000	.0290	.0064	.0019	.0017	.0012	0.0000	.0031	.0089	.0131	.023
12	4	.200	.584	8.066	1.596	0.0000	.0273	.0064	.0414	.0361	.0039	.0006	.0029	.0103	.0178	.079
13	1	.200	.584	8.068	1.602	0.0000	.0247	.0064	.0179	.0156	.0010	.0001	.0026	.0104	.0141	.019
13	2	.192	.584	8.070	1.601	0.0000	.0223	.0064	.0115	.0101	.0006	.0000	.0024	.0099	.0130	.012
13	3	.183	.583	8.077	1.635	0.0000	.0217	.0065	.0503	.0439	.0031	.0009	.0023	.0098	.0161	.063
13	4	.200	.586	8.090	1.706	0.0000	.0268	.0067	.0949	.0829	.0066	.0039	.0028	.0114	.0248	.132
14	1	.200	.586	8.093	1.715	0.0000	.0245	.0067	.0229	.0200	.0012	.0002	.0026	.0115	.0155	.025
14	2	.191	.586	8.095	1.719	0.0000	.0222	.0067	.0185	.0162	.0010	.0001	.0023	.0111	.0146	.020
14	3	.181	.590	8.113	1.818	0.0000	.0350	.0069	.1279	.1118	.0087	.0081	.0037	.0117	.0321	.174
14	4	.200	.599	8.135	1.939	0.0000	.0591	.0072	.1543	.1352	.0120	.0148	.0062	.0140	.0470	.239
15	1	.200	.600	8.140	1.958	0.0000	.0541	.0072	.0372	.0326	.0021	.0005	.0057	.0142	.0225	.041
15	2	.186	.600	8.143	1.963	0.0000	.0491	.0072	.0224	.0197	.0012	.0002	.0052	.0136	.0202	.024
15	3	.171	.601	8.158	2.045	0.0000	.0551	.0074	.1109	.0973	.0075	.0058	.0058	.0138	.0330	.151
15	4	.200	.606	8.176	2.144	0.0000	.0677	.0076	.1309	.1150	.0102	.0096	.0071	.0165	.0434	.204
16	1	.200	.606	8.179	2.148	0.0000	.0614	.0076	.0236	.0208	.0013	.0002	.0065	.0165	.0245	.026

16	2	.187	.607	8.183	2.158	0.0000	.0559	.0077	.0304	.0267	.0017	.0004	.0059	.0160	.0239	.033
16	3	.173	.615	8.207	2.290	0.0000	.0914	.0079	.1710	.1506	.0136	.0217	.0096	.0170	.0619	.272
16	4	.200	.625	8.231	2.420	0.0000	.1271	.0082	.1702	.1501	.0147	.0235	.0134	.0201	.0718	.294
17	1	.200	.629	8.247	2.507	0.0000	.1309	.0084	.1218	.1076	.0080	.0086	.0138	.0213	.0517	.160
17	2	.181	.633	8.264	2.601	0.0000	.1390	.0087	.1327	.1173	.0090	.0110	.0147	.0218	.0565	.180
17	3	.162	.646	8.289	2.747	.0011	.2264	.0090	.1927	.1706	.0203	.0524	.0239	.0229	.1195	.405
17	4	.200	.659	8.317	2.885	0.0000	.2988	.0093	.1863	.1653	.0205	.0490	.0315	.0271	.1280	.410
18	1	.200	.663	8.337	2.993	0.0000	.3057	.0095	.1538	.1366	.0115	.0189	.0323	.0288	.0915	.229
18	2	.194	.663	8.340	2.981	0.0000	.2755	.0095	.0194	.0172	.0010	.0002	.0291	.0284	.0586	.021
18	3	.187	.659	8.346	2.997	0.0000	.2498	.0096	.0503	.0448	.0029	.0010	.0264	.0283	.0584	.058
18	4	.200	.659	8.354	3.028	0.0000	.2293	.0096	.0676	.0602	.0046	.0023	.0242	.0295	.0606	.092
19	1	.200	.659	8.356	3.013	0.0000	.2066	.0096	.0163	.0145	.0009	.0001	.0218	.0293	.0521	.018
19	2	.184	.659	8.357	2.991	0.0000	.1859	.0096	.0071	.0063	.0004	.0000	.0196	.0281	.0481	.008
19	3	.162	.654	8.357	2.966	0.0000	.1673	.0095	.0045	.0040	.0005	0.0000	.0177	.0269	.0451	.011
19	4	.200	.655	8.359	2.953	0.0000	.1509	.0095	.0175	.0156	.0028	.0001	.0159	.0284	.0472	.057
20	1	.200	.655	8.361	2.937	0.0000	.1359	.0095	.0126	.0113	.0007	.0001	.0143	.0281	.0432	.014
20	2	.196	.655	8.361	2.914	0.0000	.1223	.0094	.0059	.0052	.0003	.0000	.0129	.0275	.0408	.006
20	3	.191	.650	8.365	2.917	0.0000	.1109	.0094	.0340	.0303	.0019	.0004	.0117	.0273	.0413	.037
20	4	.200	.652	8.378	2.979	0.0000	.1115	.0096	.1020	.0908	.0069	.0060	.0118	.0289	.0535	.138
21	1	.200	.652	8.380	2.965	0.0000	.1006	.0096	.0167	.0149	.0009	.0001	.0106	.0286	.0403	.018
21	2	.197	.652	8.381	2.946	0.0000	.0906	.0095	.0110	.0098	.0006	.0000	.0096	.0282	.0384	.012
21	3	.194	.649	8.391	2.993	0.0000	.0884	.0096	.0851	.0759	.0050	.0034	.0093	.0288	.0466	.101
21	4	.200	.652	8.408	3.083	0.0000	.1049	.0099	.1347	.1202	.0097	.0128	.0111	.0307	.0643	.195
22	1	.200	.653	8.418	3.131	0.0000	.1032	.0100	.0896	.0800	.0055	.0044	.0109	.0315	.0524	.110
22	2	.193	.654	8.423	3.138	0.0000	.0946	.0100	.0433	.0387	.0024	.0009	.0100	.0314	.0446	.049
22	3	.186	.652	8.438	3.214	0.0000	.1031	.0102	.1221	.1092	.0082	.0090	.0109	.0323	.0603	.164
22	4	.200	.654	8.451	3.277	0.0000	.1071	.0103	.1082	.0969	.0077	.0072	.0113	.0342	.0604	.154
23	1	.200	.654	8.454	3.270	0.0000	.0972	.0103	.0306	.0275	.0017	.0004	.0103	.0341	.0465	.034
23	2	.192	.654	8.456	3.251	0.0000	.0877	.0103	.0161	.0145	.0009	.0001	.0093	.0334	.0437	.017
23	3	.184	.650	8.464	3.282	0.0000	.0838	.0104	.0728	.0653	.0045	.0024	.0089	.0335	.0493	.090
23	4	.200	.652	8.476	3.337	0.0000	.0878	.0105	.1014	.0909	.0073	.0061	.0093	.0355	.0581	.146
24	1	.200	.653	8.485	3.376	0.0000	.0867	.0106	.0833	.0748	.0051	.0038	.0091	.0362	.0543	.102
24	2	.197	.656	8.500	3.453	0.0000	.1016	.0108	.1280	.1149	.0089	.0117	.0107	.0375	.0688	.178
24	3	.193	.700	8.520	3.575	.0112	.3925	.0111	.1807	.1624	.0583	.5543	.0414	.0396	.6937	1.167
24	4	.200	.709	8.538	3.688	.0014	.5007	.0114	.1724	.1551	.0216	.0765	.0528	.0424	.1933	.432
25	1	.200	.710	8.551	3.750	0.0000	.4702	.0115	.1166	.1050	.0078	.0096	.0496	.0437	.1107	.155
25	2	.186	.710	8.556	3.745	0.0000	.4251	.0115	.0431	.0388	.0024	.0009	.0449	.0430	.0912	.049
25	3	.172	.704	8.574	3.837	0.0000	.4228	.0117	.1534	.1383	.0119	.0196	.0446	.0441	.1202	.237
25	4	.200	.705	8.586	3.886	0.0000	.3959	.0119	.1058	.0955	.0083	.0075	.0418	.0468	.1043	.166
26	1	.200	.705	8.588	3.862	0.0000	.3569	.0119	.0250	.0226	.0014	.0003	.0377	.0464	.0857	.027
26	2	.176	.706	8.599	3.906	0.0000	.3348	.0120	.1004	.0906	.0065	.0066	.0353	.0462	.0945	.129
26	3	.152	.708	8.617	4.014	.0019	.4778	.0122	.1751	.1582	.0255	.0975	.0504	.0472	.2206	.510
26	4	.200	.710	8.634	4.097	0.0000	.4752	.0125	.1481	.1341	.0140	.0218	.0502	.0517	.1376	.280
27	1	.200	.711	8.645	4.134	0.0000	.4413	.0126	.0992	.0898	.0064	.0065	.0466	.0526	.1121	.128
27	2	.169	.715	8.665	4.225	0.0000	.4699	.0128	.1612	.1461	.0147	.0348	.0496	.0533	.1524	.295
27	3	.138	.717	8.681	4.324	.0025	.6318	.0130	.1718	.1559	.0292	.1291	.0667	.0540	.2789	.584
27	4	.200	.719	8.697	4.391	0.0000	.6066	.0133	.1389	.1261	.0135	.0180	.0640	.0590	.1546	.271
28	1	.200	.719	8.707	4.416	0.0000	.5581	.0133	.0933	.0848	.0059	.0057	.0589	.0597	.1303	.119
28	2	.171	.721	8.723	4.489	0.0000	.5517	.0135	.1474	.1341	.0120	.0233	.0582	.0602	.1537	.239
28	3	.142	.718	8.739	4.578	.0012	.6209	.0138	.1684	.1533	.0203	.0597	.0655	.0609	.2065	.405
28	4	.200	.719	8.751	4.610	0.0000	.5766	.0139	.1069	.0974	.0100	.0083	.0609	.0650	.1442	.200
29	1	.200	.720	8.758	4.619	0.0000	.5277	.0140	.0811	.0739	.0050	.0041	.0557	.0654	.1303	.100
29	2	.174	.721	8.772	4.670	0.0000	.5069	.0141	.1295	.1181	.0095	.0149	.0535	.0656	.1436	.191
29	3	.146	.717	8.791	4.750	0.0000	.5354	.0143	.1637	.1494	.0163	.0369	.0565	.0663	.1760	.325
29	4	.200	.717	8.795	4.713	0.0000	.4831	.0143	.0336	.0307	.0046	.0006	.0510	.0685	.1246	.091
30	1	.200	.717	8.797	4.669	0.0000	.4356	.0143	.0266	.0243	.0015	.0004	.0460	.0676	.1154	.029
30	2	.160	.718	8.808	4.700	0.0000	.4116	.0144	.1092	.0998	.0074	.0091	.0434	.0666	.1265	.148
30	3	.118	.711	8.820	4.740	0.0000	.3922	.0145	.1198	.1095	.0098	.0101	.0414	.0656	.1269	.196
30	4	.200	.711	8.822	4.690	0.0000	.3534	.0145	.0204	.0187	.0052	.0002	.0373	.0688	.1115	.104

MONTHLY SUMMARY FOR PASSUMPSIC RIVER AT PASSUMPSIC, VERMONT -- TWO SUB-AREAS

APR 1970

PRECIPITATION GAGE SUMMARY

SOIL MOISTURE ACCOUNTING VOLUMES

RG	PRECIP GAGE NAME	TOTAL RO	SURFACE RO	IMPV RO	INTERFLOW	GW FLOW	RECHARGE	PRECIP	POTENTIAL-ET	ACTUAL-ET
1	PASSUMPSIC RIVER-L	6.745	.967	.506	1.454	3.818	0.000	10.12	1.200	.912
2	PASSUMPSIC RIVER-H	6.990	1.521	.662	1.945	2.863	0.000	13.24	1.200	1.105

SOIL MOISTURE VARIABLES AT END OF MONTH

PRECIP GAGE NAME	UZS	LZS	SGW	GWS	RES	SRGX	SCEP	BALANCE
PASSUMPSIC RIVER-L	.51	8.64	3.31	3.41	0.00	.03	0.00	-.000
PASSUMPSIC RIVER-H	.71	8.82	4.69	4.71	0.00	.35	.20	-.000

SNOW SUMMARY

RG NO.	SNOWFALL	RAIN	PACK RO	BALANCE
1	.695	2.626	10.118	-.000
2	1.097	2.320	13.238	-.000

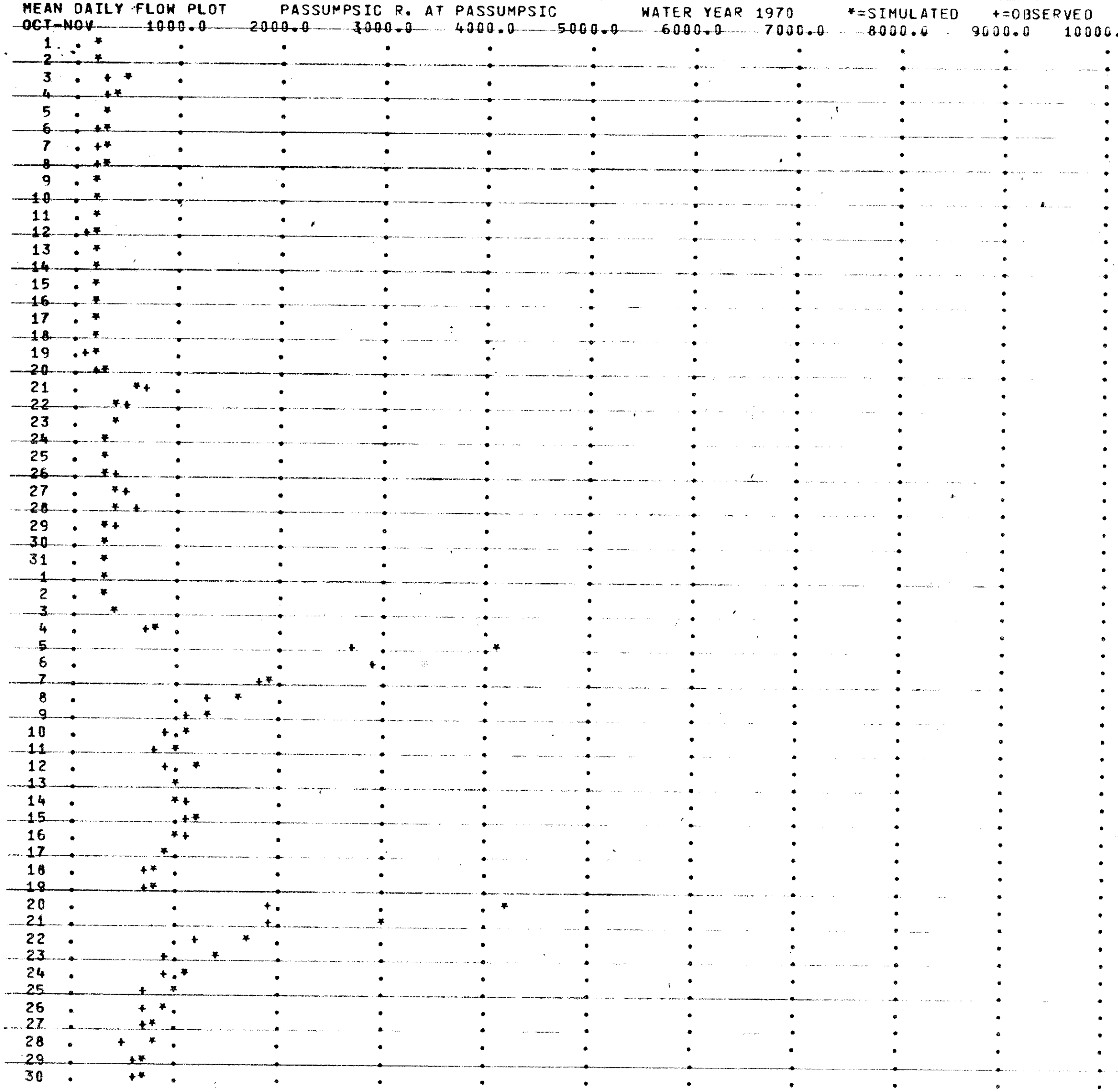
WATER YEAR SUMMARY FOR--PASSUMPSIC R. AT PASSUMPSIC

WATER YEAR 1970

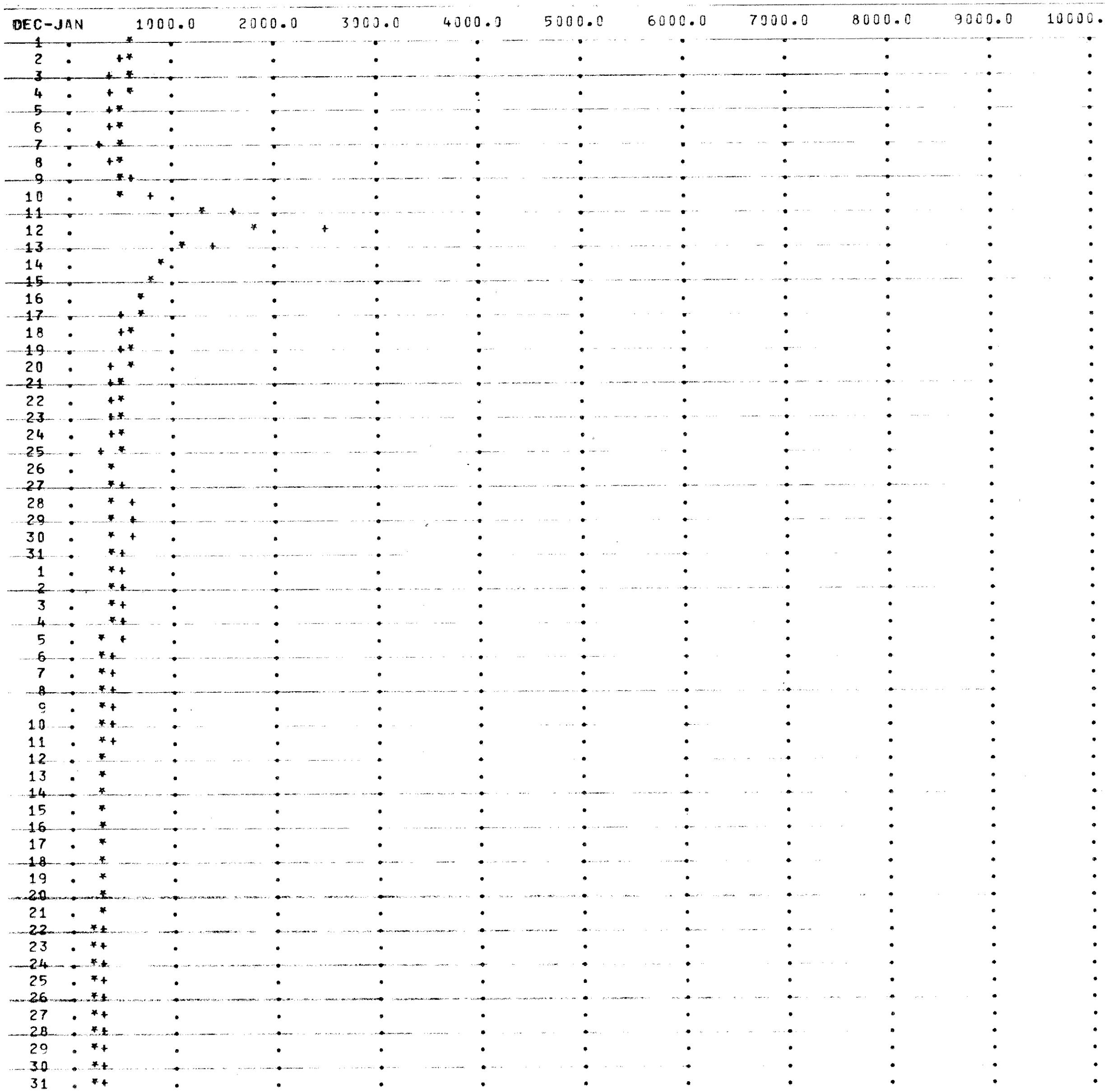
MEAN DAILY DISCHARGE SUMMARY

DAY	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT	ANNUAL
1	244.4	299.9	634.8	378.4	213.1	300.8	332.5	3765.7	412.9	811.9	255.0	194.0	
2	236.3	299.2	606.1	368.6	226.8	294.9	422.1	3266.4	511.0	509.0	610.9	168.7	
3	490.1	426.1	581.6	359.7	901.4	289.2	1085.6	2908.3	515.6	515.5	283.0	158.7	
4	359.3	792.7	558.5	351.4	1519.3	283.4	701.9	2693.7	463.2	508.1	351.6	567.9	
5	286.4	4077.1	536.7	343.3	326.9	278.1	553.4	2334.6	402.8	839.1	213.5	440.4	
6	271.6	3373.8	517.6	335.3	635.5	273.1	490.0	2152.6	1333.1	538.9	190.3	311.7	
7	262.6	1913.2	520.3	327.6	546.8	268.2	477.2	1938.4	800.7	440.9	151.8	273.1	
8	270.4	1565.2	508.9	320.7	487.8	263.2	626.9	1721.6	557.3	382.7	129.3	257.1	
9	248.5	1271.2	538.4	313.9	446.3	257.5	1356.5	1563.6	467.3	336.1	124.2	246.4	
10	225.3	1067.7	498.6	307.1	417.0	252.6	2169.9	1537.9	415.2	291.5	119.3	247.9	
11	214.1	1001.2	1347.9	300.6	437.5	248.1	1453.0	1409.2	382.3	393.3	154.5	324.7	
12	207.4	1160.3	1793.1	294.7	726.3	243.4	1129.0	1371.5	375.1	380.6	150.7	199.6	
13	200.8	951.9	1075.6	289.1	545.8	238.6	1183.6	1210.6	282.9	374.3	102.3	178.2	
14	210.9	965.9	891.2	283.2	479.0	235.3	1445.9	1120.8	234.9	264.2	102.6	159.9	
15	215.2	1222.5	789.0	277.9	448.3	230.8	2033.4	1019.6	215.1	290.6	96.4	187.7	
16	188.3	987.7	715.3	272.8	426.6	226.7	2251.8	943.0	205.1	348.4	81.2	388.5	
17	185.8	872.7	660.5	268.0	409.0	222.3	3323.0	1785.7	208.1	354.3	75.8	249.2	
18	213.7	824.7	618.7	263.1	394.3	217.4	4676.4	3300.6	238.0	257.5	68.7	223.1	
19	184.9	840.9	585.7	258.7	381.7	213.4	3377.5	1599.4	239.3	338.9	62.7	221.8	
20	314.3	4180.4	557.2	254.5	370.6	224.2	2677.1	1240.9	190.9	214.8	75.3	166.9	
21	579.6	3008.1	533.2	250.4	360.6	322.6	2569.0	1047.6	170.0	173.2	338.1	146.5	
22	396.5	1715.8	512.9	246.3	351.5	306.6	2816.9	951.2	186.9	162.1	131.4	278.0	
23	367.6	1360.5	494.6	242.5	343.0	507.9	2778.3	942.6	165.4	134.0	332.4	228.8	
24	319.5	1147.9	478.3	238.8	335.1	435.5	3656.9	763.2	122.8	128.0	493.8	178.6	
25	310.3	999.3	463.4	235.2	327.6	447.3	9468.0	711.7	127.3	125.4	150.7	159.7	
26	305.7	893.5	449.4	231.7	320.2	412.4	4805.4	757.5	129.4	113.8	122.0	199.2	
27	356.0	813.7	435.7	228.3	313.4	400.9	4941.1	888.2	758.3	105.6	210.9	357.0	
28	369.4	753.6	422.2	225.1	307.0	384.7	5489.0	641.3	663.9	100.6	196.7	374.6	
29	333.0	707.2	410.2	221.9		379.1	4960.8	573.4	331.6	115.7	695.8	338.6	
30	310.2	668.1	399.0	218.8		354.7	4399.2	495.9	692.5	96.3	222.8	309.9	
31	308.8		388.7	215.8		338.6		434.8		88.6	259.5		
TOTAL	8987.	40162.	19503.	8723.	13499.	9352.	77651.	47091.	11799.	9739.	6553.	7736.	260797. CFSD
	.766	3.424	1.663	.744	1.151	.797	6.621	4.015	1.006	.830	.559	.660	22.24 INCHES
													517942. ACRE-FT
OBSV.	8836.	31282.	19957.	10670.	14540.	11840.	82180.	39040.	13179.	7982.	5570.	6175.	251251. CFSD
	.753	2.667	1.702	.910	1.240	1.010	7.007	3.329	1.124	.681	.475	.526	21.42 INCHES
													498984. ACRE-FT

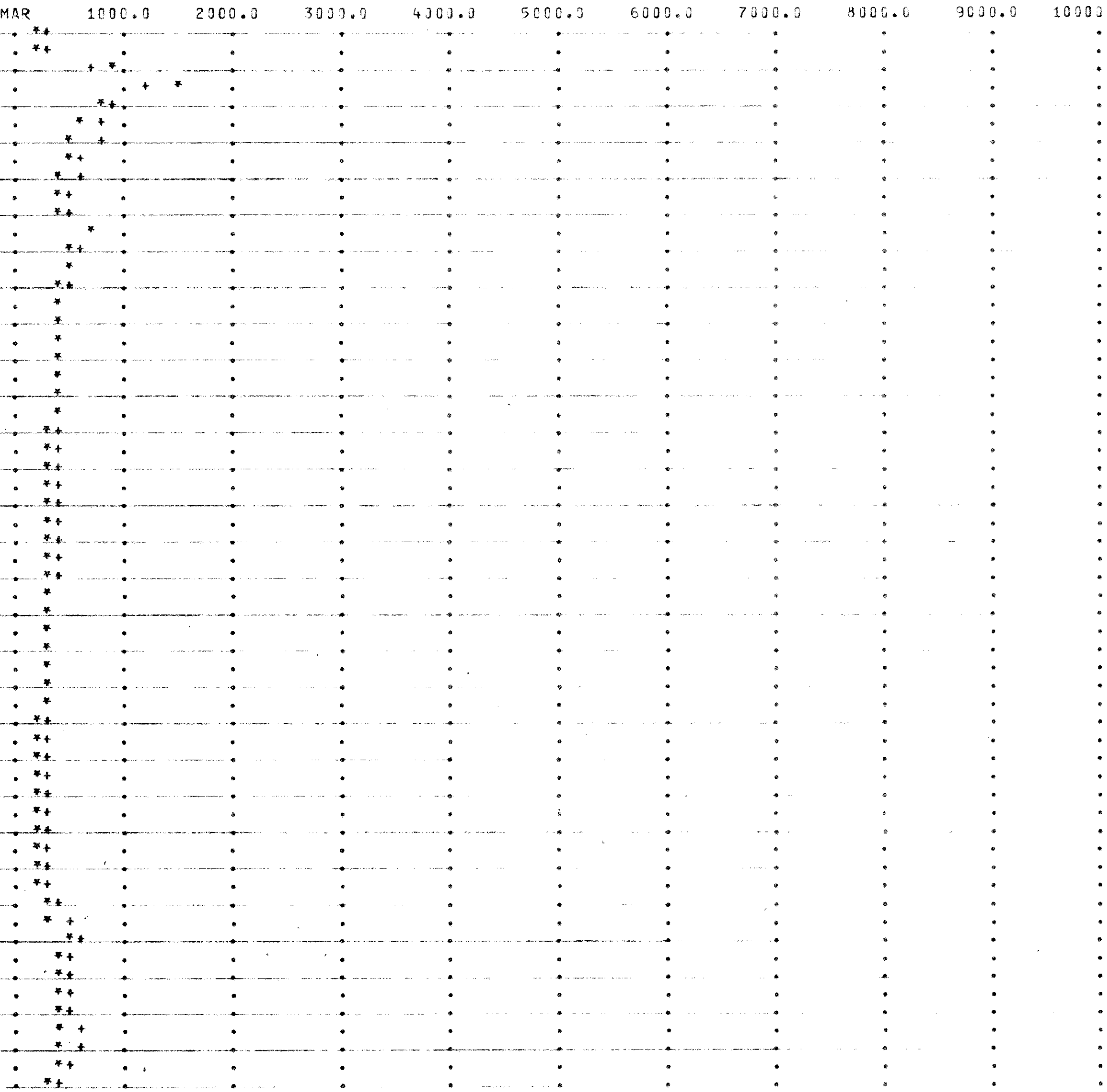
MEAN DAILY FLOW PLOT PASSUMPSIC R. AT PASSUMPSIC WATER YEAR 1970 *=SIMULATED +=OBSERVED



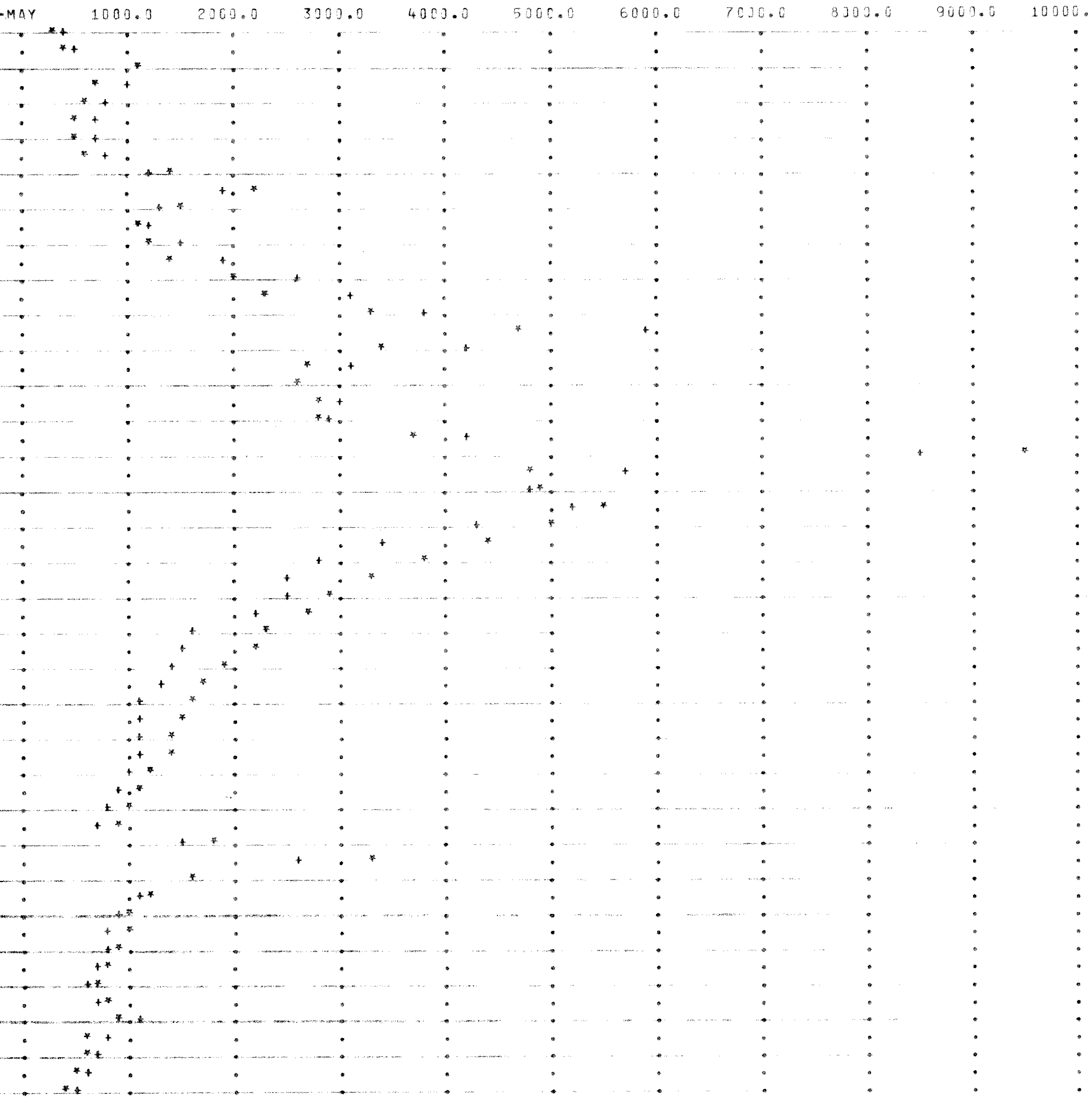
OCT-NOV	SIMULATED	OBSERVED	PRECIP
1	244.4	192.0	0.00
2	236.3	169.0	.15
3	490.1	283.0	.41
4	359.3	342.0	.00
5	286.4	282.0	0.00
6	271.6	231.0	0.00
7	262.6	211.0	.00
8	270.4	189.0	.04
9	248.5	175.0	0.00
10	225.3	188.0	0.00
11	214.1	168.0	0.00
12	207.4	131.0	0.00
13	200.8	181.0	0.00
14	210.9	183.0	.05
15	215.2	176.0	0.00
16	188.3	168.0	.00
17	185.8	172.0	.04
18	213.7	168.0	.03
19	184.9	117.0	0.00
20	314.3	231.0	.77
21	579.6	700.0	.09
22	396.5	541.0	.19
23	367.6	426.0	.01
24	319.5	327.0	.02
25	310.3	311.0	.03
26	305.7	389.0	.07
27	356.0	513.0	.19
28	369.4	583.0	.05
29	333.0	440.0	.02
30	310.2	334.0	.03
31	308.8	315.0	.02
1	299.9	261.0	.02
2	299.2	276.0	.21
3	426.1	372.0	.07
4	792.7	683.0	1.76
5	4077.1	2660.0	.92
6	3373.8	2950.0	.23
7	1913.2	1760.0	.10
8	1565.2	1340.0	.15
9	1271.2	1150.0	.03
10	1067.7	905.0	.03
11	1001.2	827.0	.27
12	1160.3	920.0	.04
13	951.9	1040.0	.09
14	965.9	1100.0	.28
15	1222.5	1080.0	.08
16	987.7	1100.0	.01
17	872.7	869.0	.02
18	824.7	708.0	.10
19	840.9	701.0	.27
20	4180.4	1890.0	1.01
21	3008.1	1880.0	.01
22	1715.8	1180.0	.01
23	1360.5	921.0	.01
24	1147.9	851.0	.01
25	999.3	680.0	.01
26	893.5	740.0	.01
27	813.7	700.0	.01
28	753.6	500.0	.01
29	707.2	610.0	.01
30	668.1	628.0	.01



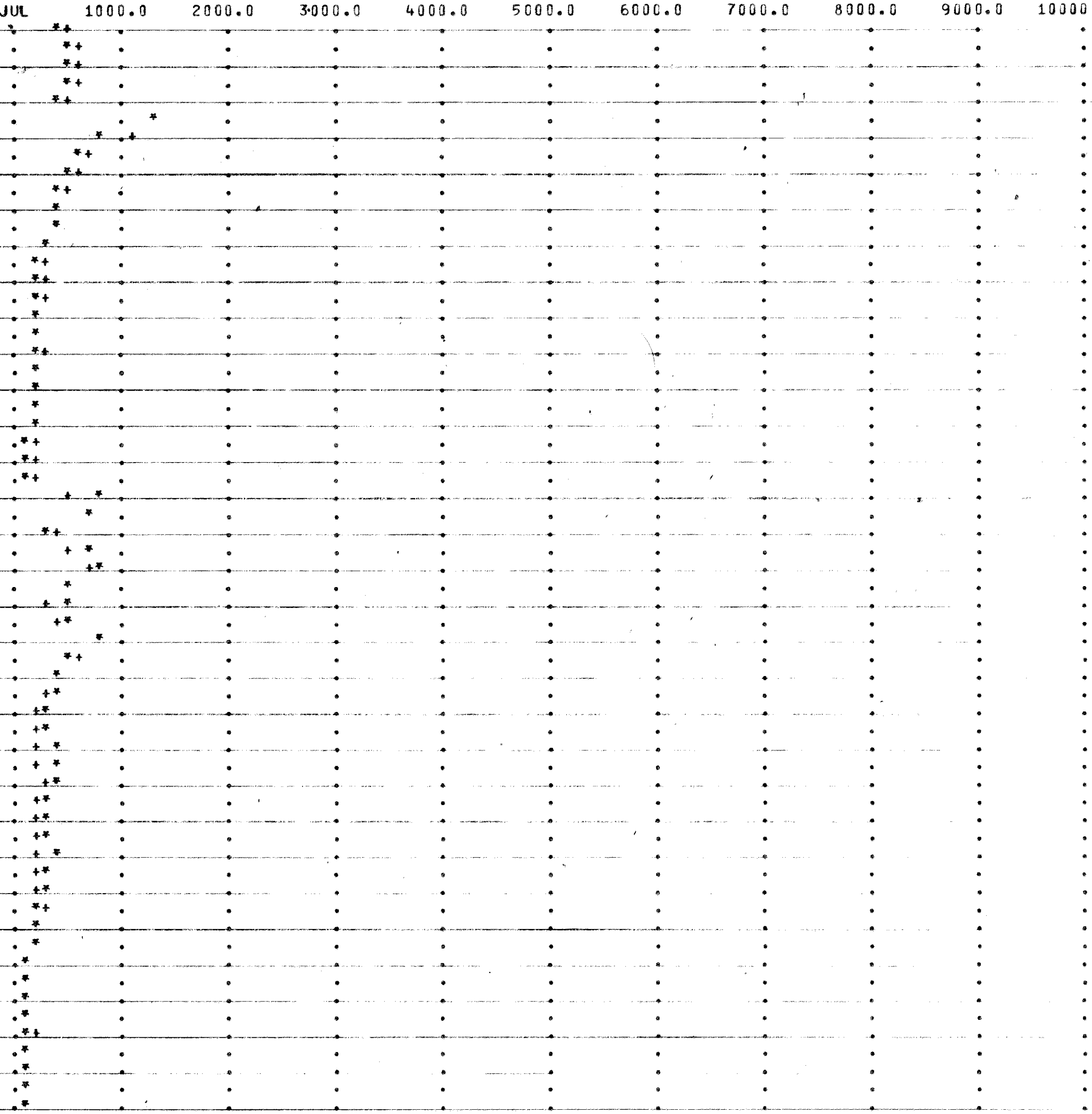
DEC-JAN	SIMULATED	OBSERVED	PRECIP
1	634.8	560.0	.01
2	606.1	480.0	.01
3	581.6	380.0	.01
4	558.5	410.0	.01
5	536.7	390.0	.01
6	517.6	390.0	.01
7	500.3	340.0	.01
8	508.9	434.0	.08
9	538.4	648.0	.02
10	498.6	781.0	.08
11	1347.9	1610.0	.92
12	1793.1	2480.0	.04
13	1075.6	1420.0	.01
14	891.2	901.0	.01
15	789.0	843.0	.01
16	715.3	670.0	.01
17	660.5	550.0	.01
18	618.7	500.0	.01
19	585.7	480.0	.01
20	557.2	450.0	.01
21	533.2	410.0	.01
22	512.9	440.0	.01
23	494.6	400.0	.01
24	478.3	370.0	.01
25	463.4	340.0	.01
26	449.4	370.0	.01
27	435.7	550.0	.01
28	422.2	650.0	.01
29	410.2	600.0	.01
30	399.0	570.0	.01
31	388.7	540.0	.01
1	378.4	500.0	.01
2	368.6	490.0	.01
3	359.7	470.0	.01
4	351.4	460.0	.01
5	343.3	450.0	.01
6	335.3	440.0	.01
7	327.6	430.0	.01
8	320.7	420.0	.01
9	313.9	410.0	.01
10	307.1	380.0	.01
11	300.6	370.0	.01
12	294.7	340.0	.01
13	289.1	330.0	.01
14	283.2	320.0	.01
15	277.9	310.0	.01
16	272.8	290.0	.01
17	268.0	280.0	.01
18	263.1	290.0	.01
19	258.7	290.0	.01
20	254.5	270.0	.01
21	250.4	260.0	.01
22	246.3	270.0	.01
23	242.5	300.0	.01
24	238.8	280.0	.01
25	235.2	280.0	.01
26	231.7	280.0	.01
27	228.3	270.0	.01
28	225.1	270.0	.01
29	221.9	280.0	.01
30	218.8	320.0	.01
31	215.8	320.0	.01



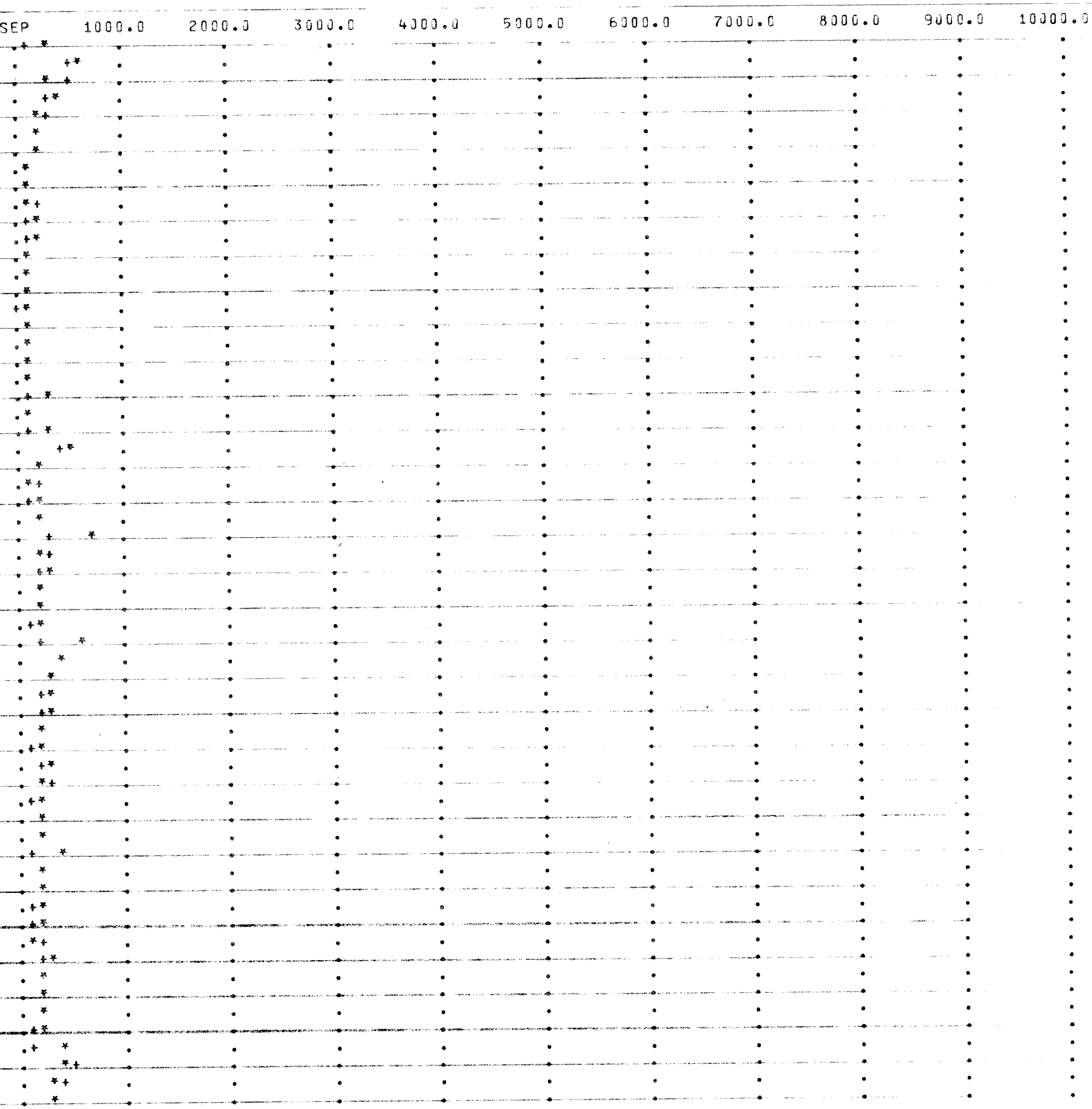
FEB-MAR	SIMULATED	OBSERVED	PRECIP
1	213.1	300.0	.01
2	226.8	300.0	.22
3	901.4	700.0	.86
4	1519.3	1200.0	.03
5	826.9	900.0	.01
6	635.5	820.0	.01
7	546.8	750.0	.01
8	487.8	640.0	.01
9	446.3	570.0	.01
10	417.0	520.0	.03
11	437.5	550.0	.29
12	726.3	700.0	.03
13	545.8	560.0	.01
14	479.0	480.0	.01
15	448.8	450.0	.01
16	426.6	440.0	.01
17	409.0	430.0	.01
18	394.3	420.0	.01
19	381.7	420.0	.01
20	370.6	410.0	.01
21	360.6	400.0	.01
22	351.5	390.0	.01
23	343.0	380.0	.01
24	335.1	370.0	.01
25	327.6	370.0	.01
26	320.2	360.0	.01
27	313.4	360.0	.01
28	307.0	350.0	.01
1	300.8	350.0	.01
2	294.9	350.0	.01
3	289.2	350.0	.01
4	283.4	340.0	.01
5	278.1	340.0	.01
6	273.1	340.0	.01
7	268.2	330.0	.01
8	263.2	320.0	.01
9	257.5	320.0	.01
10	252.6	310.0	.01
11	248.1	310.0	.01
12	243.4	300.0	.01
13	238.6	300.0	.01
14	235.3	300.0	.01
15	230.8	290.0	.01
16	226.7	280.0	.01
17	222.3	270.0	.01
18	217.4	270.0	.01
19	213.4	270.0	.02
20	224.2	300.0	.13
21	322.6	400.0	.05
22	306.6	520.0	.23
23	507.9	600.0	.13
24	435.5	550.0	.12
25	447.3	500.0	.06
26	412.4	450.0	.05
27	400.9	520.0	.04
28	384.7	620.0	.04
29	379.1	560.0	.02
30	354.7	450.0	.01
31	338.6	430.0	.01



APR-MAY	SIMULATED	OBSERVED	PRECIP
1	332.5	440.0	.06
2	422.1	520.0	.32
3	1085.6	1100.0	.21
4	701.9	1000.0	.02
5	553.4	800.0	.01
6	490.0	700.0	.03
7	477.2	700.0	.14
8	626.9	750.0	.43
9	1356.5	1200.0	.82
10	2169.9	1900.0	.23
11	1453.0	1280.0	.03
12	1129.0	1190.0	.17
13	1183.6	1460.0	.30
14	1445.9	1860.0	.52
15	2033.4	2570.0	.48
16	2251.8	3080.0	.68
17	3323.0	3790.0	1.12
18	4676.4	5940.0	.40
19	3377.5	4230.0	.11
20	2677.1	3130.0	.21
21	2569.0	2560.0	.37
22	2816.9	3010.0	.41
23	2778.3	2920.0	.25
24	3656.9	4180.0	1.64
25	9468.0	8550.0	.40
26	4805.4	5670.0	.58
27	4941.1	4800.0	.69
28	5489.0	5170.0	.48
29	4960.8	4320.0	.35
30	4399.2	3360.0	.24
1	3765.7	2850.0	.18
2	3266.4	2500.0	.13
3	2308.3	2520.0	.25
4	2693.7	2190.0	.04
5	2334.6	1610.0	.14
6	2152.6	1530.0	.09
7	1938.4	1440.0	.02
8	1721.6	1260.0	0.00
9	1563.6	1120.0	.12
10	1537.9	1110.0	.15
11	1409.2	1120.0	.19
12	1371.5	1150.0	0.00
13	1210.6	976.0	0.00
14	1120.8	908.0	.02
15	1019.6	784.0	0.00
16	943.0	734.0	.05
17	1785.7	1530.0	1.36
18	3300.6	2610.0	.01
19	1599.4	1610.0	.01
20	1240.9	1120.0	0.00
21	1047.6	904.0	0.00
22	951.2	864.0	.17
23	942.6	840.0	0.00
24	763.2	736.0	0.00
25	711.7	630.0	.03
26	757.5	717.0	.42
27	888.2	1140.0	0.00
28	641.3	836.0	0.00
29	573.4	651.0	0.00
30	495.9	591.0	.00
31	434.8	519.0	0.00



JUN-JUL	SIMULATED	OBSERVED	PRECIP
1	412.9	492.0	.10
2	511.0	609.0	0.00
3	515.6	554.0	.18
4	463.2	592.0	.01
5	402.8	497.0	.97
6	1333.1	1290.0	.13
7	800.7	1140.0	.00
8	557.3	725.0	.00
9	467.3	569.0	0.00
10	415.2	470.0	0.00
11	382.3	406.0	.08
12	375.1	366.0	0.00
13	282.9	342.0	0.00
14	234.9	293.0	0.00
15	215.1	310.0	0.00
16	205.1	268.0	0.00
17	208.1	214.0	0.00
18	238.0	225.0	.08
19	239.3	263.0	.01
20	190.9	238.0	0.00
21	170.0	224.0	0.00
22	186.9	228.0	.08
23	165.4	227.0	0.00
24	122.8	213.0	0.00
25	127.3	179.0	.02
26	129.4	188.0	.24
27	758.3	452.0	1.10
28	663.9	717.0	0.00
29	331.6	416.0	.31
30	692.5	472.0	.65
1	811.9	707.0	0.00
2	509.0	490.0	.05
3	515.5	336.0	0.00
4	508.1	382.0	.70
5	839.1	833.0	0.00
6	538.9	591.0	.01
7	440.9	364.0	0.00
8	382.7	287.0	.00
9	336.1	237.0	0.00
10	291.5	196.0	.12
11	398.3	212.0	.09
12	380.6	219.0	.16
13	374.3	288.0	.01
14	264.2	231.0	.05
15	290.6	163.0	.04
16	348.4	179.0	.19
17	354.3	218.0	0.00
18	257.5	230.0	.24
19	338.9	158.0	0.00
20	214.8	254.0	.03
21	173.2	179.0	0.00
22	162.1	151.0	0.00
23	134.0	149.0	0.00
24	128.0	130.0	0.00
25	125.4	131.0	0.00
26	113.8	59.0	0.00
27	105.6	163.0	0.00
28	100.6	129.0	.04
29	115.7	100.0	0.00
30	96.3	110.0	0.00
31	88.6	106.0	.03



AUG-SEP	SIMULATED	OBSERVED	PRECIP
1	255.0	83.0	.95
2	610.9	504.0	.19
3	283.0	461.0	.32
4	351.6	305.0	0.00
5	213.5	269.0	0.00
6	190.3	183.0	0.00
7	151.8	157.0	0.00
8	129.3	131.0	0.00
9	124.2	69.0	0.00
10	119.3	169.0	.05
11	154.5	146.0	.02
12	150.7	103.0	.01
13	102.3	109.0	0.00
14	102.6	111.0	.03
15	96.4	105.0	0.00
16	81.2	49.0	0.00
17	75.8	126.0	.00
18	68.7	84.0	0.00
19	62.7	97.0	0.00
20	75.3	74.0	.43
21	338.1	86.0	.17
22	131.4	130.0	.01
23	332.4	135.0	1.04
24	493.8	353.0	0.00
25	150.7	210.0	.02
26	122.0	160.0	.23
27	210.9	136.0	0.00
28	196.7	210.0	1.09
29	695.8	337.0	0.00
30	222.8	283.0	.10
31	259.5	195.0	.09
1	194.0	235.0	.08
2	168.7	176.0	0.00
3	158.7	126.0	.47
4	567.9	244.0	.51
5	440.4	369.0	.07
6	311.7	268.0	.07
7	273.1	243.0	.02
8	257.1	227.0	.01
9	246.4	181.0	.00
10	247.9	150.0	.20
11	324.7	187.0	0.00
12	199.6	254.0	0.00
13	178.2	144.0	0.00
14	159.9	162.0	.00
15	187.7	152.0	.20
16	388.5	140.0	.21
17	249.2	197.0	.00
18	223.1	201.0	.03
19	221.8	132.0	0.00
20	166.9	101.0	0.00
21	146.5	181.0	.06
22	278.0	151.0	.23
23	228.8	223.0	.07
24	178.6	182.0	.01
25	159.7	182.0	.13
26	199.2	129.0	.00
27	357.0	123.0	.61
28	374.6	477.0	.12
29	338.6	351.0	.15
30	309.9	287.0	.01

STATISTICAL SUMMARY

FLOW POINT = PASSUMPSIC R. AT PASSUMPSIC   WATER YEAR = 1970

MONTH	SIMULATED MEAN	OBSERVED MEAN	BIAS (SIM MEAN -OBS MEAN)	PERCENT BIAS	1ST MOMENT (SIM)-1ST MOMENT(OBS)	MAXIMUM ERROR	STANDARD ERROR	PERCENT STANDARD ERROR	CORREL. COEFF	BEST FIT LINE OBS = A + B *SIM A	B
OCTOBER	289.894	285.032	4.862	1.706	-1.808	-213.644	77.716	27.266	.843	-111.944	1.369
NOVEMBER	1338.737	1042.733	296.004	28.387	.476	2290.377	244.258	23.425	.919	275.718	.573
DECEMBER	629.143	643.774	-14.631	-2.273	-.536	-686.921	151.935	23.601	.938	-246.254	1.415
JANUARY	281.402	344.194	-62.792	-18.243	.224	-121.643	27.735	8.058	.931	-72.184	1.480
FEBRUARY	482.103	519.286	-37.183	-7.160	-.226	319.342	74.383	14.324	.931	161.923	.741
MARCH	301.662	381.935	-80.273	-21.017	-.315	-235.291	42.627	11.161	.914	5.631	1.247
APRIL	2588.381	2739.333	-150.952	-5.511	.617	-1263.586	470.774	17.186	.970	328.618	.931
MAY	1519.078	1259.355	259.724	20.624	-.940	915.699	135.101	10.728	.977	180.321	.710
JUNE	393.293	439.300	-46.007	-10.473	.740	-339.266	104.032	23.681	.917	75.874	.924
JULY	314.160	257.484	56.676	22.012	-.196	186.324	68.122	26.457	.922	-6.955	.842
AUGUST	211.397	179.677	31.720	17.654	1.041	358.845	75.440	41.986	.736	65.805	.539
SEPTEMBER	257.882	205.833	52.049	25.287	-.434	323.910	70.072	34.043	.502	96.790	.423
WATER YEAR	714.511	688.359	26.152	3.799	-.516	2290.377	249.768	36.285	.964	37.101	.911

NOTE...SUM OF (SIM-OBS)2 = 25867059......ROOT MEAN OF SUM OF (SIM-OBS)**2 = 266.212...**

FLOW INTERVAL	NUMBER OF CASES OBSERVED	OBSERVED MEAN	SIMULATED MEAN	BIAS	PERCENT BIAS	MAXIMUM ERROR	STANDARD ERROR	PERCENT STANDARD ERROR	CORREL. COEFF	BEST FIT LINE OBS = A + B *SIM A	B
0 - 8	NO OBSERVED FLOW IN THIS INTERVAL										
8 - 45	NO OBSERVED FLOW IN THIS INTERVAL										
45 - 162	42	120.762	169.164	48.402	40.080	252.135	26.571	22.003	.340	101.422	.114
162 - 440	166	293.880	296.779	2.899	.987	358.845	61,847	21.045	.631	150.542	.483
440 - 1000	98	637.194	623.430	-13.764	-2.160	439.463	87.840	13.786	.788	342.288	.473
1000 - 2000	35	1340.286	1540.792	200.506	14.960	2290.377	187.803	14.012	.721	876.531	.301
2000 - 3646	15	2759.333	2980.295	220.962	8.008	1417.118	282.761	10.247	.352	2309.194	.151
3646 - 6195	8	4762.500	4403.780	-358.720	-7.532	-1263.586	541.453	11.369	.659	2065.885	.612
6195 - 9952	1	8550.000	9467.952	917.952	0.000	917.952	0.000	0.000	0.000	0.000	0.000
ABOVE 9952	NO OBSERVED FLOW IN THIS INTERVAL										
ABOVE 1000	59	2287.288	2429.328	142.039	6.210	2290.377	572.052	25.010	.923	116.167	.894

MULTIYEAR STATISTICAL SUMMARY

FLOWPOINT = PASSUMPSIC R. AT PASSUMPSIC   WATER YEARS 1964 TO 1971

MONTH	SIMULATED MEAN	OBSERVED MEAN	BIAS (SIM MEAN -OBS MEAN)	PERCENT BIAS	1ST MOMENT (SIM)-1ST MOMENT(OBS)	MAXIMUM ERROR	STANDARD ERROR	PERCENT STANDARD ERROR	CORREL. COEFF	BEST FIT LINE OBS = A + B *SIM A	B
OCTOBER	340.098	364.367	-24.269	-6.661	-.438	-563.158	117.545	32.260	.910	19.611	1.014
NOVEMBER	543.079	581.904	-38.825	-6.672	-.277	2290.377	209.737	36.043	.877	221.353	.663
DECEMBER	466.547	483.944	-17.397	-3.595	-.067	-1051.814	168.644	34.848	.871	-48.805	1.142
JANUARY	284.033	311.512	-27.479	-8.821	.024	607.984	81.762	26.247	.861	80.958	.812
FEBRUARY	271.397	309.912	-38.515	-12.428	-.067	-413.449	95.342	30.764	.720	141.820	.619
MARCH	649.995	639.431	10.564	1.652	.164	1922.872	234.498	36.673	.955	70.505	.875
APRIL	2186.392	2177.787	8.604	.395	.551	-3333.505	689.597	31.665	.892	156.159	.925
MAY	1546.476	1488.125	58.351	3.921	-.963	2086.244	410.381	27.577	.917	363.680	.727
JUNE	515.655	562.037	-46.382	-8.253	.199	1622.286	179.848	31.999	.850	183.951	.733
JULY	346.764	326.363	20.402	6.251	-.221	-1356.042	170.683	52.298	.833	-70.835	1.145
AUGUST	378.385	322.722	55.664	17.248	.137	2070.596	147.637	45.748	.893	49.302	.723
SEPTEMBER	338.094	264.221	73.873	27.959	-.188	-628.973	131.240	49.671	.826	-56.066	.947
WATER YEAR	655.838	652.605	3.233	.495	16.473	-3333.505	293.517	44.976	.938	65.732	.895

NOTE...SUM OF (SIM-OBS)2 =   277012625......ROOT MEAN OF SUM OF (SIM-OBS)**2 =   307.900...**

FLOW INTERVAL	NUMBER OF CASES OBSERVED	OBSERVED MEAN	SIMULATED MEAN	BIAS	PERCENT BIAS	MAXIMUM ERROR	STANDARD ERROR	PERCENT STANDARD ERROR	CORREL. COEFF	BEST FIT LINE OBS = A + B *SIM A	B
0 - 8	NO OBSERVED FLOW IN THIS INTERVAL										
8 - 45	NO OBSERVED FLOW IN THIS INTERVAL										
45 - 162	271	129.085	175.972	46.887	36.322	412.734	24.982	19.353	.173	118.501	.060
162 - 440	1484	275.548	289.036	13.488	4.895	417.964	63.390	23.005	.449	195.646	.276
440 - 1000	687	644.856	600.233	-44.623	-6.920	918.403	120.738	18.723	.607	406.247	.398
1000 - 2000	303	1406.997	1411.349	4.352	.309	2290.377	235.234	16.719	.581	966.838	.312
2000 - 3646	126	2721.111	2850.275	129.164	4.747	2086.244	388.427	14.275	.523	2051.286	.235
3646 - 6195	43	4476.744	4377.947	-98.797	-2.207	-2252.143	592.932	13.245	.397	3562.564	.209
6195 - 9952	8	7290.000	6544.476	-745.524	-10.227	-3333.505	871.267	11.952	.552	5159.557	.326
ABOVE 9952	NO OBSERVED FLOW IN THIS INTERVAL										
ABOVE 1000	480	2125.000	2140.377	15.377	.724	-3333.505	625.633	29.442	.862	465.776	.775

APPENDIX E

OPTIMIZATION PROGRAM WITH SNOW -- INPUT AND OUTPUT SAMPLES

E.1 OPTIMIZATION PROGRAM WITH SNOW - INPUT SUMMARY

E.2 SAMPLE INPUT AND OUTPUT FOR OPTIMIZATION PROGRAM WITH SNOW - OPTIMIZATION MODE

E.3 SAMPLE INPUT AND OUTPUT FOR OPTIMIZATION PROGRAM WITH SNOW - SENSITIVITY MODE

E.1 OPTIMIZATION PROGRAM WITH SNOW - INPUT SUMMARY

```
*******************************************************************************
*******************************************************************************
C        NATIONAL WEATHER SERVICE RIVER FORECAST SYSTEM (OPTIMIZATION)
C                                                          (SENSITIVITY)
C                              INPUT SUMMARY
*******************************************************************************
*CARD NO. FORMAT    CONTENTS
*******************************************************************************
C    1          I5    TAPE NO. OF PRECIPITATION TAPE
C               I5    TAPE NO. OF PE TAPE
C               I5    TAPE NO. OF TEMPERATURE TAPE(SAME AS  PE  IF NO TEMP DATA)
C               I5    TAPE NO. OF MEAN DAILY FLOW TAPE
C               I5    TAPE NO. OF SIX HOUR FLOWS(SAME AS DAILY IF NO 6 FLOW DATA)
*******************************************************************************
C    2          I5    NO. RECORD SKIPS FOR TAPE WHICH HAS PREC. DATA
C               I5    NO. RECORD SKIPS FOR TAPE WHICH HAS PE    DATA
C               I5    NO. RECORD SKIPS FOR TAPE WHICH HAS TEMP. DATA
C               I5    NO. RECORD SKIPS FOR TAPE WHICH HAS DAILY FLOW DATA
C               I5    NO. RECORD SKIPS FOR TAPE WHICH HAS SIXHR FLOW DATA
C      ****NOTE****      IF MORE THAN ONE TYPE OF DATA ARE ON A TAPE, ONLY
C                       INDICATE NUMBER OF RECORD SKIPS FOR THE FIRST TYPE OF
C                       DATA ON THAT TAPE
*******************************************************************************
C    3          I5    NO. OF MBP AREAS ON INPUT TAPE
C               I5    NO. OF PE STATIONS ON TAPE
C               I5    PUNCH ZERO IN COLUMN 15
C               I5    NO. OF MEAN DAILY FLOW-POINTS ON TAPE
C               I5    NO. OF SIX HOUR FLOW-POINTS ON TAPE
*******************************************************************************
C    4          I5    NO. OF MBP AREAS USED (NGAGES)
C               I5    NO. OF PE STATIONS USED (NPEGS)
C               I5    PUNCH ONE IN COLUMN 15
C               I5    NO. OF STREAM-FLOW POINTS USED (NPTS)    OR
C                     NO OF UPSTREAM INFLOW POINTS NEEDED (WHICHEVER IS GREATER)
*******************************************************************************
C    5         5I5    IDENTIFIES THE MBP AREAS ON TAPE TO BE USED IN THE RUN
C                             ALSO DEFINES THE PRECIP. AREA ORDER FOR THE RUN
C                             1 TO NGAGES  VALUES ARE NEEDED
C                     E.G.       5 MBP AREAS ON TAPE,(NGAGES=2) CARD 5, 1,4
C                                THEN THE 1 ST GAGE ON TAPE WILL BE GAGE 1 FOR RUN
C                                         4 TH GAGE ON TAPE WILL BE GAGE 2 FOR RUN
*******************************************************************************
C    6         5I5    SAME AS CARD 5 ONLY FOR PE STATIONS
*******************************************************************************
C    7         2I5    IPEA(1)=1 , IPEA(2)=1  WHEN ONE PE STATION IS USED
C                     IPEA(1)=1 , IPEA(2)=2  WHEN TWO PE STATIONS ARE USED
*******************************************************************************
C    8          I5    PUNCH ZERO IN COLUMN 5
*******************************************************************************
C    9         2I5    SAME AS CARD 7 ONLY FOR TEMPERATURE STATIONS
```

```
C                        (INCLUDE ITAA(1)=1,ITAA(2)=1 EVEN IF NO STA)
*******************************************************************************
C  10          5I5     SAME AS CARD 5 ONLY FOR DAILY Q
*******************************************************************************
C  11          5I5     SAME AS CARD 5 ONLY FOR 6-HR Q
*******************************************************************************
C  12           I5     NUMBER OF MONTHS FOR THE RUN (MAXIMUM OF 50)
C               I5     BEGINNING YEAR FOR THE RUN(4DIGITS) FIRST  DAY OF
C               I5     BEGINNING MONTH FOR THE RUN         BUFFER PERIOD
C               I5     CALANDER DAY NUMBER FOR THE RUN     DEFINES THE START
C                      (BASED ON A 365 DAY YEAR)           OF THE RUN
C               I5     =1  SNOW IS INCLUDED,  =0  NO SNOW
*******************************************************************************
C  13      8F10.4      LAND PARAMETERS
C                      MOD. STANFORD WATERSHED MODEL
C                      A,EPXM,UZSN,LZSN,CB,POWER,CC
*******************************************************************************
C  14      2F10.4      AREA OF AREA(1),  AREA OF AREA(2)
*******************************************************************************
C  15      8F10.4      LAND PARAMETERS    K1 FOR EACH AREA()
*******************************************************************************
C  16      2F10.4      LAND PARAMETERS
C                      K24L,K3
*******************************************************************************
C  17         F5.3     UPPER LIMIT OF E CURVE (EHIGH)
C             F5.3     LOWER LIMIT OF E CURVE (ELOW)
C               I5     CALANDER DAY NUMBER WHEN E CURVE REACHES
C                         EHIGH  (IF JUNE 1  NEP=152) STHIGH          I5   STLOW
C               I5     NO DAYS E CURVE REMAINS AT EHIGH (MINUS ONE)   I5   NEP
C                      (IF JUNE 1 TO JULY 31, NDUR=212-152=60 )NDUR
C             F5.3     LAND PARAMETER   K24EL
*******************************************************************************
C  18      2F10.4      CONSTANT TIMES PE (PEADJ) FOR AREAS 1 AND 2
C                           NOTE..WHEN TWO AREAS ARE USED, PEADJ MUST BE THE
C                           SAME FOR BOTH AREAS AS THE PROGRAM IS CURRENTLY
C                           WRITTEN, UNLESS EACH AREA USES A SEPARATE PE STATION
*******************************************************************************
C  19      5F10.4      TIMING  PARAMETERS
C                      SRC1, OVERLAND FLOW (ONE HR)
C                      LIRC6, INTERFLOW    (SIX HR)
C                      LKK6, GROUNDWATER   (SIX HR)
C                      KV
C                      KGS
*******************************************************************************
C  20      8F10.4      SOIL MOISTURE INITIAL CONDITIONS
C                      UZSI,LZSI,SGWI,GWSI,RESI,SRGI,SCEPI
*******************************************************************************
*******************************************************************************
*******************************************************************************
*****NOTE*********  THE FOLLOWING 200 SERIES CARDS ARE NEEDED IF SNOW IS
C      INCLUDED.      DO NOT PUT IN OTHERWISE.    ************************
*******************************************************************************
*******************************************************************************
C 201           I5     PUNCH 1 IN COLUMN 5
```

```
********************************************************************************
C 202         I5     NUMBER OF MAT AREAS USED IN THIS RUN (NTAG)
C             I5     NUMBER OF AREAS WITH OBSERVED WATER-EQUIVALENT  (NWEG)
********************************************************************************
C 203         I5     NUMBER OF MAT AREAS ON INPUT TAPE
C             I5     NUMBER OF OBS. AREAL WATER-EQUIVALENTS ON INPUT TAPE
********************************************************************************
C 204        5A4     NAME OF MAT AREA
C          F10.0     MEAN ELEVATION OF MAT AREA IN FEET
C          4F5.1     AIR TEMPERATURE LAPSE RATES FOR MID-6AM,6AM-NOON,
C                         NOON-6PM,6PM-MID.   DEG. F/1000 FT. ELEV. CHANGE
C               NOTE..REPEAT THIS CARD FOR EACH MAT AREA. CARD ORDER
C                    DEFINES MAT ORDER NUMBER FOR THIS RUN.
********************************************************************************
C 205       16I5     IDENTIFIES THE MAT AREAS ON TAPE TO BE USED IN THIS RUN.
C                         1 TO (NTAG) VALUES ARE NEEDED.
C                    E.G. 5 MBT AREAS ON TAPE, NTAG=2 , CARD 205 = 4,2
C                         THEN THE 4 TH MAT RECORD ON TAPE IS THE TEMPERATURE
C                                        DATA FOR THE 1 ST MAT AREA.
C                                  2 ND MAT RECORD ON TAPE IS THE TEMPERATURE
C                                        DATA FOR THE 2 ND MAT AREA.
********************************************************************************
C 206       16I5     ASSOCIATES MAT AREAS TO MBP AREAS
C                         1 TO (NGAGES) VALUES ARE NEEDED
C                    E.G. (NGAGES)=3, (NTAG)=2,  CARD 206=2,1,1
C                         THEN THE 1 ST PRECIP AREA WILL USE AIR TEMPERATURE
C                                             FROM MAT AREA NO.2
C                                  2 ND PRECIP AREA WILL USE AIR TEMPERATURE
C                                             FROM MAT AREA NO.1
C                                  3 RD PRECIP AREA WILL USE AIR TEMPERATURE
C                                             FROM MAT AREA NO.1
********************************************************************************
C NOTE..CARDS 207 THROUGH 209 ONLY NEEDED IF (NWEG.GT.0)
********************************************************************************
C 207        5A4     NAME OF OBSERVED WATER-EQUIVALENT MEASUREMENT AREA
C               NOTE..REPEAT THIS CARD FOR EACH OBS. WATER-EQUIVALENT AREA
C                     USED IN THIS RUN.  CARD ORDER DEFINES ORDER NO. FOR RUN.
********************************************************************************
C 208       16I5     SAME AS CARD 205 ONLY FOR OBS. WATER-EQUIVALENT AREAS.
********************************************************************************
C 209       16I5     SAME AS CARD 206 ONLY FOR OBS. WATER-EQUIVALENT AREAS.
********************************************************************************
********************************************************************************
C NOTE..REPEAT CARDS 210,211,212 FOR EACH MEAN BASIN PRECIPITATION AREA
C               USED IN THIS RUN (NGAGES)
********************************************************************************
C 210 20X,F10.0      MEAN AREA ELEVATION IN FEET
C           F5.2     PERCENT/100 OF AREA OVER WHICH EVAPOTRANSPIRATION CAN TAKE
C                         WHEN THERE IS COMPLETE AREAL SNOW COVER (EFC)
C           F5.2     MULTIPLYING FACTOR TO CORRECT FOR GAGE CATCH DEFICIENCY
C                         IN THE CASE OF SNOWFALL.  (SCF)
C           F5.4     MAXIMUM NON-RAIN MELT FACTOR -- OCCURS ON JUNE 21. (MFMAX(
C           F5.4     MINIMUM NON-RAIN MELT FACTOR -- OCCURS ON DEC. 21. (MFMIN)
C           F5.4     MAXIMUM NEGATIVE MELT FACTOR -- (NMF)
```

```
C              NOTE..UNITS FOR MELT FACTORS ARE INCHES/DEG.F/SIX HOURS
C         F5.4      MEAN WIND FUNCTION VALUE DURING RAIN ON SNOW PERIODS
C                          UNITS ARE INCHES/INCH OF MERCURY (UADJ)
C         F5.1      AREAL WATER-EQUIVALENT (INCHES) ABOVE WHICH THERE IS
C                          ALWAYS COMPLETE AREAL SNOW COVER.  (SI)
C         F5.2      DAILY MELT AT THE SNOW-SOIL INTERFACE IN INCHES. (DAYGM)
***********************************************************************
C 211            INITIAL VALUES OF SOME SNOW COVER VARIABLES.
C      20X,F5.0     ANTECEDENT SNOW TEMP. INDEX  (DEG. F)  (ATI)
C         F5.2      FREE WATER IN SNOW IN EXCESS OF THAT HELD AGAINST GRAVITY
C                          DRAINAGE  (INCHES)
C         F5.2      POINT SB ON AREAL DEPLETION CURVE  (INCHES)
C         F5.2      PERCENT/100 AREAL SNOW COVER AT POINT SB.
C         F5.2      POINT SBWS ON AREAL DEPLETION CURVE (INCHES)
C      NOTE..SEE CHAP. 3  FOR FURTHER EXPLANATION OF THESE INITIAL VALUES.
***********************************************************************
C 212            INITIAL VALUES OF MAJOR SNOW COVER VARIABLES
C      20X,F5.2     INITIAL WATER-EQUIVALENT OF SOLID PORTION OF THE
C                          SNOWPACK.   (INCHES)
C         F5.2      INITIAL NEGATIVE HEAT STORAGE  (INCHES)
C         F5.2      INITIAL AMOUNT OF FREE WATER HELD AGAINST GRAVITY
C                          DRAINAGE (INCHES).  MAXIMUM EQUALS PERCENT LIQUID
C                          WATER HOLDING CAPACITY TIMES INITIAL WATER-EQUIVALENT.
***********************************************************************
C NOTE..CARD 213 AND 214 PARAMETERS ARE THE SAME FOR ALL AREAS IN NWSRFS3
***********************************************************************
C 213  20X,F5.0     MELT FACTOR BASE TEMPERATURE  (DEG. F) (MBASE)
C         F5.0      TEMPERATURE (DEG. F) TO DIVIDE RAIN FROM SNOW (PXTEMP)
C                          IF AIR TEMPERATURE GREATER,THEN RAIN
C                          IF AIR TEMPERATURE LESS THAN OR EQUAL,THEN SNOW
C         F5.2      PERCENT/100 LIQUID WATER HOLDING CAPACITY (PLWHC)
C                          MAXIMUM AMOUNT OF FREE WATER HELD AGAINST GRAVITY.
C         F5.2      ANTECEDENT SNOW TEMP. INDEX PARAMETER (TIPM)
C                          (.GE.0.0 --.LE.1.0)
***********************************************************************
C 214 20X,9F5.2     AREAL SNOW COVER DEPLETION CURVE
C                          PERCENT/100 AREAL EXTENT OF SNOW COVER AT
C                          WATER EQUIVALENT/AI RATIOS OF  0.1,0.2,0.3,0.4,0.5,
C                                 0.6,0.7,0.8,0.9  (SEE SECTION 3.3.3 FOR DEFINITION
C                                 OF AI)    FOR RATIO=0.0  AREAL COVER=0.05
C                                                RATIO=1.0  AREAL COVER=1.00
***********************************************************************
***********************************************************************
***********************************************************************
C  21            PARAMETERS FOR OPTIMIZATION OR SENSITIVITY ROUTINE
C        I5     NDAY=NUMBER OF DAYS IN RUN (50 MONTHS IS MAXIMUM)
C        I5     IBUF=NUMBER OF DAYS IN BUFFER PERIOD (USUALLY TWO MONTHS)
C                                     (ADD OR DELETE BY WHOLE MONTHS)
C        I5     NUMA= NO OF PARAMETERS TO BE CONSIDERED
C        I5     NPER  IF=1 DDELTA(I) MUST BE IN PERCENT/100
C                     IF=0 DDELTA(I) MUST BE AN ABSOLUTE VALUE
C        I5     KC= MAXIMUM NUMBER OF RESOLUTIONS BEFORE OPTIMIZATION
C                     IS TERMINATED
C        I5     MAXN= MAXIMUM NUMBER OF  RUNS  BEFORE OPTIMIZATION IS
```

```
C                      ABORTED (MAXN OVER-RIDES KC)
C         I5    MAXIN=3
*****************************************************************************
C  22  16I5     PARAMETERS TO BE OPTIMIZED OR USED IN SENSITIVITY ANALYSIS SEE
C               PARM( ) ARRAY BELOW FOR PARAMETER NUMBERS (E.G. CB IS NO. 3)
C
C      PARM(1) =UZSN          PARM(16)=K3               PARM(31)=NMF(1)
C      PARM(2) =LZSN          PARM(17)=SRC1             PARM(32)=NMF(2)
C      PARM(3) =CB            PARM(18)=LIRC6            PARM(33)=UADJ(1)
C      PARM(4) =POWER         PARM(19)=LKK6             PARM(34)=UADJ(2)
C      PARM(5) =CC            PARM(20)=CSSR             PARM(35)=NOT USED
C      PARM(6) =KV            PARM(21)=HWARP            PARM(36)=NOT USED
C      PARM(7) =KGS           PARM(22)=VWARP            PARM(37)=SI(1)
C      PARM(8) =K24EL         PARM(23)=NOT USED         PARM(38)=SI(2)
C      PARM(9) =A             PARM(24)=NOT USED         PARM(39)=DAYGM(1)
C      PARM(10)=K24L          PARM(25)=SCF(1)           PARM(40)=DAYGM(2)
C      PARM(11)=EPXM          PARM(26)=SCF(2)           PARM(41)=PLWHC
C      PARM(12)=K1(1)         PARM(27)=MFMAX(1)         PARM(47)=EHIGH
C      PARM(13)=K1(2)         PARM(28)=MFMAX(2)         PARM(48)=ELOW
C      PARM(14)=PEADJ(1)      PARM(29)=MFMIN(1)         PARM(49)=NEP
C      PARM(15)=PEADJ(2)      PARM(30)=MFMIN(2)         PARM(50)=NDUR
C                      NOTE..SUBSCRIPTS AFTER SNOW PARAMETER NAMES INDICATED
C                      SUBAREA 1 AND 2.  SEE SECTION 4.4.1 OF WRITE-UP.
C
C               THE MAXIMUM NUMBER OF PARAMETERS THAT CAN BE OPTIMIZED IS 16
C               THE MAXIMUM NUMBER OF PARAMETERS THAT CAN BE CONSIDERED FOR
C               SENSITIVITY ANALYSIS IS 50
C               THE ORDER OF THE PARAMETER NUMBERS IS NOT FIXED
C                                    EXCEPT
C                                    ******
C               THE  E  CURVE PARAMETERS, IF CONSIDERED, MUST BE LAST AND
C               ORDERED FROM LOW PARAMETER NUMBER TO HIGH PARAMETER
C               NUMBER (47,48,49,50)
C               REPEAT THIS CARD IF NUMA GT 16
*****************************************************************************
C  23   2I5     NEPDEL IS THE FIXED SIZE DELTA FOR PARAMETER NEP (IN DAYS)
C               NDURDEL IS THE FIXED SIZE DELTA FOR PARAMETER NDUR (IN DAYS)
C                   (IF NEP AND NDUR ARE NOT TO BE OPTIMIZED
C                      STILL INCLUDE THIS CARD)
*****************************************************************************
C  24          I5     NUMBER OF PERIODS TO BE REMOVED FROM CALCULATING
C                     THE VALUE OF THE OPTIMIZATION CRITERION--EXCLUDING
C                     THE BUFFER PERIOD. FROM ZERO(0) TO A MAXIMUM OF
C                                           TEN(10) PERIODS
*****************************************************************************
C  25                 IF OUTPER=0  THIS CARD IS NOT NEEDED
C            3I5      MONTH-DAY-YEAR(FOUR DIGITS) STOP CAL. CRITERION
C            3I5      MONTH-DAY-YEAR                 BEGIN CAL. CRITERION
C
C                     REPEAT THIS CARD FOR EACH PERIOD TO BE DROPPED
*****************************************************************************
C 25B          I5     ISENSE=0    NO SENSITIVITY ANALYSIS  WE THEREFORE ARE
C                                 IN THE OPTIMIZATION MODE (IF ISENSE=0 THE
C                                 MAX VALUE FOR NUMA IS 16)
```

```
C
C                          =1   SENSITIVITY  ANALYSIS (MAX VALUE FOR
C                                                 NUMA IS 50    )
*****************************************************************************
C 25C                    IF ISENSE=0 THIS CARD IS NOT NEEDED
C          16I5          NUMBER OF + AND/OR - PERTUBATIONS FOR EACH PARAMETER
C                                                   (8 IS MAXIMUM)
C                        REPEAT THIS CARD IF NUMA GT 16
*****************************************************************************
C 25D                    IF ISENSE=0 THIS CARD IS NOT NEEDED
C        8F10.4          PERTUBATION VALUES FOR EACH PARAMETER I
C
C                        REPEAT THIS CARD FOR EACH OF THE NUMA PARAMETERS.
*****************************************************************************
C                        IF ISENSE=1 THIS CARD IS NOT NEEDED
C  26    8F10.4          DDELTA(I)  WHEN NPER=1  DELTA(I)=ABS(DDELTA(I)*PARAMETER(I))
C                                        NPER=1  DELTA(I)=DDELTA(I)
C                        (IF MORE THAN 8  PARAMETERS IN OPT REPEAT CARD)
*****************************************************************************
C                        IF ISENSE=1 THIS CARD IS NOT NEEDED
C  27    8F10.4          CHECKL(I)= LOWER CONSTRAINT ON PARAMETER(I)
C                        (IF MORE THAN 8  PARAMETERS IN OPT REPEAT CARD)
*****************************************************************************
C                        IF ISENSE=1 THIS CARD IS NOT NEEDED
C  28    8F10.4          CHECKH(I)= UPPER CONSTRAINT ON PARAMETER(I)
C                        (IF MORE THAN 8  PARAMETERS IN OPT REPEAT CARD)
*****************************************************************************
C                        IF ISENSE=1 THIS CARD IS NOT NEEDED
C  28B    F10.5          PCENTOT=  PERCENT/100 CRITERION MUST AT LEAST CHANGE
C                          IN KSTOP TRIALS OR ANALYSIS IS STOPPED
C           I5           KSTOP  (SEE ABOVE)
*****************************************************************************
C  29       2I5          NUMBER OF NON ZERO ORDINATES IN THE CHANNEL
C                          DELAY HISTOGRAM FOR EACH AREA. (SIX HOUR INTERVALS)
*****************************************************************************
C   30      2I5          FIXED LAG (IN HOURS) FOR EACH AREA().SEE CARDS 29,32,
C                        32A.THE UPSTREAM AREA() FIXED LAG TRANSLATES ITS
C                        HISTOGRAM TO THE DOWNSTREAM FLOW POINT.  THE DOWNSTREAM
C                        AREA() HAS A FIXED LAG OF 0
*****************************************************************************
C   31       I5          INWARP=0  THEN THE CHANNEL DELAY HISTOGRAM WILL NOT BE
C                        MODIFIED DURING THE OPTIMIZATION OR SENITIVITY ANALYSIS
C                              .GT. 0 THEN VERTICAL AND HORIZONTAL WARPING OF
C                                     THE HISTOGRAM WILL BE DONE DURING OPTIMIZATION
C                                     OR SENITIVITY
C
C            I5          NOWARP=  SEQUENCE NUMBER FOR HWARP PARAMETER.  IF
C                        HWARP PARAMETER NUMBER IS TH 5 TH NUMBER ON CARD 22
C                        THEN NOWARP=5.  (VWARP PARAMETER NUMBER MUST ALWAYS
C                        FOLLOW HWARP PARAMETER NUMBER ON CARD 22, IF VWARP IS USED.)
*****************************************************************************
C   32                   IF INWARP=0 THIS CARD IS NOT NEEDED
C        20F4.4          G(I)  TWO HOUR INSTANTANEOUS ORDINATES OF THE MODIFIED
C                              CHANNEL DELAY HISTOGRAM.  THESE ORDINATES COME
```

```
C   NOTE-- THE 2 HR       FROM A CONTINUOUS CURVE FITTED TO THE ORIGINAL
C     HISTOGRAM IS FOR    6 HOUR DELAY HISTOGRAM.  G(1) SHOULD EQUAL 0
C     THE TOTAL AREA. IF
C                 TWO AREAS ARE ANALYZED
C                 COMBINE THEIR HISTOGRAMS
C
C                              (READ IN (NELEM(1)+NELEM(2))*3+1 G(I) ORDINATES
C                               IF MORE THAN 20 REPEAT THIS CARD)
**************************************************************************
C  32A                 IF INWARP = 0 THIS CARD IS NEEDED
C        20F4.4        DIMENSIONALESS ORDINATES OF THE CHANNEL DELAY
C                      HISTOGRAM FOR AREA ONE -- SIX HOUR INTERVALS
C                       (REPEAT IF TWO AREAS.  BE SURE
C                        HIST(1,I)+HIST(2,I) ORDINATES EQUAL 1.0)
**************************************************************************
**************************************************************************
C  32B          I5     VARL= 0  IF VARIABLE LAG IS NOT REQUESTED
C                          = 1  IF VARIABLE LAG IS REQUESTED
C               I5     VARK= 0  IF VARIABLE   K IS NOT REQUESTED
C                          = 1  IF VARIABLE   K    IS REQUESTED
C               I5     LOCAL= 0 HEADWATER OPTIMIZATION
C                           = 1 OR 2 LOCAL AREA OPTIMIZATION (LAND PARM)
C                      LOCAL= 3 LOCAL AREA OPTIMIZATION OF JUST CHANNEL PARM
C                             (OPTION 3 IS NOT PROGRAMED AS YET)
C               I5     NHWA  IS THE NUMBER OF UPSTREAM INFLOWS WHEN RUNNING
C                            UNDER LOCAL= 1 OR 2
**************************************************************************
C  33          4I5     IF LOCAL= 0 THIS CARD IS NOT NEEDED
C                      FIXED LAG (IN HOURS) FOR EACH UPSTREAM INFLOW
C                      WHEN RUNNING UNDER LOCAL= 1 OR 2
**************************************************************************
C  34         F4.4     FUNCTION OF CONSTANT K ROUTING FACTOR
C                         CSSR= (K-3)/(K+3)
**************************************************************************
C  35           I5     IF VARL= 0 THIS CARD IS NOT NEEDED
C                      NUMBER OF LAG VS Q POINTS TO DEFINE CURVE (MAX=15)
**************************************************************************
C  36       8F10.1     IF VARL= 0 THIS CARD IS NOT NEEDED
C                      FLOW VALUES DEFINING THE ABSCISSA OF THE
C                      LAG VS Q CURVE (FROM LOW TO HIGH Q AND FQLAG(1)
C                      USUALLY EQUALS 0.0)
C                                    REPEAT CARD IF NVL GT 8
**************************************************************************
C  37       8F10.4     IF VARL= 0 THIS CARD IS NOT NEEDED
C                      LAG VALUES (IN HOURS) DEFINING THE ORDINATE OF
C                      THE LAG VS Q CURVE. THEY MUST CORRESPOND TO THE
C                      ABOVE FQLAG( ) VALUES
C                      CALCULATIONS USING VARIABLE LAG ARE BASED ON
C                           LAGGING THE VOLUME OF FLOW IN THE INTERVAL
C                           FQLAG(N) TO FQLAG(N+1) BY VL(N+1)
C                      (NOTE DIFFERENCE BETWEEN THIS AND NWSRFS4 ROUTINE)
C                      LAG VALUE FOR HIGHEST DEFINED FLOW IS USED FOR
C                           ALL FLOW ABOVE THAT DISCHARGE
C                                     REPEAT CARD IF NVL GT 8
```

```
******************************************************************************
C  38-40            IF VARK= 0 THESE CARDS ARE NOT NEEDED
C                   IF VARK= 1 SEE CARDS 35-37 FOR FORMAT DESCRIPTION
C
C                   CALCULATION USING K ARE BASED ON A LINEAR
C                        INTERPOLATION BETWEEN POINTS
C                   K VALUE FOR HIGHEST DEFINED FLOW IS USED FOR
C                        ALL FLOWS ABOVE THAT DISCHARGE
C                   (NOTE THIS ROUTINE IS THE SAME AS NWSRFS4 ROUTINE)
******************************************************************************
C  41      8A10     HEADER CARD  (USE COLS 2 THUR 80)
******************************************************************************
******************************************************************************
C     THE FOLLOWING SNOW INPUT CARD  TELLS  THE PROGRAM FOR WHICH MONTHS VALID
C          AIR TEMPERATURE DATA ARE AVAILABLE AND THUS WHICH MONTHS SNOW
C          COMPUTATIONS ARE TO BE MADE.     =1 VALID DATA AVAILABLE
C                                           =0 AIR TEMPERATURE DATA IS MISSING
*******NOTE********   CARD 411 ONLY NEEDED IF SNOW IS INCLUDED
******************************************************************************
C 411      50I1     VALID AIR TEMP. INDICATOR FOR EACH MONTH INCLUD. BUFFER.
******************************************************************************
******************************************************************************
C      THE FOLLOWING SNOW INPUT CARD IS NEEDED FOR THE OPTIMIZATION PROGRAM
C             ONLY IF  (NGAGES.GT.1)
******************************************************************************
C 412       9I5     PARM( ) NUMBERS OF AREA TWO PARAMETERS THAT SHOULD BE
C                        THE SAME AS AREA ONE PARAMETERS -- CAN ONLY USE
C                        PARM( ) NUMBERS 26,28,30,32,34,38,40
******************************************************************************
******************************************************************************
```

E.2 SAMPLE INPUT AND OUTPUT FOR OPTIMIZATION PROGRAM WITH SNOW - OPTIMIZATION MODE

```
    1     1     1     1     1
  368     0     0     0     0
    3     1     0     1     0
    2     1     1     1
    2     3
    1
    1     1
    0
    1     2
    1
    0
   50  1967     8   213     1
        .05         .20         .25         5.0         .30         3.0         0.9
       218.        218.
        1.0         1.0
        0.0         .30
  1.0   0.0   166    92   .25
        1.0         1.0
         .9          .1        .004         .55         .99
        0.0         5.0         1.5         .95         0.0         0.0         0.0
    1
    2     0
    3     0
PASSUMPSIC R. MAT-L        1060. -1.5 -2.7 -3.9 -2.7
PASSUMPSIC R. MAT-H        1740. -1.5 -2.7 -3.9 -2.7
    2     3
    1     2
PASSUMPSIC RIVER-L         1060.   .50   1.3  .018  .007  .005  .036   3.0   .01
PASSUMPSIC RIVER-L    32.    0.0   0.0   0.0   0.0
PASSUMPSIC RIVER-L    0.0    0.0   0.0
PASSUMPSIC RIVER-H         1740.   .90   1.3  .018  .007  .005  .036   4.5   .01
PASSUMPSIC RIVER-H    32.    0.0   0.0   0.0   0.0
PASSUMPSIC RIVER-H    0.0    0.0   0.0
BASINWIDE PARAMETERS  32.    33.   .03   .50
AREAL DEPLETION       .24    .39   .52   .64   .75   .82   .88   .92   .96
 1522    61    11     1     3   125     3
    1     2     3    25    26    27    29    31    33    37    38
    1     1
    1
    3    25  1969     5    19  1969
    0
        .04         .01         .04         .02         .02         .02         .05         .05
        .03         .02         .02
        .20         3.0         .20         1.0         1.0        .015        .003        .002
        .02         2.0         3.0
        .40         7.0         .40         1.5         1.5        .025        .010        .008
        .15         6.0        10.0
        .10     3
    2     1
```

```
    0    12
    0
 .10 .40
 .50
    0      0      0      0
  .5
 PASSUMPSIC RIVER AT PASSUMPSIC,VT.--SAMPLE OUTPUT OPTIMIZATION PROGRAM-W/SNOW
000111111100000111111100001111111100000111111110000
   28    30    32    34    40
```

SNOW PARAMETERS--CASE=1

INPUT GAGES USED

RG	TA GAGE	WE GAGE
1	PASSUMPSIC R. MAT-L	
2	PASSUMPSIC R. MAT-H	

TA GAGE	ELEV.	PERIOD TA LAPSE RATES			
PASSUMPSIC R. MAT-L	1060.	-1.5	-2.7	-3.9	-2.7
PASSUMPSIC R. MAT-H	1740.	-1.5	-2.7	-3.9	-2.7

AREA SNOW PARAMETERS

RG	ELEV	EFC	SCF	MFMAX	MFMIN	NMF	UADJ	SI	DÁYGM
1	1060.	.50	1.30	.0180	.0070	.0050	.0360	3.00	.010
2	1740.	.90	1.30	.0180	.0070	.0050	.0360	4.50	.010

INTIAL SNOW VALUES

RG	WE	NEGHS	LIQW	STORAGE	SB	SBAESC	SBWS	TINDEX
1	0.00	0.000	0.000	0.000	0.000	0.000	0.000	32.
2	0.00	0.000	0.000	0.000	0.000	0.000	0.000	32.

BASINWIDE PARAMETERS

MELT-BASE	PX-TEMP	PLWHC	TI-PARM
32.0	33.0	.030	.500

AREAL DEPLETION CURVE

WE/AI	0.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
AESC	.05	.24	.39	.52	.64	.75	.82	.88	.92	.96	1.00

PASSUMPSIC RIVER AT PASSUMPSIC,VT.--SAMPLE OUTPUT OPTIMIZATION PROGRAM-W/SNOW

THE PERIOD OF RECORD BEING ANALYZED IS FROM 8 1967 THRU 9 1971 THE BUFFER PERIOD IS THE FIRST 61 DAYS

PARAMETER VALUES

1	2	3	0	0	0	0	0	0	0	0	0
UZSN	LZSN	CB	POWER	CC	KV	KGS	K24EL	A	K24L	EPXM	K1(1)
.2500	5.0000	.3000	3.0000	.9000	.5500	.9900	.2500	.0500	0.0000	.2000	1.0000

PARAMETER VALUES

0	0	0	0	0	0	0	0	0	0	0	0
K1(2)	PEADJ(1)	PEADJ(2)	K3	SRC1	LIRC6	LKK6	CSSR	HWARP	VWARP	FOREST(1)	FOREST(2)
1.0000	1.0000	0.0000	.3000	.9000	.1000	.0040	.5000	1.0000	1.0000	I	I

PARAMETER VALUES

4	5	6	0	7	0	8	0	9	0	0	0
SCF(1)	SCF(2)	MFMAX(1)	MFMAX(2)	MFMIN(1)	MFMIN(2)	NMF(1)	NMF(2)	UADJ(1)	UADJ(2)	FUCOEF(1)	FUCOEF(2)
1.3000	1.3000	.0180	.0180	.0070	.0070	.0050	.0050	.0360	.0360	I	I

PARAMETER VALUES

10	11	0	0	0	0	0	0	0	0	0	0
SI(1)	SI(2)	DAYGM(1)	DAYGM(2)	PLWHC	TOPM	AK	AN	RAIX	SAIX	EHIGH	ELOW
3.0000	4.5000	.0100	.0100	.0300	I	I	I	I	I	1.0000	0.0000

PARAMETER VALUES

0	0
NEP	NDUR
166.0000	92.0000

(NOTE ABOVE INUMBERS CORRESPOND TO A ( ) SUBSCRIPT NUMBERS)

THE FOLLOWING PERIODS WILL BE REMOVED FROM CALCULATING THE VALUE FOR THE OPTIMIZATION CRITERION AND (MEAN Q , R)

	DATE	DAY NO.
THE BUFFER PERIOD (THE FIRST 61 DAYS)		
	3 25 1969 TO 5 19 1969	603 TO 658

INITIAL STORAGE VALUES

UZSI	LZSI	SGWI	GWSI	RESI	SRGXI	SCEPI
0.0000	5.0000	1.5000	.9500	0.0000	0.0000	0.0000

FIXED LAG CHANNEL DELAY HISTOGRAM

		FIXED LAG	CHANNEL DELAY HISTOGRAM	
GAGE	1	0	.1000	.4000
GAGE	2	12	.5000	

PASSUMPSIC RIVER AT PASSUMPSIC,VT.--SAMPLE OUTPUT OPTIMIZATION PROGRAM-W/SNOW

NDAY WATER BALANCE QUANTITIES (FOR RUN 1)

SURFACE RO	INTERFLOW	IMPERVIOUS RO	GROUNDWATER	INTERCEPTION	ACT. ET LOSS	PREC.	P.E.	AVAIL ET	BALANCE
6.104	10.294	8.688	63.795	39.493	84.810	173.761	104.176	84.822	-.000

MEAN DAILY FLOWS (FOR RUN 1 BUFFER PER NOT INC)

10.229	16,952	9.928	74.051	42.940	86.742	198.554	104.176	86.744	-.000

MEAN DAILY FLOWS (FOR RUN 1 BUFFER PER NOT INC)

208.86	308.49	215.70	198.96	284.95	364.26	232.00	204.20	217.98	410.63
1298.99	599.28	424.10	384.14	383.83	344.84	340.07	338.93	908.96	549.90
424.80	423.42	369.29	346.08	331.17	1245.12	941.25	578.05	495.94	447.69
412.87									
386.41	367.86	492.98	450.27	544.32	419.50	387.32	365.62	352.37	343.98
330.88	328.96	403.89	336.83	314.81	304.12	294.51	285.68	277.14	269.22
261.81	254.80	314.61	588.51	364.09	323.94	307.67	298.01	285.39	275.80
412.87									
267.48	259.68	252.58	245.92	239.55	233.73	228.24	222.99	217.95	213.20
208.87	764.95	2525.62	1114.77	784.42	651.03	567.44	509.13	468.38	458.70
441.63	416.93	423.06	395.35	379.21	367.39	356.78	347.04	338.02	329.48
321.28									
313.65	306.75	300.04	293.62	287.48	281.65	276.03	271.63	265.47	260.56
255.82	251.26	246.89	242.72	238.69	234.80	231.06	227.45	223.98	220.62
217.36	214.24	211.22	208.31	205.49	202.77	200.15	197.60	195.13	192.75
190.44									
188.21	186.04	279.39	326.99	253.52	236.59	230.02	224.85	220.48	216.63
213.12	209.85	206.79	203.78	200.95	198.32	195.80	193.35	190.97	188.67
186.42	184.24	182.12	180.05	178.02	176.04	174.10	172.19	170.32	192.75
190.44									
168.53	166.72	164.94	163.17	161.43	159.70	157.96	156.23	154.50	158.15
164.38	155.72	152.62	150.61	148.69	155.07	423.39	602.78	874.21	1359.69
1346.90	1907.69	2605.63	3959.53	2621.27	1993.90	1892.88	2133.16	2470.94	3126.47
2865.50									
3412.30	3123.00	2681.66	2852.65	3309.27	3081.49	2646.25	2616.15	2891.82	2313.47
2714.98	2652.69	3187.22	3850.29	3913.07	4644.49	3523.21	3030.16	2671.70	2380.42
2115.59	1901.19	1727.59	1705.95	5621.22	3850.32	2810.52	2556.34	2020.04	1728.40
2865.50									
1517.46	1351.79	1219.63	1187.05	1043.50	942.55	872.68	812.09	765.50	781.62
665.38	637.25	596.32	501.34	458.37	428.11	870.28	931.02	1271.40	1535.32
2199.65	1321.14	1085.22	907.98	797.50	715.53	648.46	595.90	550.57	591.92
728.35									
728.08	596.22	636.61	758.09	573.24	518.17	494.00	460.23	685.77	1144.93
837.00	744.73	700.39	731.52	659.59	1367.58	881.25	784.52	854.87	877.56
704.29	638.85	603.58	601.97	970.92	670.17	591.98	566.94	586.77	887.39
728.35									
774.11	607.09	516.55	467.21	412.94	565.95	522.09	414.90	364.14	941.63
803.28	576.25	515.51	448.03	451.23	400.05	399.88	869.20	534.07	588.30
438.31	374.05	341.39	286.56	283.85	249.42	249.73	403.82	556.30	356.07
275.49									
302.13	357.65	249.43	198.65	185.12	191.63	209.72	177.07	186.10	281.40
169.99	134.73	123.03	109.95	103.17	97.13	158.60	360.19	138.82	277.37
658.14	277.84	208.55	177.49	247.94	263.68	169.39	152.18	143.65	133.09
129.09									
125.15	112.86	137.44	116.45	98.56	139.20	298.08	141.59	113.75	92.72
406.73	821.16	354.69	255.41	238.17	221.59	204.72	171.92	160.48	154.78
149.15	144.03	139.18	134.79	198.06	218.31	169.05	163.68	151.63	121.38

129.09									
122.12	109.77	117.61	319.11	349.91	202.07	311.07	388.81	217.71	199.54
250.18	210.20	182.83	176.54	170.82	161.41	147.85	143.13	169.24	453.27
222.20	184.87	186.24	181.41	253.43	293.37	197.03	321.59	412.48	256.07
238.09									
228.20	250.52	258.40	224.31	209.68	203.33	208.50	277.33	236.95	219.55
205.08	199.55	194.65	190.18	185.96	181.86	177.75	202.16	685.86	384.93
296.76	283.13	285.55	273.29	296.76	270.67	259.25	268.82	1114.04	893.05
238.09									
579.58	510.52	485.23	469.72	569.57	545.07	476.74	453.88	436.60	421.74
408.89	396.44	384.04	393.38	597.71	462.44	423.58	406.61	392.30	380.29
369.16	358.34	348.50	339.41	330.01	321.80	314.42	307.17	300.19	292.88
286.40									
280.34	274.24	268.36	263.09	257.53	251.25	247.27	242.80	238.12	234.20
229.91	226.03	222.08	218.46	214.91	211.57	208.53	205.27	202.35	199.05
196.42	193.68	191.05	188.13	185.86	183.51	181.28	179.09	177.04	174.97
173.03									
171.05	169.23	167.44	165.68	163.93	162.28	160.67	159.11	157.60	156.12
154.67	153.28	151.92	150.60	149.31	148.05	146.82	145.62	144.43	143.26
142.10	140.98	139.89	138.82	137.81	136.74	135.56	134.45	177.04	174.97
173.03									
133.34	132.37	131.22	129.70	128.21	127.43	126.41	125.13	124.12	122.98
122.03	120.65	119.21	117.91	116.97	115.28	113.88	114.21	113.13	141.48
184.27	189.38	154.14	186.90	302.21	541.21	410.78	320.77	291.90	278.39
265.00									
254.79	244.71	238.23	227.20	377.50	645.44	470.05	471.73	444.16	782.27
1427.01	1027.57	901.00	1226.43	2149.69	3315.52	3476.18	4021.75	6451.95	5591.36
4016.57	3864.12	4474.39	4932.49	4180.32	4109.84	4467.42	6846.18	9907.12	7784.02
265.00									
6785.46	6093.85	6286.96	6294.52	5591.57	4839.84	4654.61	4485.21	6338.49	7391.18
5925.70	6078.29	5137.92	4833.16	4342.85	3979.33	3878.04	3619.93	3396.53	6386.85
6165.07	4009.73	3229.32	2704.94	2338.26	2148.52	1795.84	1626.68	1440.32	1290.18
1180.03									
1082.21	984.01	1009.07	1006.71	823.29	762.88	818.55	650.29	530.04	471.01
430.74	394.09	426.06	827.06	1204.65	2373.67	1238.09	881.88	724.61	764.98
635.70	518.46	488.10	628.41	483.97	392.76	337.92	440.80	324.01	251.98
1180.03									
248.28	216.69	200.42	255.66	188.86	209.00	160.53	129.69	119.03	117.96
276.41	1480.56	1101.26	622.78	463.88	392.33	348.16	289.10	231.89	195.78
184.11	614.32	421.18	301.28	257.76	385.99	522.02	462.73	1625.67	1584.64
1237.45									
887.10	843.09	852.54	663.89	1507.41	1314.84	936.15	798.92	793.96	700.45
754.10	592.80	543.32	507.95	478.01	439.28	676.93	604.86	687.33	599.61
511.62	466.63	414.18	462.85	464.94	492.86	391.92	348.43	315.78	297.81
281.40									
276.40	321.80	283.10	251.03	240.65	295.22	484.51	627.88	635.26	484.38
431.36	422.68	409.54	377.83	356.85	349.54	469.79	574.70	401.72	374.29
358.84	340.43	317.55	309.69	384.65	337.91	308.65	284.05	267.58	256.53
281.40									
241.49	233.62	487.46	356.85	283.95	269.18	260.19	268.06	246.24	224.14
212.14	205.39	198.83	208.97	213.17	186.38	183.94	211.69	182.99	312.54
578.62	396.38	367.68	320.75	311.03	306.20	359.48	370.58	337.26	313.33
313.84									
305.94	310.97	448.65	823.69	4250.56	3481.09	1973.75	1609.61	1305.76	1093.94
1022.60	1182.79	974.83	992.51	1224.51	1008.62	889.30	840.83	881.55	4317.95
3097.26	1755.43	1392.96	1178.99	1025.07	916.37	834.48	772.61	724.66	684.38
313.84									
649.95	620.23	594.87	570.93	548.41	528.61	510.61	508.37	519.47	499.31
1274.59	1727.77	1070.77	891.98	794.54	724.14	671.22	630.38	597.66	569.18
544.91	524.21	505.44	488.67	473.19	458.75	444.56	430.54	418.07	406.50
395.87									
385.14	374.99	365.85	357.23	348.81	340.57	332.58	325.44	318.44	311.46
304.77	298.70	292.94	286.87	281.37	276.20	271.27	266.22	261.71	257.38
253.17	248.97	245.04	241.26	237.57	234.04	230.52	227.22	223.94	220.78
217.79									
214.95	217.95	641.27	1279.19	716.11	556.08	489.62	439.21	405.28	380.86

383.83	596.74	466.36	417.33	395.24	378.79	365.35	353.96	344.02	335.13
327.03	319.54	312.54	305.83	299.38	293.31	287.74	282.28	223.94	220.78
217.79									
277.02	272.07	267.19	252.21	257.62	253.40	249.14	244.85	239.83	235.57
231.66	227.51	223.20	220.40	216.38	212.81	208.89	204.37	200.27	196.23
192.48	202.13	360.18	326.17	339.53	313.22	297.78	286.82	281.35	267.48
257.03									
249.50	303.91	890.62	548.88	426.94	378.25	349.57	436.24	965.24	1621.71
1092.81	841.28	872.78	1046.34	1462.16	1672.78	2643.99	4101.55	3033.41	2373.53
2294.92	2720.92	2799.22	3997.90	9763.23	5530.03	5796.11	6491.03	6572.98	6482.94
257.03									
6617.89	6670.25	5352.99	4536.67	3950.72	3383.85	2952.57	2549.68	2252.48	2124.05
1916.62	1818.63	1604.45	1470.09	1331.45	1234.47	2152.97	3747.30	1878.92	1473.96
1249.66	1128.80	1100.23	904.14	838.37	872.13	997.79	740.58	661.92	571.71
506.24									
468.17	572.93	573.53	515.89	450.58	1401.44	853.11	600.91	505.91	449.80
414.48	404.47	307.41	253.39	231.69	220.14	221.73	251.50	252.63	201.43
180.68	195.44	172.11	127.64	132.69	135.56	776.37	687.49	345.91	710.65
506.24									
840.43	527.22	529.37	519.52	860.06	553.80	453.84	395.89	347.33	297.16
402.66	384.76	377.57	266.68	292.64	350.23	355.63	258.62	339.85	215.30
173.94	162.34	134.09	128.50	125.57	113.79	105.56	100.51	115.53	96.07
88.38									
255.24	614.55	288.33	357.33	219.10	196.91	156.21	132.47	125.82	121.65
157.66	153.59	104.11	104.91	98.36	82.77	77.34	70.17	64.06	77.04
340.13	134.10	336.14	500.60	157.07	127.49	216.64	202.64	705.92	232.71
269.40									
202.41	175.60	166.44	578.37	452.57	323.84	284.71	268.13	256.87	257.97
334.03	208.27	189.11	167.58	194.99	396.65	257.66	231.26	229.47	173.83
152.17	284.12	235.40	185.37	166.24	205.23	362.82	382.16	345.48	317.91
269.40									
263.48	251.12	390.93	436.44	323.60	288.27	269.71	259.18	244.30	210.50
214.94	263.51	245.49	344.50	475.49	565.07	386.17	343.27	324.36	310.70
300.15	303.79	490.33	384.56	318.19	309.29	299.44	285.51	274.66	267.77
258.27									
247.98	241.18	231.00	223.83	223.61	222.92	209.64	192.75	183.81	188.12
310.71	237.73	189.76	192.11	314.38	407.56	272.46	256.02	266.14	350.46
510.49	424.60	385.87	384.34	353.19	341.64	331.55	377.30	573.33	425.64
258.27									
411.08	454.42	484.70	430.19	408.64	393.89	379.66	367.45	357.18	346.96
336.63	328.25	320.37	312.28	303.77	296.82	289.86	282.39	275.15	269.41
262.95	258.01	253.16	247.93	242.32	238.12	233.23	228.60	224.14	219.63
215.52									
211.96	208.64	205.08	201.02	198.37	194.79	191.29	188.80	186.59	184.16
181.55	179.08	176.71	174.72	172.44	170.16	168.23	166.45	164.57	162.78
160.90	159.26	157.45	155.74	154.10	152.56	151.23	149.82	148.49	147.12
145.76									
144.58	143.38	142.20	141.07	139.94	138.84	137.75	136.73	135.71	134.74
133.79	132.86	131.95	131.07	130.20	129.35	128.53	127.71	126.90	126.11
125.37	124.63	123.90	123.17	122.36	121.65	120.87	120.13	148.49	147.12
145.76									
118.94	118.06	117.47	117.03	116.26	115.06	114.29	114.02	112.64	111.78
110.62	110.23	108.62	107.53	106.14	111.20	160.74	123.92	116.42	115.84
119.80	114.11	110.50	108.72	105.64	103.74	102.44	100.05	105.92	141.41
140.53									
114.27	139.00	415.39	506.10	334.40	302.02	350.42	322.23	290.60	409.51
1110.88	1088.45	1424.17	1613.48	1274.41	1067.10	972.27	960.39	1353.59	2058.14
2497.45	2741.29	2361.94	2158.22	2728.08	2975.20	2930.59	3011.40	3809.40	4109.57
140.53									
4797.80	4945.43	6288.16	7693.91	7031.13	6831.93	6766.12	6395.63	6530.55	6504.96
6901.66	7320.68	6746.30	5683.27	4634.57	4011.23	3563.37	3137.36	2716.75	2367.63
2140.41	2294.87	2041.66	1773.34	1626.27	1848.01	1631.43	1605.03	1395.02	1223.33
1058.13									
926.44	768.78	844.56	875.45	691.68	565.51	571.64	1048.75	1132.08	846.03
714.28	609.02	482.55	453.89	492.74	410.88	372.22	328.79	297.73	263.61
394.56	763.26	445.94	385.76	432.36	870.69	491.62	403.91	330.23	282.55

1058.13									
479.77	1339.28	633.02	522.24	460.57	415.91	411.28	292.66	269.00	232.13
192.88	185.73	190.63	527.80	458.27	295.03	347.42	590.08	348.18	551.04
343.80	245.72	201.53	204.39	315.36	232.73	283.46	274.78	226.66	426.59
356.28									
505.92	501.66	1027.58	5004.41	1565.19	979.84	783.44	645.15	527.00	404.61
468.24	570.49	385.00	301.65	292.39	292.76	234.93	219.66	210.17	252.24
544.49	416.31	867.42	823.73	498.53	468.52	472.24	1845.52	2827.92	1290.52
1049.37									
872.82	777.08	710.27	657.05	615.36	602.36	551.84	453.82	385.62	375.67
398.91	554.95	665.05	636.33	677.09	538.37	516.18	620.01	509.19	486.20
579.91	497.20	439.75	438.36	386.04	330.81	311.97	332.52	349.95	320.24
1049.37									

TRIAL	RUN	CRITERION	MEAN Q	R	A(1)	A(2)	A(3)	A(4)	A(5)	A(6)	A(7)	A(8)	A(9)	A(10)	A(11)	A(12)	A(13)	A(14)	A(15)	A(16)
					INITIAL VALUES OF THE PARAMETERS															
1	1	.3386E+09	689.5	.9016	.2500	5.0000	.3000	1.3000	1.3000	.0180	.0070	.0050	.0360	3.0000	4.5000					

TRIAL	RUN	CRITERION	MEAN Q	R	A(1)	A(2)	A(3)	A(4)	A(5)	A(6)	A(7)	A(8)	A(9)	A(10)	A(11)	A(12)	A(13)	A(14)	A(15)	A(16)
1	2	.3388E+09	689.2	.9011	.2600	5.0000	.3000	1.3000	1.3000	.0180	.0070	.0050	.0360	3.0000	4.5000					
1	3	.3385E+09	689.7	.9020	.2400	5.0000	.3000	1.3000	1.3000	.0180	.0070	.0050	.0360	3.0000	4.5000					
1	4	.3383E+09	689.7	.9017	.2400	5.0500	.3000	1.3000	1.3000	.0180	.0070	.0050	.0360	3.0000	4.5000					
1	5	.3389E+09	689.9	.8997	.2400	5.0500	.3120	1.3000	1.3000	.0180	.0070	.0050	.0360	3.0000	4.5000					
1	6	.3380E+09	689.6	.9036	.2400	5.0500	.2880	1.3000	1.3000	.0180	.0070	.0050	.0360	3.0000	4.5000					
1	7	.3547E+09	693.2	.9022	.2400	5.0500	.2880	1.3260	1.3000	.0180	.0070	.0050	.0360	3.0000	4.5000					
1	8	.3246E+09	686.0	.9046	.2400	5.0500	.2880	1.2740	1.3000	.0180	.0070	.0050	.0360	3.0000	4.5000					
1	9	.3514E+09	691.2	.8998	.2400	5.0500	.2880	1.2740	1.3260	.0180	.0070	.0050	.0360	3.0000	4.5000					
1	10	.3008E+09	680.9	.9090	.2400	5.0500	.2880	1.2740	1.2740	.0180	.0070	.0050	.0360	3.0000	4.5000					
1	11	.2872E+09	680.1	.9135	.2400	5.0500	.2880	1.2740	1.2740	.0184	.0070	.0050	.0360	3.0000	4.5000					
1	12	.2810E+09	679.9	.9155	.2400	5.0500	.2880	1.2740	1.2740	.0184	.0073	.0050	.0360	3.0000	4.5000					
1	13	.2874E+09	680.0	.9138	.2400	5.0500	.2880	1.2740	1.2740	.0184	.0073	.0053	.0360	3.0000	4.5000					
1	14	.2740E+09	679.8	.9173	.2400	5.0500	.2880	1.2740	1.2740	.0184	.0073	.0048	.0360	3.0000	4.5000					
1	15	.2728E+09	679.7	.9177	.2400	5.0500	.2880	1.2740	1.2740	.0184	.0073	.0048	.0371	3.0000	4.5000					
1	16	.2730E+09	679.7	.9175	.2400	5.0500	.2880	1.2740	1.2740	.0184	.0073	.0048	.0371	3.0600	4.5000					
1	17	.2727E+09	679.7	.9178	.2400	5.0500	.2880	1.2740	1.2740	.0184	.0073	.0048	.0371	2.9400	4.5000					
1	18	.2719E+09	679.8	.9180	.2400	5.0500	.2880	1.2740	1.2740	.0184	.0073	.0048	.0371	2.9400	4.5900					

TRIAL	RUN	CRITERION	MEAN Q	R	A(1)	A(2)	A(3)	A(4)	A(5)	A(6)	A(7)	A(8)	A(9)	A(10)	A(11)
1	18	.2719E+09	679.8	.9180	.2400	5.0500	.2880	1.2740	1.2740	.0184	.0073	.0048	.0371	2.9400	4.5900
PATTERN MOVE															
2	19	.2153E+09	670.5	.9325	.2300	5.1000	.2760	1.2480	1.2480	.0187	.0077	.0045	.0382	2.8800	4.6800

TRIAL	RUN	CRITERION	MEAN Q	R	A(1)	A(2)	A(3)	A(4)	A(5)	A(6)	A(7)	A(8)	A(9)	A(10)	A(11)	A(12)	A(13)	A(14)	A(15)	A(16)
2	20	.2157E+09	670.8	.9327	.2204	5.1000	.2760	1.2480	1.2480	.0187	.0077	.0045	.0382	2.8800	4.6800					
2	21	.2151E+09	670.3	.9322	.2396	5.1000	.2760	1.2480	1.2480	.0187	.0077	.0045	.0382	2.8800	4.6800					
2	22	.2150E+09	670.3	.9320	.2396	5.1505	.2760	1.2480	1.2480	.0187	.0077	.0045	.0382	2.8800	4.6800					
2	23	.2163E+09	670.2	.9332	.2396	5.1505	.2645	1.2480	1.2480	.0187	.0077	.0045	.0382	2.8800	4.6800					
2	24	.2144E+09	670.4	.9307	.2396	5.1505	.2875	1.2480	1.2480	.0187	.0077	.0045	.0382	2.8800	4.6800					
2	25	.2037E+09	667.0	.9317	.2396	5.1505	.2875	1.2225	1.2480	.0187	.0077	.0045	.0382	2.8800	4.6800					
2	26	.1862E+09	662.2	.9355	.2396	5.1505	.2875	1.2225	1.2225	.0187	.0077	.0045	.0382	2.8800	4.6800					
2	27	.1777E+09	661.7	.9385	.2396	5.1505	.2875	1.2225	1.2225	.0191	.0077	.0045	.0382	2.8800	4.6800					
2	28	.1737E+09	661.5	.9400	.2396	5.1505	.2875	1.2225	1.2225	.0191	.0081	.0045	.0382	2.8800	4.6800					
2	29	.1696E+09	661.5	.9411	.2396	5.1505	.2875	1.2225	1.2225	.0191	.0081	.0043	.0382	2.8800	4.6800					
2	30	.1689E+09	661.5	.9413	.2396	5.1505	.2875	1.2225	1.2225	.0191	.0081	.0043	.0393	2.8800	4.6800					
2	31	.1687E+09	661.5	.9414	.2396	5.1505	.2875	1.2225	1.2225	.0191	.0081	.0043	.0393	2.8212	4.6800					
2	32	.1683E+09	661.5	.9415	.2396	5.1505	.2875	1.2225	1.2225	.0191	.0081	.0043	.0393	2.8212	4.7718					
2	32	.1683E+09	661.5	.9415	.2396	5.1505	.2875	1.2225	1.2225	.0191	.0081	.0043	.0393	2.8212	4.7718					
PATTERN MOVE																				
3	33	.1058E+09	644.1	.9562	.2392	5.2510	.2870	1.1710	1.1710	.0198	.0088	.0038	.0415	2.7024	4.9536					

TRIAL	RUN	CRITERION	MEAN Q	R	A(1)	A(2)	A(3)	A(4)	A(5)	A(6)	A(7)	A(8)	A(9)	A(10)	A(11)	A(12)	A(13)	A(14)	A(15)	A(16)
3	34	.1056E+09	643.8	.9561	.2488	5.2510	.2870	1.1710	1.1710	.0198	.0088	.0038	.0415	2.7024	4.9536					
3	35	.1057E+09	643.9	.9559	.2488	5.3025	.2870	1.1710	1.1710	.0198	.0088	.0038								

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                                              .0415     2.7024     4.9536

  3  36   .1055E+09  643.8 .9563     .2488     5.1995     .2870     1.1710     1.1710     .0198     .0088     .0038
                                          .0415     2.7024     4.9536

  3  37   .1049E+09  643.9 .9557     .2488     5.1995     .2985     1.1710     1.1710     .0198     .0088     .0038
                                          .0415     2.7024     4.9536

  3  38   .1003E+09  640.5 .9561     .2488     5.1995     .2985     1.1466     1.1710     .0198     .0088     .0038
                                          .0415     2.7024     4.9536

  3  39   .9339E+08  636.1 .9578     .2488     5.1995     .2985     1.1466     1.1466     .0198     .0088     .0038
                                          .0415     2.7024     4.9536

  3  40   .9068E+08  635.8 .9590     .2488     5.1995     .2985     1.1466     1.1466     .0202     .0088     .0038
                                          .0415     2.7024     4.9536

  3  41   .8895E+08  635.7 .9596     .2488     5.1995     .2985     1.1466     1.1466     .0202     .0092     .0038
                                          .0415     2.7024     4.9536

  3  42   .8753E+08  635.7 .9601     .2488     5.1995     .2985     1.1466     1.1466     .0202     .0092     .0036
                                          .0415     2.7024     4.9536

  3  43   .8725E+08  635.7 .9602     .2488     5.1995     .2985     1.1466     1.1466     .0202     .0092     .0036
                                          .0426     2.7024     4.9536

  3  44   .8725E+08  635.7 .9602     .2488     5.1995     .2985     1.1466     1.1466     .0202     .0092     .0036
                                          .0426     2.6460     4.9536

  3  45   .8705E+08  635.7 .9603     .2488     5.1995     .2985     1.1466     1.1466     .0202     .0092     .0036
                                          .0426     2.6460     5.0490

  3  45   .8705E+08  635.7 .9603     .2488     5.1995     .2985     1.1466     1.1466     .0202     .0092     .0036
                                          .0426     2.6460     5.0490

                    PATTERN  MOVE
  4  46   .7074E+08  611.4 .9630     .2488     5.2485     .2985     1.0707     1.0707     .0213     .0092     .0029
                                          .0460     2.4708     5.3263

 TRIAL RUN  CRITERION MEAN Q   R      A( 1)      A( 2)      A( 3)      A( 4)      A( 5)      A( 6)      A( 7)      A( 8)
                                          A( 9)      A(10)      A(11)      A(12)      A(13)      A(14)      A(15)      A(16)
                               - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

 PARAMETER  A( 1) =      .249  REMOVED FROM OPTIMIZATION
  4  47   .7051E+08  611.4 .9631     .2488     5.1965     .2985     1.0707     1.0707     .0213     .0092     .0029
                                          .0460     2.4708     5.3263

 PARAMETER  A( 3) =      .299  REMOVED FROM OPTIMIZATION
  4  48   .7089E+08  608.3 .9628     .2488     5.1965     .2985     1.0477     1.0707     .0213     .0092     .0029
                                          .0460     2.4708     5.3263

  4  49   .7083E+08  614.5 .9631     .2488     5.1965     .2985     1.0936     1.0707     .0213     .0092     .0029
                                          .0460     2.4708     5.3263

  4  50   .7168E+08  607.5 .9625     .2488     5.1965     .2985     1.0707     1.0477     .0213     .0092     .0029
                                          .0460     2.4708     5.3263

  4  51   .7012E+08  615.3 .9634     .2488     5.1965     .2985     1.0707     1.0936     .0213     .0092     .0029
                                          .0460     2.4708     5.3263

  4  52   .7059E+08  615.1 .9632     .2488     5.1965     .2985     1.0707     1.0936     .0217     .0092     .0029
                                          .0460     2.4708     5.3263

  4  53   .7020E+08  615.5 .9634     .2488     5.1965     .2985     1.0707     1.0936     .0209     .0092     .0029
                                          .0460     2.4708     5.3263
```

```
  4  54   .7025E+08  615.3 .9634      .2488    5.1965     .2985    1.0707    1.0936     .0213     .0087     .0029
                                          .0460    2.4708    5.3263

  4  55   .7005E+08  615.3 .9634      .2488    5.1965     .2985    1.0707    1.0936     .0213     .0092     .0027
                                          .0460    2.4708    5.3263

  4  56   .7004E+08  615.3 .9634      .2488    5.1965     .2985    1.0707    1.0936     .0213     .0092     .0027
                                          .0473    2.4708    5.3263

  4  57   .7012E+08  615.3 .9634      .2488    5.1965     .2985    1.0707    1.0936     .0213     .0092     .0027
                                          .0473    2.4178    5.3263

  4  58   .7001E+08  615.3 .9634      .2488    5.1965     .2985    1.0707    1.0936     .0213     .0092     .0027
                                          .0473    2.5237    5.3263

  4  59   .7008E+08  615.3 .9634      .2488    5.1965     .2985    1.0707    1.0936     .0213     .0092     .0027
                                          .0473    2.5237    5.4273

  4  60   .6995E+08  615.3 .9635      .2488    5.1965     .2985    1.0707    1.0936     .0213     .0092     .0027
                                          .0473    2.5237    5.2253

  4  60   .6995E+08  615.3 .9635      .2488    5.1965     .2985    1.0707    1.0936     .0213     .0092     .0027
                                          .0473    2.5237    5.2253

                     PATTERN  MOVE
  5  61   .7651E+08  605.9 .9599      .2488    5.1965     .2985    1.0707    1.0406     .0224     .0092     .0027
                                          .0519    2.4014    5.4015

TRIAL RUN  CRITERION MEAN Q    R      A( 1)     A( 2)     A( 3)     A( 4)     A( 5)     A( 6)     A( 7)     A( 8)
                                          A( 9)     A(10)     A(11)     A(12)     A(13)     A(14)     A(15)     A(16)
                                  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

PARAMETER  A( 1) =      .249  REMOVED FROM OPTIMIZATION
PARAMETER  A( 2) =     5.196  REMOVED FROM OPTIMIZATION
PARAMETER  A( 3) =      .299  REMOVED FROM OPTIMIZATION
  5  62   .7640E+08  608.8 .9599      .2488    5.1965     .2985    1.0921    1.0406     .0224     .0092     .0027
                                          .0519    2.4014    5.4015

  5  63   .7392E+08  609.6 .9612      .2488    5.1965     .2985    1.0707    1.0625     .0224     .0092     .0027
                                          .0519    2.4014    5.4015

  5  64   .7949E+08  602.2 .9585      .2488    5.1965     .2985    1.0707    1.0187     .0224     .0092     .0027
                                          .0519    2.4014    5.4015

  5  65   .7850E+08  605.7 .9588      .2488    5.1965     .2985    1.0707    1.0406     .0228     .0092     .0027
                                          .0519    2.4014    5.4015

  5  66   .7495E+08  606.0 .9607      .2488    5.1965     .2985    1.0707    1.0406     .0220     .0092     .0027
                                          .0519    2.4014    5.4015

  5  67   .7746E+08  605.9 .9594      .2488    5.1965     .2985    1.0707    1.0406     .0224     .0096     .0027
                                          .0519    2.4014    5.4015

  5  68   .7557E+08  605.9 .9604      .2488    5.1965     .2985    1.0707    1.0406     .0224     .0087     .0027
                                          .0519    2.4014    5.4015

  5  69   .7608E+08  605.9 .9601      .2488    5.1965     .2985    1.0707    1.0406     .0224     .0092     .0028
                                          .0519    2.4014    5.4015

  5  70   .7664E+08  605.9 .9598      .2488    5.1965     .2985    1.0707    1.0406     .0224     .0092     .0027
                                          .0534    2.4014    5.4015

  5  71   .7642E+08  605.9 .9599      .2488    5.1965     .2985    1.0707    1.0406     .0224     .0092     .0027
                                          .0505    2.4014    5.4015

  5  72   .7641E+08  605.9 .9599      .2488    5.1965     .2985    1.0707    1.0406     .0224     .0092     .0027
```

TRIAL	RUN	CRITERION	MEAN Q	R	A(1) / A(9)	A(2) / A(10)	A(3) / A(11)	A(4) / A(12)	A(5) / A(13)	A(6) / A(14)	A(7) / A(15)	A(8) / A(16)
					.0519	2.4518	5.4015					
5	73	.7665E+08	605.9	.9598	.2488	5.1965	.2985	1.0707	1.0406	.0224	.0092	.0027
					.0519	2.3509	5.4015					
5	74	.7640E+08	605.9	.9599	.2488	5.1965	.2985	1.0707	1.0406	.0224	.0092	.0027
					.0519	2.4014	5.2970					
5	75	.7665E+08	605.9	.9598	.2488	5.1965	.2985	1.0707	1.0406	.0224	.0092	.0027
					.0519	2.4014	5.5061					

PATTERN= 1 RESOLUTION= 0

TRIAL	RUN	CRITERION	MEAN Q	R	A(1) / A(9)	A(2) / A(10)	A(3) / A(11)	A(4) / A(12)	A(5) / A(13)	A(6) / A(14)	A(7) / A(15)	A(8) / A(16)
5	75	.6995E+08	605.9	.9598	.2488	5.1965	.2985	1.0707	1.0936	.0213	.0092	.0027
					.0473	2.5237	5.2253					
5	76	.6974E+08	615.1	.9636	.2587	5.1965	.2985	1.0707	1.0936	.0213	.0092	.0027
					.0473	2.5237	5.2253					
5	77	.6954E+08	615.0	.9637	.2587	5.1445	.2985	1.0707	1.0936	.0213	.0092	.0027
					.0473	2.5237	5.2253					
5	78	.6865E+08	615.1	.9640	.2587	5.1445	.3105	1.0707	1.0936	.0213	.0092	.0027
					.0473	2.5237	5.2253					
5	79	.6907E+08	618.0	.9640	.2587	5.1445	.3105	1.0921	1.0936	.0213	.0092	.0027
					.0473	2.5237	5.2253					
5	80	.6900E+08	618.9	.9641	.2587	5.1445	.3105	1.0707	1.1155	.0213	.0092	.0027
					.0473	2.5237	5.2253					
5	81	.6901E+08	611.4	.9638	.2587	5.1445	.3105	1.0707	1.0717	.0213	.0092	.0027
					.0473	2.5237	5.2253					
5	82	.6904E+08	614.9	.9638	.2587	5.1445	.3105	1.0707	1.0936	.0217	.0092	.0027
					.0473	2.5237	5.2253					
5	83	.6876E+08	615.4	.9640	.2587	5.1445	.3105	1.0707	1.0936	.0209	.0092	.0027
					.0473	2.5237	5.2253					
5	84	.6888E+08	615.1	.9639	.2587	5.1445	.3105	1.0707	1.0936	.0213	.0096	.0027
					.0473	2.5237	5.2253					
5	85	.6886E+08	615.2	.9640	.2587	5.1445	.3105	1.0707	1.0936	.0213	.0087	.0027
					.0473	2.5237	5.2253					
5	86	.6872E+08	615.1	.9640	.2587	5.1445	.3105	1.0707	1.0936	.0213	.0092	.0028
					.0473	2.5237	5.2253					
5	87	.6863E+08	615.1	.9640	.2587	5.1445	.3105	1.0707	1.0936	.0213	.0092	.0027
					.0487	2.5237	5.2253					
5	88	.6861E+08	615.1	.9640	.2587	5.1445	.3105	1.0707	1.0936	.0213	.0092	.0027
					.0487	2.5741	5.2253					
5	89	.6853E+08	615.1	.9641	.2587	5.1445	.3105	1.0707	1.0936	.0213	.0092	.0027
					.0487	2.5741	5.1208					
5	89	.6853E+08	615.1	.9641	.2587	5.1445	.3105	1.0707	1.0936	.0213	.0092	.0027
					.0487	2.5741	5.1208					

PATTERN MOVE

TRIAL	RUN	CRITERION	MEAN Q	R	A(1)	A(2)	A(3)	A(4)	A(5)	A(6)	A(7)	A(8)
6	90	.6778E+08	615.0	.9644	.2687	5.0926	.3224	1.0707	1.0936	.0213	.0092	.0027

.0501 2.6246 5.0163

TRIAL	RUN	CRITERION	MEAN Q	R	A(1)	A(2)	A(3)	A(4)	A(5)	A(6)	A(7)	A(8)	A(9)	A(10)	A(11)	A(12)	A(13)	A(14)	A(15)	A(16)
6	91	.6783E+08	614.9	.9644	.2790	5.0926	.3224	1.0707	1.0936	.0213	.0092	.0027	.0501	2.6246	5.0163					
6	92	.6776E+08	615.2	.9644	.2583	5.0926	.3224	1.0707	1.0936	.0213	.0092	.0027	.0501	2.6246	5.0163					
6	93	.6757E+08	615.2	.9646	.2583	5.0411	.3224	1.0707	1.0936	.0213	.0092	.0027	.0501	2.6246	5.0163					
6	94	.6751E+08	615.3	.9645	.2583	5.0411	.3348	1.0707	1.0936	.0213	.0092	.0027	.0501	2.6246	5.0163					
6	95	.6752E+08	612.4	.9645	.2583	5.0411	.3348	1.0492	1.0936	.0213	.0092	.0027	.0501	2.6246	5.0163					
6	96	.6786E+08	618.2	.9645	.2583	5.0411	.3348	1.0921	1.0936	.0213	.0092	.0027	.0501	2.6246	5.0163					
6	97	.6796E+08	619.0	.9644	.2583	5.0411	.3348	1.0707	1.1155	.0213	.0092	.0027	.0501	2.6246	5.0163					
6	98	.6771E+08	611.6	.9644	.2583	5.0411	.3348	1.0707	1.0717	.0213	.0092	.0027	.0501	2.6246	5.0163					
6	99	.6761E+08	615.1	.9645	.2583	5.0411	.3348	1.0707	1.0936	.0217	.0092	.0027	.0501	2.6246	5.0163					
6	100	.6787E+08	615.5	.9643	.2583	5.0411	.3348	1.0707	1.0936	.0209	.0092	.0027	.0501	2.6246	5.0163					
6	101	.6745E+08	615.3	.9645	.2583	5.0411	.3348	1.0707	1.0936	.0213	.0096	.0027	.0501	2.6246	5.0163					
6	102	.6748E+08	615.3	.9645	.2583	5.0411	.3348	1.0707	1.0936	.0213	.0096	.0025	.0501	2.6246	5.0163					
6	103	.6746E+08	615.3	.9645	.2583	5.0411	.3348	1.0707	1.0936	.0213	.0096	.0028	.0501	2.6246	5.0163					
6	104	.6751E+08	615.3	.9645	.2583	5.0411	.3348	1.0707	1.0936	.0213	.0096	.0027	.0516	2.6246	5.0163					
6	105	.6746E+08	615.3	.9645	.2583	5.0411	.3348	1.0707	1.0936	.0213	.0096	.0027	.0487	2.6246	5.0163					
6	106	.6737E+08	615.3	.9646	.2583	5.0411	.3348	1.0707	1.0936	.0213	.0096	.0027	.0501	2.6761	5.0163					
6	107	.6732E+08	615.3	.9646	.2583	5.0411	.3348	1.0707	1.0936	.0213	.0096	.0027	.0501	2.6761	4.9139					
6	107	.6732E+08	615.3	.9646	.2583	5.0411	.3348	1.0707	1.0936	.0213	.0096	.0027	.0501	2.6761	4.9139					
		PATTERN	MOVE																	
7	108	.6727E+08	615.4	.9646	.2579	4.9377	.3592	1.0707	1.0936	.0213	.0096	.0027	.0515	2.7781	4.7069					
TRIAL	RUN	CRITERION	MEAN Q	R	A(1)	A(2)	A(3)	A(4)	A(5)	A(6)	A(7)	A(8)	A(9)	A(10)	A(11)	A(12)	A(13)	A(14)	A(15)	A(16)

7	109	.6706E+08	615.5	.9647	.2476	4.9377	.3592	1.0707	1.0936	.0213	.0096	.0027
					.0515	2.7781	4.7069					
7	110	.6687E+08	615.5	.9648	.2476	4.8873	.3592	1.0707	1.0936	.0213	.0096	.0027
					.0515	2.7781	4.7069					
7	111	.6749E+08	615.6	.9644	.2476	4.8873	.3726	1.0707	1.0936	.0213	.0096	.0027
					.0515	2.7781	4.7069					
7	112	.6648E+08	615.4	.9651	.2476	4.8873	.3458	1.0707	1.0936	.0213	.0096	.0027
					.0515	2.7781	4.7069					
7	113	.6633E+08	612.5	.9651	.2476	4.8873	.3458	1.0492	1.0936	.0213	.0096	.0027
					.0515	2.7781	4.7069					
7	114	.6658E+08	616.2	.9650	.2476	4.8873	.3458	1.0492	1.1155	.0213	.0096	.0027
					.0515	2.7781	4.7069					
7	115	.6689E+08	608.8	.9650	.2476	4.8873	.3458	1.0492	1.0717	.0213	.0096	.0027
					.0515	2.7781	4.7069					
7	116	.6625E+08	612.3	.9652	.2476	4.8873	.3458	1.0492	1.0936	.0217	.0096	.0027
					.0515	2.7781	4.7069					
7	117	.6641E+08	612.3	.9651	.2476	4.8873	.3458	1.0492	1.0936	.0217	.0092	.0027
					.0515	2.7781	4.7069					
7	118	.6626E+08	612.3	.9652	.2476	4.8873	.3458	1.0492	1.0936	.0217	.0096	.0025
					.0515	2.7781	4.7069					
7	119	.6638E+08	612.3	.9651	.2476	4.8873	.3458	1.0492	1.0936	.0217	.0096	.0028
					.0515	2.7781	4.7069					
7	120	.6624E+08	612.3	.9652	.2476	4.8873	.3458	1.0492	1.0936	.0217	.0096	.0027
					.0531	2.7781	4.7069					
7	121	.6638E+08	612.3	.9651	.2476	4.8873	.3458	1.0492	1.0936	.0217	.0096	.0027
					.0531	2.8316	4.7069					
7	122	.6628E+08	612.3	.9652	.2476	4.8873	.3458	1.0492	1.0936	.0217	.0096	.0027
					.0531	2.7245	4.7069					
7	123	.6619E+08	612.3	.9652	.2476	4.8873	.3458	1.0492	1.0936	.0217	.0096	.0027
					.0531	2.7781	4.6087					
7	123	.6619E+08	612.3	.9652	.2476	4.8873	.3458	1.0492	1.0936	.0217	.0096	.0027
					.0531	2.7781	4.6087					

PATTERN MOVE

E.3 SAMPLE INPUT AND OUTPUT FOR OPTIMIZATION PROGRAM WITH SNOW - SENSITIVITY MODE

```
   1     1     1     1     1
  96     0     0     0     0
   3     1     0     1     0
   1     1     1     1
   1
   1
   1     1
   0
   1     1
   1
   0
  44  1964    10   274     1
       .05          .20          .25          5.0          .33          3.0          0.9
     436.
       1.0
       0.0          .30
 1.0   0.0   166    92   .25
       1.0
        .9           .1         .004          .55          .99
       0.0         4.41          .77          .30          0.0          0.0          .03
   1
   1     0
   3     0
PASSUMPSIC R. MAT          1400.  -1.5  -2.7  -3.9  -2.7
   1
   1
PASSUMPSIC RIVER           1400.   .70   1.1  .023  .006  .003  .054   5.0   .01
PASSUMPSIC RIVER      32.   0.0   0.0   0.0   0.0
PASSUMPSIC RIVER      0.0   0.0   0.0
BASINWIDE PARAMETERS  32.   33.   .03   .50
AREAL DEPLETION       .24   .39   .52   .64   .75   .82   .88   .92   .96
 1339   61     6     1     3   125     3
   25   27    29    31    33    37
   1     1
   0
   1
   6     6     6     6     6     6
     -.20         -.10         -.05          .05          .10          .20
    -.013        -.008        -.003         .002         .007         .017
    -.005        -.003        -.001         .002         .004         .009
    -.002        -.001         .001         .002         .004         .007
    -.036        -.018         .018         .054         .090         .126
     -5.0         -3.0         -1.0          2.0          5.0         10.0
   3
   0
   0
 .10 .40 .50
   0     0     0     0
 .5
 PASSUMPSIC RIVER AT PASSUMPSIC,VT.--SAMPLE OUTPUT-SENSITIVITY WITH SNOW
11111111000000111111100000111111000000111111
```

SNOW PARAMETERS--CASE=1

INPUT GAGES USED

RG	TA GAGE	WE GAGE
1	PASSUMPSIC R. MAT	

TA GAGE	ELEV.	PERIOD TA LAPSE RATES			
PASSUMPSIC R. MAT	1400.	-1.5	-2.7	-3.9	-2.7

AREA SNOW PARAMETERS

RG	ELEV	EFC	SCF	MFMAX	MFMIN	NMF	UADJ	SI	DAYGM
1	1400.	.70	1.10	.0230	.0060	.0030	.0540	5.00	.010

INTIAL SNOW VALUES

RG	WE	NEGHS	LIQW	STORAGE	SB	SBAESC	SBWS	TINDEX
1	0.00	0.000	0.000	0.000	0.000	0.000	0.000	32.

BASINWIDE PARAMETERS

MELT-BASE	PX-TEMP	PLWHC	TI-PARM
32.0	33.0	.030	.500

AREAL DEPLETION CURVE

WE/AI	0.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
AESC	.05	.24	.39	.52	.64	.75	.82	.88	.92	.96	1.00

PASSUMPSIC RIVER AT PASSUMPSIC,VT.--SAMPLE OUTPUT-SENSITIVITY WITH SNOW

THE PERIOD OF RECORD BEING ANALYZED IS FROM 10 1964 THRU 5 1968 THE BUFFER PERIOD IS THE FIRST 61 DAYS

PARAMETER VALUES

0	0	0	0	0	0	0	0	0	0	0	0
UZSN	LZSN	CB	POWER	CC	KV	KGS	K24EL	A	K24L	EPXM	K1(1)
.2500	5.0000	.3300	3.0000	.9000	.5500	.9900	.2500	.0500	0.0000	.2000	1.0000

PARAMETER VALUES

0	0	0	0	0	0	0	0	0	0	0	0
K1(2)	PEADJ(1)	PEADJ(2)	K3	SRC1	LIRC6	LKK6	CSSR	HWARP	VWARP	FOREST(1)	FOREST(2)
0.0000	1.0000	0.0000	.3000	.9000	.1000	.0040	.5000	1.0000	1.0000	I	I

PARAMETER VALUES

1	0	2	0	3	0	4	0	5	0	0	0
SCF(1)	SCF(2)	MFMAX(1)	MFMAX(2)	MFMIN(1)	MFMIN(2)	NMF(1)	NMF(2)	UADJ(1)	UADJ(2)	FUCOEF(1)	FUCOEF(2)
1.1000	I	.0230	I	.0060	I	.0030	I	.0540	I	I	I

PARAMETER VALUES

6	0	0	0	0	0	0	0	0	0	0	0
SI(1)	SI(2)	DAYGM(1)	DAYGM(2)	PLWHC	TOPM	AK	AN	RAIX	SAIX	EHIGH	ELOW
5.0000	I	.0100	I	.0300	I	I	I	I	I	1.0000	0.0000

PARAMETER VALUES

0	0
NEP	NOUR
166.0000	92.0000

(NOTE ABOVE INUMBERS CORRESPOND TO A ( ) SUBSCRIPT NUMBERS)

THE FOLLOWING PERIODS WILL BE REMOVED FROM CALCULATING THE VALUE FOR THE OPTIMIZATION CRITERION AND (MEAN Q , R)

THE BUFFER PERIOD (THE FIRST 61 DAYS) DATE DAY NO.

INITIAL STORAGE VALUES

UZSI	LZSI	SGWI	GWSI	RESI	SRGXI	SCEPI
0.0000	4.4100	.7700	.3000	0.0000	0.0000	.0300

	FIXED LAG	CHANNEL DELAY HISTOGRAM		
GAGE 1	0	.1000	.4000	.5000

SENSITIVITY ANALYSIS

INITIAL OPT	PRESENT OPT	PERCENT	R COEF	MEAN Q	NAME	VALUE	PERCENT
.9407097E+08	.9407097E+08	0.00000	.9184361	596.68			
.9407097E+08	.1540833E+09	-63.79468	.8899478	527.88	SCF(1)	.90000	-18.18182
.9407097E+08	.1166231E+09	-23.97350	.9079875	562.23	SCF(1)	1.00000	-9.09091
.9407097E+08	.1033799E+09	-9.89567	.9140281	579.45	SCF(1)	1.05000	-4.54545
.9407097E+08	.9019183E+08	4.12364	.9202995	613.93	SCF(1)	1.15000	4.54545
.9407097E+08	.9118286E+08	3.07015	.9207406	630.87	SCF(1)	1.20000	9.09091
.9407097E+08	.1089562E+09	-15.82339	.9180374	665.51	SCF(1)	1.30000	18.18182
.9407097E+08	.1424186E+09	-51.39488	.8722433	601.88	MFMAX(1)	.01000	-56.52174
.9407097E+08	.9014098E+08	4.17769	.9221760	598.54	MFMAX(1)	.01500	-34.78261
.9407097E+08	.8617022E+08	8.39871	.9262853	596.94	MFMAX(1)	.02000	-13.04348
.9407097E+08	.1028799E+09	-9.36411	.9098624	596.37	MFMAX(1)	.02500	8.69565
.9407097E+08	.1299061E+09	-38.09375	.8843284	595.74	MFMAX(1)	.03000	30.43478
.9407097E+08	.1896409E+09	-101.59343	.8305815	594.98	MFMAX(1)	.04000	73.91304
.9407097E+08	.8715788E+08	7.34881	.9243720	597.82	MFMIN(1)	.00100	-83.33333
.9407097E+08	.8678341E+08	7.74688	.9248389	597.14	MFMIN(1)	.00300	-50.00000
.9407097E+08	.9063237E+08	3.65533	.9215277	596.89	MFMIN(1)	.00500	-16.66667
.9407097E+08	.1039968E+09	-10.55144	.9091862	596.25	MFMIN(1)	.00800	33.33333
.9407097E+08	.1164448E+09	-23.78402	.8972953	595.86	MFMIN(1)	.01000	66.66667
.9407097E+08	.1528078E+09	-62.43885	.8614782	595.06	MFMIN(1)	.01500	150.00000
.9407097E+08	.1010165E+09	-7.38326	.9120101	596.43	NMF(1)	.00100	-66.66667
.9407097E+08	.9732250E+08	-3.45646	.9154502	596.56	NMF(1)	.00200	-33.33333
.9407097E+08	.9183865E+08	2.37302	.9204474	596.79	NMF(1)	.00400	33.33333
.9407097E+08	.8924661E+08	5.12843	.9228064	596.91	NMF(1)	.00500	66.66667
.9407097E+08	.8534034E+08	9.28090	.9263078	596.92	NMF(1)	.00700	133.33333
.9407097E+08	.8040616E+08	14.52607	.9306947	597.23	NMF(1)	.01000	233.33333
.9407097E+08	.9189803E+08	2.30990	.9203124	597.12	UADJ(1)	.01800	-66.66667
.9407097E+08	.9297424E+08	1.16586	.9193933	596.88	UADJ(1)	.03600	-33.33333
.9407097E+08	.9617877E+08	-2.24064	.9164917	596.49	UADJ(1)	.07200	33.33333
.9407097E+08	.1014476E+09	-7.84155	.9114747	596.16	UADJ(1)	.10800	100.00000
.9407097E+08	.1075711E+09	-14.35099	.9055099	596.08	UADJ(1)	.14400	166.66667
.9407097E+08	.1152826E+09	-22.54854	.8980334	595.97	UADJ(1)	.18000	233.33333
.9407097E+08	.1361017E+09	-44.67984	.8809736	597.31	SI(1)	0.00000	-100.00000
.9407097E+08	.1197065E+09	-27.25122	.8945981	597.03	SI(1)	2.00000	-60.00000
.9407097E+08	.1007946E+09	-7.14741	.9117155	596.78	SI(1)	4.00000	-20.00000
.9407097E+08	.9227908E+08	1.90483	.9209498	596.12	SI(1)	7.00000	40.00000
.9407097E+08	.9319258E+08	.93376	.9200994	596.10	SI(1)	10.00000	100.00000
.9407097E+08	.9319258E+08	.93376	.9200994	596.10	SI(1)	15.00000	200.00000

APPENDIX F

OPERATIONAL RIVER FORECASTING PROGRAM WITH SNOW--INPUT AND OUTPUT SAMPLES

F.1 OPERATION PROGRAM WITH SNOW-INPUT SUMMARY

```
C         INPUT SUMMARY FOR OPERATIONAL PROGRAM
*******************************************************************************
*CARD NO. FORMAT    CONTENTS
*******************************************************************************
C    1          I5      PUNCH 1 IN COLUMN 5
C               I5      =1 IF THE INITIAL RUN, =0 IF STARTING FROM PREVIOUS DATE
C                            (INITIAL)
C               I5      TAPE NO. OF PREVIOUS CARRYOVER TAPE(TAPE THAT CONTAINS
C                            PARAMETER VALUES AND INITIAL STORAGES)
C               I5      TAPE NO. OF CARRYOVER TAPE TO BE USED AT THE END OF THE RUN
C               I5      =1 INPUT NEW PARAMETER VALUES,   =0 NO   (INPM)
*******************************************************************************
C    2          I5      YEAR(LAST TWO DIGITS)
C               I5      MONTH NUMBER -- MONTH NO. OF INITIAL DAY
C               I5      DAY NUMBER OF INITIAL DAY
C               I5      PERIOD NUMBER OF INITIAL PERIOD (4 SIX HOUR PERIODS USED)
C               I5      CURRENT DAY NUMBER (IF IN NEXT MONTH USE DAY NO.=(DAYS IN
C                            PREVIOUS MONTH PLUS DAY NO.))
C               I5      PERIOD NUMBER OF CURRENT PERIOD
C               I5      =1 THIS IS A RERUN TO ADJUST PRECIPITATION VOLUME OR TO
C                            ROUTE NON-COMPUTER MADE FORECASTS DOWNSTREAM,
C                            =0 NO RERUN FOR ABOVE REASONS (RERUN)
C               I5      =1 INPUT NEW INITIAL SOIL MOISTURE STORAGES, =0 NO (INSTOR)
C               I5      =1 CHANGE FLOWS TO BE ROUTED DOWNSTREAM, =0 NO (INOBSER)
C               I5      =1 BEGINNING OF STORM, =0 NO
C               I5      =1 RUN TOTAL STORM INSTEAD OF JUST CURRENT UPDATE, =0 NO
C               I5      =1 ADJUST SNOWPACK CONDITIONS,  =0 NO SNOW ADJUSTMENTS
*******************************************************************************
*******************************************************************************
*FOLLOWING 300 SERIES CARDS ONLY NEEDED IF SNOWPACK CONDITIONS ARE
*                                                          TO BE ADJUSTED.
*******************************************************************************
*******************************************************************************
C 301          I5      NUMBER OF MBP AREAS TO ADJUST SNOWPACK CONDITIONS.
*******************************************************************************
C    ***NOTE*** REPEAT CARD 302 FOR EACH MBP AREA WHERE SNOW IS ADJUSTED.
C 302           I5      MBP AREA NUMBER
C     FOR THE FOLLOWING ADJUSTMENTS LEAVE THE COLUMNS BLANK IF NO ADJUSTMENT.
C             F5.2      NEW INITIAL TOTAL WATER-EQUIVALENT OF THE SNOWPACK.
C                            PROGRAM PROPORTIONS CHANGE BETWEEN SOLID AND LIQUID
C                            PHASE BY KEEPING PERCENT LIQUID WATER CONSTANT
C             F5.2      NEW AREAL EXTENT OF SNOW COVER (.GE.0.05 --.LE.1.0)
C                            PROGRAM COMPUTES RATIO BETWEEN NEW AREAL COVER AND
C                            OLD AREAL COVER AND USES THIS RATIO ON ALL FUTURE
C                            RUNS UNTIL AREAL COVER IS ADJUSTED AGAIN OR THE
C                            SNOWPACK IS GONE.
C             F5.2      ADJUSTMENT MULIPLYING FACTOR FOR NON-RAIN MELT-FACTOR.
C             F5.2      ADJUSTMENT MULTIPLYING FACTOR FOR WIND FUNCTION DURING
C                            RAIN ON SNOW EVENTS.
```

```
C          F5.2     ADJUSTED GAGE CATCH DEFICIENCY FACTOR FOR SNOW OCCURING
C                         DURING THIS RUN.
C          F5.2     NEW INITIAL VALUE OF NEGATIVE HEAT STORAGE.
*****************************************************************************
*****************************************************************************
CARD5 3-4 NEEDED ONLY IF (INITIAL.EQ.0.AND.INSTOR.EQ.1)
*****************************************************************************
C   3       I5      NO. OF MBP AREAS AT WHICH TO CHANGE INITIAL SOIL MOISTURE
C                         (NGCHGE)
*****************************************************************************
C   4       I5      MBP AREA NUMBER FOR THE RUN
C         7F5.2     INITIAL SOIL MOISTURE VALUES
C                        (UZSI,LZSI,SGWI,GWSI,RESI,SRGXI,SCEPI)
C                         REPEAT CARD 4 FOR (NGCHGE) MBP AREAS)
*****************************************************************************
CARD 5  ONLY NEEDED IF (INITIAL.EQ.0).AND.(INOBSER.EQ.1)
*****************************************************************************
C    5     16I5     FLOW TO BE ROUTED DOWNSTREAM (1 TO NPTS)
C                         =1 ROUTE OBSERVED
C                         =0 ROUTE SIMULATED
*****************************************************************************
CARD 6 ONLY NEEDED IF (INITIAL.EQ.0.AND.INPM.EQ.0)
*****************************************************************************
C   6       I5      =1 OUTPUT PARAMETER VALUES, =0 NO
C           I5      LENGTH OF FORECAST IN DAYS -- THUS LAST FORECAST DAY WILL
C                         BE CURRENT DAY PLUS LENGTH    =0 IF NO FORECAST NEEDED
C           I5      =1 SNOW IS TO BE INCLUDED IN THIS RUN,  =0 NO SNOW PRESENT.
*****************************************************************************
*    CARDS 7 THROUGH 23 (INCLUD. 200 SERIES CARDS) ARE ONLY NEEDED IF (INITIAL.
C                          EQ.1.OR.INPM.EQ.1)
*****************************************************************************
C   7     20A4      BASIC RUN INFORMATION SUCH AS DATE,ETC.
*****************************************************************************
C   8     20A4      BASIN NAME
*****************************************************************************
C   9       I5      NO. OF MBP AREAS USED IN RUN (NGAGES)
C           I5      NO. OF PE STATIONS USED (NPEGS)
C           I5      NO. OF STREAM-FLOW-POINTS USED (NPTS)
C           I5      NO. OF UPSTREAM INFLOW POINTS NEEDED FROM OUTSIDE
C                        AREA BEING RUN (NPTSUP)
*****************************************************************************
C  10     10A4      NAME OF PE STATION
C           I5      NEP
C           I5      NDUR
C   (REPEAT CARD 10 FOR EACH PE STATION(1 TO NPEGS))--ORDER OF READ DETERMINES
C                         PE STATION NUMBER FOR THE RUN)
*****************************************************************************
C  11     16I5      ASSOCIATES PE STATIONS TO MBP AREAS
C                         1 TO (NGAGES) VALUES ARE NEEDED
C                   E.G. (NGAGES)=3,(NPEGS)=2, CARD 11=2,1,2
C                             .HEN THE 1ST PRECIP AREA WILL USE PE FROM NO.2
C                                                                PE STATION
C                                  THE 2ND PRECIP AREA WILL USE PE FROM NO.1
C                                                                PE STATION
C
```

```
C                                  THE 3RD PRECIP AREA WILL USE PE FROM NO.2
C                                                                PE STATION
*************************************************************************
C  12      16I5     DESCRIBES OBSERVED DISCHARGE TO BE READ IN AT EACH
C                        FLOW-POINT (1-NPTS)
C                   =0 NO OBSERVED SIX HOUR DISCHARGE
C                   =1 OBSERVED SIX HOUR DISCHARGE IN THE PAST (INITIAL DAY,
C                        INITIAL PERIOD TO CURRENT DAY,CURRENT PERIOD)
C                   =2 OBSERVED SIX HOUR Q IN PAST PLUS EST. OF SIX HOUR Q IN
C                        THE FUTURE (THROUGH CURRENT DAY PLUS LENGTH)
C                        IF FUTURE Q IS MISSING (NEGATIVE), THEN SIMULATED
C                        FORECAST IS USED.
*************************************************************************
C  13      16I5     TYPE OF ROUTING TO BE APPLIED TO REACH ABOVE FLOW-
C                        POINT (1 TO NPTS) EQUAL TO 1 FOR NOW
C                   1 IS FOR LAG AND K ROUTING INCLUDING VARIABLE
C                   SEE CHAPTER 6 OF HYDRO-14 FOR ADDING OTHER ROUTING
C                        PROCEDURES.
*************************************************************************
C  14      16I5     FLOW TO ROUTE DOWNSTREAM (1 TO NPTS)
C                   =1 ROUTE OBSERVED
C                   =0 ROUTE SIMULATED
*************************************************************************
C  15        I5     =1 OUTPUT PARAMETER VALUES, =0 NO
C            I5     LENGTH OF FORECAST IN DAYS -- THUS LAST FORECAST DAY WILL
C                        BE CURRENT DAY PLUS LENGTH    =0 IF NO FORECAST NEEDED
C            I5     =1 SNOW IS TO BE INCLUDED IN THIS RUN,  =0 NO SNOW PRESENT.
C            I5     =1 IN COLUMN 20
C            I5     =1 INPUT SNOW PARAMETERS (CAN BE DONE EVEN IF THERE IS
C                                      CURRENTLY NO SNOW ON THE GROUND).
*************************************************************************
C  16        I5     NUMBER OF FUTURE(QPF) AREAS TO BE USED  (NFPXGS)
*************************************************************************
C  16A     16I5     ASSOCIATES QPF AREAS TO MBP AREAS -- SAME TYPE AS CARD 11
C          CARD 16A NEEDED ONLY IF (NFPXGS.ET.0)
C              IF (NFPXGS.EQ.0) THEN FUTURE PRECIP AND PE IS SET TO 0.0
C              IF FUTURE PRECIP IS INPUT THEN FUTURE PE MUST ALSO BE INPUT
C              FOR EACH PE STATION.
*************************************************************************
C**NOTE**  REPEAT CARDS 17 THROUGH 20 FOR EACH MBP AREA (NGAGES)
C  17       5A4     NAME OF MBP AREA
C          4F5.2    SOIL-MOISTURE VOLUME PARAMETERS
C         ,F5.1,         MOD. STANFORD WATERSHED MODEL
C          F5.2,         ORDER OF PARAMETERS IS --
C         2F5.1,              K1,A,EPXM,UZSN,LZSN,CB,POWER,CC,K24L
C           F5.2        (PARAMETERS DEFINED IN SECTION 4.3 OF HYDRO-14)
*************************************************************************
C  18       20X,    EVAPOTRANSPIRATION PARAMETERS FOR SOIL MOISTURE
C          5F5.2         ORDER IS  K3,GAGEPE,EHIGH,ELOW,K24EL
*************************************************************************
C  19       20X,    SOIL MOISTURE  TIMING PARAMETERS
C         2F5.2,         ORDER IS---
C          F5.4,          SRC1,LIRC6,LKK6,KV,KGS
C         2F5.2
```

```
*****************************************************************************
C  20      20X,      SOIL MOISTURE INITIAL CONDITIONS
C          7F5.1          ORDER IS---UZSI,LZSI,SGWI,GWSI,RESI,SRGXI,SCEPI
C                              UZS=UPPER ZONE STORAGE
C                              LZS=LOWER ZONE STORAGE
C                              SGW=GROUNDWATER STORAGE
C                              GWS=ANTECEDENT GW INFLOW INDEX
C                              RES=SURFACE DETENTION     '
C                              SRGX=INTERFLOW DETENTION
C                              SCEP=INTERCEPTION STORAGE
***   *NOTE*.................CARD 20 IS NOT NEEDED IF(INITIAL.EQ.0)
C               INITIAL MOISTURE STORAGES ARE CARRIED OVER FROM PREVIOUS RUN
C                                                          IN THIS CASE
*****************************************************************************
*****************************************************************************
*****************************************************************************
*********NOTE**********  THE FOLLOWING 200 SERIES CARDS ARE NEEDED IF SNOW
C  PARAMETERS ARE NEEDED.    SNOW MAY OR MAY NOT CURRENTLY BE PRESENT.  ********
*****************************************************************************
*****************************************************************************
C 202          I5      NUMBER OF MAT AREAS USED IN THIS RUN (NTAG)
C              I5      NUMBER OF PREDICTED TEMPERATURE AREAS(FUTURE TEMP.) USED.
*****************************************************************************
C 203         5A4      NAME OF MAT AREA
C           F10.0      MEAN ELEVATION OF MAT AREA IN FEET
C           4F5.1      AIR TEMPERATURE LAPSE RATES FOR MID-6AM,6AM-NOON,
C                           NOON-6PM,6PM-MID.   DEG. F/1000 FT. ELEV. CHANGE
C                NOTE..REPEAT THIS CARD FOR EACH MAT AREA. CARD ORDER
C                      DEFINES MAT ORDER NUMBER FOR THIS RUN.
*****************************************************************************
C 204         5A4      NAME OF PREDICTED TEMPERATURE AREA
C           F10.0      MEAN ELEVATION OF PREDICTED TEMPERATURE AREA IN FEET.
C                NOTE..REPEAT THIS CARD FOR EACH PREDICTED TEMPERATURE AREA.
C                    CARD ORDER DEFINES PREDICTED TEMP. ORDER-NUMBER FOR THIS RUN.
*****************************************************************************
C 205        16I5      ASSOCIATES MAT AREAS TO MBP AREAS
C                           1 TO (NGAGES) VALUES ARE NEEDED
C                      E.G. (NGAGES)=3, (NTAG)=2,  CARD 205=2,1,1
C                           THEN THE 1 ST PRECIP AREA WILL USE AIR TEMPERATURE
C                                                FROM MAT AREA NO.2
C                                  2 ND PRECIP AREA WILL USE AIR TEMPERATURE
C                                                FROM MAT AREA NO.1
C                                  3 RD PRECIP AREA WILL USE AIR TEMPERATURE
C                                                FROM MAT AREA NO.1
*****************************************************************************
C 206        16I5    SAME AS CARD 205 EXCEPT FOR PREDICTED TEMPERATURE AREAS.
*****************************************************************************
*****************************************************************************
C NOTE..REPEAT CARDS 207 THRU 211 FOR EACH MEAN BASIN PRECIPITATION AREA IF
C        INITIAL RUN-(INITIAL=1).    IF NOT INITIAL RUN THEN INITIAL VALUES OF
C        SNOWPACK VARIABLES ALREADY EXIST.  THUS CARDS 208,209 ARE NOT NEEDED.
*****************************************************************************
C 207 20X,F10.0      MEAN AREA ELEVATION IN FEET
C           F5.2      PERCENT/100 OF AREA OVER WHICH EVAPOTRANSPIRATION CAN TAKE
```

```
C                        PLACE WHEN THERE IS COMPLETE AREAL SNOW COVER (EFC)
C          F5.2     MULTIPLYING FACTOR TO CORRECT FOR GAGE CATCH DEFICIENCY
C                        IN THE CASE OF SNOWFALL. (SCF)
C          F5.4     MAXIMUM NON-RAIN MELT FACTOR -- OCCURS ON JUNE 21. (MFMAX)
C          F5.4     MINIMUM NON-RAIN MELT FACTOR -- OCCURS ON DEC. 21. (MFMIN)
C          F5.4     MAXIMUM NEGATIVE MELT FACTOR -- (NMF)
C               NOTE..UNITS FOR MELT FACTORS ARE INCHES/DEG.F/SIX HOURS
C          F5.4     MEAN WIND FUNCTION VALUE DURING RAIN ON SNOW PERIODS
C                        UNITS ARE INCHES/INCH OF MERCURY (UADJ)
C          F5.1     AREAL WATER-EQUIVALENT (INCHES) ABOVE WHICH THERE IS
C                        ALWAYS COMPLETE AREAL SNOW COVER.  (SI)
C          F5.2     DAILY MELT AT THE SNOW-SOIL INTERFACE IN INCHES. (DAYGM)
*****************************************************************************
C 208           INITIAL VALUES OF SOME SNOW COVER VARIABLES.
C     20X,F5.0      ANTECEDENT SNOW TEMP. INDEX  (DEG. F)  (ATI)
C          F5.2     FREE WATER IN SNOW IN EXCESS OF THAT HELD AGAINST GRAVITY
C                        DRAINAGE  (INCHES)
C          F5.2     POINT SB ON AREAL DEPLETION CURVE  (INCHES)
C          F5.2     PERCENT/100 AREAL SNOW COVER AT POINT SB.
C          F5.2     POINT SBWS ON AREAL DEPLETION CURVE (INCHES)
C     NOTE..SEE CHAP. 3  FOR FURTHER EXPLANATION OF THESE INITIAL VALUES.
*****************************************************************************
C 209         - INITIAL VALUES OF MAJOR SNOW COVER VARIABLES
C     20X,F5.2      INITIAL WATER-EQUIVALENT OF SOLID PORTION OF THE
C                        SNOWPACK.    (INCHES)
C          F5.2     INITIAL NEGATIVE HEAT STORAGE  (INCHES)
C          F5.2     INITIAL AMOUNT OF FREE WATER HELD AGAINST GRAVITY
C                        DRAINAGE (INCHES).  MAXIMUM EQUALS PERCENT LIQUID
C                        WATER HOLDING CAPACITY TIMES INITIAL WATER-EQUIVALENT.
*****************************************************************************
*****************************************************************************
C 210           ADDITIONAL SNOW PARAMETERS
C     20X,F5.0      MELT FACTOR BASE TEMPERATURE  (DEG. F)  (MBASE)
C          F5.0     TEMPERATURE (DEG. F) TO DIVIDE RAIN FROM SNOW  (PXTEMP)
C                        IF AIR TEMPERATURE GREATER,THEN RAIN
C                        IF AIR TEMPERATURE LESS THAN OR EQUAL,THEN SNOW
C          F5.2     PERCENT/100 LIQUID WATER HOLDING CAPACITY (PLWHC)
C                        MAXIMUM AMOUNT OF FREE WATER HELD AGAINST GRAVITY.
C          F5.2     ANTECEDENT SNOW TEMP. INDEX PARAMETER  (TIPM)
C                        (.GE.0.0 --.LE.1.0)
*****************************************************************************
C 211 20X,9F5.2     AREAL SNOW COVER DEPLETION CURVE
C                        PERCENT/100 AREAL EXTENT OF SNOW COVER AT
C                        WATER EQUIVALENT/AI RATIOS OF  0.1,0.2,0.3,0.4,0.5,
C                              0.6,0.7,0.8,0.9  (SEE SECTION 3.3.3 FOR DEFINITION
C                              OF AI)    FOR RATIO=0.0  AREAL COVER=0.05
C                                            RATIO=1.0  AREAL COVER=1.00
*****************************************************************************
*****************************************************************************
*****************************************************************************
C**NOTE**CARD 21A IS ONLY NEEDED WHEN THE NUMBER OF UPSTREAM INFLOWS
C        FROM OUTSIDE THE AREA BEING RUN IS.GT.0 (NPTSUP.GT.0)
C  21A      7A4     NAME OF UPSTREAM INFLOW POINT
C     2X,F10.0      AREA OF UPSTREAM INFLOW POINT  (TOTAL AREA ABOVE GAGE SQ.MI)
```

```
C        REPEAT CARD 21A FOR EACH UPSTREAM INFLOW POINT (1 TO NPTSUP))
C               ORDER OF CARDS DETERMINES FLOW-POINT NUMBER FOR RUN
C               FIRST UPSTREAM INFLOW POINT IS ASSIGNED FLOW-POINT NUMBER
C                     EQUAL TO (NPTS+1) ETC. E.G. IF NPTS=3 THEN THE FIRST
C                     UPSTREAM INFLOW POINT BECOMES FLOW-POINT 4 FOR
C                     THE RUN.
*******************************************************************************
C**NOTE** REPEAT CARDS 21 THROUGH 23 (IF ALL NEEDED) FOR EACH FLOW-POINT
C          WITHIN RUN AREA (NPTS)
C         ORDER OF CARDS DETERMINES FLOW-POINT NUMBER FOR THE RUN.
C         NOTE...ALL FLOW-POINTS UPSTREAM FROM GAGE MUST HAVE A SMALLER RUN
C               NUMBER THAN THE GIVEN GAGE--EXCEPT FOR UPSTREAM INFLOW-POINTS
C               FROM OUTSIDE THE AREA BEING RUN(SEE CARD 21A)
C  21       7A4       NAME OF FLOW-POINT
C      2X,F10.0       TOTAL AREA ABOVE FLOW-POINT IN SQUARE MILES
C        ,F5.2,       CONSTANT K ROUTING FACTOR IN HOURS   =0.0 IF VAR. K USED
C           I5        =1 USE VARIABLE K    =0 NO
C           I5        =1 USE VARIABLE LAG =0 NO
C           I5        ROUTING INTERVAL IN HOURS  (MUST=6 FOR NOW)
C           I5        NO. OF VALUES  IN TIME-DELAY HISTOGRAM FOR LOCAL AREA
C           I5        NO. OF UPSTREAM  INFLOW POINTS TO LOCAL AREA (NUPIN)
C                           THESE CAN BE UPSTREAM INFLOWS FROM OUTSIDE OR
C                           INSIDE THE RUN AREA
C           I5        NO.OF POINTS TO DEFINE VARIABLE K VS OUTFLOW CURVE
C           I5        NO. OF POINTS TO DEFINE VARIABLE LAG VS INFLOW CURVE
*******************************************************************************
C  21B   8F10.0       VARIABLE K VS.OUTFLOW CURVE IF NEEDED     K IN HOURS
C                           MAXIMUM POINTS TO DEFINE CURVE IS 10 (THUS 3 CARDS)
C                           VALUES READ IN PAIRS  (FLOW,K)
C                                 SO 4 PAIRS OF (FLOW,K) CAN GO ON A CARD
C                           K AT ZERO FLOW MUST BE FIRST POINT
C                           CALCULATIONS USING K ARE BASED ON A LINEAR
C                                 INTERPOLATION BETWEEN POINTS
C                           K VALUE FOR HIGHEST DEFINED FLOW IS USED FOR
C                                 ALL FLOWS ABOVE THAT DISCHARGE
*******************************************************************************
C  21C   8F10.0       VARIABLE LAG VS. INFLOW CURVE IF NEEDED    LAG IN HOURS
C                           MAX.PTS=10, VALUES IN PAIRS(FLOW,LAG), 4 PAIRS PER CARD
C                           LAG AT ZERO FLOW MUST BE FIRST POINT
C                           CALCULATIONS USING VARIABLE LAG ARE BASE ON
C                                 LAGGING THE VOLUME OF FLOW IN THE INTERVAL
C                                 FLOW(N) TO FLOW(N+1) BY THE AVERAGE LAG FOR
C                                 THAT INTERVAL (LAG(N)+LAG(N+1))*0.5
C                           LAG VALUE FOR HIGHEST DEFINED FLOW IS USED FOR
C                                 ALL FLOW ABOVE THAT DISCHARGE
*******************************************************************************
C  22       30X,      TIME DELAY HISTOGRAM (MAX.NO OF POINTS=30)
C         10F5.2            HISTOGRAM IS FOR LOCAL AREA   SUMMATION OF VALUES=1.0
*******************************************************************************
C  23       30X,      MBP AREAS TO BE ASSIGNED TO EACH ELEMENT OF THE TIME-DELAY
C           10I5            HISTOGRAM ---  MBP AREAS DESIGNATED BY RUN NO. WHICH
C                           IS DETERMINED BY THE ORDER CARDS 17 TO 20 WERE READ.
*******************************************************************************
C  21D      30X,      RUN NO. OF EACH UPSTREAM INFLOW POINT TO LOCAL AREA
```

```
C          5I5                    NEEDED IF (NUPIN.GT.0)
*****************************************************************************
C  21E     30X,      CONSTANT LAG FOR EACH UPSTREAM INFLOW POINT
C         5F5.1           (LAG IN HOURS)
C              **NOTE** TOTAL LAG CONSISTS OF CONSTANT PLUS VARIABLE COMPONENT
*****************************************************************************
*****************************************************************************
*****************************************************************************
*NEXT GROUP OF CARDS INPUTS DATA FOR THE PERIOD FROM (INITIAL DAY-INITIAL PERIOD
*              TO CURRENT DAY-CURRENT PERIOD)  FROM SUBROUTINE DATAIN
*****************************************************************************
*****************************************************************************
*****************************************************************************
C  24          I5      MONTH NUMBER
C              I5      DAY NUMBER
C           4F5.2      PRECIPITATION FOR EACH SIX HOUR PERIOD
C              (REPEAT CARD 24 FOR EACH DAY THAT PRECIPITATION IS .GT.0.0
C                      PLUS ALWAYS HAVE A CARD FOR THE CURRENT DAY)
C           (REPEAT CARD 24 FOR EACH MBP AREA AFTER IT IS REPEATED FOR EACH DAY)
*****************************************************************************
C  25       10X,       PE FOR EACH PE STATION (1-NPEGS)
C         14F5.3
C              (REPEAT CARD 25 FOR EACH DAY(INITIAL DAY THROUGH CURRENT DAY)
*****************************************************************************
C  25A         THIS CARD IS ONLY NEEDED IF SNOW IS INCLUDED IN THIS RUN.
C           10X,       AIR TEMPERATURE FOR EACH SIX HOUR PERIOD.
C           4F5.0         (REPEAT CARD 25A FOR EACH MAT AREA AFTER IT IS
C                              REPEATED FOR EACH DAY AT A GIVEN MAT AREA.)
*****************************************************************************
C  26       10X,       STAGE TENDENCY PLUS DISCHARGE AT END OF EACH SIX HOUR PERIOD
C      4(F1.0,F9.0)      STAGE TENDENCY--  ZERO OR BLANK (NO REPORT)
C                        =1 (RISING)  =2 (FALLING)  =3 (STATIONARY)
C              (REPEAT CARD 26 FOR EACH DAY (INITIAL THROUGH CURRENT))
C          NOTE.GROUPS OF CARD 26 ARE NEEDED AT EACH FLOW-POINT WHERE SIX-HOUR
C              DISCHARGE IS TO BE READ IN--(SEE CARD 12)
C              PLUS ALL UPSTREAM FLOW-POINTS FROM OUTSIDE THE BASIN
C                    FOR UPSTREAM INFLOWS STAGE TENDENCY CAN BE BLANK
C       NOTE..INPUT OF CARD 26 GROUPS IS IN ORDER OF FLOW-POINT RUN NUMBER
C       NOTE.IF OBSERVED FLOW IS TO BE ROUTED DOWNSTREAM THEN A FLOW VALUE
C           MUST BE SUPPLIED FOR EACH SIX HOURS -- IF SIMULATED ROUTED
C           DOWNSTREAM FLOW VALUES DO NOT HAVE TO BE SUPPLIED EACH SIX HOURS
C           BUT ONLY WHEN READINGS ARE AVAILABLE.
*****************************************************************************
*****************************************************************************
*NEXT GROUP OF CARDS ONLY NEEDED IF(LENGTH.GT.0.)
*****************************************************************************
*****************************************************************************
C       CARDS 27 AND 28 ONLY NEEDED IF (NFPXGS.GT.0)
*****************************************************************************
C  27    SAME AS CARD 24 GROUP ONLY FOR (CURRENT DAY TO CURRENT DAY PLUS LENGTH
C             AND FOR QPF AREAS INSTEAD OF MBP AREAS)
*****************************************************************************
C  28    SAME AS CARD 25 GROUP ONLY FOR FUTURE PE DATA
*****************************************************************************
C        CARD 28A IS ONLY NEEDED IF SNOW IS INCLUDED IN THIS RUN.
*****************************************************************************
```

```
C  28A    SAME AS CARD 25A GROUP EXCEPT FOR PREDICTED TEMPERATURE AREAS AND
C                FOR CURRENT DAY TO CURRENT DAY PLUS LENGTH. (FUTURE TEMP. DATA)
*************************************************************************************
***                         CARD 29 NEEDED IF THERE ARE FLOW POINTS WITH A CARD
C              12 VALUE EQUAL 2 OR UPSTREAM FLOW-POINTS FROM OUTSIDE THE BASIN
*************************************************************************************
C  29     SAME AS CARD 26 GROUP ONLY FOR FORECAST FLOWS FROM ALL FLOW-POINTS
C               WITH A CARD 12 VALUE OF 2 OR UPSTREAM INFLOWS FROM OUTSIDE THE
C                CURRENT RUN AREA (IN ORDER OF THEIR RUN NUMBER) (TENDENCY=BLANK)
*************************************************************************************
*************************************************************************************
*NEXT GROUP OF CARDS ONLY NEEDED IF RERUN.EQ.1
*************************************************************************************
*************************************************************************************
C  30          I5      NO. OF MBP AREAS TO ADJUST PRECIP BY A MULTIPICATION FACTOR
C              I5      NO. OF FLOW-POINTS TO INPUT A FORECAST (THESE ARE
C                            POINTS WHERE THE HYDROLOGIST WANTS TO CHANGE THE
C                            COMPUTER FORECAST)
*************************************************************************************
C  31          I5      MBP AREA NUMBER
C            F5.2      ADJUSTMENT MULTIPLYING FACTOR
C                  (REPEAT CARD 31 FOR EACH MBP AREA TO BE ADJUSTED)
C              NOTE..CARD 31 NEEDED ONLY IF AT LEAST ONE MBP AREA IS ADJUSTED
*************************************************************************************
CARDS  32,33 ONLY NEEDED IF HYDROLOGIST WANTS TO CHANGE A COMPUTER FORECAST
*************************************************************************************
C  32        16I5      FLOW-POINT NUMBERS WHERE FORECAST IS TO BE CHANGED
C                          NOTE..A HIGHER NUMBER CANNOT PRECEED A LOWER NUMBER
*************************************************************************************
C  33        10X,      HYDROLOGIST FORECAST (CFS) FOR EACH SIX HOURS
C          4F10.0
C                  (REPEAT CARD 33 FOR EACH DAY (CURRENT DAY-CURRENT DAY+LENGTH))
C                  (REPEAT CARD 31 GROUPS FOR EACH FLOW-POINT WHERE FORECAST
C                     IS TO BE CHANGED -- IN ORDER GIVEN BY CARD 32)
*************************************************************************************
*************************************************************************************
*************************************************************************************
```

F.2 SAMPLE INPUT AND OUTPUT FOR OPERATION PROGRAM
WITH SNOW - EXAMPLE ONE

```
    1    1    0    1    1
   69    4    1    1    5    1    0    0    0    0    0    0
 SAMPLE INPUT DATA FOR NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM     JUNE,1973
 ROCK RIVEP AT ROCK RAPIDS,IOWA
    1    1    1    0
SIOUX CITY,IOWA -- T.R.NO. 38 PE DATA        91   136
    1
    1
    1
    0
    1    0    1    1    1
    1
    1
MBP AB. ROCK RAPIDS   1.0  0.0  .30  .75  4.0  .02  2.5  1.4  0.0        VOL PARM
MBP AB. ROCK RAPIDS   .20  .92  1.1  0.0  0.0                             ET PARM
MBP AB. ROCK RAPIDS    .9  .07.0075  4.0  .98                           TIME PARM
MBP AB. ROCK RAPIDS   1.0  4.2  .15  .10  0.0  0.0  .30                   INITIAL
    1    1
MAT AB. ROCK RAPIDS      1600.  -1.  -3.  -5.  -3.
SW MINN. FORECAST TA     1600.
    1
    1
AREA AB. ROCK RAPIDS     1600.  0.0  1.3  .04  .02.0075  .15  1.5  0.0
AREA AB. ROCK RAPIDS  32.  0.0  7.2  1.0  7.2
AREA AB. ROCK RAPIDS  6.0  0.0  1.2
BASINWIDE SNOW PARM.  32.  33.  .20   .5
AREA DEPLETION CURVE  .24  .39  .52  .64  .75  .81  .87  .92  .96
POCK PIVEP ABOVE ROCK RAPIDS         788.  3.4    0    0    6   16    0    0    0
TIME-DELAY-ROCK RAPIDS          .037 .071 .094 .087 .090 .097 .111 .125 .104 .073
TIME-DELAY-ROCK RAPIDS          .048 .028 .019 .009 .005 .002
GAGE-AREA -ROCK RAPIDS             1    1    1    1    1    1    1    1    1    1
GAGE-AREA -ROCK RAPIDS             1    1    1    1    1    1
    4    4       .01
    4    5  0.0
    4    1 .103
    4    2 .106
    4    3 .110
    4    4 .113
    4    5 .116
    4    1   32   37   40   32
    4    2   29   34   37   32
    4    3   30   37   42   36
    4    4   33   38   40   31
    4    5   27
    4    1           3        53.
    4    2           3        53.
    4    3           1       166.
    4    4           1       760.1     1370.3      2299
    4    52     2244.
```

```
                 ROCK RIVER AT ROCK RAPIDS,IOWA

SAMPLE INPUT DATA FOR NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM    JUNE,1973

                                            BASIC RUN INFORMATION

NUMBER OF PRECIPITATION GAGES= 1     NUMBER OF FLOW-POINTS= 1     NUMBER OF POTENTIAL ET STATIONS= 1     QPF AREAS= 1
          EVAPORATION PARAMETERS ARE     SIOUX CITY,IOWA -- T.R.NO. 38 PE DATA     NEP= 91     NDUR=136
                         OPERATIONAL FORECAST MODE     APR ,1969     DAY  1-1  TO DAY  5-1     FORECAST  0 DAYS

                         SNOW IS INCLUDED
```

ROCK RIVER AT ROCK RAPIDS,IOWA

SAMPLE INPUT DATA FOR NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM   JUNE,1973

SOIL MOISTURE VOLUME PARAMETERS

RG	PRECIP. GAGE NAME	K1	A	EPXM	UZSN	LZSN	CB	POWER	CC	K24L	K3	GAGEPE	EHIGH	ELOW	K24EL
1	MBP AB. ROCK RAPIDS	1.000	0.000	.300	.750	4.000	.020	2.500	1.400	0.000	.200	.920	1.100	0.000	0.000

SOIL MOISTURE TIMING PARAMETERS

RG	SRC1	LIRC6	LKK6	KV	KGS
1	.900	.070	.0075	4.000	.9800

SOIL MOISTURE INITIAL VALUES

RG	UZS	LZS	SGW	GWS	RES	SRGX	SCEP
1	1.00	4.20	.15	.10	0.00	0.00	.30

SNOW PARAMETERS--CASE=1

INPUT GAGES USED

RG	TA GAGE	PREDICTED TEMPERATURE AREA	
1	MAT AB. ROCK RAPIDS	SW MINN. FORECAST TA	1600. FEET

TA GAGE	ELEV.	PERIOD TA LAPSE RATES			
MAT AB. ROCK RAPIDS	1600.	-1.0	-3.0	-5.0	-3.0

AREA SNOW PARAMETERS

RG	ELEV	EFC	SCF	MFMAX	MFMIN	NMF	UADJ	SI	DAYGM
1	1600.	0.00	1.30	.0400	.0200	.0075	.1500	1.50	0.000

INTIAL SNOW VALUES

RG	WE	NEGHS	LIQW	STORAGE	SB	SBAESC	SBWS	TINDEX
1	6.00	0.000	1.200	0.000	7.200	1.000	7.200	32.

BASINWIDE PARAMETERS

MELT-BASE	PX-TEMP	PLWHC	TI-PARM
32.0	33.0	.200	.500

AREAL DEPLETION CURVE

WE/AI	0.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
AESC	.05	.24	.39	.52	.64	.75	.81	.87	.92	.96	1.00

ROCK RIVER AT ROCK RAPIDS,IOWA

SAMPLE INPUT DATA FOR NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM JUNE,1973

FLOW-POINT PARAMETERS

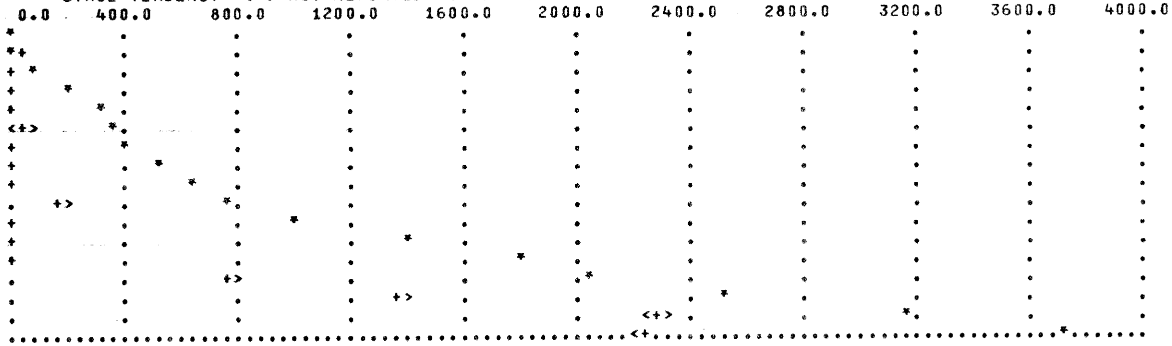
FP	FLOW-POINT NAME	AREA	KS1	OBSER	SIXIN	CHECK
1	ROCK RIVER ABOVE ROCK RAPIDS	788.00	3.40	0	1	1

HISTOGRAMS

TIME-DELAY	.037	.071	.094	.087	.090	.097	.111	.125	.104	.073
	.048	.028	.019	.009	.005	.002				
GAGE AREA	1	1	1	1	1	1	1	1	1	1
	1	1	.1	1	1	1				

SIX HOUR FLOW PLOT   ROCK RIVER ABOVE ROCK RAPIDS   APR ,1969   *=SIMULATED   +=OBSERVED $=FORECAST

STAGE TENDENCY (+) NOT REPORTED (+>) RISING (<+) FALLING (<+>) STATIONARY



TIME	SIMULATED	OBS-FORE
1-1	4.6	-0.0
1-2	15.3	53.0
1-3	82.2	-0.0
1-4	195.6	-0.0
2-1	301.6	-0.0
2-2	360.1	53.0
2-3	411.8	-0.0
2-4	515.7	-0.0
3-1	636.8	-0.0
3-2	753.5	166.0
3-3	1017.2	-0.0
3-4	1407.5	-0.0
4-1	1786.9	-0.0
4-2	2027.8	760.0
4-3	2535.3	1370.0
4-4	3160.2	2299.0
5-1	3721.9	2244.0

MOISTURE STORAGES AND VOLUMES AT THE CURRENT TIME

PRECIP GAGE NAME	UZS	LZS	SGW	GWS	RES	SRGX	SCEP	PRECIP	TOTAL RO	GW RO	PXC
MBP AB. ROCK RAPIDS	1.75	4.47	.41	.36	0.00	.24	.30	2.05	.541	.075	1.00

SNOW PACK STORAGES,VOLUMES AND CORRECTIONS AT THE CURRENT TIME

PRECIP GAGE NAME	WE	LIQW	TOTAL WATER	AREAL COVER	NEGHS	SNOWFALL	RAIN	PACK RUNOFF	**********CORRECTIONS*************** MELT	WIND	SNOWFALL	AEADJ	AWEADJ
MBP AB. ROCK RAPIDS	4.29	.86	5.16	1.00	.03	0.00	.01	2.055	1.00	1.00	1.30	1.00	1.00

F.3 SAMPLE INPUT AND OUTPUT FOR OPERATION PROGRAM WITH SNOW - EXAMPLE TWO

```
     1     0     1     2     0
    69     4     5     2     6     1     0     0     0     1     0     0
     1     4     1
     4     6   0.0
     4     5  .116
     4     6  .119
     4     5          36    41    31
     4     6    26
     4     5           1       3938.           3       9875.
     4    62       7770.
     4     8   .10   .10
     4    10   0.0   0.0   0.0   0.0
     4     6  .119
     4     7  .122
     4     8  .125
     4     9  .128
     4    10  .131
     4     6          42    52    43
     4     7    38    52    60    50
     4     8    45    55    60    45
     4     9    40    50    55    40
     4    10    32    45    55    40
```

```
                   ROCK RIVER AT ROCK RAPIDS,IOWA

 SAMPLE INPUT DATA FOR NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM    JUNE,1973

                                                        BASIC RUN INFORMATION

NUMBER OF PRECIPITATION GAGES= 1     NUMBER OF FLOW-POINTS= 1     NUMBER OF POTENTIAL ET STATIONS= 1     QPF AREAS= 1
          EVAPORATION PARAMETERS ARE     SIOUX CITY,IOWA -- T.R.NO. 38 PE DATA     NEP= 91     NDUR=136
                         OPERATIONAL FORECAST MODE     APR ,1969     DAY  5-2  TO DAY  6-1     FORECAST  4 DAYS

                         SNOW IS INCLUDED

                         BEGIN STORM PERIOD
```

ROCK RIVER AT ROCK RAPIDS, IOWA

SAMPLE INPUT DATA FOR NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM JUNE, 1973

SOIL MOISTURE VOLUME PARAMETERS

RG	PRECIP. GAGE NAME	K1	A	EPXM	UZSN	LZSN	CB	POWER	CC	K24L	K3	GAGEPE	EHIGH	ELOW	K24EL
1	MBP AB. ROCK RAPIDS	1.000	0.000	.300	.750	4.000	.020	2.500	1.400	0.000	.200	.920	1.100	0.000	0.000

SOIL MOISTURE TIMING PARAMETERS

RG	SRC1	LIRC6	LKK6	KV	KGS
1	.900	.070	.0075	4.000	.9800

SOIL MOISTURE INITIAL VALUES

RG	UZS	LZS	SGW	GWS	RES	SRGX	SCEP
1	1.75	4.47	.41	.36	0.00	.24	.30

SNOW PARAMETERS--CASE=1

INPUT GAGES USED

RG	TA GAGE	PREDICTED TEMPERATURE AREA	
1	MAT AB. ROCK RAPIDS	SW MINN. FORECAST TA	1600. FEET

TA GAGE	ELEV.	PERIOD TA LAPSE RATES			
MAT AB. ROCK RAPIDS	1600.	-1.0	-3.0	-5.0	-3.0

AREA SNOW PARAMETERS

RG	ELEV	EFC	SCF	MFMAX	MFMIN	NMF	UADJ	SI	DAYGM
1	1600.	0.00	1.30	.0400	.0200	.0075	.1500	1.50	0.000

INTIAL SNOW VALUES

RG	WE	NEGHS	LIQW	STORAGE	SB	SBAESC	SBWS	TINDEX
1	4.29	.034	.859	.003	5.152	1.000	7.200	29.

BASINWIDE PARAMETERS

MELT-BASE	PX-TEMP	PLWHC	TI-PARM
32.0	33.0	.200	.500

AREAL DEPLETION CURVE

WE/AI	0.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
AESC	.05	.24	.39	.52	.64	.75	.81	.87	.92	.96	1.00

ROCK RIVER AT ROCK RAPIDS,IOWA

SAMPLE INPUT DATA FOR NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM   JUNE,1973

FLOW-POINT PARAMETERS

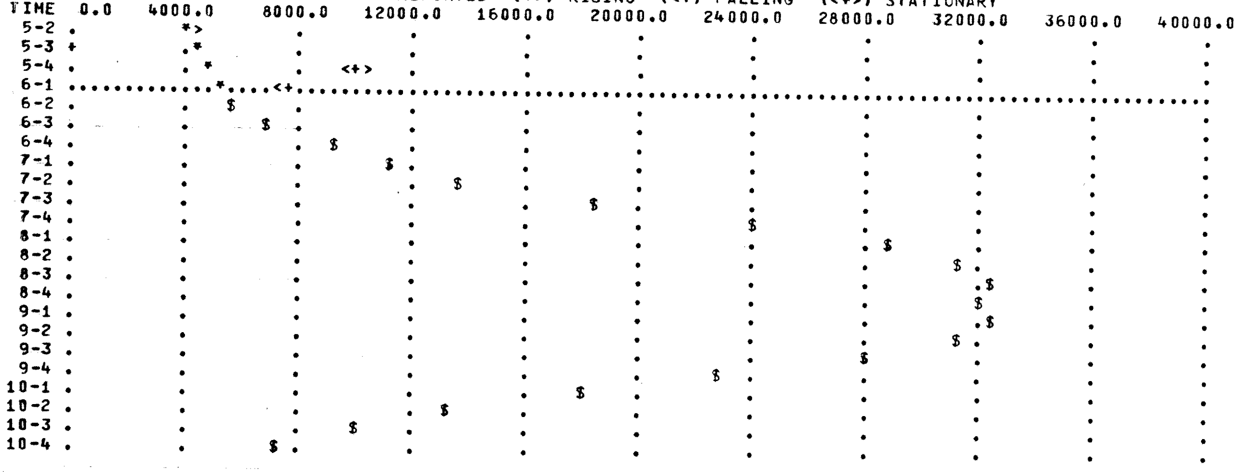
FP	FLOW-POINT NAME	AREA	KS1	OBSER	SIXIN	CHECK
1	ROCK RIVER ABOVE ROCK RAPIDS	788.00	3.40	0	1	1

HISTOGRAMS

TIME-DELAY	.037	.071	.094	.087	.090	.097	.111	.125	.104	.073
	.048	.028	.019	.009	.005	.002				
GAGE AREA	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1				

SIX HOUR FLOW PLOT   ROCK RIVER ABOVE ROCK RAPIDS   APR ,1969   *=SIMULATED   +=OBSERVED $=FORECAST

STAGE TENDENCY (+) NCT REPORTED (+>) RISING (<+) FALLING (<+>) STATIONARY



TIME	SIMULATED	OBS-FORE
5-2	4034.8	3938.0
5-3	4458.6	-0.0
5-4	4872.0	9875.0
6-1	5218.7	7770.0
6-2	5436.4	5436.4
6-3	6881.2	6881.2
6-4	9088.8	9088.8
7-1	11247.1	11247.1
7-2	13732.0	13732.0
7-3	18526.6	18526.6
7-4	24082.9	24082.9
8-1	28625.6	28625.6
8-2	31340.7	31340.7
8-3	32295.7	32295.7
8-4	32196.3	32196.3
9-1	32212.5	32212.5
9-2	31380.9	31380.9
9-3	27995.2	27995.2
9-4	22985.7	22985.7
10-1	17832.7	17832.7
10-2	13278.4	13278.4
10-3	9859.1	9859.1
10-4	7362.0	7362.0

MOISTURE STORAGES AND VOLUMES AT THE CURRENT TIME

PRECIP GAGE NAME	UZS	LZS	SGW	GWS	RES	SRGX	SCEP	PRECIP	TOTAL RO	GW RO	PXC
MBP AB. ROCK RAPIDS	1.81	4.52	.45	.40	0.00	.29	.30	.46	.257	.035	1.00

SNOW PACK STORAGES,VOLUMES AND CORRECTIONS AT THE CURRENT TIME

PRECIP GAGE NAME	WE	LIQW	TOTAL WATER	AREAL COVER	NEGHS	SNOWFALL	RAIN	PACK RUNOFF	**********CORRECTIONS*************** MELT	WIND	SNOWFALL	AEADJ	AWEADJ
MBP AB. ROCK RAPIDS	3.91	.78	4.70	1.00	.04	0.00	0.00	.458	1.00	1.00	1.30	1.00	1.00

F.4 SAMPLE INPUT AND OUTPUT FOR OPERATIONAL PROGRAM WITH SNOW - EXAMPLE THREE

```
  1     0     1     2     0
 69     4     5     2     6     1     0     0     0     1     0     1
  1
  1 4.25        1.5
  0     4     1
  4     6   0.0
  4     5  .116
  4     6  .119
  4     5          36    41    31
  4     6    26
  4     5             1     3938.           3     9875.
  4     62     7770.
  4     8   .10   .10
  4    10   0.0   0.0   0.0   0.0
  4     6  .119
  4     7  .122
  4     8  .125
  4     9  .128
  4    10  .131
  4     6          42    52    43
  4     7    38    52    60    50
  4     8    45    55    60    45
  4     9    40    50    55    40
  4    10    32    45    55    40
```

```
                    ROCK RIVER AT ROCK RAPIDS,IOWA

SAMPLE INPUT DATA FOR NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM    JUNE,1973

                                                  BASIC RUN INFORMATION

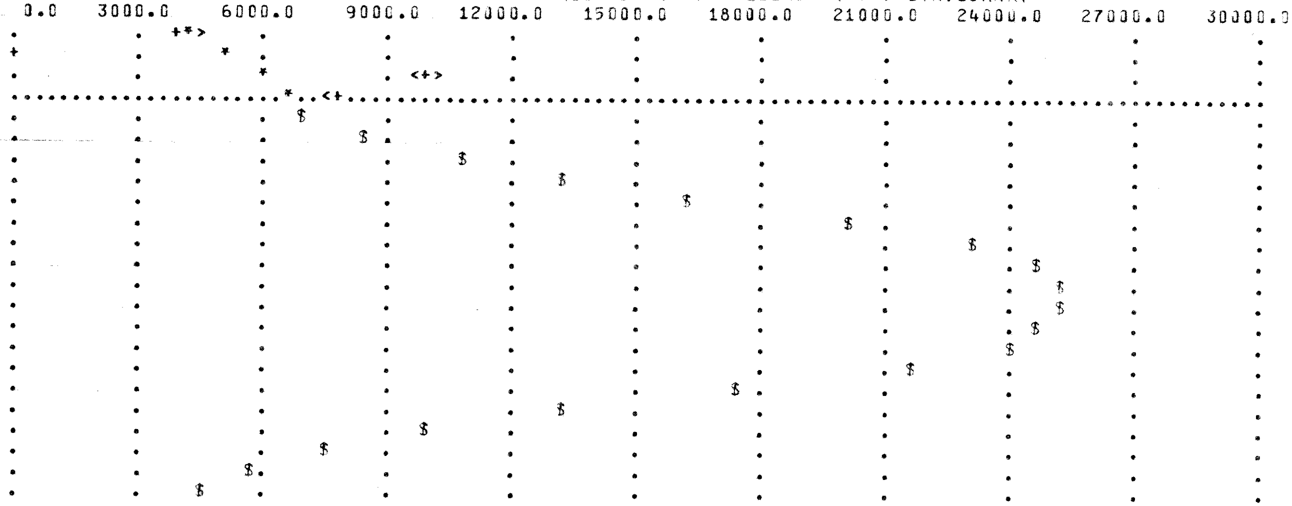
NUMBER OF PRECIPITATION GAGES= 1    NUMBER OF FLOW-POINTS= 1    NUMBER OF POTENTIAL ET STATIONS= 1    QPF AREAS= 1
                        OPERATIONAL FORECAST MODE    APR ,1969    DAY  5-2  TO DAY  6-1    FORECAST  4 DAYS

                        SNOW IS INCLUDED

                        BEGIN STORM PERIOD
```

SIX HOUR FLOW PLOT ROCK RIVER ABOVE ROCK RAPIDS APR ,1969 *=SIMULATED +=OBSERVED $=FORECAST

STAGE TENDENCY (+) NOT REPORTED (+>) RISING (<+) FALLING (<+>) STATIONARY



TIME	SIMULATED	OBS-FORE
5-2	4055.9	3938.0
5-3	4997.0	-0.0
5-4	5327.2	9875.0
6-1	6528.9	7770.0
6-2	6817.2	6817.2
6-3	8397.2	8397.2
6-4	10785.4	10785.4
7-1	13158.0	13158.0
7-2	16100.5	16100.5
7-3	20049.4	20049.4
7-4	23179.8	23179.8
8-1	24720.6	24720.6
8-2	25232.2	25232.2
8-3	25222.3	25222.3
8-4	24480.2	24480.2
9-1	23850.2	23850.2
9-2	21685.0	21685.0
9-3	17505.8	17505.8
9-4	13244.1	13244.1
10-1	9346.5	9846.5
10-2	7463.8	7463.8
10-3	5826.2	5826.2
10-4	4619.5	4619.5

MOISTURE STORAGES AND VOLUMES AT THE CURRENT TIME

PRECIP GAGE NAME	UZS	LZS	SGW	GWS	RES	SRGX	SCEP	PRECIP	TOTAL RO	GW RO	PXC
MBP AB. ROCK RAPIDS	1.84	4.53	.46	.41	0.00	.31	.30	.71	.440	.036	1.00

SNOW PACK STORAGES,VOLUMES AND CORRECTIONS AT THE CURRENT TIME

PRECIP GAGE NAME			TOTAL	AREAL				PACK	**********CORRECTIONS***************				
	WE	LIQW	WATER	COVER	NEGHS	SNOWFALL	RAIN	RUNOFF	MELT	WIND	SNOWFALL	AEADJ	AWEADJ
MBP AB. ROCK RAPIDS	2.95	.59	3.54	1.00	.06	0.00	0.00	.709	1.50	1.00	1.30	1.00	1.00

APPENDIX G

LISTING OF PROGRAM TEMPADJ

```
      PROGRAM TEMPADJ(INPUT,OUTPUT,TAPE1,TAPE2)
C     PROGRAM TO TRANSFER NWSRFS DATA FROM ONE TAPE(TAPE 2)
C     TO ANOTHER(TAPE 1) AND ADJUST AIR TEMPERATURE RECORDS
C     IN THE PROCESS.
***********************************************************************
***********************************************************************
C     CARD NO.  FORMAT       CONTENTS
***********************************************************************
C     1             I5    NUMBER OF BASINS ON DATA TAPE (TAPE 2)
***********************************************************************
C     REPEAT CARDS 2 THROUGH 4 FOR EACH BASIN WITH DATA ON TAPE 2 EVEN
C         THOUGH SOME BASINS DO NO NEED TEMPERATURE ADJUSTMENTS OR MAY
C         NOT EVEN HAVE TEMPERATURE DATA.
***********************************************************************
C     2            8A10   GENERAL INFORMATION
***********************************************************************
C     3             I5    INITIAL MONTH ON TAPE
C                   I5    INITIAL YEAR(4 DIGITS)
C                   I5    LAST MONTH ON TAPE
C                   I5    LAST YEAR(4 DIGITS)
C                   I5    NO. OF PRECIPITATION RECORDS ON TAPE
C                   I5    NO.OF PE RECORDS ON TAPE
C                   I5    NO. OF AIR TEMPERATURE RECORDS ON TAPE
C                   I5    NO. OF OBSERVED WATER-EQUIVALENT AND
C                             MEAN DAILY FLOW RECORDS ON TAPE
C                   I5    NO. OF SIX HOUR DISCHARGE RECORDS ON TAPE
***********************************************************************
C     4             I5    MONTH OF TEMPERATURE ADJUSTMENT
C                   I5    YEAR(4 DIGITS)
C                   I5    STATION NUMBER
C                             E.G. IF ADJUSTING 2ND TA RECORD AND NO. OF
C                             PREC. RECORDS=3 AND NO. OF PE RECORDS=1,
C                             THEN STATION NUMBER=6.
C                             (6TH RECORD FOR THE MONTH ON TAPE)
C                   I5    DAY WHEN ADJUSTMENT BEGINS
C                   I5    SIX HOUR PERIOD WHEN ADJ. BEGINS
C                   I5    NUMBER OF PERIODS TO ADJUST (10 IS MAX)
C                10F5.0   NEW AIR TEMPERATURE VALUES FOR EACH PERIOD
***********************************************************************
C     REPEAT CARD 4 FOR EACH ADJUSTMENT PERIOD. ADJUSTMENTS
C     MUST BE INPUT SEQUENTIALLY,I.E. IN ORDER BY MONTH
C     AND WITHIN EACH MONTH, IN ORDER BY STATION NUMBER.
C     LAST CARD SHOULD HAVE 99 IN COL. 4-5 AND 9999
C     IN COL. 7-10.
***********************************************************************
***********************************************************************
      DIMENSION VAL(10),A6(124),A24(31),TA(124),A(8)
```

```
      READ 900,NBASIN
      REWIND 1
      REWIND 2
      DO 200 NB=1,NBASIN
      READ 904,A
  904 FORMAT (8A10)
      PRINT 905
  905 FORMAT (1H1,20X,34HMEAN AREAL TEMPERATURE ADJUSTMENTS)
      PRINT 906,A
  906 FORMAT (1H0,8A10)
      READ 900,IMO,IYR,LMO,LYR,NPX,NPE,NTA,NQ24,NQ6
  900 FORMAT (9I5)
      KMO=IMO
      KYR=IYR
      READ 901,MO,NYR,NSTA,ID,IP,NC,(VAL(I),I=1,NC)
  901 FORMAT (6I5,10F5.0)
      START MONTHLY LOOP
  120 IF (NPX.EQ.0) GO TO 111
      DO 100 I=1,NPX
      READ (2) A6
      WRITE (1) A6
  100 CONTINUE
  111 IF (NPE.EQ.0) GO TO 112
      DO 101 I=1,NPE
      READ (2) A24
      WRITE (1) A24
  101 CONTINUE
  112 IF (NTA.EQ.0) GO TO 119
      DO 102 I=1,NTA
      II=NPX+NPE+I
      IF ((MO.EQ.KMO).AND.(NYR.EQ.KYR)) GO TO 117
      GO TO 107
  117 IF (NSTA.EQ.II) GO TO 105
  107 READ (2) A6
      WRITE (1) A6
      GO TO 102
  105 READ (2) TA
  103 MP6=(ID-1)*4+IP
      LAST=MP6+NC-1
      DO 104 J=MP6,LAST
      L=J-MP6+1
      TA(J)=VAL(L)
  104 CONTINUE
      READ 901,MO,NYR,NSTA,ID,IP,NC,(VAL(J),J=1,NC)
      IF ((MO.EQ.KMO).AND.(NYR.EQ.KYR)) GO TO 118
      GO TO 108
  118 IF (NSTA.EQ.II) GO TO 103
  108 PRINT 902,II,KMO,KYR
  902 FORMAT (1H0,3HDAY,22X,7HSTATION,I4,5X,5HMONTH,I4,5X,4HYEAR,I6)
      L=1
  110 N1=(L-1)*4+1
      N2=N1+15
      IF (N2.GT.124) N2=124
      PRINT 903,L,(TA(J),J=N1,N2)
```

```
  903 FORMAT (1H ,I2,4(4F8.2,1H/))
      L=L+4
      IF (L.GT.31) GO TO 109
      GO TO 110
  109 WRITE (1) TA
  102 CONTINUE
  119 IF (NQ24.EQ.0) GO TO 115
      DO 113 I=1,NQ24
      READ (2) A24
      WRITE (1) A24
  113 CONTINUE
  115 IF (NQ6.EQ.0) GO TO 116
      DO 114 I=1,NQ6
      READ (2) A6
      WRITE (1) A6
  114 CONTINUE
  116 CONTINUE
C     END MONTHLY LOOP
      IF ((KMO.EQ.LMO).AND.(KYR.EQ.LYR)) GO TO 199
      KMO=KMO+1
      IF (KMO.LT.13) GO TO 120
      KMO=1
      KYR=KYR+1
      GO TO 120
  199 CONTINUE
  200 CONTINUE
      STOP
      END
```

APPENDIX H

```
*****  CHANGES TO OPERATIONAL RIVER FORECASTING PROGRAM (NWSRFS5)  *************
*
*
********************************************************************************
*     STATEMENT                                                     CARD NUMBER
********************************************************************************
*
********** CHANGES IN MAIN PROGRAM **********
*
     8AEADJ(10),SCFC(10),FGNAME(3,5),AWEADJ(10)                             0047
     2MFC(IRG),WINDC(IRG),SCORR,AEADJ(IRG),AWEADJ(IRG)                      0255
  231 AWEADJ(IRG)=1.0                                                       0274
     14X,36H**********CORRECTIONS***************)                           0305
     22X,8HSNOWFALL,2X,5HAEADJ,2X,6HAWEADJ)                                 0308
  931 FORMAT(1H ,5A4,5X,5F7.2,2F10.2,F10.3,2F7.2,F10.2,F7.2,F8.2)           0309
*
********** CHANGES IN SUBROUTINE READCO **********
*
     8AEADJ(10),SCFC(10),FGNAME(3,5),AWEADJ(10)                             0044
     4COVERI,COVERB,PWEI,PWEB,AEADJ,NTAG,NFTAGS,FGNAME,AWEADJ               0062
*
********** CHANGES IN SUBROUTINE WRITCO **********
*
     8AEADJ(10),SCFC(10),FGNAME(3,5),AWEADJ(10)                             0044
     4COVERI,COVERB,PWEI,PWEB,AEADJ,NTAG,NFTAGS,FGNAME,AWEADJ               0062
```

(Continued from inside front cover)

NWS HYDRO 13 Time Distribution of Precipitation in 4- to 10-Day Storms--Ohio River Basin. John F. Miller and Ralph H. Frederick, May 1972. (COM-72-11139)

NWS HYDRO 14 National Weather Service River Forecast System Forecast Procedures. December, 1972. COM-73-10517)

NWS HYDRO 15 Time Distribution of Precipitation in 4- to 10-Day Storms--Arkansas-Canadian River Basins. Ralph H. Frederick, June 1973. (COM-73-11169)

NWS HYDRO 16 A Dynamic Model of Stage-Discharge Relations Affected by Changing Discharge. D. L. Fread, December 1973.

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