US Army Corps
of Engineers
North Pacific Division

User Manual

SSARR

Model
Streamflow Synthesis and Reservoir Regulation

DRAFT

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PREFACE

Operational hydrology is becoming more and more dependent on the application of conceptual hydrologic computer models. Limitations in data quality and quantity and in the development of mathematical expressions of the various fundamental relationships prevent the development of an all purpose, theoretically sound model. Thus, there is a need for a model that is conceptually based, yet not so detailed as to prevent its application on a daily basis. Also, any computer model must be regarded as only a "tool" and it must be realized that sound judgement on the part of the hydrologist is a necessary ingredient. Based on these ideas, the Streamflow Synthesis and Reservoir Regulation (SSARR) Model was developed. The SSARR Model was designed for operational use in hydrologic engineering studies and daily streamflow forecasting.

The methods used in the current version of the SSARR program are based on computational procedures conceived by Mr. David M. Rockwood, Chief (Retired), Water Management Branch. His original work was documented in Technical Bulletin 22, "Program Description and Operating Instructions: Streamflow Synthesis and Reservoir Regulation Computer Program No. 24.J3.H001", January 1964 (out of print). Subsequent versions of the program and documentation were built upon this original work.

The current version of SSARR is called SSARR-8. This version includes most of the facilities of the 1972 and 1976 versions. 1/ Major enhancements include additions designed for interactive operation of the program to assist the hydrologist in forecast operations; long-term data storage and retrieval suitable for holding 50 years or more of data; and the "Integrated Snowband" watershed option, a model formulated to provide the capability to simulate on a continuous basis rainfall-runoff, snow accumulation and ablation, and snowmelt runoff in mountainous areas.

The SSARR model computer program source language is IBM-VS FORTRAN-77. Versions of the program are also available for the VAX-11/780 computer and IBM-PC-compatible micro-computers. For additional information about program availability, transmittal medium (floppy disk or magnetic tape) and cost, contact:

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1. INTRODUCTION

The Streamflow Synthesis and Reservoir Regulation Model (SSARR) has been in the process of development and application since 1956. It was developed initially to meet the needs of the North Pacific Division of the U.S. Corps of Engineers to provide mathematical hydrologic simulations for systems analysis as required for the planning, design, and operation of water control works. The SSARR Model has been further developed for operational river forecasting and river management activities in connection with the Cooperative Columbia River Forecasting unit, sponsored by the National Weather Service, U.S. Corps of Engineers, and Bonneville Power Administration. In recent years, numerous river systems in the United States and abroad have been modeled with the SSARR by various agencies, organizations, and universities. (See References).

PURPOSE AND SCOPE

The purpose of this manual is to present the basic formulation of the SSARR Model together with background information on the philosophy of its design. The appendices contain the user's manuals for operation of the computer program, and examples of applications to specific hydrologic engineering and water management problems. The manual is prepared primarily for the hydrologic engineer rather than the computer scientist, but sufficient information is given to provide a general understanding of the computer requirements for the preparation of input data, system operation and control, and control of output.

OVERVIEW OF SSARR MODEL DESIGN

The SSARR is a numeric model of the hydrology of a river basin system. Streamflow at headwater points in the system can be synthesized by evaluating rainfall, snow accumulation, and snowmelt. Streamflows throughout the basin can be synthesized by simulating the effects of channel routing, diversions, and reservoir regulation and storage. The "model" is comprised of a generalized watershed model and a streamflow and reservoir regulation model:

The Watershed Model simulates rainfall-runoff, snow accumulation, and snowmelt-runoff. Algorithms are included for modelling of snow pack cold content, liquid water content, and seasonal conditioning for melt. Interception, evapotranspiration, soil moisture, baseflow infiltration, and routing of runoff into the stream system are accounted for.

The River System and Reservoir Regulation Model routes streamflows from upstream to downstream points through channel and lake storage, and reservoirs under freeflow or controlled-flow modes of operation. Flows may be routed as a function of multivariable relationships involving backwater effects from tides or reservoirs. Diversions and overbank flows may be simulated.

Compute-Period Length. The simulation procedes through time by computing the model state at successive intervals. The time increment may be as short as 0.1 hour or as long as 24 hours, depending on the goals and objectives of the modeler, and model-dependent factors such as drainage area, hydrologic response time, and the availability of hydrometeorological data with which to drive and calibrate the model.

PROGRAM DESIGN CONSIDERATIONS

The development of the SSARR Model has been based on a practical engineering approach to program design in order to achieve a balance between hydrologic theory and practical considerations related to daily operational use. Specific major considerations in the design of the model components are:

- To use practical yet theoretically sound methods in evaluating hydrologic processes.
- To employ storage routing techniques so that on a day-to-day basis the computation may be started at any time in the simulation process without disrupting the continuity from prior computations.
- To develop necessary hydrologic and channel characteristics either from empirical trial-and-error techniques or from known physical data.
- To provide flexible methods of specifying functional relationships used in the simulation.
- To simplify the input data formats to avoid excessive day-to-day preparation.
- To provide a capability which allows the model to adjust itself to specified or observed conditions of streamflow from previously computed amounts, and maintain continuity of functions in further processing.
- To develop the model in a generalized way so that it may be applied to many watershed, stream, river, and reservoir systems.
- To provide output, including data tabulations and plots, that can be conveniently and quickly applied in everyday use.
- To provide computations in English or metric units.
- To employ programming and data management techniques which facilitate the refinement, addition, or replacement of any portion of the hydrologic models.

The computer program is composed of a number of relatively independent subprograms (Figure 1-1). The SSARR Work File is the database for communication between the subprograms. Appendix G describes the program organization and file contents in some detail.

Both batch and interactive modes of operation are supported by the program structure. When control is given to the "interactive driver" subprogram, prompting messages are displayed to assist the user in a real-time dialog with the computer for model data entry and editing, operation of the simulation models, and display of the results.

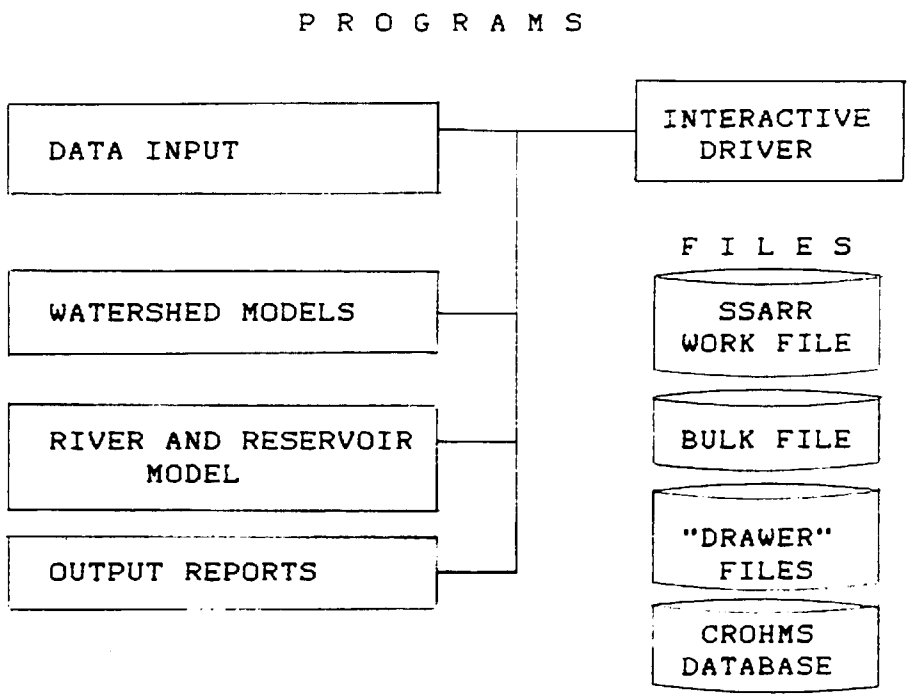


FIGURE 1-1. SSARR PROGRAM COMPONENTS

APPLICABILITY

As a general purpose mathematical model of a water system, the SSARR model is a useful tool for streamflow and runoff forecasting, as well as for long term studies of the hydrology of a river system. Some examples of applications for which this program is applicable are:

- The analysis of the effects of multiple-purpose reservoir operations.
- Simulation of design storms.

- The investigation of streamflow diversion schemes as needed for irrigation management

- Daily streamflow forecasting at many points throughout a river system.

- Seasonal streamflow forecasting.

The model has been developed around the requirements of relatively large drainage basins with a sparse network of observed data. However, it has been applied to a wide variety of large and small catchments, for both snowmelt and rain-only simulations in many different regions of the world.

It is a deterministic conceptual model rather than a hydraulic model and, as such, may not be suitable for small drainages such as those encountered in studies of urban hydrology. The minimum computation step is one tenth of an hour, which may be too long for accurate simulation of runoff peaks from very small areas.

For both forecasting and study applications, the data processing capabilities of the SSARR Model program provide a comprehensive set of tools for hydromet data management. Data retrieval from external files such as the Columbia River Operational Hydrometeorological Management System (CROHMS) data base, interactive data input and editing assisted by prompting from the computer, management of short and long term hydromet data files, and a variety of analytical displays of the simulation results are facilities included in the program.

CALIBRATION

The successful application of the SSARR Model is dependent upon derivations of the various parameters and relationships specific to a particular watershed or river system. Some of the relationships are general and, therefore, are applicable to many subbasins within a major drainage. Others can be specifically derived for a particular watershed. Some are relationships which can be observed or derived, while others must be considered to be "model parameters" which only have qualitative physical significance. Watershed runoff characteristics are primarily determined by trial-and-error solutions with the computer program to obtain the best fit of historic streamflow data. This procedure is repeated until adequate verification of observed flows is obtained. The characteristics are then tested with independent data. The efficiency of adjustment procedures is dependent upon the judgement and skill of the user who must evaluate the interactions of the various parameters. Conversely, the knowledge gained in verification studies can add significantly to the overall understanding of basin hydrologic characteristics.

One systematic approach to calibration is presented by Cundy and Brooks in their paper, "Calibrating and Verifying the SSARR Model - A Case Study".[7/]

BASIC ROUTING METHOD

The basic routing method used in the watershed and river models is a "cascade of reservoirs" technique, wherein the lag and attenuation of the flood wave are

simulated through successive increments of lake-type storage. A watershed or channel can be visualized as a series of small "lakes" which represent the natural delay of runoff from upstream to downstream points. The user specifies the routing characteristic of the prototype "lake" as well as the number of "lake" increments.

This routing technique was selected because of its flexibility and ease of computation. The instantaneous condition of the simulated flood wave may be saved by recording the discharge of each of the incremental "lakes", allowing restart of the model at that time without loss of continuity. The in-house paper by Speers and Davis 8/ describes the routing algorithm in detail. The appendices of this manual contain several examples and discussions of the specification of routing characteristics and calibration.

The routing method is similar to that described by Wilson. 5/ Routing through watershed, river system, and reservoir components of the model relies on the law of continuity in the storage equation:

$$[(I_1 + I_2)/2 - (O_1 + O_2)/2]\ t = S_2 - S_1 \qquad (1.1)$$

where

I_1 = Inflow at the beginning of the compute period

I_2 = Inflow at the end of the period

O_1 = Outflow at the beginning of the period

O_2 = Outflow at the end of the period

S_1 = Storage at the beginning of the period

S_2 = Storage at the end of the period

t = Time duration, compute period length

In differential form, the inflow (I_t) is expressed by:

$$I_t = O_t + dS/dt$$

In natural lakes where storage is a function of outflow at any given elevation, T_s represents the proportionality factor between storage and outflow:

$$S = T_s O$$

By substitution, the following form of the equation may be derived. This is the form used to compute outflow from one prototype "lake" increment:

$$O_2 = O_1 + t\ (Im - O_1)/(T_s + t/2) \qquad (1.2)$$

where

I_m = Mean inflow

O_1 = Outflow at beginning of period

t = Time duration of computational period

T_s = Time of storage

In the computer program, the value of $\frac{t}{T_s + t/2}$ is evaluated for a specified condition, and multiplied by the difference between I_m and O_1 to obtain the change in outflows. The outflow (O_2) computed from the first incremental routing is then saved and converted to initial outflow (O_1) for the next period routing.

DATA REQUIREMENTS

Input data needed for operation of the model include:

Non-Variable Characteristics Data which describe physical features such as drainage area, reservoir storage capacity and watershed characteristics that affect runoff.

Initial-Conditions Data for specifying current conditions of all watershed-runoff indexes, flow in each increment of each channel reach, and initial reservoir or lake elevations and outflows.

Time Variable Data which include physical data expressed as time series; for example, precipitation data and air temperatures, streamflow data, reservoir regulation data, and other hydrometeorological elements.

Miscellaneous Job Control and Time Control Data which specify such items as total computation period, routing intervals, and special computer instructions to control printouts and other input-output alternatives.

2. WATERSHED MODELS

A major part of the SSARR program is the Watershed Models, in which precipitation, temperature and other hydrometerological variables are input with derived catchment characteristics to simulate runoff into a River System Model. The user does not have to use the Watershed Models but can input known streamflow directly into the River Model for such applications as reservoir regulation and streamflow studies.

The current version of the SSARR Model program includes two complete watershed models; the "Integrated-Snowband" model, and the "Depletion Curve" model. The "Integrated-Snowband" model was formulated to provide the ability to simulate snow accumulation and melt and rainfall runoff continously year-around. The greatest value of the integrated-snowband model in daily short term forecasting is in the coastal area where the snow line flucuates over short time periods. The snow conditioning provisions of the model contribute significantly to the forecast product. Also, the ability of the model to compute the snowpack from climatologic data makes it effective in the area of volume forecasting. The computed discharges from the model in combination with the National Weather Services' Extended Streamflow Prediction (ESP) procedure provide useful probability statements of future seasonal runoffs.

The second watershed model is called the "Depletion Curve" model. Except for differences in data handling facilities and station naming conventions, this model is unchanged from the version described in the 1975 issue of the SSARR User Manual.[1] For snowmelt simulation, this model uses a relationship called the "depletion curve". The depletion curve relates proportion-to-date of seasonal runoff to percent of snow covered area. An example of a depletion curve is included as Figure 2-13 (Page 39). The "depletion curve" option is used during the melt season to simulate the depletion of the snow pack.

An option within the Depletion Curve Model is termed the "snow band option". This option allows simulation of only the portion of a catchment falling within a relatively narrow elevation range, and may simulate snowpack accumulation as well as melt (experience with this option led to the development of the "Integrated-Snowband" Model mentioned above).

The "Depletion Curve" Model has been applied to many drainage basins around the world both for rain-only runoff simulation and for snowmelt plus rainfall runoff simulation.

SNOW SIMULATION

In some parts of the world, runoff from snowmelt constitutes the major portion of streamflow, while in other areas snowmelt runoff is minimal. In either case, snowmelt runoff poses complex problems to the hydrologist. The relationships between snow hydrology and flood hydrograph analysis are primarily determined by melt rates and the areal extent and water equivalent of the snowpack which are affected by terrain, vegetative cover, and climate. Streamflow synthesis from snowmelt is discussed in detail in Chapter 9 of "Snow Hydrology."[2]

Snowmelt is a function of energy transfer to the snowpack. The natural sources of heat responsible for melting snow are:

a. Absorbed solar radiation
b. Net longwave radiation (terrestrial)
c. Convective and advective transfer from the air (sensible heat transfer)
d. Latent heat of condensation from the air
e. Conduction of heat from the soil and surroundings
f. Heat content of precipitation

In application, however, few of these sources of energy are directly evaluated for a watershed. Even when several of the energy components are measured, it is often difficult to obtain representative values for a watershed from point measurements.

Generalized equations have been developed whereby some of the above parameters are lumped together into the following five components of melt:

a. Shortwave (solar) radiation melt
b. Longwave radiation melt
c. Convection- condensation melt
d. Rain melt
e. Ground melt

The relative influence of these components vary according to the amount of forest cover in the watershed.

The SSARR Model has several options available to synthesize streamflow from snowmelt, and can be tailored somewhat to the user's needs, data availability, and physical characteristics of the watershed. Operational requirements often dictate the more simplified procedures which require a minimum of data handling.

Summary of Snowmelt Options. Basically the SSARR Model offers the user either the temperature index approach or the generalized snowmelt equation to compute snowmelt from the basin snow pack. The basin snowpack in turn, can be defined by either the elevation band or the snow cover depletion curve.

The temperature index approach is easiest to employ. Precipitation, air temperature, and melt rate specifications are essentially the only data input required. The temperature index method is more widely used in operational hydrology because of the lack of energy budget data on a real-time basis. In most cases, precipitation and air temperatures are the only day-to-day data available for snowmelt computations. Also, air temperature is a simple index that provides good estimates of snowmelt for forested areas.[2/] Temperature data can be input for one or more stations for each watershed as specified by the basin characteristic data.

The basic difference between the elevation band option and the depletion curve option is that the elevation band option maintains an inventory of snow water equivalent and soil-moisture parameters on each elevation band. The depletion curve option simulates the catchment as an entity and depletes the snow covered area as a function of seasonal accumulated runoff.

The elevation band approach takes into account the variation with elevation of temperature, precipitation, and other meteorological parameters. The watershed is divided into elevation bands. Each elevation band is treated as if the entire area of the band was at the same elevation. Simulation of snowpack conditions and moisture input for runoff routing is independently accomplished for each band. This approach is particularly suited for mountainous watersheds where snow depth is a function of elevation.

The depletion curve option is appropriate for simulation of the active melt season in regions where snowmelt dominates. During this period, runoff from rainfall on snow free areas is negligible and new snow accumulations are usually not significant. When rainfall-runoff on snow free areas is substantial, the split-watershed option may be used instead of the single watershed option. When the single watershed option is used, single watershed runoff parameters are maintained. If the runoff conditions for the snow free area differ substantially from the snow covered area, an adjustment can be made to split the watershed. When the split-watershed option is used, the two areas are handled as two separate watersheds, each with its own characteristics and initial condition specifications. The program determines the snow covered and snow free areas from the snow cover depletion curve. Thus, as the melt season progresses, the snow free area becomes larger.

The following tabulation outlines the watershed options available in the current version of the SSARR Model program:

	WATERSHED MODEL		
		DEPLETION CURVE	
SIMULATION ALGORITHM	INTEGRATED SNOWBAND	SCD	SINGLE BAND MODE
Weighted Average Precipitation	Yes	Yes	Yes
Daily Precip. Distributed to Compute Period		Yes	Yes
Precipitation Gage Catch Deficiency	Yes		
Precipitation as Function of Elevation	Yes		Yes
Interception	Yes		
Evapotranspiration (ET) Function of Season	Yes	Yes	Yes
ET Function of Temperature, Snowcover	Yes		
Weighted Average Temperature	Yes	Yes	Yes
Temperature Lapse Rate Variable	Yes		
Snow Accumulation	Yes		Yes
Snow Conditioning	Yes		
Snowmelt: Temperature Index Method	Yes	Yes	Yes
Melt-During-Rain Algorithm	Yes		
Generalized Equation		Yes	Yes
Snowcover Depletion Curve		Yes	
Distribute Daily Snowmelt to Compute Period		Yes	Yes
Ground Melt	Yes		
Limit Melt Rate at End of Season	Yes	Yes	
Soil Moisture-Runoff	Yes	Yes	Yes
Lumped Routing of Elevation Bands	Yes	Yes	
Fourth (Long-Term) Component of Runoff	Yes		
Printout of Basin-Average Parameters from Snowband Simulation	Yes		

INTEGRATED SNOWBAND WATERSHED MODEL

The design of the Integrated-Snowband model includes as many as possible of the features suggested by SSARR users as the program has evolved since 1975. None of the new variables are "forced" on the user; he can use them or not, as needed in any particular simulation. None of the coefficients are locked into the computer program, but default values are provided in most cases. Many of the methods, variables, and default values come directly from "Snow Hydrology".[2] Although the main emphasis in its development was snow simulation in mountainous areas, this model includes all of the features of the "Depletion Curve" model for rain-only simulation, plus three additional

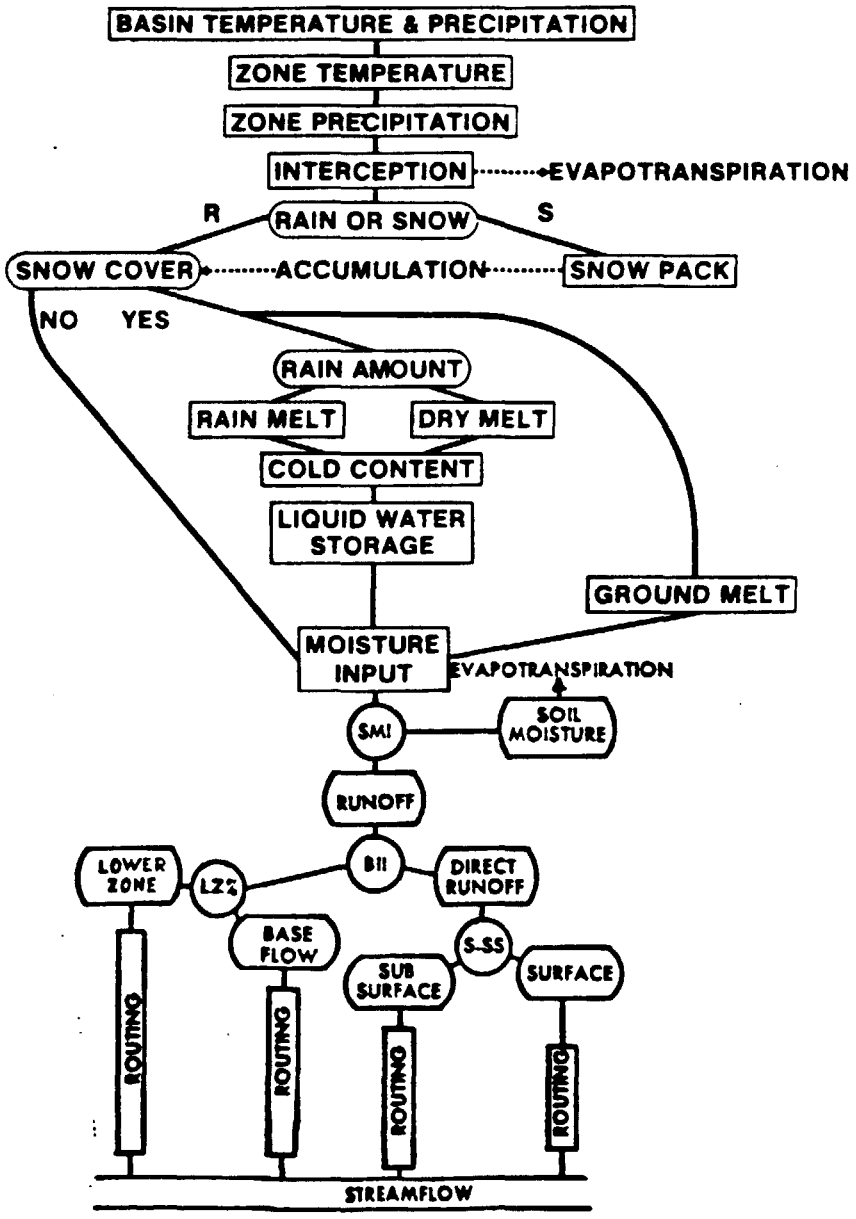


FIGURE 2-1 SSARR "SNOWBAND" WATERSHED MODEL

features considered most valuable in long-term simulations; a simple interception algorithm which assists in analysis of the annual water balance, a more flexible evapotranspiration simulation, and a fourth component of routing to simulate long-term return flow from groundwater.

The watershed accounting is accomplished through the use of elevation bands, with independent accounting of precipitation, snow water equivalent, soil moisture and other characteristics for each band. The program permits flexible subdivision of the basin into from 1 to 20 bands with no restriction on the area of each band. Each band is considered to be either 100% snow covered or snow free. An algorithm is included in the snowmelt simulation to delay the melt of the last few inches of snow off a snowband, thereby reducing the impact on the computed hydrograph of a relatively large proportion of the snow covered area simultaneously losing its snow cover. Runoff is calculated for each separate band and then combined to obtain basin runoff before routing to form total watershed streamflow.

A flow chart summarizing the computation process undertaken in each band in the watershed is shown in Figure 2-1.

ELEVATION BAND CALCULATIONS IN THE INTEGRATED-SNOWBAND MODEL

Compute Period Length: The Model Time Increment. The model steps through the simulation time range in user-specified time increments, calculating the model state at the end of each interval. In the following discussion, this time increment is referred to as the "compute period". The time increment may be as short as 0.1 hour or as long as 24 hours. Valid compute period lengths are .1, .2, .5, 1, 2, 3, 4, 6, 8, 12, and 24 hours.

The compute period length is determined by analyzing the purpose of the simulation, the frequency of the data that is available to drive the model, and the size and response time of the drainage area.

Division of Drainage Into Elevation Bands. The catchment may be treated as one elevation band, or divided into as many as 20 bands. The bands may be defined by either listing the area of each band as a percent of the total catchment, or listing the upper elevation limit of each band (the lowest band begins at the lowest point in the elevation-vs-area curve).

This approach was designed to simulate the snowpack and soil moisture condition of a drainage as they vary with elevation. For the simulation of a rain-only basin, the variation of precipitation and soil moisture with elevation can also be modeled with this technique.

Temperature Lapse Rate. A single lapse rate is applied to the entire elevation range. The lapse rate may be a constant for all time, or specified for each compute period.

Basin Weighted Average Temperature. Average temperature over a basin is computed from temperatures retrieved from a list of temperature gages. The gage list is part of the basin fixed characteristic description specified by the user. Each temperature gage provides time-variable temperatures at a

constant elevation. The temperature lapse rate for a given compute period is used to lapse the temperature to elevation zero (sea level). The temperatures for all the gages lapsed to elevation zero are averaged to arrive at the basin average temperature at elevation zero.

The weighted average temperature for a compute period is calculated as follows:

$$TA_t = \sum_{n}^{i=1} (TA_{it} * W_i + E_i * L_t)/n$$

where

TA_t is basin weighted average temperature at zero elevation for time t.

TA_{it} is temperature from gage i at time t.

W_i is weight of gage i.

E_i is elevation of gage i.

L_t is lapse rate for time t.

n is the number of temperature gages providing data for this basin.

Snowband Temperature. Temperature for a compute period is calculated with either constant or variable lapse rate, the snowband midpoint elevation, and the basin weighted average temperature.

$$TA_{zt} = TA_t + L_t * E_z$$

where

TA_{zt} is temperature for snowband z at time t.

TA_t is basin weighted average temperature at time t.

L_t is lapse rate for time t.

E_z is elevation of midpoint snowband z.

Basin Weighted Average Precipitation. Precipitation is retrieved from a list of precipitation gages. The gage list is part of the basin fixed characteristics and contains a weight for each gage relating the precipitation reported at the gage to overall basin average precipitation. Adjustment may be made for gage-catch deficiency during snow events before calculating the basin weighted average, through the user-specified characteristics of the precipitation gage.

Gage weights are usually estimated with the Thiessen method, or from a ratio of normal station to normal watershed precipitation.

Precipitation is computed as follows:

$$PP_t = \sum_{n}^{i=1} \text{ of } (PP_{it} * W_i) / n$$

where

PP_t is basin weighted average precipitation during the compute period ending at time t.

PP_{it} is precipitation at gage i during the compute period ending at time t.

W_i is weight of gage i.

n is the number of precipitation gages providing data for this basin.

Snowband Precipitation. The user may provide an elevation vs. precipitation percent relation for each basin. Figure 2-2 shows a typical set of values for this relation. From this relation, using snowband mid-point elevation, a precipitation percent is obtained ($\%P_z$). This value multiplied times the basin average precipitation results in the snowband precipitation:

$$PP_{zt} = PP_t * \%P_z$$

where

$\%P_z$ is precipitation percent from the elevation-vs-precipitation percent relation for snowband z.

PP_{zt} is the precipitation on snowband for compute period ending at time t.

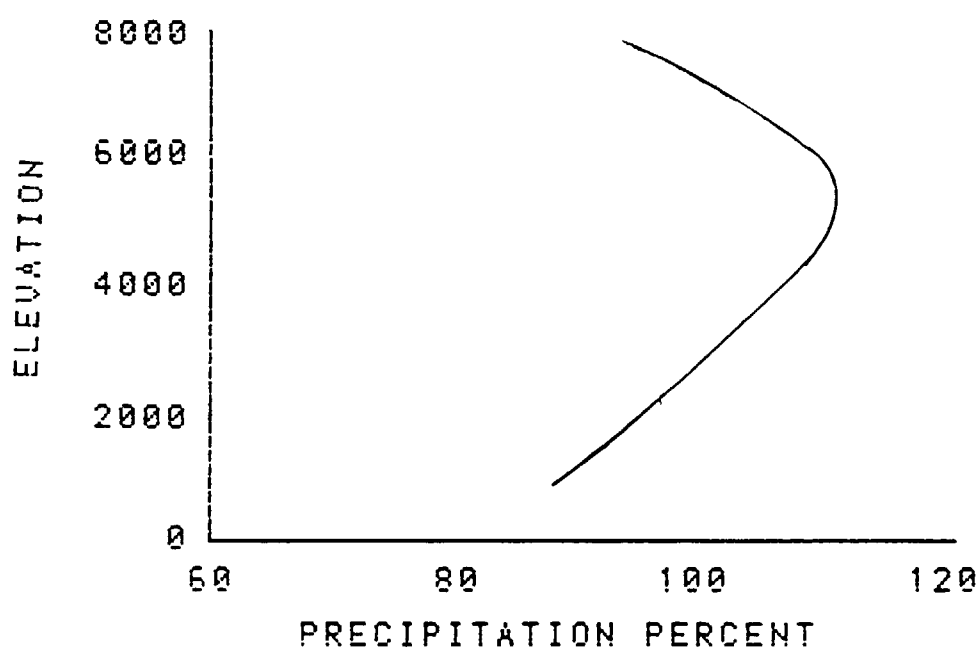


FIGURE 2-2

Evapotranspiration. Potential Evapotranspiration (PET) is computed using Thornthwaite's formula converted to produce daily values. A temperature vs. PET relation may be used (see Figure 2-3), or PET may be specified as hydromet input. Adjustments for season and latitude (as per Thornthwaite) and for elevation are also made. PET is adjusted by a factor (EKE) reducing PET on rainy days. EKE is specified in the relation precipitation rate vs. EKE. If the snowband is snow covered, PET is reduced by a constant adjustment, SNETF. An evapotranspiration index (ETI) is then evaluated through a relationship relating an adjustment factor (DKE) to Soil Moisture Index (SMI). DKE varies from 100% for moist conditions to low percentages for dry soil conditions. The calculation of ETI for a compute period ending at time t for snowband z is as follows:

$$PET_{zt} = ETP_t * ETMO_t * ETEL_z * EKE_{zt}$$

If there is snow on the snowband:

$$PET_{zt} = PET_{zt} * SNETF$$

Finally:

$$ETI_{zt} = PET_{zt} * DKE_{zt}$$

where

ETI_{zt} is evapotranspiration index for snowband z for compute period ending at time t.

ETP_t is basin unadjusted potential ET at time t. This quantity may be specified as hydromet data, or derived from a relation of temperature (TA_t) vs. ETP_t. See paragraph below titled, "Potential Evapotranspiration."

PET_{zt} is snowband potential evapotranspiration.

$ETMO_t$ is monthly adjustment factor as a function of the month.

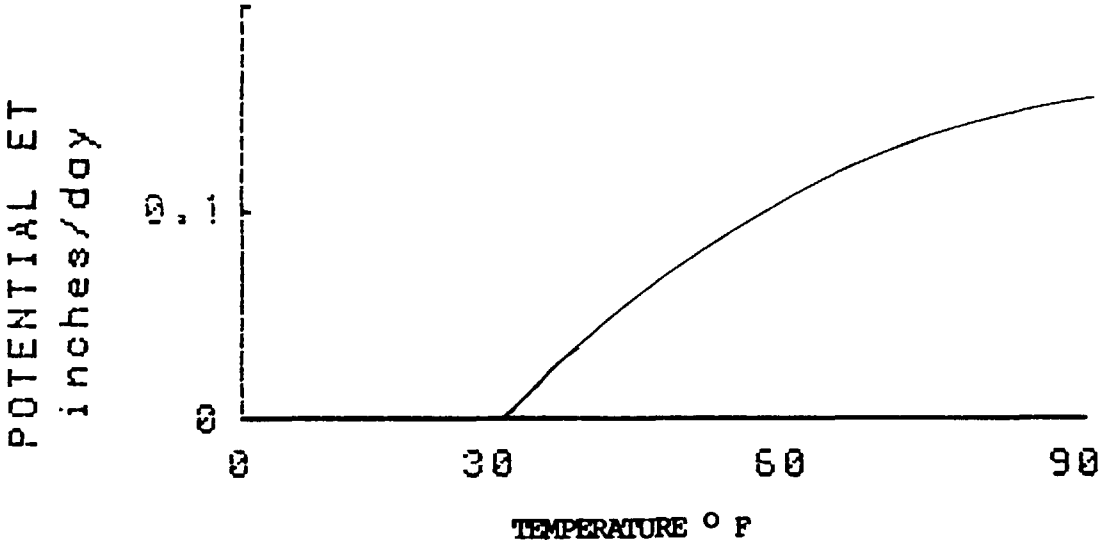
$ETEL_z$ is elevation adjustment factor dependent on the snowband midpoint elevation.

DKE_{zt} is soil moisture adjustment factor for reducing ETI when soil moisture becomes depleted.

EKE_{zt} is the adjustment to PET for rainfall intensity. It is dependent on precipitation rate on the snowband.

SNETF is the ratio of ETI effective if there is snow on the snowband. A typical value is 0.9.

Potential Evapotranspiration. In "Snow Hydrology"[2/] the Thornthwaite Method is adopted as being satisfactory and practicable with respect to data availability. For implementation of this method in the SSARR model, the equation is reduced to compute daily "unadjusted" values of potential ET as a function of temperature. The Thornthwaite monthly adjustment factors for possible sunshine and latitude are entered as relationships in the characteristics.



TYPICAL RELATION OF TEMPERATURE TO POTENTIAL EVAPOTRANSPIRATION
FIGURE 2-3

Instead of the "unadjusted" values of potential ET being a function of temperature, they may be provided as hydromet data by the user. The data values are in units of inches per day.

Interception. The quantitative loss of water by evaporation from vegetative surfaces is usually quite small. In heavily forested regions, however, this small quantity of water may be hydrologically significant in terms of the percentage of total annual precipitation. It is desirable, therefore, to have a simple function in the SSARR Model that simulates the interception process.

The user specifies a maximum interception quantity based on the type and density of vegetation present. An easy way to visualize the concept is to think of it as a "bucket" which must be filled before water can reach the snow or ground surface. The bucket is depleted by evapotranspiration.

The "bucket" capacity may be a constant, or vary as a function of month of the year.

A typical value is 0.2 inches. At the onset of a precipitation event, the interception storage quantity could range from 0. inches up to 0.2 inches as precipitation occurs. The difference between the interception accumulation (in the "bucket"), and the specified maximum interception capacity of 0.2 inches represents a deficit which must be satisfied before any precipitation reaches the snow or ground surface.

Snow Accumulation. If the temperature on the snowband is less than discrimination temperature, any precipitation not captured by interception adds to the snow water equivalent on the snowband. Each individual elevation band is treated as entirely snow-free, or evenly snow-covered.

In addition, the temperature and precipitation rate affect the snow pack cold content, discussed below under "Snow Conditioning."

Snowmelt. The snow pack on a snowband may be melted both at the snow-air interface and the snow-ground interface. Groundmelt is accounted for by a month vs. groundmelt relation, and the resulting water enters the runoff simulation without being affected by the snow conditioning algorithm. Melt at the snow-air interface, on the other hand, must travel through the snowpack before entering the soil system and the snow pack "cold content" and "liquid water" deficits must be satisfied before any water is available to runoff.

A different calculation of snow melt at the snow-air interface is made depending upon the absence or presence of rain. The clear weather melt is calculated by the temperature index approach, where

$$M = MR\ (Ta-Tb)$$

where

M = Snowmelt, inches
MR = Melt Rate Factor, a function of an antecedent temperature index
Ta = Temperature ^{o}F
Tb = Base Temperature, typically $32^{o}F$

The seasonal variation of melt rate is indexed by an antecedent temperature function (ATI) of the following form:

$$ATIMR_2 = (Ta-Tb) + K\ (ATIMR_1)$$

where

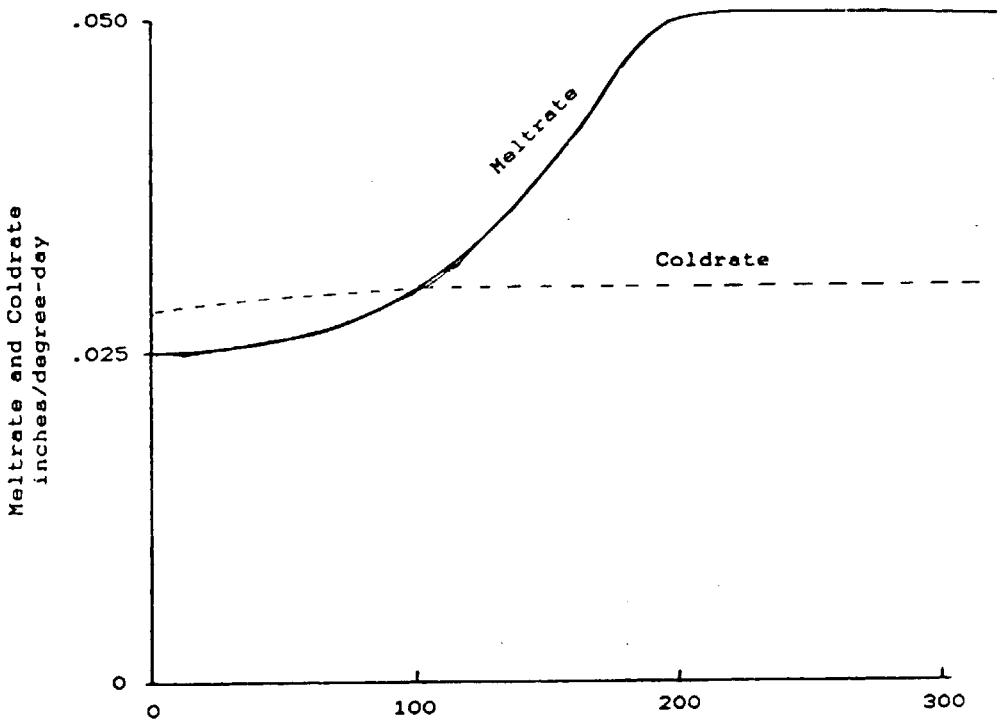
K is a "die-way" coefficient of approximately 0.98 for 24 hour calculations.

Melt during rain is distinguished from the preceding clear weather melt by a specified rainfall, on the order of 1 inch/24 hours. The following equation, taken from Snow Hydrology 2/, represents the general equation for snowmelt during rain for a heavily forested area:

$$M = (RMR+.007\ P)\ (Ta-Tb)$$

where

M = Snowmelt, inches
RMR = Rain melt rate, usually 0.074 inches/degree day
P = 24 Hour precipitation, inches



ANTECEDENT TEMPERATURE INDEX (ATIMR)
FIGURE 2-4

Adjustment to Dry Melt Rate By Season. A relation may be provided for the dependent variable "percent effectiveness of dry melt rate" as a function of month. The dry melt rate is derived as a function of antecedent temperature index (that is, an accumulation of melting degree days with a damping factor). When the average of maximum and minimum daily temperatures, or daily maximum temperature alone is used, the degree-day index values in the winter may not have the same melting effect as the same values in the spring because of differences in the length of the days and number of hours per day the air remains at the index temperature, even though the accumulation of preceding degree days is the same. Therefore, the capability is provided to adjust the melt rate by month regardless of antecedent conditions.

Limitation on Snow Melt Rate. The model assumes that an individual snowband is either entirely snow-free or snow-covered. As the melt season progresses, the basin snow covered area diminishes. The model simulation of the receding snowline jumps a snowband at a time as each band goes bare. During periods of high melt rates, the effect of a relatively large proportion of the snow covered area going bare with the resulting drop in input to runoff can cause a discontinuity in the computed hydrograph.

The technique chosen to delay the melt of last remaining snow on a band is to limit the rate of melt. This is accomplished by the constants WEMIN, WEPCT, and WEMAX.

a. When the snow water equivalent (SWE) of a snowband drops below WEMIN, then the snow melt rate may be limited.

b. If limited, the amount of melt in a compute period is limited to WEPCT per day of the SWE on the snowband at the beginning of the period.

c. When the SWE gets as low as WEMAX, then the limitation is removed because no delay of this small amount is required.

For example, let WEMIN be 2 inches, WEPCT be 60% and WEMAX be 0.4 inches. With 24 hour compute periods, a constant melt rate of 0.1 inches per hour, and initial SWE as follows:

Day	SWE	Computed Melt Limited to 60% SWE	End of Period SWE	If Melt Not Restricted Ending SWE
1	4.3	2.4 (no limit, SWE≥WEMIN)	1.9	1.9
2	1.9	1.1	.8	.0
3	.8	.5	.3	
4	.3	.3 (no limit, SWE≤WEMAX)	.0	
5	.0			

In this example, the melt of the last 2 inches of snow off the snowband was spread out over two additional days to simulate the natural reduction of the melting area as the elevation band goes bare.

Snow Conditioning. The snowpack conditioning routine accounts for the "cold content" and liquid water deficiency of the snowpack which must be satisifed before liquid water can enter the soil system. The formulation utilized essentially follows that used by Anderson for the NWS model [3/]. Cold content is calculated as a function of an antecendent index, ATICC:

$$ATICC_2 = ATICC_1 + TIPM(Ta - ATICC_1)$$

where

ATICC = Index to the Snow Temperature near the surface

TIPM = Factor which considers the depth of cooling

If the precipitation rate reaches the ATICC input threshhold (PMAX), ATICC is set to the temperature of the precipitation, or base temperature (whichever is lower).

Cold content is then calculated by

$$CC = (Ta - ATICC_1)\ Cr$$

where

CC = Cold Content, inches of water required to raise the snowpack to 0^oC.

Cr = Cold rate, a function of ATIMR

Successive period quantities of cold content are accumulated while air temperature is below the base temperature. The cold content total is depleted by the presence of liquid water from snowmelt or rainfall.

Liquid water deficiency is accounted for by specifying percent liquid water holding capacity, taken as a constant on the order of 2-5% of the water equivalent of the snowpack. This capacity must be exceeded before rain or snowmelt is available for input to the soil.

Groundmelt. Snowmelt resulting from the conduction of heat from the ground is accounted for by specifying constant melt rates on the order of .001 to .05 inches/day, or inches per day as a function of month of year.

Soil Moisture - Runoff Simulation. Water escaping from the snowpack or rain falling on a snow-free snowband must either (a) runoff, (b) be retained in the soil system, (c) return to the atmosphere by evapotranspiration, or (d) percolate into the ground water system and thereby be lost to the surface water system. If Item (d) is considered negligible, the moisture input may be divided into:

(1) Runoff
(2) Soil moisture increases
(3) Evapotranspiration losses

Runoff. The percent of total moisture input (MI) available for runoff is found from empirically derived relationships of soil moisture index (SMI) versus runoff percent (ROP). If desired, input (MI) intensity (inches per hour) may be included as a third variable in the SMI-ROP relationship. Figure 2-5 illustrates typical SMI relationships with and without the precipitation intensity parameter.

The total generated runoff for a period (RGP) is computed as follows:

$$RGP = ROP * MI$$

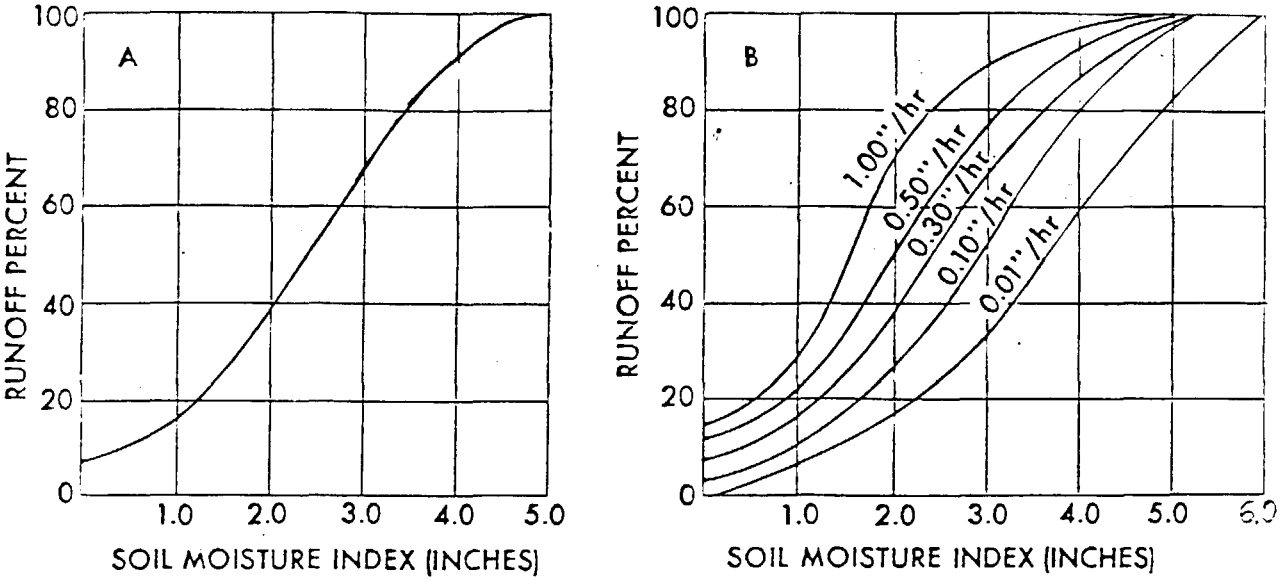
where:

RGP = Generated runoff for the period, in inches

ROP = Runoff percent (from SMI table)

MI = Moisture input from snow pack or precipitation for the period, in inches.

The partitioning of RGP into the components of surface, subsurface, and base flow runoff is described in subsequent sections.



A. SMI vs. RUNOFF PERCENT

B. SMI vs. PRECIPITATION INTENSITY AND RUNOFF PERCENT

FIGURE 2-5. SOIL MOISTURE INDEX (SMI)

Soil Moisture - Evapotranspiration Relationships. The soil moisture index (SMI) is an indicator of the relative soil wetness and is used to determine runoff. When the soil moisture is depleted to approximately the permanent wilting point, the SMI is a small number which yields little or no runoff. When precipitation recharges soil moisture, the value of the SMI increases until it reaches a maximum value considered to represent its field capacity or water holding capacity. At this value, the runoff percent would approach 100 percent. The SMI is depleted only by the evapotranspiration index (ETI).

SMI is calculated as follows:

$$SMI_2 = SMI_1 + (MI-RGP) - \frac{PH * ETI}{24}$$

where

SMI_1 = Soil Moisture Index (in inches) at beginning of period

SMI_2 = Soil Moisture Index (in inches) at end of period

PH = Compute Period Length in hours

ETI = Evapotranspiration Index, in inches per day

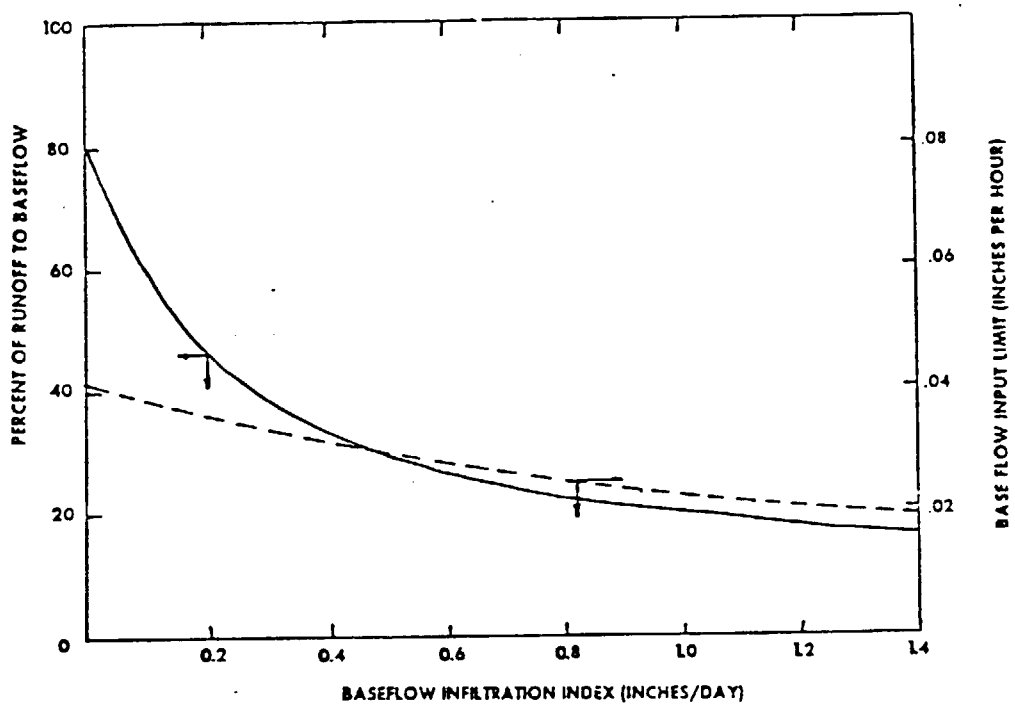


FIGURE 2-6. BASEFLOW INFILTRATION INDEX (BII) vs. BASEFLOW PERCENT (BFP)

Base Flow. The generated runoff (RGP) for a period is separated into the input to four zones of temporary storage delay to runoff. RGP is first divided into the base flow component and the direct component. The base flow component represents the storage effect to flow that reaches the underlying aquifers and deep groundwater. The portion of runoff that contributes to base flow is a function of the base flow infiltration index (BII). Base flow infiltration index may be thought of as an index of depression storage, which holds runoff available for deep percolation. The base flow components are computed as the product of Base Flow Percent (BFP) and Runoff Rate (RG). The BII versus base flow percent (BFP) table may have a third element, a base flow input limit, which is specified in inches per hour. With this option, each tabled value of BII must have a corresponding BFP value and a base flow input limit value.

The base flow infiltration index is computed for each period as follows:

$$BII_2 = BII_1 + (24^* \ RG - BII_1) * \frac{PH}{BIITS + PH/2}$$

IF BII_2 is greater than BIIMX, set BII_2 to BIIMX.

where

BII_1 = Base Flow Infiltration Index (in inches per 24 hours) at beginning of period.

BII_2 = Base Flow Infiltration Index (in inches per 24 hours) at end of period.

RG = RGP/PH = Runoff rate in inches per hour.

BIITS = Time delay or time of storage, for calculation of change in BII. Typical values range from 30 to 60 hours.

BIIMX = Maximum value for BII.

The total base flow input rate is a function of BII:

TBF = BFP * RG

IF TBF is greater than BFLIM, set TBF to BFLIM.

where

TBF is the input rate, inches per hour, to the Baseflow and Lower zone routing components.

BFP is total baseflow percent; a function of BII via a relation like that shown in Figure 2-6.

RG is Runoff rate.

BFLIM may be a constant, or the BII vs. BFP relation may contain BFLIM as the second dependent variable.

The BFLIM rate can be somewhat dependent on the length of the compute period. Short compute periods such as 1 hour, 3 hours, or 6 hours, may generate some relatively high hourly rates of input from normal melt and precipitation events in the higher latitudes; while daily (24 hour) compute periods tend to keep the intensity levels lower due to averaging the storms over a longer period. A typical value for BFLIM for daily calculations is .05 inches per hour. This may be too low for a model running 6 hour compute periods.

Lower Zone Flow. The baseflow components of runoff are a long term part called "lower zone" and a shorter term part called "baseflow." The separation of input to these two components is by percentage (PBLZ):

LZ = TBF * PBLZ

If LZ greater than DGWLIM, then set LZ to DGWLIM.

where

LZ is input rate in inches per hour to lower zone routing component.

TBF is "total baseflow" plus "lower zone" input rate.

PBLZ is percentage of total baseflow going to lower zone routing. A typical value is 50%.

DGWLIM is maximum input rate to lower zone routing, a constant. The effect of this variable has not been investigated; if DGWLIM equals BFLIM, it is effectively removed from consideration.

This component gives the watershed model the capability of reproducing the late summer, fall and winter groundwater recession. This represents a sizeable quantity in much of the Pacific Northwest. In the rather volcanic North Santiam basin of western Oregon, the "lower zone" runoff averaged 16 inches of the total water year runoff of 71 inches during the six year study period.

Baseflow Flow. Input to the baseflow component of routing is the remainder of the total base flow input (TBF):

BF = TBF - LZ

where

BF is input to baseflow routing, in inches per hour.

Surface and Subsurface Runoff Components. The surface part of generated runoff for the period (RGP) is divided into input to surface routing and subsurface routing. Surface storage routing represents the storage effect of the upper zones of the soil mantle, and subsurface routing represents the storage effect of the middle aquifers. The input to surface and subsurface runoff (RGS) is computed as follows:

RGS = RG - TBF

Surface - Subsurface Flow Separation. A table of surface runoff input (RS) versus total input to surface and subsurface runoff (RGS) may be provided. An example of surface - subsurface separation is illustrated in Figure 2-7.

Any relationship may be specified in the table, but the separation commonly used is based on the following assumptions:

a. The minimum surface component (RS) is 10% of the total generated runoff (RGS).

b. The subsurface flow component reaches a maximum (KSS) and remains constant for input rates (RGS) above 200% of KSS.

c. Values commonly used are determined from the following equations:

$$RS = [0.1 + 0.2\ (RGS/KSS)]\ \ RGS$$

and

$$\text{IF } RS > KSS,\ RSS = KSS$$

where

RS = Surface component input rate

RSS = Subsurface component input rate

RGS = Total input rate to surface and subsurface components

KSS = Maximum subsurface input rate

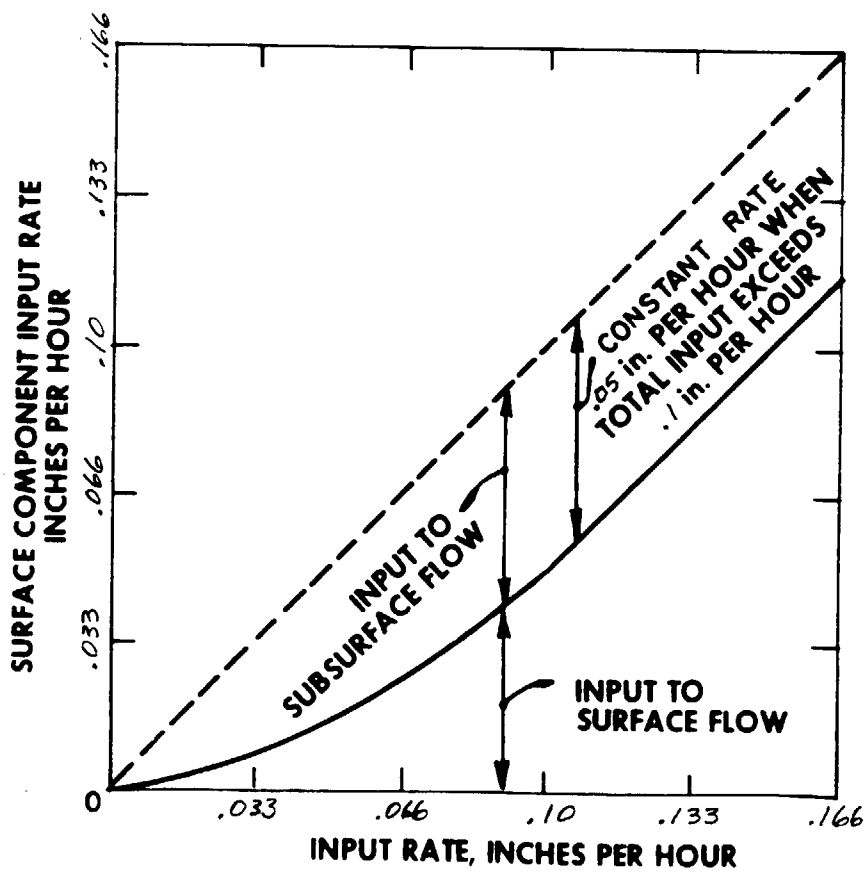


FIGURE 2-7. SURFACE - SUBSURFACE SEPARATION

Routing of Surface, Subsurface, Baseflow and Lower Zone. Each component of runoff excess is computed as an input rate, expressed in inches per hour. Each period value is converted to the equivalent inflow rate, in cubic feet per second, based on the drainage area of each snowband. Once the individual snowbands have all been processed through the entire range of compute periods, the results are summarized to arrive at basin values of input to surface, subsurface, baseflow, and lower zone routing components for each compute period.

Each component is routed through a specified number of increments of storage. These increments can be considered as a series of small lakes which delay runoff.

The modification of the inflow to represent the shape of the outflow hydrograph is determined by the specified number of increments, or routing phases, and time of storage per increment. Routing is accomplished by solution of the basic storage equation in finite time periods for each increment of storage routing. Inflows are computed as mean values for the period for watershed routing.

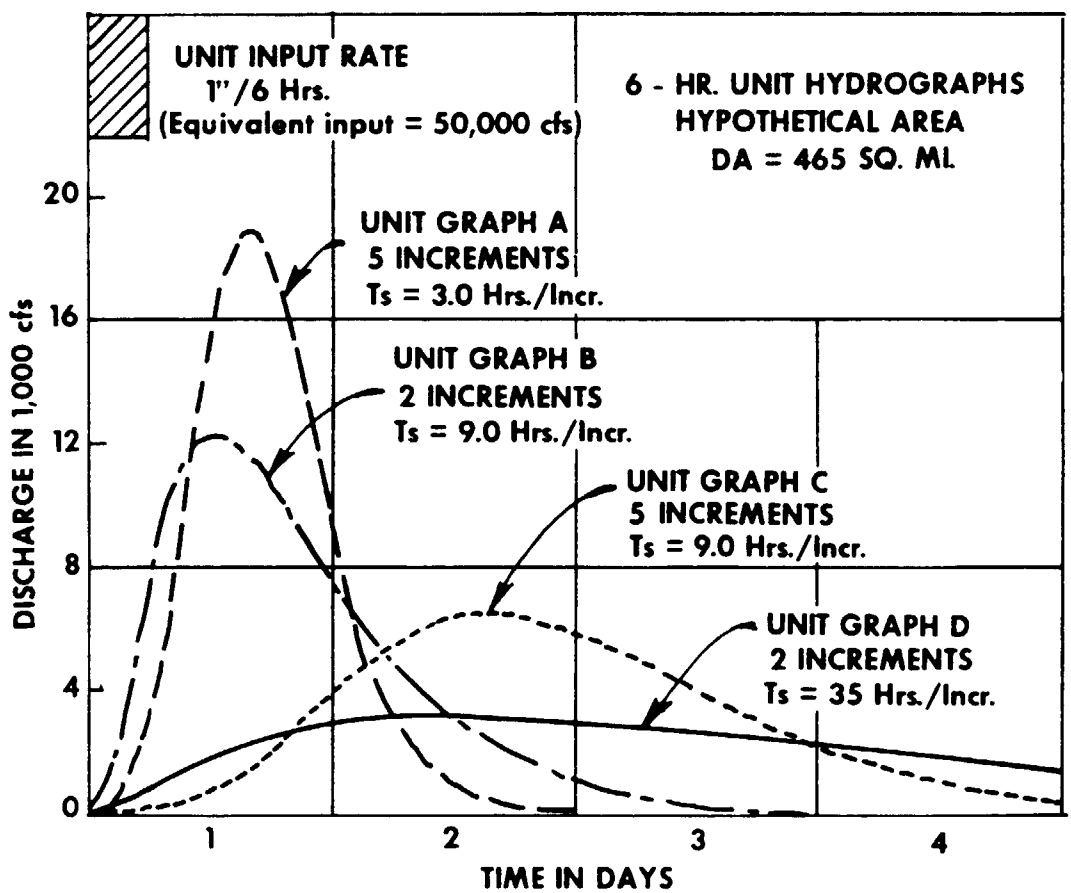


FIGURE 2-8. UNIT HYDROGRAPHS DERIVED BY SSARR ROUTING

Generally, two to five increments are used in typical drainage basins. The "time of storage" per increment can be from a few hours to a month or more. The routing specifications determine the time delay to the outflow point of the watershed and, to a large extent, the shape of the outflow hydrograph. Typical routing specifications for the four components of flow for a 208-square mile watershed in the Willamette River Basin, Oregon, are listed below:

Component of Runoff	No. of Phases	Time of Storage per Phase (Hrs)	Total Time of Storage (Hrs)
Surface	4	2.5	10
Subsurface	3	11.0	33
Baseflow	2	200.0	~400
Lower Zone	2	2000.0	~4000

Examples of several unit hydrographs derived by this method are shown in Figure 2-8.

DEPLETION-CURVE WATERSHED MODEL

This watershed model is conceptually unchanged from that described in the 1975 version of the SSARR User Manual.[1/] Data processing aspects of the program have been updated, such as the addition of new techniques for hydromet data input and management, initial condition editing and adjustment, and naming conventions allowing the use of alphabetic names in addition to numbers to identify catchments, relationships, and gages. But the model simulation calculations are the same as those in the 1975 version (SSARR-4) and characteristics and relations prepared for SSARR-4 are compatable with SSARR-8.

The "Depletion-Curve" model is so named because its principle snowmelt algorithm is based on a snow-covered area depletion curve. The option to accumulate snow (the so-called "snowband option"of the "Depletion-Curve" model) was the forerunner to the development of the Integrated-Snowband model. The "snowband option" in the Depletion Curve model includes no snow conditioning algorithms and is cumbersome to manage; hence the development of the Integrated-Snowband model described previously (see Page 10).

The rain-runoff simulation of the Depletion Curve model is completely incorporated into the Integrated-Snowband model so that characteristics that have been calibrated for the Depletion Curve model for a rain-only basin may be converted to Integrated-Snowband model format with little recalibration. However, the depletion-curve approach to snowmelt simulation is unique to the Depletion Curve model.

Figure 2-9 depicts the major elements of the Depletion-Curve model. The following discussion describes the rainfall-runoff simulation first, and then describes the snowmelt options:

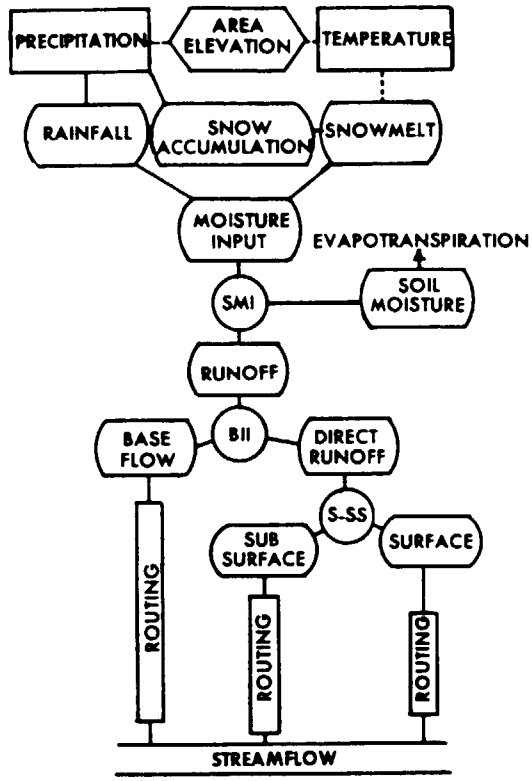


FIGURE 2-9. DEPLETION-CURVE WATERSHED MODEL

PRECIPITATION INPUT FOR DEPLETION-CURVE MODEL

Station Weighting. Precipitation on a watershed may be computed from period precipitation amounts at one or more stations as follows:

$$WP_n = (P_1 * W_1 + P_2 * W_2 + \text{———} P_n * W_n)/n \qquad (6)$$

where

$P_1, P_2 \ldots P_n$ = Period precipitation amounts at Stations 1, 2, ...n respectively, in inches.

$W_1, W_2 \ldots W_n$ = Weights applied to the station precipitation.

n = Total number of stations; a maximum of 30 stations may be used for any one watershed.

WP_n = Weighted period Net Watershed Precipitation inches.

Weights must be determined by the user and specified to the computer. Stations weights are usually calculated on the basis of either percent of area indexed by the station using Thiessen Polygons, or by a ratio of normal annual precipitation of that portion of the basin to normal annual precipitation of the index station.

Precipitation may be entered as input for any time period available to the user (from 0.1 to 24 hour values). Daily amounts can be distributed as determined by the user, as described in the next paragraph.

Periodic Distribution. The period distribution routine provides that daily precipitation can be distributed over eight three-hour periods. It is not necessary to specify a percentage in each three-hour period, but the total of all eight periods normally equal 100 percent. The net weighted precipitation distributed for a period is determined as follows:

$$WP_d = WP_n * DIST$$

where

WP_d = Weighted net precipitation distributed for a given period, in inches.

DIST = The percentage of the daily precipitation for that period, in percent.

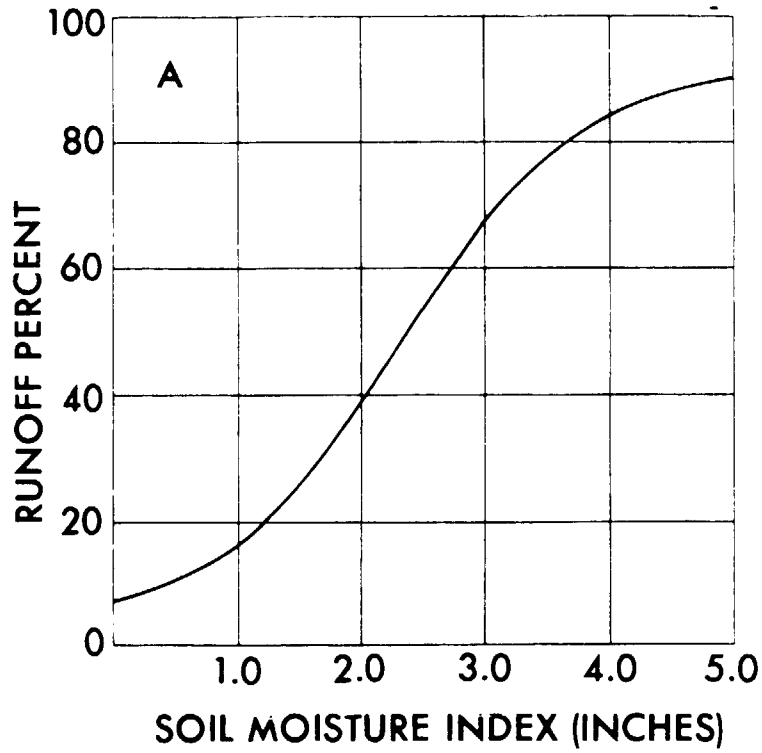
When the distribution routine is not specified, the computer uses the actual period values.

SOIL MOISTURE - RUNOFF RELATIONSHIPS IN THE DEPLETION-CURVE MODEL

Rain falling on a watershed must either (a) runoff, (b) be retained in the soil system, (c) be intercepted and evaporated from trees and other plants, (d) evaporate from ponds, lake and stream surfaces, (e) evaporate from the soil, (f) return to the atmosphere by transpiration from trees and other plants, or (g) percolate into the ground water system and thereby be lost to the surface water system. If Item (g) is considered negligible, the rainfall input may be divided into:

(1) Runoff
(2) Soil moisture increases
(3) Evapotranspiration losses

Runoff. The percent of total rainfall input available for runoff is found from empirically derived relationships of soil moisture index (SMI) versus runoff percent (ROP). If desired, rainfall intensity (inches per hour) may be included as a third variable in the SMI-ROP relationship. For a particular basin, the SMI relationship is entered into the program in the form of a table. Figure 2-10 illustrates typical SMI relationships with and without the precipitation intensity parameter.



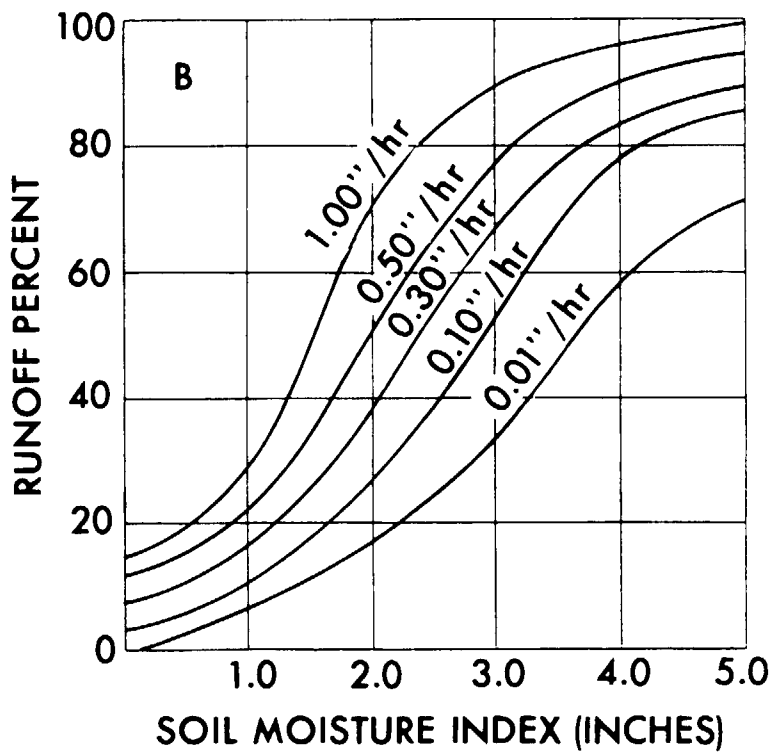


FIGURE 2-10 Soil Moisture Index (SMI): A. Two Variable Relationship, SMI vs. Runoff Percent. B. Three Variable Relationship, SMI vs. Precipitation Intensity vs. Runoff Percent

The total generated runoff for a period (RGP) is computed as follows:

$$RGP = ROP * (WP_n \text{ or } WP_d)$$

where

RGP = Generated runoff for the period, in inches

ROP = Runoff percent (from SMI table)

WP_n or WP_d = Weighted net precipitation or distributed net precipitation, for the period, respectively, in inches

The partitioning of RGP into the components of surface, subsurface, and baseflow runoff is described in subsequent sections.

Soil Moisture - Evapotranspiration Relationships. The soil moisture index (SMI) is an indicator of the relative soil wetness and is used to determine runoff. When the soil moisture is depleted to approximately the permanent wilting point, the SMI is a small number which yields little or no runoff. When precipitation recharges soil moisture, the value of the SMI increases until it reaches a maximum value considered to represent its field capacity or water holding capacity. At this value the runoff percent would approach 100 percent. The SMI is depleted only by the evapotranspiration index (ETI). The ETI can be specified either in table form as month versus average daily potential evapotranspiration (inches per day), or as weighted daily pan evaporation data (inches per day) at one or more stations.

The table form of average monthly values of ETI is usually used when pan evaporation or other estimates on a day-to-day basis are not available, or when evapotranspiration amounts are not hydrologically significant. When monthly ETI values are used, the SMI is calculated at the end of each period as follows:

$$SMI_2 = SMI_1 + (WP-RGP) - \frac{PH}{24} * KE * ETI$$

where

SMI_1 = Soil Moisture Index (in inches) at beginning of period

SMI_2 = Soil Moisture Index (in inches) at end of period

PH = Period Length in hours

ETI = Evapotranspiration Index, in inches per day

KE = A factor for reducing ETI on rainy days, specified to the computer in a table of KE versus rate of precipitation in inches per day.

For zero precipitation, KE is 1.0 and SMI will be reduced during the period by the constant factor PH/24 * ETI. When the rainfall not contributing to runoff exceeds the adjusted evapotranspiration quantity, the soil moisture index will increase. As rainfall occurs, the amount of soil water depleted by ETI diminishes in accordance with the KE relationship. A typical KE curve is shown in Figure 2-11.

When accurate accounting of soil moisture changes is required, daily ETI calculations can be made by entering daily evaporation data (such as pan evaporation) into the program. Daily estimates of ETI are desirable over monthly indices in arid and semi-arid basins where evapotranspiration losses are high in relation to precipitation input. Daily ETI values are calculated from pan evaporation data from one or more stations as follows:

$$ETI_d = (ETI_1 * Wt_1 \ldots ETI_n * Wt_n)/n$$

where

ETI_d	=	Weighted daily evapotranspiration index (inches)
$ETI_1 \ldots ETI_n$	=	Pan evaporation amounts (inches per day) for each station
$Wt_1 \ldots Wt_n$	=	Weighting percentages for the respective pan evaporation stations to approximate actual evapotranspiration

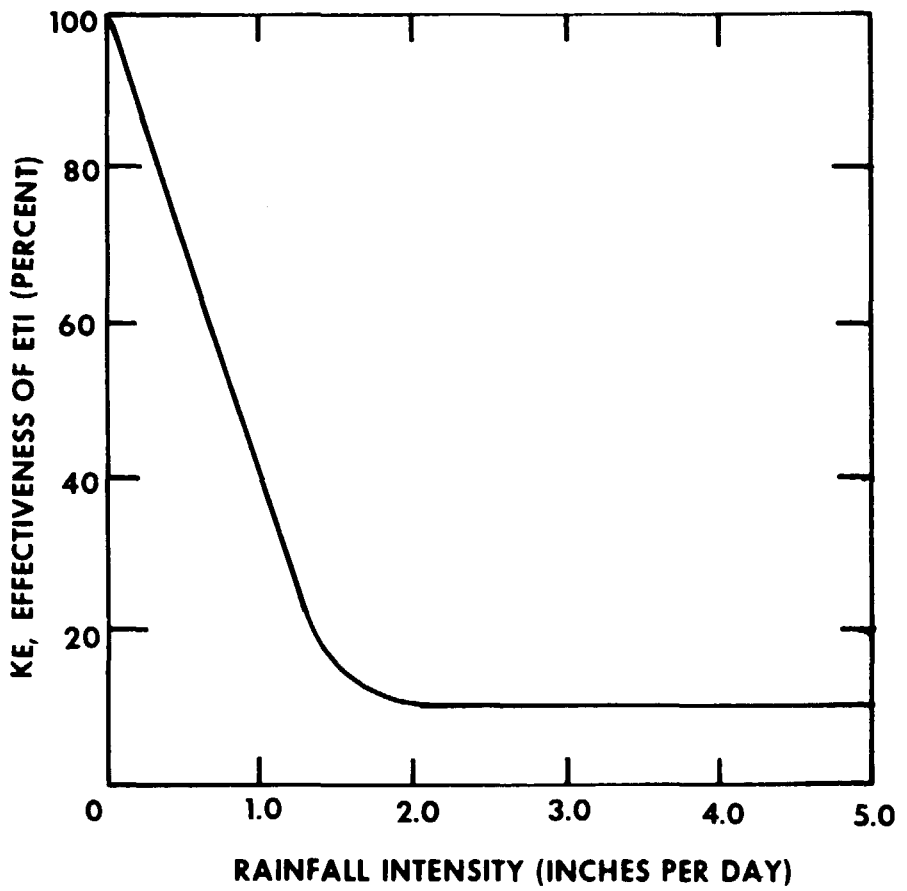


FIGURE 2-11. EXAMPLE OF KE vs RAINFALL INTENSITY RELATION

The weighted ETI (ETI_d) can be distributed over eight periods per day as previously described for precipitation.

The effects of rainfall on ETI are inherent to the daily pan evaporation data. Therefore, the SMI calculation used with daily ETI input is:

$$SMI_2 = SMI_1 + (WP - RGP) - (DKE * ETI_d)$$

where

DKE = A factor for reducing the daily ETI when soil moisture becomes depleted.

When soil moisture is adequate, DKE = 1.0, and the ETI approximates potential evapotranspiration. As the soil dries, DKE (percentage of ETI) diminishes, as illustrated in Figure 2-12.

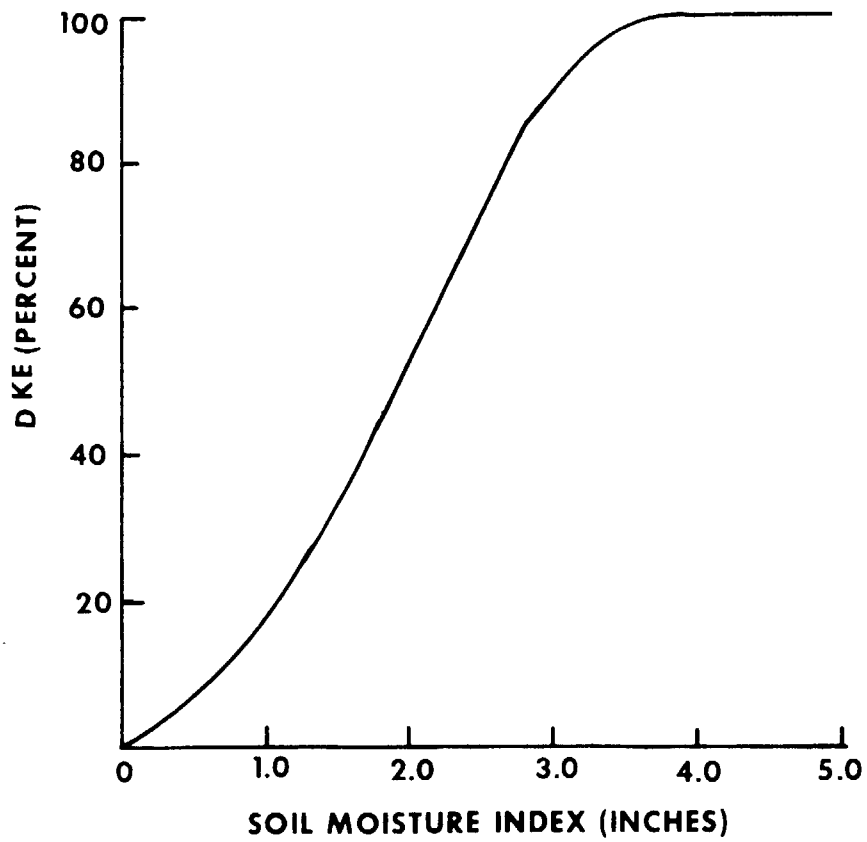


FIGURE 2-12 EXAMPLE OF DKE (PERCENT EFFECTIVE ETI) VS. SMI FOR USE WITH DAILY ETI INPUT

The daily ETI option cannot be used simultaneously with snowmelt calculations. Therefore, when snowmelt calculations are required, ETI input must be entered in table form as month versus ETI (inches per day).

BASE FLOW (DEPLETION-CURVE MODEL)

The portion of runoff that contributes to base flow is a function of the base flow infiltration index (BII). A relationship is provided to the computer as a continuous function in the form of a table (see Figure 2-6 on Page 21). The BII versus base flow percent (BFP) table may have a third element, a base flow input limit, which is specified in inches per hour. With this option, each tabled value of BII must have a corresponding BFP value and a base flow input limit value.

The base flow infiltration index is computed for each period as follows:

$$BII_2 = BII_1 + (24^* RG - BII_1) \frac{PH}{TSBII + PH/2}$$

where

BII_1 = Base Flow Infiltration Index (in inches per 24 hours) at beginning of period

BII_2 = Base Flow Infiltration Index (in inches per 24 hours) at end of period

RG = RGP/PH = Runoff rate in inches per hour

TSBII = Time delay or time of storage, for calculation of change in BII. If desired, separate time of storage values may be designated for rising and falling flows. Typical values range from 30 to 60 hours.

Base flow infiltration index may be thought of as an index of depression storage, which holds runoff available for deep percolation. The base flow component is computed as the product of Base Flow Percent (BFP) and Runoff Rate (RG). The input to surface and subsurface runoff (RGS) is computed as follows:

$$RGS = RG\ (1.0 - BFP)$$

SURFACE - SUBSURFACE FLOW SEPARATION (DEPLETION-CURVE MODEL)

A table of surface runoff input (RS) versus total input to surface and subsurface runoff (RGS) is specified to the computer for a particular basin. An example of surface - subsurface separation is illustrated in Figure 2-7, Page 24. Any relationship may be specified in the table, but the separation commonly used is based on the following assumptions:

The minimum surface component (RS) is 10% of the total generated runoff (RGS).

The subsurface flow component reaches a maximum (KSS) and remains constant for input rates (RGS) above 200% of KSS.

Values commonly used are determined from following equations:

$$RS = [0.1 + 0.2\ (RGS/KSS)]\ RGS$$

and

$$IF\ RS > KSS,\ RSS = KSS$$

where

RS = Surface component input rate, (inches per hour)

RSS = Subsurface component input rate, (inches per hour)

RGS = Total input rate to surface and subsurface components, (inches per hour)

KSS = Maximum subsurface input rate, (inches per hour)

ROUTING OF SURFACE, SUBSURFACE, AND BASE FLOW (DEPLETION-CURVE MODEL)

Each component of runoff excess to surface, subsurface, and base flow are computed as input rates, expressed in inches per period. Each period value is converted to the equivalent inflow rate, in cubic feet per second, based on the drainage area and the length of the period, in hours. Each component of inflow is routed through a specified number of increments of storage. These increments can be considered as a series of small lakes which delay runoff.

The modification of the inflow to represent the shape of the outflow hydrograph is determined by the specified number of increments, or routing phases, and time of storage per increment. Routing is accomplished by solution of the basic storage equation in finite time periods for each increment of storage routing. Inflows are computed as mean values for the period of watershed routing.

Generally, three to five increments are used in typical drainage basins. The "time of storage" per increment can be from a few hours to a month or more. The routing specifications determine the time delay to the outflow point of the watershed and, to a large extent, the shape of the outflow hydrograph. Typical routing specifications for the three components of flow for a 208-square mile watershed in the Willamette River Basin, Oregon, are listed below:

Component of Runoff	Number of Phases	Time of Storage Per Phase (Hours)
Surface	4	2.5
Subsurface	3	11.0
Baseflow	2	200.0

Examples of several unit hydrographs derived by this method are shown in Figure 2-8, Page 25.

COMPUTATION OF SNOWMELT IN THE DEPLETION-CURVE MODEL

Methods. The calculation of snowmelt with the SSARR "depletion" model can be accomplished by either the temperature index approach or the use of the generalized snowmelt equation for a partly forested area.[2/] The temperature index method is commonly used for a daily forecast operations, whereas the more detailed energy budget approach of the generalized snowmelt equation may be more appropriate for design flood derivations.

Temperature Index Method. The temperature index method is more widely used in operational hydrology because of the lack of energy budget data on a real-time basis. In most cases, air temperatures are the only day-to-day data available for snowmelt computations. Also, air temperature is a simple index that provides good estimates of snowmelt for forested areas.[2/]

Temperature data (usually mean daily or maximum daily) can be input for one or more stations for each watershed as specified by the basin characteristic data. Each temperature station is weighted as with precipitation stations. The weighted temperatures for each computation period are then averaged as follows:

$$T_a = [T_1 * W_1 + \ldots T_n * W_n]/n$$

where

T_a = Average temperature for the stations

$T_1 \ldots T_n$ = Period temperatures for each station (^oF)

$W_1 \ldots W_n$ = Respective station weighting factors

n = Number of stations

The average elevation of the temperature stations (E_s) is also calculated. The station average temperature (T_a) is then lapsed from E_s to the mean elevation of the snowmelt zone. The zone of snowmelt is that portion of the snowpack below the elevation of the base temperature and above the snowline. The elevation of base temperature (E_b), or the melting elevations, is calculated by:

$$E_b = E_s + (T_a - T_b)/LR$$

where

E_s = Average elevation of temperature stations (ft.)

T_b = Base temperature, specified as a constant for a watershed (^oF)

LR = Lapse rate, specified as a constant in ^oF per 1,000 feet: Default is $3.3^oF/1000$ feet.

Snowmelt runoff (M) in inches for the snow covered area is calculated for the temperature index method as follows:

$$M = (T_A - T_b) * R * PH/24$$

where

T_A = Period temperature at the median elevation of the melting snowpack (^oF)

T_b = Base temperature (^oF)

R = Melt rate, specified to the computer, or given as a function of accumulated runoff, in inches of water per degree day

PH = Period length in hours.

Values for base temperature and melt rates can be adjusted to conform to either mean daily or maximum daily temperature data. Melt rates are variable during the snowmelt season and can be specified for each day. If desired, the melt rate may be specified only for beginning and ending days, or for critical intermediate periods (depending upon availability of data). Linear interpolation by the computer provides values for the days not specified. Melt rates can be specified in a table as a function of accumulated seasonal runoff, which enables the user to "condition" the snowpack. Experience is required, however, to estimate when the snowpack becomes "ripe". Examples of melt calculations with the temperature index method are described in Appendix C.

Generalized Snowmelt Equation. The generalized snowmelt equation provides an energy budget approach to compute snowmelt for a watershed. This procedure is usually used for design flood derivations and reconstitution studies when adequate data are available. The equation used by the model is:

$$M = k'(1-F)(0.0040\ Ii)(1-a) + k(0.0084v)\ (0.22T'_a + 0.78\ T'_d) + F(0.029\ T'_a)$$

where

M = Snowmelt rate in inches per day

T'_a = Difference between the air temperature measured at 10 feet above the snow surface and the snow surface temperature in degrees Fahrenheit (^oF), the snow surface temperature is assumed to be 32^oF

T'_d = Difference between the dewpoint temperature measured 10 feet above the surface of the snow and the temperature of the snow surface (32^oF)

v = Wind velocity at 50 feet above the snow, in mile per hour

Ii = Solar radiation on a horizontal surface, langleys

a = Average snow surface albedo expressed as a decimal

k' = Basin shortwave radiation melt factor, expressed as a decimal

F = Average forest canopy cover, expressed as a decimal

K = Convection-condensation melt factor, expressed as a decimal

The above equation is applicable only for partly forested areas.

An example of the application of the generalized snowmelt equation is presented in Appendix C.

Period Distribution of Snowmelt. When snowmelt runoff is occurring, there is a diurnal fluctuation of heat supply for melting snow, and a consequent diurnal fluctuation in water input from snowmelt. (an exception may be in deep, "fresh" snowpacks, where melt water may not reach the ground surface until successive melt periods).

Although temperature and other hydrologic conditions vary continuously throughout the day, mean daily values are often used because detailed data are not available. A provision has been made in the program to compute daily snowmelt and to distribute the daily values of melt into 3, 6, or 12 hour periods. Any distribution may be specified. Typical daily distributions of snowmelt are discussed in paragraph 9-04 in "Runoff from Snowmelt", 6/ and a sample distribution is illustrated below:

Period Hours	Percentage of Daily Snowmelt
0000-0300	6
0300-0600	4
0600-0900	3
0900-1200	5
1200-1500	18
1500-1800	30
1800-2100	22
2100-2400	12
	100

These values represent the portion of the daily snowmelt quantity that reaches the snow-ground interface, and include the delay of liquid water in traveling through the snowpack.

Daily Total Moisture Input. The computed snowmelt for each period is combined with rainfall to provide the total water input for runoff computations. Rainfall contributes to runoff below the rain-freeze elevation (E_{rf}) which is determined as:

$$E_{rf} = E_s + (T_a - T_{rf})/LR$$

where

E_s = Average elevation of temperature stations (ft)

T_a = Average temperature for the stations (°F)

T_{rf} = Rain-freeze temperature, specified as a constant for a watershed (°F)

LR = Lapse rate, °F per 1,000 ft

The area of the watershed below E_{rf} is then determined from the area- elevation relationship specified for the watershed.

WATERSHED-SNOWMELT OPTIONS IN THE DEPLETION-CURVE MODEL

In addition to the two methods of calculating snowmelt, two options are available to evaluate the snowpack characteristics in a watershed. The first option describes the snow covered area-runoff relationships of a watershed utilizing a snowcover depletion function. The second option provides the capability to subdivide a watershed into elevation bands each of which are treated separately with respect to snow accumulation and melt.

Snowcover Depletion. One of the prime variables in computing daily snowmelt runoff is the area of snowcover. The snowcovered area for a watershed is observed only occasionally, if at all. Nevertheless, rational snowmelt determination requires that the snowcovered area be evaluated continuously. Studies of snowcover indicate that in the mountainous areas of the western United States, snowcover depletion during the active snowmelt period can be expressed as a function of accumulated generated runoff in percent of seasonal total.[2/] The general shapes of curves relating snowcover (expressed in percent of watershed area) to generated runoff are fairly uniform for different watersheds and from year to year. The computer program computes snowcover depletion in accordance with the relationship specified in table form. The general shape of these functions are described in "Snow Hydrology" 2/ and are expressed as the following equation:

$$\frac{SCA}{100} = 1.0 - \left(\frac{Qgen}{100}\right)^n$$

where

SCA = Snowcovered area in percent of total watershed area

Qgen = Accumulated generated runoff from snowmelt, in percent of seasonal total

n = Parameter expressing characteristic of snowcover depletion for a watershed

Figure 2-13 illustrates a typical snowcover depletion curve. At the beginning of a particular computer run, the initial snowcovered area, a total seasonal generated runoff, and initial accumulated runoff are specified by the user. The program uses these specified values to compute the initial percent of accumulated generated runoff. From this initial percent of accumulated runoff, the program determines the ratio (Rsc) of the actual initial snowcovered area to the theoretical snowcovered area determined from the curve. In this example, Rsc is approximately 60/85. The daily increment of computed snowmelt, converted to basin inches on the basis of that day's snowcover, is added to the initial generated runoff. The incremented generated runoff is then used to determine the next day's snowcover, by applying the values of Rsc to the theoretically computed snowcover. This process is continued by daily increments throughout the computation period, and results in a computed snowcover depletion curve which is proportional to the theoretically shaped curve.

In mountainous watersheds, the differentiation between snowcovered and snow free areas is represented by a "snow line" which usually follows an elevation contour. The area above the snow line elevation is assumed to be completely snowcovered and the area below is assumed snowfree. Snowmelt occurs on that portion of the basin lying above the snow line and below the melting level. The decreasing snowcovered area, associated with the retreat of the snow line, is then computed on a day-to-day basis by use of the snowcover depletion curve.

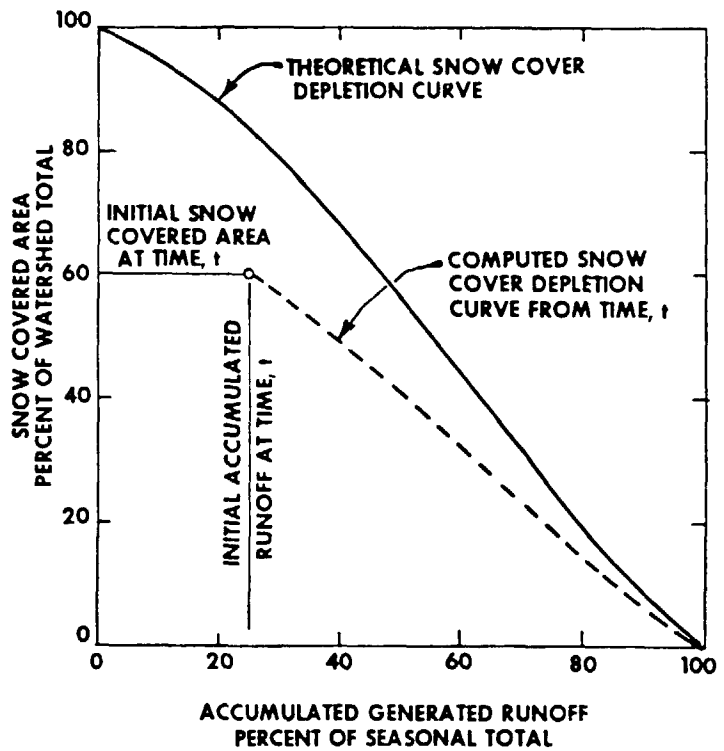


FIGURE 2-13. SNOW COVER DEPLETION CURVE

New snow is not automatically compensated for in the snowcover depletion relationship. The user has the option to specify snowcover values at any time during the computations. If snowcover values are input as data, the snowcover depletion routine becomes inoperative. Furthermore, the snowcovered area can be specified for a particular day or days and yet allow the snowcover depletion routine to operate on those days not specified. This provision allows the user to make adjustments for increases in snowcovered area resulting from new snow. In many cases, including most of the Columbia River Basin, new snow during the active melt season is negligible.

Two program options are available within the snowcover depletion option for analysis of runoff from rainfall as related to snowcover:

Single Watershed. This is the standard snowcover depletion approach described in the preceding paragraphs. A single index of each of the watershed parameters (SMI, BII, etc.) is maintained for the entire watershed, i.e., for both snowcovered and snowfree areas.

Split Watershed. The snowcovered and snowfree areas are treated as two separate watersheds, each with its own characteristics and parameters. The snowfree area is the complement of the snowcovered area derived from the snowcover depletion function. Since the number of watersheds is doubled, this approach is more cumbersome to use operationally.

The single watershed approach is useful in the early melt season, when the snowfree areas have a high soil water content and thus yield a high percentage of runoff from rainfall. As the snowfree area "dries out", however, rainfall-runoff from the snowfree area is often much less than from the snowcovered area. In such a case, the split watershed approach should be used so that a separate accounting of the soil moisture index is maintained for the snowfree and snowcovered areas. In some instances rainfall-runoff from the snowfree area is negligible; the snowfree area can then be ignored by using the split watershed approach and omitting the characteristics for the snowfree portion. Figure 2-14 illustrates the various hydrologic components and procedures used in the split watershed approach.

Snow Band Option of the "Depletion" Model. A second technique, the snow band option, allows a more quantitative appraisal of the snowpack. With this method, a watershed is subdivided into one or more bands, or zones of relatively equal elevation. An inventory of snow accumulation and melt is maintained on each band. This approach is particularly suited for mountainous watersheds where snow depth increases with elevation. (The newer "Integrated-Snowband" model was developed to make this approach more practical) Runoff from the "Depletion Curve" model band method is determined as follows:

The drainage area is divided by the user into some convenient number of bands (usually elevation-contour bands).

Each elevation band is treated as a separate watershed with its own characteristics and initial snow water equivalent.

Temperature for each time period is lapsed from the index station to the rain-freeze and base temperature elevations.

Precipitation in each period is assumed to fall as snow above the rain-freeze elevation and rain below that elevation. On any one of the bands, precipitation might be all rain, all snow, or a combination of the two.

Rain on a band or part of a band is added directly to moisture input. Snow is added to the previous accumulation, if any.

Accumulated snow is assumed to cover the entire band. Each band must be either snowfree or 100 percent snowcovered.

Temperature (T_a) is lapsed, at either 3.3 degrees per 1,000 feet or at a specified rate, from the mean elevation of the index stations to the median elevation of the melt area of each band. The temperature at which snowmelt begins is the base temperature specified to the computer.

The melt area of a snowcovered band is that area below the base temperature elevation (E_b). This could be all, none, or part of the area in the band.

The quantity of melt is computed by either the temperature index or generalized melt equation.

Moisture input for each band is the sum of snowmelt and rainfall.

Runoff for each band is computed from watershed runoff characteristics developed for that particular band.

Streamflow for the whole basin is found by summing the runoff synthesized for all bands.

The program stores for every elevation band a value for each component of flow and each routing increment. The program maintains an inventory of soil moisture, snow accumulation, and all other values required to make the computation for the next period.

Figure 2-15 illustrates schematically the various conditions of precipitation (rain or snow) and snowmelt that may occur simultaneously on each of the elevation bands (in this case five) representing the entire watershed.

The snow band option described above follows a rational procedure for the accounting of snow accumulation and melt in mountainous areas. Preparation of characteristics and adjustment of initial conditions, however, make this version cumbersome for daily forecasting. For some applications, satisfactory results are obtained by using the elevation band option with only one band. The one band mode would be applicable for watersheds with little topographic relief, or in milder regions where snow may fall in one storm but melts within a few days.

Soil Moisture and Runoff Evaluation. Runoff is computed in the same manner for snowmelt as for rainfall except that snowmelt and rainfall are summed to yield a total moisture input to the watershed on a period or daily basis. The continuity of runoff is maintained individually on each band or subbasin area when watersheds are divided into elevation bands or snowcovered and snow free areas. This provides the capability to evaluate differences in soil moisture and runoff conditions on a zonal basis.

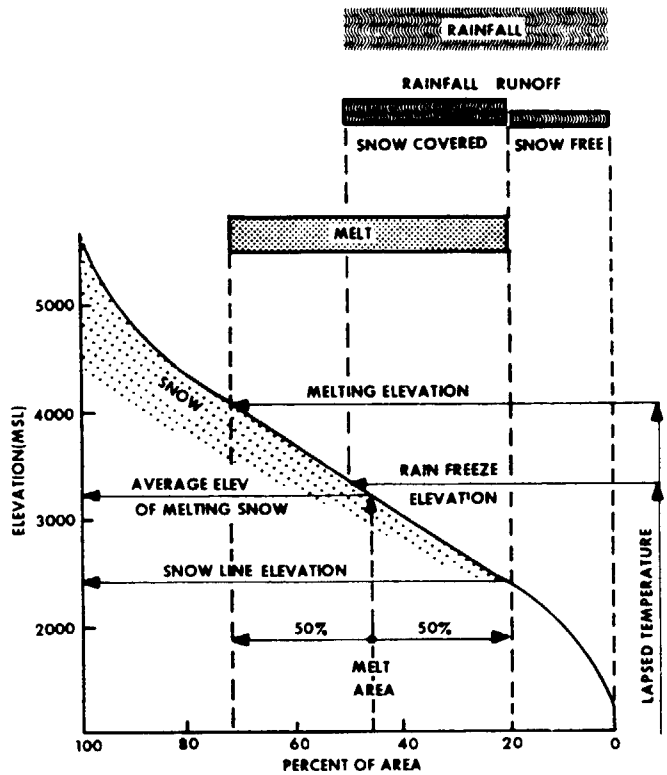


FIGURE 2-14 SPLIT WATERSHED OPTION OF THE SNOW COVER DEPLETION METHOD

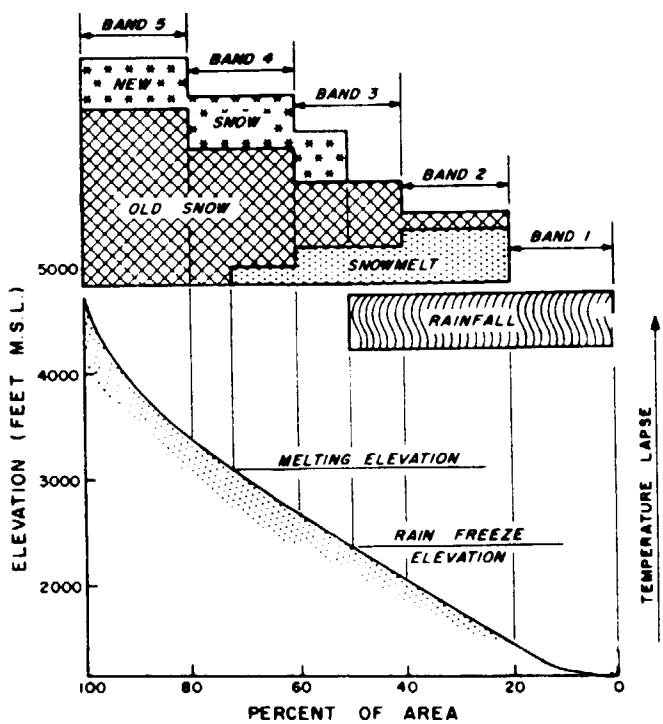


FIGURE 2-15 SNOW-ELEVATION BAND, EXAMPLE OF RAIN, SNOW AND MELT

3. RIVER SYSTEM AND RESERVOIR REGULATION MODEL

The modeling of a river system or a portion thereof, is dependent upon the ability to characterize the hydrologic response of individual watersheds, channel reaches, lakes, and reservoirs, and yet coordinate these responses to simulate the reaction of the system as a whole. The objective of river basin simulation is to be able to predict river flow at various points in the system for any given sequence of climatic events, and any specified reservoir regulation scheme when applicable.

After the hydrological parameters of individual watersheds within the system have been characterized, channel routing characteristics must be developed so that river flow at downstream points of interest can be accurately determined. Often the routing characteristics of a channel reach can be more precisely defined than watershed characteristics because there are fewer "unkowns". Usually, several gaging stations exist from the upper to the lower reaches which allow good estimates of routing times for different streamflows. Also known reservoir outflows within a system enhance the determination of river flow at downstream points.

Frequently the river system model is used without the watershed model for flood control planning and design work. In such applications, historic streamflow data are entered at upstream points and the model is used to route flow through the system.

CHANNEL ROUTING

Proper characterization of channel routing provides an integrated response of river system entities to hydrometerological input. The program allows considerable flexibility to determine routing coefficients which simulate downstream peaks and timing response.

The time rate of change of streamflow in a river reach is evaluated by first dividing the reach into a series of increments or a "chain of lakes". The routing method for each of the "lakes" is described by equation 1.2. Outflow from each increment is used as inflow to the next downstream increment and the step-by-step procedure completed for each increment for each time period. Outflow routed through three such successive increments is illustrated in Figure 3-1.

Time of storage for channel routing increments may be specified in a table of time of storage versus discharge (for such cases as overbank routing), or may vary inversely or directly as a power function of discharge. Normally when flows are confined to the channel, the time of storage decreases as discharge increases, and it is convenient to express the relation from the following equation:

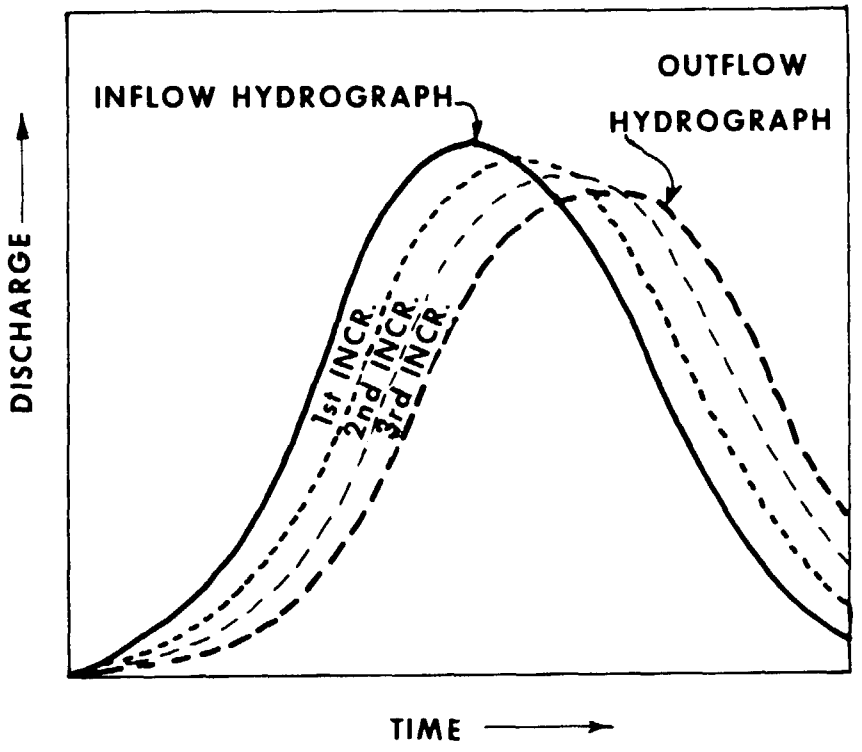


FIGURE 3-1. CHANNEL ROUTING

$$T_S = \frac{KTS}{Q^n}$$

where

T_S = The time of storage per increment in hours.

KTS = A constant determined by trial and error or estimated from physical measurements of flow and corresponding routing times.

Q = Discharge in cubic feet per second.

n = A coefficient usually between -1 and 1.

Figure 3-2 can be used to estimate KTS for a given reach if the average discharge for the reach is known and an n value has been selected.

It is possible to use a negative value of n if time of storage increases as discharge increases. Appendix E describes in detail the relationships and application of the routing equation with positive and negative n values.

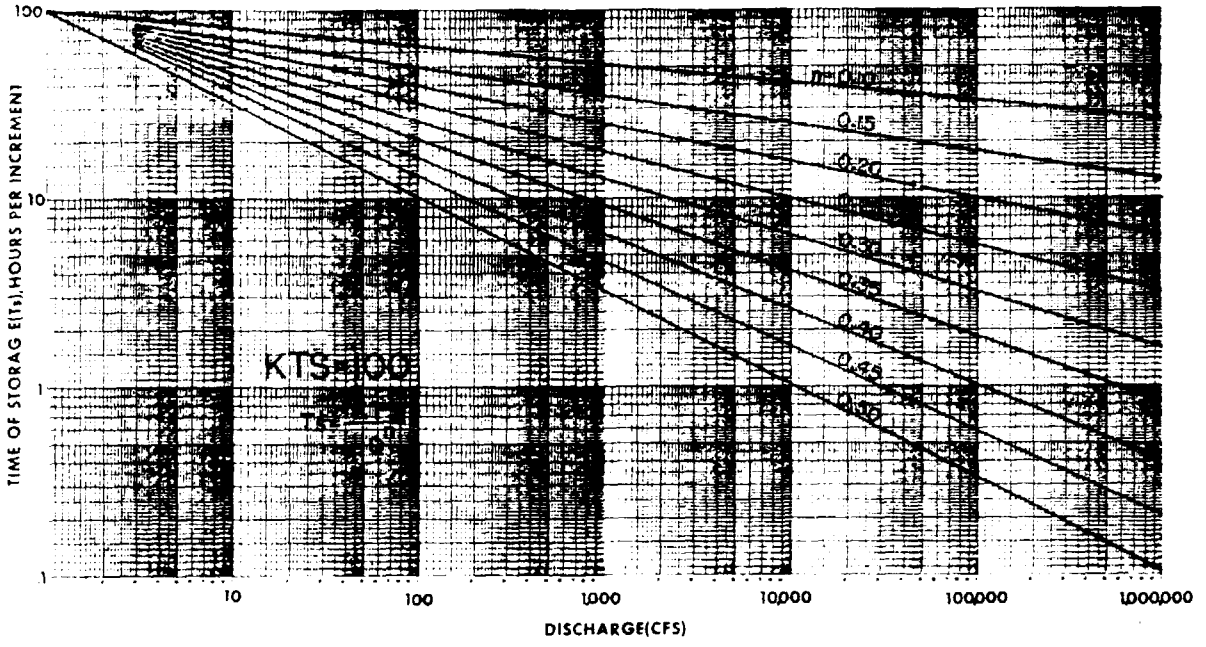
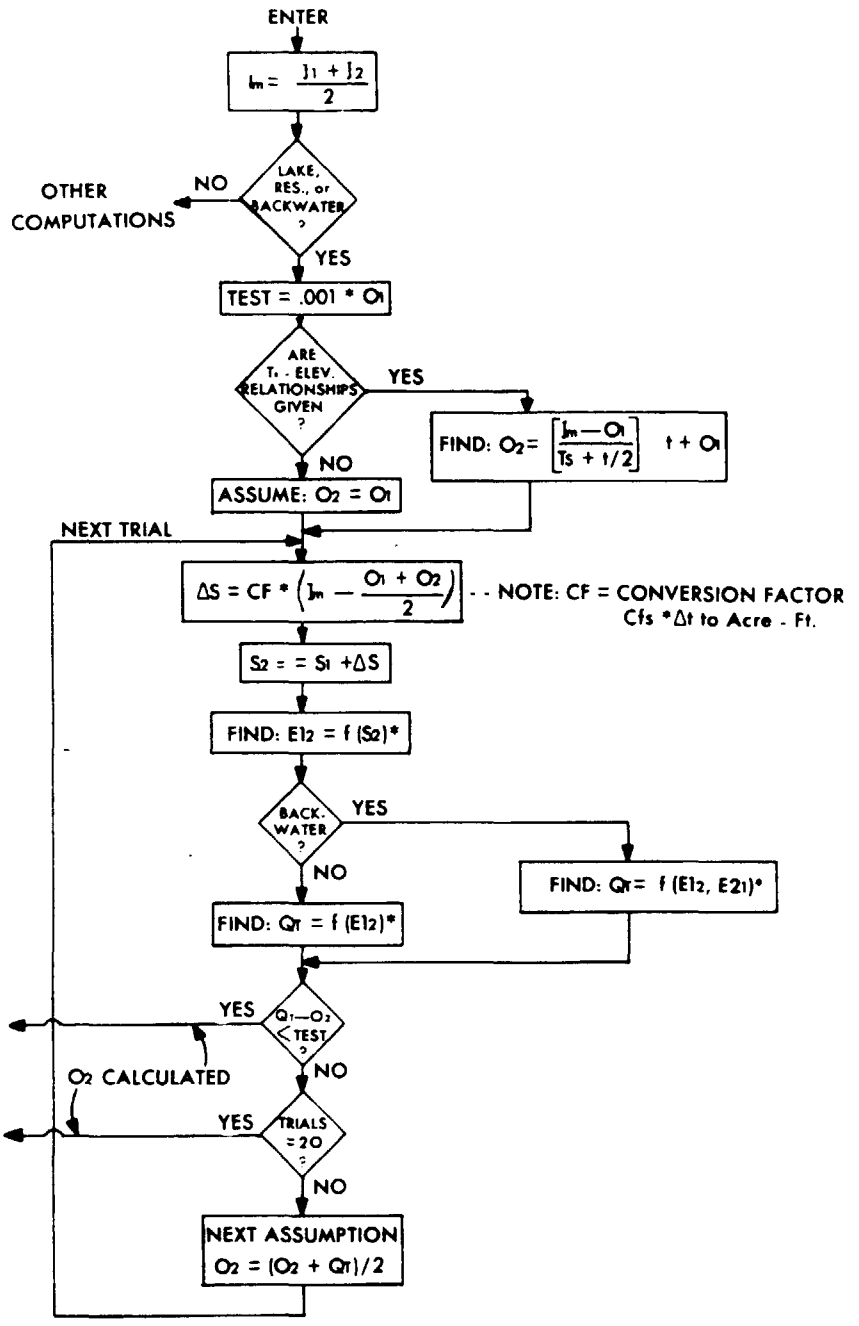


FIGURE 3-2 RELATIONSHIP BETWEEN KTS, DISCHARGE (Q) AND N VALUES FOR KTS EQUAL TO 100

LAKE ROUTING

The routing of flow through natural lake is based on free-flow conditions, i.e., elevation-outflow relationships are fixed, and outflow is determined by hydraulic head. Routing is accomplished by an iterative solution of the continuity of storage equation (Equation 1.1). This routing process is illustrated in Figure 3-3. If time of storage (T_S) values are input as a function of either flow or elevation, the initial estimate for outflow (O_2) is obtained from Equation 1.2. Otherwise, the initial estimate of outflow (O_2) is assumed to equal the outflow at the beginning of the period (O_1).

An outflow value O_T is then determined by solution of the storage equation, and according to elevation-storage relationships that are entered into the computer in table form. The O_T value is then tested and the process repeated until an acceptable outflow is obtained. This iterative process insures an accurate solution of lake routing.



*NOTE These relationships are given in the appropriate tables.

FIGURE 3-3 LAKE AND BACKWATER ROUTING TECHNIQUES USED IN SSARR

RESERVOIR ROUTING AND REGULATION

Routing through man-made reservoirs is determined by the same procedures used for natural lakes except that several controls can be exerted by the user. As with natural lakes, upper and lower bounds or limits must be delineated.

Several types of reservoir operations can be specified to the program. These include (a) free flow, (b) outflow, (c) pool elevation or changes in elevations, and (d) storage quantities or changes in storage. If no specifications are made, outflow is computed equal to inflow. The specifications are met unless violations of reservoir characteristics occur. For example: (1) The reservoir cannot be evacuated below lower bounds; (2) discharge cannot exceed that obtained from the elevation-discharge relation; (3) when the reservoir elevation exceeds upper bounds, outflow will be computed by free-flow routing, or the reservoir will pass inflow if no elevation-discharge relationship is given. In some of the modes of operation referred to above, the model must utilize an "instantaneous flow change" to preserve volumetric continuity. Appendix E explains this feature.

ROUTING STREAMFLOW - BACKWATER MODE

The lake and channel routing methods described in the preceding paragraphs assume that a unique relationship exists between the elevation in the lake or channel segment and the outflow from the body. There are cases, however, where elevation and discharge are affected by backwater from a downstream time-variant source. Examples of such occurrences are river estuaries affected by tidal fluctuations, river reaches upstream from a junction with a major tributary, and the upstream reaches of a reservoir or a lake whose outflow is affected by the elevation of another lake just downstream. For such situations, routing can be accomplished by the "backwater mode" of the SSARR Model. This method utilizes a three-variable relationship between upstream elevation (E1), downstream elevation (E2) or flow (Q2), and discharge from the upstream location (Q1):

$$Q1 = f\ (E1,\ E2)$$

or

$$Q1 = f\ (E1,\ Q2)$$

An example of such relationships is illustrated in Figure 3-4. The program treats the flow at any period of the upstream station as dependent upon the water surface elevation (or flow) of the downstream control station and also the water surface elevation of the upstream station. The elevation used for the downstream station, however, is that which was computed for the previous time period. Short computational time periods should be used when using this method.

Each station must have a specified elevation-storage relationship. Outflows are then computed as a function of upstream water surface elevation and the downstream "control". This three-variable function represents the only difference between the backwater mode and the lake routing method as pointed out in Figure 3-3.

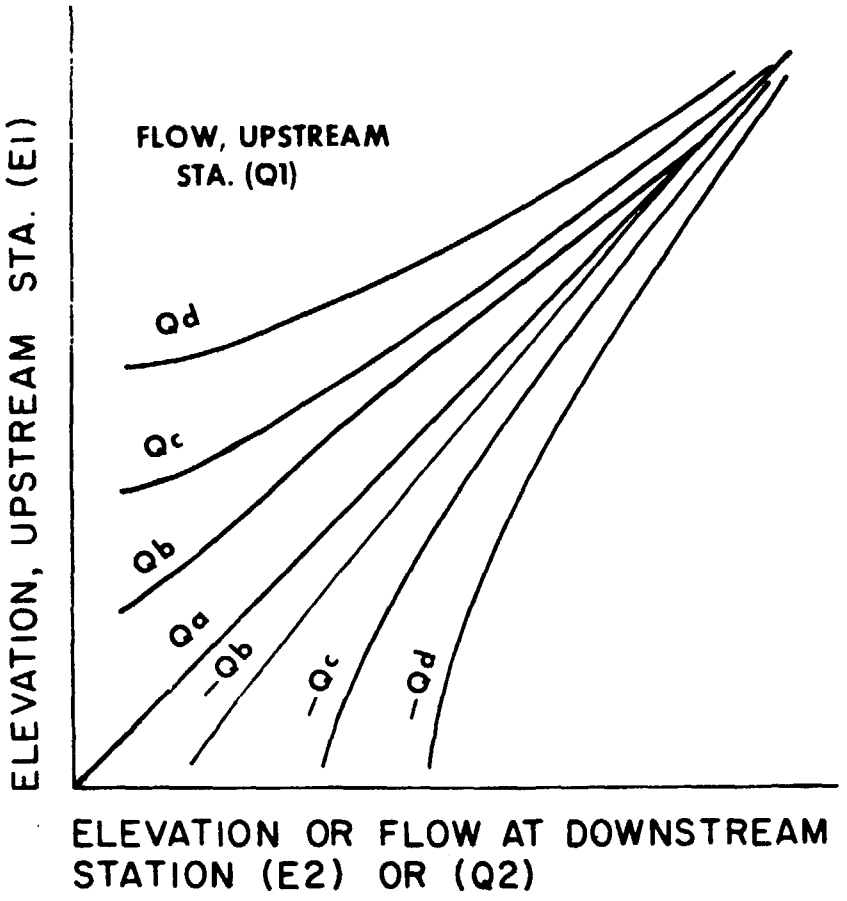


FIGURE 3-4 EXAMPLE OF DISCHARGE-ELEVATION RELATIONSHIPS HANDLED BY THE SSARR BACKWATER MODE

The above relationships can be used singly, as in the case of a lake whose outflow is defined by lake elevation and downstream elevation; or a series of backwater relationships can be established. In the latter case, the elevation of the upstream "segment" of the reach is dependent upon the elevation of the next downstream segment; that elevation in turn is determined from the elevation of the third "segment", and so on. The elevation relationships for the backwater mode of routing can be determined from observed data relating elevation and discharge, or from steady-flow backwater computations.

ADJACENT STATION PROVISION, DIVERSIONS AND LOCAL-FLOWS

The modeling of a river basin can include a diversion and a return flow at given points in the system. This is accomplished with the "adjacent station" provision of the program. Diversions and their return flows can be specified as either a percentage of some station value or they can be specified in a table relationship which would represent some functional value of another station in the system. For example, this provision can be used to remove irrigation flow from a river system and compute irrigation return flows as a function of the quantity of flow diverted. The adjacent station provision can

also be used to compute local inflows which are specified as a function of some other station in the system. Several examples of application of this provision are illustrated in Appendix E.

SYSTEM CONFIGURATION

The preceding sections of this report have discussed the various components of a river system analysis. The remaining step then, is to organize and coordinate all of the components to produce a river basin model which simulates the hydrologic response of the physical system. The system configuration essentially describes to the computer the physical layout and relationships of all components of the system.

The user must specify to the computer the upstream to downstream order of all watersheds, lakes, reservoirs, channel reaches, and confluence points for a particular basin. When a complete system has been described to the computer, the watershed routing is performed first. The computer program performs the model simulation of the river basin system. A hypothetical river basin system and the corresponding basin configuration scheme are illustrated in Figure 3-5. There may be, however, more than one acceptable subdivision and organization of such a river basin. The basin may be further subdivided at the discretion of the user as data availability and basin characteristics permit. Numerous examples of different basin layouts and corresponding configuration schemes are given in Appendix E.

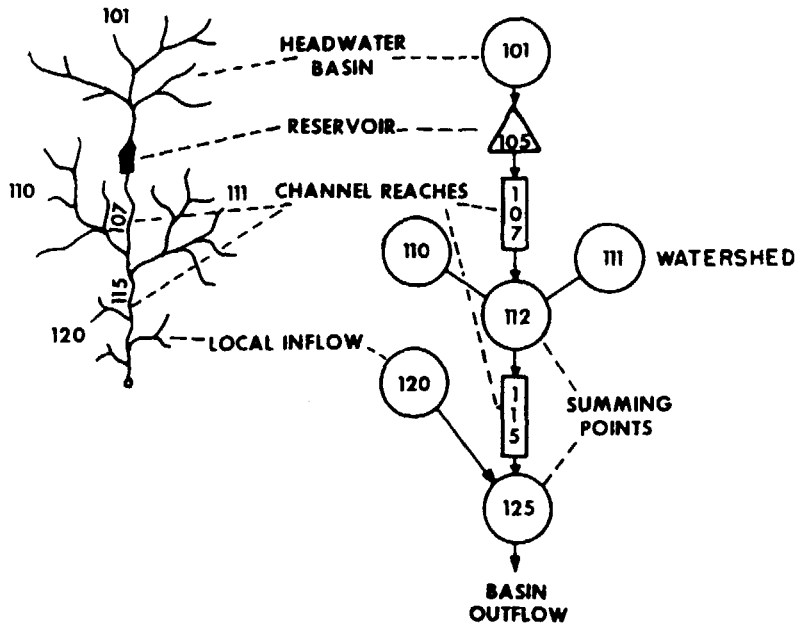


FIGURE 3-5. HYPOTHETICAL RIVER BASIN WITH A CORRESPONDING SCHEMATIC OF BASIN CONFIGURATION AS SPECIFIED TO THE COMPUTER FOR THE SSARR MODEL

4. COMPUTER CONCEPTS

The SSARR Model computer program includes a repertoire of data management and analysis facilities in addition to the watershed and river models. The program is actually a collection of relatively independent subprograms which talk to each other via temporary and permanent disk files. The most central of these files is the "SSARR work file", the repository of model characteristic data, time-variable data, and process control information.

The program is designed to support both operational day-to-day forecasting, as well as long term simulations. The program may be run interactively to carry on a dialogue in real-time with the hydrologist. This capability is designed for forecast operations and provides "help" messages to guide the user through the dialogue. The user may interactively set run controls such as model start/end time; review, change or enter hydromet and regulation data; manipulate initial condition parameters; and run all or part of the models.

Long-term batch runs are facilitated by the "automatic sequence mode", which automatically determines when the models' input data stream has been processed, runs the models, and prepares output requested by the model characteristics. The "Bulk Data" file has capacity for long-term (50 years or more) data records making batch-run data management easier and more convenient.

There are a variety of outputs available including detailed lists of watershed results, operational summaries of the simulation in both tabular and printer-plot forms, a statistical summary of river model results, and "card-image" output which may be used in subsequent runs as input to the SSARR or other programs.

INPUT DATA FORMATS AND THE INPUT STREAM

The input stream may be composed of three types of lines: (1) card formats with fixed-column fields (as used by the predecessor program, SSARR-4); (2) "Z"-card formats with variable length fields, called "positional free-form" formats, and (3) responses (which are nearly all "positional free-form" format) to prompting messages issued by the interactive driver. There is some overlap in usage of the types of formats; that is, some of the same information can be input via more than one format. For example, a relationship can be input via either the fixed-format "CT" format card image, or the free-form "ZCT" format. Precipitation, temperature, flows, and other time-variable hydrometerological data may be input by fixed-format (i.e., "4D"), free-form (i.e., "Z4"), or as responses to subcommands of the interactive processor such as the "L" (Temperature/Precip) Processor.

The source of the input stream may be redirected through the use of the special commands "INU=", "INFILE", and "GET/"ZGET". The input stream is normally read by the program from the default input source provided by the host computer system. In a batch run, this may be a card reader or a prepared file of card images. The "INU=" and "INFILE" commands may be included in that input stream to redirect the program to read input from another file. The effect is to logically incorporate this file into the input stream as if it took the place

of the redirect command. This technique allows the user to prepare the input stream in segments, and to combine the segments with the program as needed during a particular run.

The "GET"/"ZGET" command incorporates card image lines from the SSARR work file into the input stream. This technique allows the user via the program to develop input data streams for later use by the program. The initial application of this capability was to store a set of "PR" format cards (River model printout command cards) on the SSARR work file, to be used for each year of a multiple year simulation. Since addressing external files from the program is clumsy on some host computers (such as those with the IBM-MVS operating system), the "GET"/"ZGET" facility can be used in place of the "INU=" command.

DATA FILES

External files that may be addressed by SSARR are all optional, except for the SSARR work file. The function of thes files is briefly described below:

The SSARR Work File. This file carries data and results between the various program parts, and provides continuity of operation when the program is restarted. This allows each session of program use to resume where the last left off. It also allows several users to work concurrently on the same data base. For example, the entire Columbia basin forecast system is contained in one SSARR work file; Corps of Engineers, River Forecast Center, Bureau of Reclamation, and Geologic Survey personnel may concurrently work with the data, models, forecasts, and results via this one file.

For long-term simulations (for example, during model calibration) the SSARR work file is usually treated as a temporary work file, since all data for the run is contained in the input stream and the Bulk Data file, and each run is a trial which will be repeated until model adjustments are complete.

Bulk Data File. Long-term sets of time-variable data may be kept in and retrieved from this file. A separate set of management program are used to maintain the file for such things as removal of obsolete records, copying from one Bulk file to another, and reorganization of file space. The addition and replacement of data in the Bulk file is accomplished with the SSARR program. Data may be loaded into the SSARR file from various sources such as the input stream, the CROHMS file (see discussion below), or computed with one of the SSARR models. Once a time-series has been loaded into the SSARR file, it can be merged into the Bulk file long-term records with a single "store" command.

The SSARR work file is designed to hold only the time-series data needed for the current study period. The SSARR file can hold only a year or so of 6-hour data at a time. The Bulk Data file is designed to hold the entire period of record of a time-series, which might be 50 years or more of data. The SSARR program, with one command, can retrieve the data for a gage from the Bulk file for a study period. If the Bulk file facility is not used to manage and hold the data, the time-series data must be included in the SSARR input stream, which can make the input stream long, complex, and difficult to prepare.

"Drawer" Files. In an operational forecast system, the first step is to develop model characteristics and other semi-permanent information to be used in the day-to-day procedure. This basic data is the backbone of the forecast system and must be protected and preserved across any eventuality, as well as be available for modification as adjustments are made and new procedures are developed. In the punched-card era, this data was recorded on punched cards and carefully maintained in card "drawer" files. When a change waas made, the affected cards were removed from the drawer, corrected, read by the computer to change information in the SSARR work file, and then the cards were put back in the drawer. From time-to-time, the entire contents of the drawer file was copied to magnetic tape for long-term permanent offsite backup. This technique was very simple, reliable (even across computer program changes), and practical; even when the drawer files reach huge proportions.

Today, the punched card is not very popular since on-line systems are available to most everyone. The on-line system is superior to punched card data handling for many reasons, not the least of which is that data management on-line (with the computer handling the card images instead of the user) is usually much more reliable. There are excellent software packages available to maintain permanent files of card images on the various storage mediums available on computers, and for users that have one of these packages available (with adequate access, documentation, and a mentor to help in getting started and solve the occasional problem, the "drawer" file facility in the SSARR program should be ignored. The "drawer" file facility was included so that the permanent characteristic file management procedures in place before the advent of on-line computers had to be changed as little as possible to continue the daily forecast operation.

The "drawer" files are sequential files of the card images representing the fixed characteristics of the hydrologic models, and procedural information (such as "P"-card lists defining models, and sets of "PR" print control cards defining reports). These files may be copied to magnetic tape for backup, listed without formatting (since all records in the files are card images), and modified with any file editor. These files are ordered in the same way a physical manually-maintained card drawer file might be ordered; the card images for a station are together, but the stations need not be in any order and can be grouped by tributary, region, or other reason meaningful to the user. The SSARR program can retrieve from this file through a request to search the file for a station or model name (the "INPUT" subcommand of the interactive processor).

CROHMS Database File. The Columbia River Operational Hydromet Management System (CROHMS) database is the file of near real-time hydrometerological data shared by the many agencies managing the operation of the Columbia River system. This file is, in general, designed to hold the most recent 60 days of observed data from the Columbia basin.

An interface subroutine is included in the SSARR program to copy data from the CROHMS database to the SSARR work file. The access subroutines are part of the CROHMS system of programs and utilize the proprietary "IDMS" software by Cullinane. This interface subroutine in the SSARR program cannot be transported to another host computer without satisfaction of the copyright agreements associated with "IDMS".

Associated with the use of CROHMS is a report-writing subroutine in SSARR which also uses the "IDMS" software. This subroutine, called "HMLIST", requires a special file of station identification. The contents of this special file are managed by a separate program.

Miscellaneous Work Files. The watershed and river models have several temporary work files that require direct access disk space. These files only exist during execution of the SSARR program.

MODES OF OPERATION

The program is designed to support both operational day-to-day forecasting, and long term simulations. The main difference in these two uses, from the operating point of view, is the length of processing runs and input data streams.

The "Batch" Mode. Long term simulations require long time-series of hydromet data and many minutes of processing which are not attended by the user. Initial conditions ("I.C.", the model state variables) are set up at the beginning of the run and then automatically carried forward by the program. The user may display the IC at key points during the progress of the simulation, but he does not adjust them. For long term runs, the data and processing commands are composed in a job-stream file. The SSARR program is then executed using the job-stream file as input instead of the keyboard. In addition, the SSARR file is initialized at the beginning of the run to empty condition. All fixed and time variable data for the run are contained in the job-stream file. This style of use is called a "batch" run.

The "Interactive" Mode. Forecasting is characterized by frequent (often daily) updating of the hydromet time series of observations and forecasts. The Model IC are adjusted daily to match observed conditions, and the simulation and forecast runs are for a relatively short term. For forecast operations, the SSARR program is designed to be run interactively. The computer program carries on a dialog with the user via computer terminal keyboard and screen and/or printer to assist him with automatic data storage, retrieval and updating. Prompting and descriptions of the alternatives available to the user at any point during the update process provide a "user friendly" environment. Data is accumulated on the SSARR work file through daily updating as the forecast season progresses. Fixed characteristics of the catchment, runoff, and river model are loaded to the SSARR work file once at the start of the season, and do not have to be reentered again.

INTERACTIVE OPERATION

In the interactive mode, a dialogue is carried on with the user to assist him in such tasks as setting model time control, editing hydromet and regulation data, review and mody initial conditions, and direct (interactive) execution of the models.

The command "IA" in the SSARR input stream causes the program to enter the interactive prompting mode. The main prompt is simply an asterisk (*). In response to this prompt, the user may enter one of several commands. A summary of these may be obtained by entering a question mark (?). In fact, the

question mark response may be entered at any time in the dialogue and the program will reply with a brief summary of appropriate optional responses. For example, suppose the user has entered an "L" in response to the * prompt (the L command gives control to the Hydromet Processor). If a "?" is then entered, a summary of Hydromet Processor commands will be displayed. If the user then enters the identity of a hydromet time series, the response by the computer is a display of data in the current time range and the prompt "CHANGES?". Entry of a "?" will then cause display of instructions for changing the data values.

INTERACTIVE COMMANDS

"T" Command. Set time control. Time control may be established in three ways: (1) start time will default to 6 a.m. on the current day (according to the host computer system clock) and the run length defaults to one day with 6-hour compute periods if no time control is provided by the user; (2) time control may be supplied with the fixed-format "T" card in the "batch" input stream; and (3) the "T" subcommand of "IA" may be used, which is restricted to specifying the run length in days and all compute periods to be the same length (the "batch" "T" card gives end times with an ending hour, and there may be as many as four time ranges with different compute-period lengths).

"IC" Command. Run the Initial Condition (IC) processor. The user may enter the name of a model-list; the program will display the initial conditions for each station in the model-list and prompt the user for changes, if needed. An option is provided to allow a change to a parameter in all basins listed in the model-list, through the entry of one subcommand. For example, the soil moisture index for all basins in a region could be reduced 50%, or increased 1 inch (the current value of the parameter may be multiplied by a constant, and another constant may be added to the product). The IC values at a point in time may be listed, as well as the times for which IC values have been saved.

"L" Command. Temperature/Precipitation processor. As with the IC processor, the user may enter the name of a model-list; the program will display the hydromet data for each gage name in the list and prompt the user for changes or additions. One line of data is displayed, one value per compute period, and the display width may be adjusted to as many as 24 data values if the output device supports long enough lines (132 character).

"6" Command. Regulation processor to manage reservoir regulations and other streamflow data. The user may supply a model-list name. The program will then prompt for input or correction data for each station, in turn, in the model-list. A "regulation" consists of a series of entries in time sequence; each entry is made up of an hour-date and a value, along with a code identifying the units-of-measure of the value and its meaning. The "regulation" may specify a reservoir control schedule in terms of discharge or pool elevation or storage contents, or it may be used to specify a time-series of discharge or gage-height for a point in the river system.

"SPECFLO" Command. A "regulation" input program developed for the operational forecasting environment. This program asks the user to provide a list of points in time for which values will be provided; then prompts the user for the values for these times for each station in a model-list.

"CROHMS" Command. (This command is only available on the Corps of Engineers, NPD computer because the CROHMS Database uses copy-righted software). This processor retrieves data from the Columbia River Operational Hydromet Management System (CROHMS) Database and stores it into the SSARR work file in time-series format. Both hydromet data (such as temperature and precipitation) and regulation data (flows and gage heights) may be accessed. Data may be transformed as needed to match the requirements of the SSARR models. For example, most flow data in CROHMS is scaled in KCFS whereas SSARR flows are scaled in CFS units.

"HMLIST" Command. (This command is only available on the Corps of Engineers, NPD computer because the CROHMS Database uses copy-righted software). This processor produces a tabulation of time-series data. It is an adaptation of the "HMLIST" program used for general purpose data tabulation in the CROHMS data system. The "HMLIST" processor has two output formats; the first produces one print line per day; the second produces one print line per hour. Each column across the page may be a value for a particular hour at a gage. The data may be from a time-series in the SSARR work file, or from the CROHMS Database. The report format may be with or without headings, and gage identification may be included on the report if wanted. A separate file of gage identification is available with the CROHMS data system.

"EM" Command. The "Edit a Model" processor. The "model-list" has been mentioned above as a control device for the "IC", "L", "6", and other interactive commands. the "model-list" is also the River model configuration control, defining the stations to be included in the river model, the order of processing, and the tributary structure of the river system. In the "batch" input stream, a "model-list" is loaded into the SSARR work file by including a set of "P" (configuration) cards. A "model-list" may be given a name with the fixed-format "N" card. In the interactive mode, the "EM" command will make a new "model-list", or edit an existing one.

"EF" Command. "Edit a FILE" processor. In the paragraph "INPUT DATA FORMATS AND THE INPUT STREAM" (Page 51) the "GET"/"ZGET" special command is mentioned as an alternative source of input for a set of card images. These sets of card images may be stored on the SSARR work file with the "FILE"/"ZFILE" card format, and are called a "FILE record" in this manual. A "FILE record" may also be originated and edited interactively with the "EF" command.

"L,name,code" command lists the contents of a record in the SSARR work file. The ",code" part of the command indicates the type of record to be listed; if "code" is left off of the command, the characteristic record with this name is listed. This command is useful for review of data contained in the SSARR work file both during model development (as a check on the results of reading in the input stream to load the SSARR work file) and during forecast operations where the SSARR work file is maintained as a permanent database. The "name" part of the command may be the name of a "model-list", to list a group of records of the same type.

"RUN", "BASIN", and "RIVER" Commands. These commands execute the watershed and river models while under control of the interactive processor. They may specify a single watershed or a "model-list" of watersheds and river stations.

The watershed models produce output lists the same as if they were run under "batch" control; and the river model produces no output except for temporary work files, just as it does under "batch" control.

After processing the watershed model or river model through the specified time range, control returns to the interactive processor. If the river model was run, only the ending instantaneous conditions were automatically saved; if other river model output is to be produced, such as tabulations, printer-plot, or time-series in the SSARR work file, the user must enter the appropriate control cards ("PR", "PQ", or "ZSQ", for example). This can be a good opportunity to use the "GET"/"ZGET" special command, to avoid entering the long fixed-format "PR" and "PQ" type control cards on an interactive keyboard.

"INPUT" Command. This command retrieves card images from the "drawer" files and processes them as a "batch" input stream. For example, the "drawer" file may contain the cards defining the fixed characteristics and tables used in the model system. The "INPUT" processor asks the user for the name of card images to be retrieved. Then, the "drawer" file is searched for a set of card images with that name. These card images are read by SSARR as if they were part of a "batch" input stream, producing or replacing a fixed characteristic record in the SSARR work file. The purpose for this operation is discussed in the paragraph "drawer" Files on Page 53.

"HMAINT" Command. The SSARR work file maintenance processor. The SSARR work file is designed to be used as permanent database for an operational forecast environment. The words "permanent" and "operational" are meant to indicate that the file is not to be erased or lost in any way, and that the real-time operational data is flowing through the file. Every effort must be made to keep this file intact during operational use becasue so many people are dependent on it. Rebuilding such a file from basic data and backup information is time consuming and can disrupt the forecast system. When errors occur, some techniques must be available to identify the error and, if possible, fix things up until the source of the error can be corrected. The "HMAINT" processor lets the system manager look at the SSARR work file contents and structure, and make fundamental changes. There is a password lock on the "HMAINT" subcommands which change file contents so that these subcommands will not be used inadvertently.

OUTPUT

The repertoire of optional output include detailed lists of watershed results, operational summaries of simulation results in both tabular and printer-plot forms, and card image output which may be used in subsequent runs as SSARR input, or as input to other programs. In addition, there are information messages and prompting messages written by the program to assist the user in following the progress of a run.

The destination of the outputs is, in some cases, controlled by the users' input commands. The disposition of outputs (that is, the display on CRT or printer, or capture in external files) is a function of operating system job control used to run the SSARR program on the host computer. Appendix H presents the job control information needed for disposition of outputs on the

computer system in use by the Corps of Engineers, NPD. Supplemental documents are available which describe the operation of the SSARR program on other host computers.

Watershed Model Output. Internally in the file system, the principle output is a time-series of instantaneous discharges, one discharge for the end of each compute period. This time-series is then available as input to the River model.

In addition, the period-end values of most model parameters are written to temporary work files from where they may be displayed with the printer-plot facility (the "PZ" control card). Instantaneous condition of the model is always saved at the end of a run, and may also be saved at intermediate times in the run if requested by the user.

The Integrated Snowband model can produce a detailed printout of model parameters for each compute period for selected snowbands.

A printout of parameters as basin-wide averages for each compute period is the normal watershed output for all watershed options. The Depletion model printout may be optionally limited to 79-character lines for display on narrow devices.

Time-series results may be written into card image formats on external files with the "ZPUNCH" command.

River Model Output. All output from the River model is internal, to the file system. The results may be displayed in printed form, or written to external files with the following commands:

"PR" commands produce a tabular printout, one line per compute period (or periods may be skipped; for example, a run with 6-hour compute period may be printed showing one line per day).

"PQ" and the other printer-plot commands produce a plot with the data across the page, and time down the page.

"X" commands produce a report designed for teletype display.

"ZS" command produces a monthly and annual statistical summary of river model results including mean, deviation statistics, volume, and peak information.

"AQ" and the other River model save commands ("SQ", "SR", etc.) copy River model results from the temporary files into the SSARR work file, thereby permanently preserving the time-series for later use.

The river model characteristics may be coded to automatically produce card image output and printed tabulations of results and instantaneous conditions (as done in 1975 version of the program, SSARR-4).

Initial Condition (IC) Output. The models may be directed to save and punch IC with controls in the characteristic cards, which is the way output was controlled in the 1975 (SSARR-4) version of the program. Also, another facility is the "ZLI" command which outputs instantaneous conditions, either to printer or card image file. Initial conditions may be saved on the SSARR work file in a "FILE" record (see "INPUT DATA FORMATS AND THE INPUT STREAM", Page 51). This initial condition set may then be used to start runs with data from other years. This technique is important when analyzing potential future hydrology by simulating historic records of hydromet data. For example, suppose the date is April 1, and a catchment has been simulated to this point with observed data. One technique for forecasting the runoff which might occur during the coming April-August season is to start the model with the April 1 IC set, and simulate April-August with weather information from past years representing future potential weather scenarios.

Information and Prompting Messages. The program may operate in two modes; the "batch" mode, and the "interactive" mode. "Batch" mode information messages are designed to be seen on a printout with other simulation results, after the run is completed. These messages include a complete list of the input stream, and interactive prompting messages are suppressed in most cases.

"Interactive" mode is intended to support true interactive operation, where the user is giving the program input lines one at a time in response to prompting messages.

The program mode is controlled by the user by the first command given to the program. The mode may be changed by the interactive subcommand "J".

DIFFERENCES BETWEEN THIS AND PRIOR VERSIONS OF THE SSARR PROGRAM

The prior version of the SSARR program was called "SSARR-4" and documented by the User Manual last updated in 1975.[1/] The current version of SSARR is called "SSARR-8" and differs from "SSARR-4" in the following ways:

Station and Table Names. Identifiers for SSARR may be alphanumeric and can be no longer than 8 characters (SSARR-4 identifiers are all numeric and may be 9 digits).

Most fixed-format characteristic cards have the station identifier in Columns 6-13, left justified. If the station is all numeric, blanks are replaced by zeros. For example, a station number punched in columns 11-13 with blanks in 6-10 will appear on printouts with columns 6-10 replaced with zeros.

Relative Date. All card formats including a date field may use "relative dating." "Relative date" is a date field with month of zero (or blank). If month is zero, the day field is multiplied by 240 and added to the tenth-of-hours field, and added to the current run-start time to arrive at the "relative" date.

Annual Date. If month is non-zero but year is zero, the hour-day-month are assumed to occur in the 12 months following the current run-start time.

SSARR Work File. Designed to support daily forecast operations. When the SSARR program is used in studies, the SSARR work file may be a temporary disk allocation that is deleted after each execution of the program.

The implementation of the SSARR file for SSARR-8 is suitable for a permanent database, and supports simultaneous updating by concurrent users. This allows a number of hydrologists to share the same file and data for real-time operations.

Instantaneous Conditions. A special initial condition (IC) record is in the SSARR work file for each snowband basin, depletion basin, reach, and lake. The IC record for a station has capacity for instantaneous condition values at 20 different times. As IC are added to the record at new times, the oldest IC is deleted to make room. (If the IC to be stored is older than 10 IC entries currently in the record, the newest IC is pushed off to make room.)

New Card Formats Available In SSARR. The "Integrated-Snowband" basin model uses much the same terminology and organization as the original SSARR watershed model. The Snowband characteristics are defined by cards identified as "ZC1" through "ZC5, "ZCH", "ZCA", and "ZCP." These roughly correspond to CB01 through CB04 and C3 card formats. A new general table format identified as "ZCT" and ZCF" may be used in place of the SSARR "CT" and CF" formats. Initial conditions for individual zones of snowband basin are given with the "Z2" format.

A group of commands provide for manipulation of data on the SSARR file. These commands are ZR (run control), ZLI and ZLIP (instantaneous condition list and punch), ZLIST (list 4D and 6 data), ZPUNCH (punch 4D and 6 data), ZLAPSE (compute lapse rates), ZFILE, ZEND, ZGET, ZGETL, (store and retrieve card images in SSARR file), and Z1 and ZBSTORE (bulk-file access).

The ZS (statistical summary) command cards process river model results.

The Z4 and Z6 free-form formats may be used to input hydromet and regulation data in place of the 4D and 6 fixed-format cards.

The Z7 and Z8 formats provide an "override" or correction technique. A set of observed data may be loaded into the SSARR work file with a package of 4D or Z4 cards, or from the Bulk file. The Z7 format may then be used to override a portion of that data. In this way, the original set of observed data is kept intact. This is useful for "what if" trials to investigate a hypothetical storm superimposed on historic record.

"ASQ", "ZAQ", "SQ", "AQ", (plus "SE", "AE", etc. variations), and the "SR" Card. Copy time-series data from river-model results into the SSARR file for use as input to the bulk-data system, the Interactive processor and as input to subsequent river and watershed modeling,

"GET", "FILE", "FEND". Groups of input cards such as PR and PQ are often repeated in the input stream. They may be stored in the SSARR File via the "FILE" card and "FEND" card, and included in the input stream via the "GET" card.

The "FILE" card contains a name in columns 6-13. All cards following the "FILE" card are stored in the SSARR File as one record. The "FILE" record is terminated by a "FEND" card.

The "GET" card contains the name of a "FILE" record in columns 6-13. A "GET" card may appear any place in the input stream and as a response to any interactive prompt when using the IA command. The "GET" command causes the card images in the "FILE" record to be included into the input stream.

"ZGET", "ZFILE", and "ZEND" are synonymons with "GET", "FILE", "FEND", respectively.

COMPUTER PROGRAM AVAILABILITY

The SSARR program is written in FORTRAN-77. Considerable effort has been made to make the program independent of the host computer, but there are still several dependencies in the code. Versions of the program have been installed on several computer systems including both large scale and micro-scale computers. Current information about machine requirements and program availability may be obtained from Water Management Branch, U.S. Army Engineer Division, North Pacific, P.O. Box 2870, Portland, Oregon 97208.

5. REFERENCES

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2. U.S. Army Corps of Engineers, Snow Hydrology, North Pacific Division, Portland, Oregon, 30 June 1956.

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5. Wilson, W. T., A Graphical Flood-Routing Method, Transactions, American Geophysical Union, Part III, 1941.

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7. Cundy, T. W. and Brooks, K. N., Calibrating and Verifying the SSARR Model - A Case Study, Water Resources Bulletin, AWRA, October 1981.

8. Speers, D. D. and Davis, E. M., SSARR Model Routing Algorithm, Corps of Engineers, NPD, September 1985.

9. U.S. Army Corps of Engineers, Development and Application of the SSARR Model, Summaries of Technical Reports, North Pacific Division, Portland, Oregon, January 1976.

10. Rockwood, D. M., Program Description and Operating Instructions: Streamflow Synthesis and Reservoir Regulation Computer Program No. 24J3.H001, Technical Bulletin 22, January 1964.

APPENDIX A

ERROR AND INFORMATION MESSAGES

The error and information messages issued by the SSARR program have never been rewritten into a coordinated structure. The various parts of the program were developed independently and over a long period of time. At the current level of development, at least one useful tabulation of messages seems to be to simply list them in alphabetic order. If they were listed in sections according to the part or function of SSARR, then the user would have to know which part of the program issued the message before the message description could be found.

In the following message tabulation, lower-case letters are used to signify variable information filled in by the program at the time the message is issued. The following conventions are used:

sssssssss — Name of a basin, reach, lake, confluence point, table, gage, and/or record in the SSARR work file.

rrr — Record type in the SSARR work file. The record types have the following meanings:

0	station characteristics	24	temperatures
1	initial conditions	25	dew point or ETI
2	model p-card list	26	albedo or lapse-rate
5	FILE/ZFILE stream	27	insolation
10	gage characteristic	28	wind speed
11	relationship (table)	29	melt rate
13	daily distribution	61-69	corrections to 21-29
21	snowline elevations	100	regulation
22	snow covered area	101	basin outflow
23	precipitation	102	river elevation output
		104	snowband hydromet summary
		108	correction to regulation

... — There is more to the message than is shown in this tabulation.

Many of the messages are shown to be caused by "program error". When these messages occur, they should be brought to the attention of NPDEN-WM-HES, Corps of Engineers, Portland, Oregon.

MESSAGES IN ALPHABETIC ORDER

(alphabetized on the first alphabetic character in the message)

BAD TYPE OR NO RECORD FOR STATION ssssssss, TYPE ,rrr
ZLAPSE command lists a station or record type that does not exist.

BASIN ssssssss RUNNING nnn PERIODS.
RUN, BASIN, or RIVER subcommand of IA has started a model running. The delay between this message and the beginning of the basin printout is dependent on the type of basin, the number of periods, and the speed of the host computer.

BASINE ENTRY-NID nnnn
this message is given when the depletion watershed model is entered and TRACE is on.

BULK FILE CLOSED. THERE WERE nnnn WRITES ...
If the bulk file is written into during this session ("ZR BUPD" and "ZBSTORE" cards processed), this information message is issued when the SSARR program is exited.

BULK-FILE RECORD IS NOT A TIME-SERIES, AS REQUESTED ...
This long message indicates a mis-match among the parameters of a Z1 command.

BULK-FILE UPDATE REQUEST REJECTED. FILE NOT OPEN
ZBSTORE command was not preceded by the command "ZR BUPD".

BUSTORE ERROR; DIRECTORY POINTER NOT = 2. IBUDRC=nnnnnnn
ZBSTORE command encountered an error in the format of the Bulk file. Bulk file is probably lost. It may be possible to repair with the BULKINIT standalone program.

CANNOT IDENTIFY COMMAND. ENTER ? FOR SUMMARY
The EM or EF subcommand of IA has been given an edit command that is not understood. Usually, this occurs when trying to insert lines, and the input was not proceeded by an "I ". For example, to insert a line such as "ABC", one must type "I ABC".

CANNOT INTERPRET FIELD nn, PLEASE REENTER COMMAND
The Temp/Precip processor, entered with the "L" subcommand of IA, has been given a command which, in field nn following the name field, contains a code or word that is not understood. Enter ? for a summary of valid codes.

CANNOT RECOGNIZE WORD IN COL. nn aaaa
The J subcommand of IA has been given an improper keyword (aaaa). Enter ? for summary of valid keywords.

DAOPEN FAIL. IC=nnnnn

CROHMS subcommand of IA is not useable because the Job Control Language (JCL) for this execution of SSARR does not correctly allocate the CROHMS Database.

ELEVATIONS OF TEMP STATIONS IN WRONG RELATION.

The ZLAPSE command must list a "high" temperature station which is higher in elevation than the "low" temperature station.

END OF INPUT

The command "BY" has been read from the input stream, or an end-of-file has been encountered on FORTRAN unit 5 (the default input device).

ENTER INPUT-CARD FORMAT:

This prompting message is sent to FORTRAN unit 3 to request either Z-format input cards, fixed format input cards, the IA command, or the BY or end-of file. This message is issued when SSARR is in interactive mode (the first command to SSARR at the start was IA), and the RETURN subcommand or a Z command has been given.

ERROR PR-CARD SPECIFIES ILLEGAL PRINT UNIT

Valid FORTRAN unit numbers in col. 4 of the PR card are units 1-3 and 6-9.

ERROR (IDCARD) - TOO MANY CARDS TO FILE (OR ZFILE).

The group of cards following a FILE or ZFILE card is too long. This limitation varies with host computer. On the Amdahl, the maximum number of cards is 390. The micro version limits the number to 50.

ERROR (IDCARD) CARD CODE INVALID. CARD IGNORED

A fixed-format or Z- card identifier is wrong. This error can happen if subcommands to IA are given without first giving the IA command.

***ERROR - BUSTOR; DIRECTORY IS TOO LONG FOR THIS VERSION ...

ZBSTORE command attempted to add an entry to the Bulk file directory, making the directory too long. Use the standalone BULKINIT program to delete some entries to make room.

*** ERROR - BUSTOR; EXCEEDED BULK-FILE CAPACITY...

ZBSTORE attempted to store a record to the Bulk file, but the file is full. The capacity of the Bulk file is set by the standalone BULKINIT program when the file is established. As successive ZBSTORE commands are processed, space is lost to old copies of replaced records in the file. This space may be reclaimed by running the C (compress) command of the standalone BULKINIT program.

ERROR - CANNOT FIND ANY NAMES ON TAPE UNIT nn

The INPUT subcommand of IA requested the search of a "drawer" file tape; the tape either is empty (if the search in "N" mode) or it contains no finder cards (search in the "F" mode).

ERROR - NO P-CARD LIST IN FILE BY THE NAME ssssssss

INPUT subcommand of IA gives a model name (P-card list name) for the list of stations to retrieve, and the P-card list is not in the SSARR file.

ERROR - PZ 0 ASKS FOR NONEXISTANT BASIN; ssssssss
Printer-plot control card error; plot continues.

ERROR - PZ N ASKS FOR NONEXISTANT BASIN; ssssssss
Printer-plot control card error; plot continues.

ERROR - RIVER MODEL SAVE COMMAND IS REJECTED BECAUSE NO TARGET STATION GIVEN...
Card formats AE, AQ, SE, SQ, ZAE, ZAQ, ZSE, ZSQ, and SR must contain a target station name; the name will not default to the source name. If these formats were to have the source name as the target, the river model processing would be suppressed for this station the next time it is run. A type 100 record is written in the SSARR file by these cards, and a type 100 record specifies the discharge from a station in the river model.

ERROR - SOMETHING WRONG WITH UNIT FIELD AT COL.nnn
The "U=" keyword for the INPUT subcommand of IA is not followed with a valid unit number for a "drawer" file tape.

ERROR BULK-FILE ON FT18F001 HAS NOT BEEN OPENED PRIOR TO THIS CALL TO BUGET
Bulk-file retrieval program error, in response to a Z1 card.

ERROR BULK-FILE ON FT18F001 HAS NOT BEEN OPENED PRIOR TO THIS CALL TO BUSTORE
Bulk-file store program error, in response to a ZBSTORE card.

ERROR IN PURGE PGM.. NUMBER OF VALUES TO PURGE,...
Indication of possible program error, or time-series record format error, in response to the P subcommand of HMAINT.

ERROR IN STORE SUBR.; TIMES OUT OF SEQUENCE ssssssss rrr...
Possible program error in attempting to store data to the time-series record identified by "ssssssss rrr".

ERROR SSUPDT; SSARR FILE FULL
The SSARR work file capacity is set by the standalone initialization program (D24G022I or D24G001I). Space can be made in the file by deleting records and purging values from time-series records with the HMAINT command.

ERROR STORE SUBR. CALL; NO VALUES TO STORE. ssssssss rrr
Possible program error in attempting to store data to the time-series record identified by "ssssssss rrr".

ERROR001 RECORD ADDRESS ON SSARR FILE IS WRONG....
Probable error in SSARR work file format. File may possibly be corrected with HMAINT command.

ERROR002 FILE EXCEEDED DURING DIRECTORY UPDATE AND...
The SSARR work file capacity is set by the standalone initialization program (D24G022I or D24G001I). Space can be made in the file by deleting records and purging values from time-series records with the HMAINT command.

ERROR006 FAILURE IN SUBR SSWRIT. PROBABLY NO PRIOR CALL...
Program error.

ERROR100 PREVIOUS CARD IGNORED. INCONSISTENT CARD CODE
Something is wrong with the coding on a card code C card.

ERROR1301 UNIDENTIFIED X-CARD ON INPUT DATA SET NO.nnn
Col. 2 of a card code X card is wrong.

ERROR1302 X-CARD HAS ILLEGAL OUTPUT UNIT NUMBER;nnn
Valid output unit numbers are 1-3, 6-14, and 23-99.

ERROR201 CHARACTERISTIC LOST DUE TO ERROR IN CARD ORDER: STATION ssssssss
Card code C cards must be correctly ordered. All cards for a station characteristic must be together, including the C1, C2, and C3 tables.

ERROR302 THIS INIT. CONDITION CARD IS FOR THE WRONG TYPE STATION...
Initial condition input cards must match the type of station described by the characteristics of the same name. For example, this message will be given if card code 2R (reach IC) cards are input for a station defined by CL (lake) characteristics.

ERROR502 BASIN ssssssss HAS TOO MUCH DATA FOR THIS VERSION OF THE SSARR MODEL
All time-series records used by a basin are loaded into memory to calculate the weighted averages. If the time- series are long, or many are used by a basin, it is possible to exceed the available memory. The direct solution to this problem is to shorten the length of the time-series so that they contain only data that pertains to the current model time range, as defined by the T (time) card. It may also be necessary to shorten the time range.

ERROR: PLOT TIME CONTROL FAILED. SEE SUBR. PLOTLK
The printer-plot program has detected that the river model results are not correct. The river model must be processed before processing printer-plot commands. This is automatic in the batch mode, but the automatic sequencing is disrupted when the IA and RETURN commands are used, and care must be used in the order of commands dealing with the river model and the river model output programs.

ERROR; STATION ssssssss IS NOT IN MODEL. COMMAND IS:...
The source station on a river model save card (card code A, S, ZA, ZSQ, and ZSE) is not in the model list (P-card list) for which the preceding river model was run.

FAILURE IN SUBR. SSREAD; PROBABLY NO PRIOR CALL TO SUBR. SROPEN
Program error in accessing the SSARR work file. May indicate trouble with the SSARR work file format. Use HMAINT to analyse, and possibly correct.

FINAL FILE STATISTICS: FILE NAME: ssss
NEXT AVAILABLE SEGMENT ISnnnnn OUT OF CAPACITY OF ccccc

DIRECTORY RESIDES ON dddd SEGMENTS. ("yyyy" FORMAT)

This message is given when the SSARR program is stopped, to show the current status of the SSARR work file. File name (ssss), capacity (ccccc), and format (yyyy) are set by the initialization program (D24G022I or D24G001I) when the file is initially established. Format "1984" is limited by the program structure to a capacity to 12600 segments. Format "1985" is virtually unlimited, both in total capacity and in logical record length. Eventually, the "1984" format will be phased out.

The file name (ssss) is used by the computer system to give exclusive use of the file to individual users for the brief time required for updating.

"GET" ERROR. GET STREAM TOO LONG FOR 10000 WORD BUFFER.

A GET command may input from a FILE record which contains a GET command. The FILE records are held in the GET stream buffer while being processed into the input stream.

Note: The only way a GET command can be included in a FILE record is with the EF subcommand of IA.

IDCARD TRACE; ICC, STATION=ccc ssssssss

With TRACE on, this message is printed for each fixed- format and Z-format card. ICC (ccc) is the internal card identifier. TRACE may be turned on and off with the card code J card, or the J subcommand of IA.

IERROR=nnnnn, ICC= ccc; MAIN SSARR8 PROGRAM CAUSING DUMP AT LABEL 12

This message is the result of one of the parts of SSARR leaving a "ABEND" request for the main control program. The IERROR number (nnnnn) indicates which part of SSARR left the request, and the ICC code (ccc) is the internal identifier of the next card in the input stream. The most typical cause of this message is following the message "ERROR201 ..."; the input processing program procedes through the input stream until all characteristic cards have been looked at, before signalling that the run should be stopped.

nnnnn will be as follows for these errors:

-1	PR card processing error
-20	Card code C (fixed-format characteristics)
-21	Watershed model error
-22	Snowband watershed error
-23	River model error
-25	River model output error (as controlled by col. 21 of the charac. cards CB01, CL01, CR01, CC01)

In most cases, one or more of the other error messages will precede this message, giving more detailed information.

INTERACTIVE PROCESSOR CANNOT RECOGNIZE COMMAND.

Enter ? for a command summary.

INVALID COMMAND aaaa

An HMAINT subcommand is not recognizable, or a request has been made to change a record, and the password has not been given.

MODEL STOPPED; IERROR=nnnnn

The automatic adjustment routine initiated by the ADJUST subcommand of IA has detected an error signal from the model part of the SSARR program.

NO ELEVATION AVAILABLE FOR STATION ssssssss

ZLAPSE card lists a temperature station for which the elevation has not been loaded into the SSARR work file via a CP card or a ZH card.

NO I.C. AT hhhddmmyy FOR STATION ssssssss

ZLI or ZLIP requests initial condition output at a time for which there is none in the IC record for station ssssssss. ICs are stored either as the result of IC cards (card codes 2 and Z2) read through the input stream, as input from the IC subcommand of IA, or as output from the watershed and river models. Output from the models is controlled by the card code T card and the ICOUT subcommand of IA. ICs are always saved at the end of the time range by the models, regardless of the other IC output controls.

NO INITIAL CONDITIONS FOR THIS TIME FOR STATION ssssssss

There is no provision for input of snowband initial conditions in the IC subcommand of IA. These IC must be input via card code Z2 cards.

NO P-CARD LIST IN FILE FOR ssssssss

An IA subcommand used the form "M=ssssssss" or just "ssssssss" to give the name of a model list (P-card list) of stations to operate on. These lists are entered into the SSARR file via the N (name) card followed by P (configure) cards, or the EM subcommand of IA.

NO PARAMETER CODES? ENTER ? FOR COMMAND SUMMARY

HMLIST subcommand of IA requires parameter codes with the station name on the command line.

NO TEMPERATURE ADJUSTMENT RECORD FOR NAME ssssssss

ADJUST subcommand of IA requires that the temperature adjustment time series, which is the output from this command, exist. A temperature time-series can easily be originated in the SSARR file with the L subcommand of IA.

PHASE COUNT BAD, N=nnnn

The IC subcommand of IA has detected an error in the format of a Reach initial condition record. This can be repaired by reloading the characteristics for the reach. The number of routing phases must be more than 0 and less then 50.

READ AUTHORITY DENIED:...

HMLIST subcommand of IA has attempted to retrieve data from CROHMS. The CROHMS password used for access does not have the authority to look at this data. Use HMLIST the command:

R password units timezone to re-logon to CROHMS with the correct authority.

RECORD CODE rrr NOT LISTABLE. LENGTH=llll

The "L ssssssss rrr" subcommand of IA is not valid for record type rrr.

RECORDS TOO LARGE FOR COMMON. WDS NEEDED=nnnnnn

ZLAPSE card has attempted to use temperature time-series for which this version of the SSARR program does not have enough memory.

*****REJECTED *** WORD IN ERROR=nnn ...**

ZS (statistical summary of river model) card is not understood. It cannot have more than 23 fields (words) of data. After the date fields, the only alphabetic characters allowed are the P code (punch) and the Axxx (area) field.

The "ZER ..." messages are also followed by this message.

REJECTED BY JSR PROGRAM

Program error. Subroutine IDCARD has produced an ICC that is not supported by subroutine INPUT.

REQUESTED FILE RECORD NOT FOUND FOR NAME: ssssssss

GET or ZGET card requests a FILE record (type 5 record) that does not exist.

SBPUT ERROR; MORE THAN 49 BASINS IN MODEL

The model list (P-card list) driving the watershed model processing has more than 49 basins in it. As each basin is processed, it produces a type 101 record containing the computed basin outflows. Therefore, it is practical to break up the model-list into sets of basins (less than 50 basins in each set), process these models in basin-only mode, and then use a combined list of all the basins plus other river stations to run the river model, in the river- only mode.

Basin-only and river-only modes are set by col. 80 of the T card, or the BASIN and RIVER subcommands of IA.

SOMETHING IS WRONG WITH THE FORMAT OF THIS CARD:...

A Z-format card is wrongly coded.

SOURCE nn IS CBTT PARM; YOU MUST USE PEDRA (SHEF) FORM

CROHMS subcommand of IA: command number nn defining CROHMS time-series as a data source has too few characters in the SHEF parameter code.

SPACING OF hhh TENTHS-OF-HOURS NOT ACCEPTABLE....

Z4, Z6, Z7, or Z8 card indicates an illegal number of hours (in tenths) between values.

SSFIND TRACE - ITERATIONS,STA,IREC,IX,ICODE=...

Trace of SSARR work file access search subroutine. IREC is record type; IX is location within directory segment, and ICODE is result of search.

SSPUT ERROR; RECORD TOO LONG. STA,IREC,SIZE=...

The "1984" format of the SSARR work file limits the logical record length to 7812 words. This error can occur if a time-series record is too long. IREC in the message is teh SSARR record type.

SSREAD IAD,LENGTH=...

Trace of SSARR work file reads. IAD is the physical address of the first segment in the logical record.

SSWRIT IAD,LENGTH=...

Trace of SSARR work file writes. IAD is the physical address of the first segment in the logical record.

STATION TYPE NOT LISTABLE. TYPE= t

The "L ssssssss 0" subcommand of IA has retrieved a characteristic record which is illegal. Program error.

STLU2 ERROR: CT/ZCT TABLE SETUP WRONG...

Each time a relation is evaluated, subroutine STLU2 is called. This message will be issued if the table/relation format is not correct. The "name" is the name of the relation. In the case of a C1 or C3 table, the name is the name of the station. Valid format codes are 0, 2, 3, and 4. The ARGUMENT WORD NO. indicates which variable within the table points is the argument. For example, if the format code is 2 (2 variables per point) and the argument word no. is 1, the first of the variables is the argument.

The argument is printed in both real and integer formats (if the ARGUMENT WORD NO. is 4, the table can only be a C1 table, and the argument is storage, an integer.)

SUBR. SBINMG CALL ERROR. LENGTH,STA,IREC=...

Program error.

TEMPERATURE MISSING, STA ssssssss hhhddmmyy tt.tt SUBSTITUTED

Snowband model ZCH cards list a temperature station (ssssssss) for which no data is available at time hhhddmmyy so the value from the previous period (tt.tt) was substituted.

TFGET ERROR, IOTA, BUFFER=...

Program error. The river model must be processed before processing river model output commands such as PR and the printer-plot commands. This is automatic in the batch mode, but the automatic sequencing is disrupted when the IA and RETURN commands are used, and care must be used in the order of commands dealing with the river model and the river model output programs.

THERE ARE MORE THAN 500 STATIONS IN P-CARD LIST

Model lists (P-card lists) are limited to 500 stations. Output from one model may be transferred to another model with the river model save cards A, S, ZSE, and ZSQ.

TOO MANY TIME PERIODS FOR THIS VERSION OF PROGRAM

Probably a program error. The condition of too many time periods should have been detected before this point in the snowband model (subr. SBROUT).

TRACE BUFIND; NM,IBR,I=...

Trace the location of a record in the bulk file with name NM, bulk-code IBR, and search result I.

TRACE BUSTOR CLEAR COPY; IAD,NM,IBR=...

Trace ZBSTORE of a SSARR non-time-series record into the bulk file.

TRACE BUSTOR UPDATE; IAD,NM,IBR=...
Trace ZBSTORE of a SSARR time-series record into the bulk file.

TRACE MAIN, IERROR=nnnn, ICC=cccc
Trace the flow of main programs. This message is issued before entry of each of the SSARR parts, if TRACE is on. IERROR is the result code set by the last part of SSARR executed. ICC=cccc is the internal identification of the next input card, which controls which part of SSARR is entered next.

TRACE SS8FND; ISTA,IREC,ICODE=...
Trace the directory search in the "1985" format of the SSARR work file.

VALUE IS WRONG TYPE FOR KEYWORD aaaa
IC subcommand of IA. An IC change entry contains alpha characters when the value being changed is numeric.

WASHED NID nnnn ssssssss
When TRACE is on, this message is issued as each relation is loaded into memory in preparation for processing a depletion-curve basin.

WASHED TRACE - BASIN ssssssss, CHARAC:...
When TRACE is on, this hexidecimal display of the basin characteristics record is printed before processing of the basin starts.

YOU MUST PROVIDE A KEYWORD TO USE THE CHANGE OPTION.
Change option of IC subcommand of IA.

Z1 COMMAND, BULK-FILE RETRIEVE FOUND NO DATA FOR:...
Either the source record in the bulk file is missing, or it contains no data values during the time range defined by the Z1 card.

ZBSTORE COMMAND IGNORED. NO OLD RECORD IN SSARR-FILE:...
SSARR file does not contain the record identified by the ZBSTORE card.

ZBSTORE RECORD TRUNCATED BECAUSE OF DATE REVERSE. ...
Bulk-file format error.

ZER BASIN ssssssss AREA NOT AVAILABLE
ZS card requests volume statistics, but the Axxx (area) field is not provided, and the "computed" station characteristic is not a basin, so the area cannot be extracted.

ZER DATES ON ZS CARD INCONSISTENT WITH T CARD
The ZS card derives statistics from river model output, but the time range on the ZS card does not include any of the river model time range.

ZER STATIONS ON ZS CARD NOT IN P-CARD LIST
The ZS card derives statistics from the river model output, but the river model does not contain the stations requested on the ZS card.

ZER001 NOT ENOUGH ROOM FOR TABLE IN MEMORY:ssssssss
Snowband model tables and data are too long for the available memory in this version of the SSARR program.

ZER005M BAD:...

ITY,ICNAME= nnn ssssssss

Program error related to processing a Z-card that could not be understood.

ZER006 CHARACTERISTIC RECORD REJECTED; NO BAND ELEV OR AREA SPECIFICATION ssssssss

Snowband characteristics must include either ZCA or ZCE cards to define the snowbands, and ZCP cards to define the elevation vs. area relationship.

ZER007 ssssssss ZONE AREA TOTAL=xxxxx.xx

This message indicates that the total area defined on ZCA cards does not equal exactly 100% of the basin area. The snowband model was developed around the concept that the area of the snowbands would add up to 100% of the basin area.

ZER009 NO IC RECORD IN FILE: ssssssss

The snowband IC record is put into the SSARR file at the same time the characteristic record is loaded from ZC cards. It is possible to erase it with HMAINT, one way of causing this error. Fix this error by reloading the ZC cards.

ZER010 TABLE CARD WRONG TYPE: ...

This message indicates that ZCT and ZCF cards are mixed for the same table name.

ZER013 NO RECORD ON FILE:ssssssss rrr

Program error in the snowband model, subr. SBMAIN, WASHED.

ZER019 NO IC SEGMENT FOR OUTPUT.

Program error in snowband model; subr. SBROUT.

ZER026 NO TYPE rrr RECORD FOR ssssssss

A time-series listed on the ZCH cards is not found in the SSARR file. Valid "TYPE rrr":

23 precipitation
24 temperature
25 potential evapotranspiration
26 temperature lapse rate

These records are loaded into the SSARR file through the input of card codes 4, Z4, and Z7, and retrieval from the bulk file with Z1 cards. Hydromet data may also be input with the CROHMS and L subcommands of IA.

ZER027 NO CHARACTERISTICS RECORD ON FILE FOR ssssssss

ZC cards have not been read for station ssssssss.

ZER028 PGM TOO SMALL FOR TIME CARD. nnnn WORDS NEEDED ...

Too many compute periods are defined by the time card for this version of the SSARR program.

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INPUT DATA REFERENCE

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FIXED-FORMAT INPUT CARD DESCRIPTIONS (Card Drawings on Page B-4 thru B-17)

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6P	DATA	B-87
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SUMMARY OF SNOWBAND FORMATS
(Including defaults in parenthesis, when provided)

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ZAQ	source, target	B-30
ZBSTORE	station, type, bulkname, bulkcode	B-31
ZCA	station, % area-1, %area-2, etc.	B-31
ZCE	station, elevation-1, elevation-2, etc.	B-31
ZCF	table, Z1, X1, Y1, X2, Y2, X3, Y3	B-31
ZCH	station, type hsta wt, type hsta wt, etc.	B-32
ZCP	station, elevation %area-below, elevation %area-below, etc.	B-32
ZCT	station words/point, X1, Y1, etc.	B-32
ZC1	station description	B-34
ZC2	station area zones, ns, sts, nss, ssts, nbf, bfts, nlz, lzts, BIITS, BIIMX, BFLIM, PBLZ(0%), DGWLIM(0)	B-34
ZC3	station elevation/%PP(100%), ATIMR/SMR,CR TIPMR(.98) TIPM(.84) RMR(.074) PLWC(.03) SNETF(.90) ELINT(100000) lapse (3.3)	B-34
ZC4	station SMI/ROP(100%) BII/BFP(0) S-SS/S(50%) RI/EKE(100%) TA/ETP(0) SMI/DKE(100%) Month/ETMO(100%)	B-35
ZC5	station TINTMX(.2) BASE(32) PXTEMP(35) PMIN(.017) PMAX(.0333) Month/GMLT(0) Elev/ETIPCT(100%) WEMIN(2.) WEPCT(60.) WEMAX(0.4)	B-35
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	Aarea, S,S,S...Etc.	B-39
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Z2n	station time, ROP BFP CC SLIQW ATIMR ATICC WE SMI BII TINT	B-41
Z4s	hstation, time, code, value, value, ...	B-42
Z6s	station, time, code, value, value, ...	B-43
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BASIN name	Set RUN Command to Process Watersheds	B-110
RIVER name	Set RUN Command to Process a River Model	B-111
RUN name	Process Either Watersheds or a River Model	B-111

ADD RIVER MODEL RESULTS TO TYPE-100 (REGULATION) RECORD

E = ELEVATIONS   Q = FLOWS

Card	E/Q	*	RIVER MODEL STATION		TYPE—100 STATION
A					

DEPLETION-CURVE MODEL CHARACTERISTICS 1 of 4

Card	Card No.	STATION NAME	SPEC. EXIT 1 = SNOW BAND	OUTPUT CONTROL 0 = NO OUTPUT 1 = PRINTED OUTPUT 2 = PUNCHED OUTPUT 3 = PRINTED & PUNCHED OUTPUT	INITIAL CONDITIONS OUTPUT CONTROL, 0 = NO OUTPUT 2 = PUNCHED 4 = FILED 6 = BOTH	DEPLETION BASIN DESCRIPTION	OBSERVED Q STATION
CB	1						

NOTE: 8 IN COL. 21 WILL SUPPRESS BASIN PRINTOUT

DEPLETION-CURVE MODEL CHARACTERISTICS 2 of 4

Card	Card No.	STATION	DRAINAGE AREA SQ. NO.	SURFACE N	SURFACE Ts HOURS	SUB-SUR N	SUB-SUR Tss HOURS	BASE N	BASE Tsbf HOURS	RISING BII-Ts (HOURS)	KE TABLE	SNOW COVER DEPL. TABLE	SNOW COVER AREA OUTPUT NAME	ETI MONTHLY TABLE	SMI ROP TABLE	FALLING BII-Ts (HOURS)
CB	2															

NOTE: NAME IN COL 52-55 INDICATE THIS IS THE SNOW PART OF SPLIT-WATERSHED,

DEPLETION-CURVE MODEL CHARACTERISTICS 3 of 4

Card	Card No.	STATION	SURFACE Ts vs. OUTFLOW TABLE	BII TABLE	BII MAX (IN.)	SURFACE SUB-SUR SPLIT TABLE	EXPOSURE RATIO TO RADIATION K'	EXPOSURE RATIO TO WIND K	EFFECTIVE FOREST COVER RATIO, 1	CONSTANT WIND SPEED MPH	AIR TEMP vs DEW PT. TABLE	MELT RATE TABLE	I.C. ADJUST CONTR. %	I.C. ADJUST CONTR. Q. MAX	RAIN FREEZE TEMP °F	BASE TEMP °F	LAPSE RATE PER 1000'
CB	3																

DEPLETION-CURVE MODEL CHARACTERISTICS 4 of 4

		STATION NAME	HYDROMET DATA STATIONS 1			2			3			4			5			6			7		
			CODE	STA	WGT.	CODE	STA	WGT.	CODE	STA	WGT.	CODE	STA	WGT.	CODE	STA	WGT.	CODE	STA	WGT.	CODE	STA	WGT.
C	B	4																					

CODES:
1 SNOWLINE ELEVATION, FT.
2 SNOW COVERED AREA, %
3 RAIN, INCHES
4 AIR TEMPERATURE, °F
5 DUE POINT TEMP., °F., OR DAILY EVAPOTRANSPIRATION INDEX, (Inches/day) WHEN SNOWMELT OPTION NOT USED
6 ALBEDO, %
7 INSOLATION, LANGLEYS
8 WIND SPEED, MPH
9 SNOW MELT RATE, Inches/Degree-day

TRANSFER POINT CHARACTERISTICS 1 of 2

		STATION NAME	OUTPUT CONTROL 0 = NO OUTPUT 1 = PRINTED OUTPUT 2 = PUNCHED OUTPUT 3 = PRINTED & PUNCHED OUTPUT	CODE	STATION DESCRIPTION
C	C	1			

NOTE: CODES IN COL. 24-26 IS CODE TO DESIGNATE UNITS FOR C F TABLES
24 = Y, 25 = X, 26 = Z
CODE 0 OR 1 = FLOW
2 = ELEVATION

TRANSFER POINT CHARACTERISTICS 2 of 2

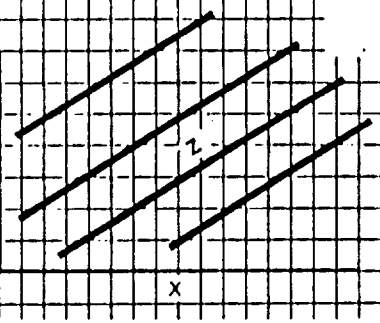
		STATION	SIGN REVERSAL	LOCAL CALC. D/S STATION or "X" Station	ADJACENT STATION or "Z" Station	ADJ STA TABLE or "CF" TABLE	ADJ STA WGT. %
C	C	2					

FAMILY-OF-CURVES TABLE

	CARD NUMBER	TABLE NAME	Z PARAMETER	FIRST POINT X	FIRST POINT Y	SECOND POINT X	SECOND POINT Y	THIRD POINT X	THIRD POINT Y
C	F								

NOTE: ELEVATION (XX.XX)
FLOW (XXXX.)
(DO NOT PUNCH DECIMAL)

NOTE: LOWEST Z CURVE MUST BE ZERO FOR ENTIRE RANGE i.e. 0 at 0 & 0 at 999999 OTHERWISE NEGATIVE FLOWS WILL RESULT.



LAKE/RESERVOIR CHARACTERISTIC 1 of 2

			STATION NAME	OUTPUT CONTROL 0 = NO OUTPUT 1 = PRINTED OUTPUT 2 = PUNCHED OUTPUT 3 = PRINTED & PUNCHED OUTPUT	INITIAL CONDITIONS OUTPUT CONTROL, 0 = NO OUTPUT 2 = PUNCHED 4 = FILED 6 = BOTH	STATION DESCRIPTION
C	L	1				

LAKE/RESERVOIR CHARACTERISTIC 2 of 2

			STATION NAME	BACKWATER CODE	BACKWATER CONTROL STATION	ELEVATION UPPER BOUNDS FEET	ELEVATION LOWER BOUNDS FEET
C	L	2					

HYDROMET GAGE CHARACTERISTIC

		HYDRO STATION	PX TEMP	ELEVATION OF HYDRO STATION (FT)	% SNOW CATCH	REMARKS
C	P					

CHANNEL REACH CHARACTERISTIC 1 of 2

	STATION NAME		OUTPUT CONTROL 0 = NO OUTPUT 1 = PRINTED OUTPUT 2 = PUNCHED OUTPUT 3 = PRINTED & PUNCHED OUTPUT	INITIAL CONDITIONS OUTPUT CONTROL, 0 = NO OUTPUT 2 = PUNCHED 4 = FILED 6 = BOTH	CODE	STATION DESCRIPTION
C R 1						

NOTE: CODES IN COL. 24-26 IS CODE TO DESIGNATE UNITS FOR C F TABLES

24 = Y, 25 = X, 26 = Z

CODE 0 OR 1 = FLOW

2 = ELEVATION

CHANNEL REACH CHARACTERISTIC 2 of 2

	STATION NAME		NO. Phs.	Ts = KTS / Q'	
				n	KTS
C R 2					

GENERAL PURPOSE TABLE/RELATION

	CARD NUMBER	TABLE NAME		TABLE ELEMENTS (PUNCH DECIMALS)							REMARKS
				1	2	3	4	5	6	7	
C T											

WORD 1 OF 1ST CARD IS TABLE FORMAT CODE

RATING: ELEVATION-DISCHARGE-CONTENTS RELATION

	CARD NUMBER 10, 11, 12 ... STATION NAME	POINT 1				POINT 2			
		ELEVATION (FEET)	FLOW (CFS)	TIME OF STORAGE (HOURS)	STORAGE (AC. - FT.)	ELEVATION (FEET)	FLOW (CFS)	TIME OF STORAGE (HOURS)	STORAGE (AC. - FT.)
C 1									

NOTE: LAST TABLE POINT SHOULD BE FILLED WITH 9's IN ALL FIELDS

BACKWATER TABLE FOR LAKE/RESERVOIR

	STATION NAME	POINT 1				POINT 2			
		FLOW (CFS)	ELEVATION (FEET)		CONTROL ELEV. or Q	FLOW (CFS)	ELEVATION (FEET)		CONTROL ELEV. or Q
C 2									

DEPLETION-CURVE MODEL ELEVATION VS. AREA RELATION

	STATION NAME	1st POINT ELEVATION	1st POINT % AREA	2 ELEVATION	2 % AREA	3 ELEVATION	3 % AREA	4 ELEVATION	4 % AREA	5 ELEVATION	5 % AREA	6 ELEVATION	6 % AREA
C3													

NOTE: % AREA IS PERCENT OF DRAINAGE BASIN BELOW THE CORRESPONDING ELEVATION
TABLE MAY CONTAIN UP TO 100 POINTS LAST POINT MUST BE AT 99.9%
ALSO LAST ELEVATION SHOULD BE INFINITELY LARGE.

"FILE" END MARKER

FEND

"FILE" START HEADER

	NAME
FILE	

INSERT "FILE" IN INPUT STREAM

L = LIST

		NAME
GET	L	

CHANGE JOB DESCRIPTION

	JOB DESCRIPTION
H	

JOB CONTROL

MUST HAVE "J" IN COL. 1	JOB NAME	RUN DATE Day	Mo.	Yr.	HOURS PER PRINT LINE IN "OUTPUT" PHASE	JOB TITLE
J						

PUNCH "1" FOR COLUMBIA RIVER FORECAST CENTER HEADINGS
TRACE CODE-NORMALLY BLANK

UNIT MEASURE: BLANK OR 0 = ENGLISH UNITS, "1" = METRIC UNITS
RIVER MODEL PRINT CODE, PUNCH "1" IF PRINTOUT TO BE ON ON UNIT 8
MONTH-END PAGE CONTROL PUNCH "1" IF NEW PAGE AT START OF MONTH IS NOT NEEDED.
1/CARD PUNCH FORMAT; PUNCH "P" FOR 1/CARD FORM, RATHER THAN "6D".
PUNCH "1" TO SUPRESS PRINTING OF STATION LIST, "T" CARD, ETC.
0 = MELT, 1 = MELT + RAINFALL RUNOFF IN % RUNOFF COMPUTATION

NAME OF MODEL-LIST OF P-CARDS (CONFIGURATION CARDS)

	MODEL NAME
N	

CONFIGURATION

	CARD NUMBER	STATION NAME	PRIMARY DOWNSTREAM STATION	ADDITIONAL DOWNSTREAM STATIONS 1	2	3	4	5
P								

PRINTER-PLOT OF RIVER MODEL RESULTS

	OESM	CONTINUE	1st STATION	SYMBOL	2st STATION	SYMBOL	3rd STATION	SYMBOL	4th STATION	SYMBOL	PILOT TIME CONTROL START HOUR	DAY	MO	YR	END HOUR	DAY	MO	YR	HOURS PER ABSCISSA POINT	DISCHARGE (PQ OR PM), CFS ELEVATION (PE) FEET STORAGE (PS) 10 AC.-FT. MIN PLOT	MAX PLOT
P																					

NOTES: 1. PLOT SYMBOLS FOR EACH STATION FOLLOW STATION NUMBER, SYMBOLS MAY BE ANY CHARACTER ON KEYBOARD.
2. COLUMN 2 SHOULD CONTAIN A Q IF PLOT IS FOR DISCHARGE, E IF PLOT IS ELEVATION, AND S IF STORAGE, M IN COL. 2 WILL PLOT MEAN DAILY STREAM FLOWS.
3. A C IN COL. 3 MEANS THAT VALUES ON THIS CARD WILL PLOT ON SAME SHEET AS VALUES ON PREVIOUS CARD.

PRINTER-PLOT OF HYDROMET DATA

	C = CONTINUATION	1st STATION			2nd STATION			3rd STATION			4th STATION			START PLOT TIME				END PLOT TIME				HOURS PER ABSCISSA POINT	PLOT SCALE	
		STATION	CODE	WEIGHT %	STATION	CODE	WEIGHT %	STATION	CODE	WEIGHT %	STATION	CODE	WEIGHT %	HOUR	DAY	MO	YR	HOUR	DAY	MO	YR		MINIMUM	MAXIMUM
P H																								

CODES:
1. SNOWLINE ELEVATION
2. SNOW COVERED AREA
3. RAIN
4. AIR TEMPERATURE
5. DEW POINT TEMPERATURE
6. ALBEDO, %
7. INSOLATION, LYS.
8. WIND SPEED
9. SNOW MELT RATE

THESE DATA ARE PLOTTED FROM 21-29 RECORDS IN SSARR WORK FILE. i.e., RAIN IS IN 23 RECORD.

OPTIONAL TABULATION OF RIVER MODEL RESULTS

	CONTINUATION	NUMBER	1		2		3		4		5		START TIME				END TIME				SPACING (HOURS)	OVERFLOW	SUPPRESS
			STATION	CODE	STATION	CODE	STATION	CODE	STATION	CODE	STATION	CODE	HOUR	DAY	MO	YR	HOUR	DAY	MO	YR			
P R																							

CODES:
1. FLOW
2. ELEV. OR STAGE
3. FLOW + ELEVATION
4. STORAGE
5. FLOW + STORAGE
6. ELEVATION + STORAGE
7. FLOW + ELEVATION + STORAGE (DEFALT)
8. MEAN DAILY FLOW
9. PERCENT CAPACITY (NEEDS A CORRESPONDING C1 TABLE OF PERCENT CAPACITY VS ELEVATION)

NOTES:
1. COL 55-78 MAY BE DELETED ON CONTINUATION CARDS
2. COL 77 - 0 = NEW PAGE MONTH, 1 = CONTINUOUS
3. COL 78 - 0 = DATE PRINTS BOTH SIDES, 1 = DATE PRINTS LEFT SIDE
4. NUMBER IN COL 4 IS A FORTRAN UNIT NUMBER A BLANK OR ZERO PRINTS ON THE SAME UNIT AS PLOTS AND OUTPUT.

TITLES FOR OPTIONAL TABULATION OF RIVER MODEL RESULTS

			STATION 1	2	3	4	
			TITLE	TITLE	TITLE	TITLE	
P	T						

NOTES: 1. NUMBER REFERS TO NUMBER ON PR CARD.
2. IF PT CARD NOT USED TITLES COME FROM CHARACTERISTICS CARDS. (CB, CL, CR, CC)

PUNCH MEAN DAILY FLOW FROM RIVER MODEL

			STATION NAMES					START TIME				END TIME				REMARKS
			1	2	3	4	5	HOUR	DAY	MO	YR	HOUR	DAY	MO	YR	
P	U															

NOTE: PU CARD IS FOR PUNCHING MEAN DAILY FLOWS ON 6D CARD FORMAT, DATA CODE 1

MAXIMUM OF 9 STATIONS MAY BE PUNCHED

COL. 55-72 MAY BE OMITTED ON CONTINUATION CARDS.

PRINTER-PLOT BASIN SUMMARY RESULTS

			STATION	2nd STATION	3rd STATION	4th STATION	PLOT TIME CONTROL START HOUR	START DAY	START MO	START YR	END HOUR	END DAY	END MO	END YR	HOURS PER ABSCISSA POINT	MINIMUM	MAXIMUM
P	Z	0															

CODE: to punch in Col. 14, 24, 34, or 44 Field name on basin printout

1	PCPN	Period precip, at sea level, inches.
2	TA	Average temperature at sea level.
3	SURF	Discharge from surface component, cfs.
4	SUBSF	Discharge from subsurface component, cfs.
5	BASEF	Discharge from baseflow component, cfs.
6*	LOWERZ	Discharge from lower-zone component, cfs.
7	TOTAL	Total basin discharge at end of compute period, cfs.
8	QOBS	Total basin observed discharge (CBO1 card or ZC6 card).
9	INT	Loss to tree interception, inches.
A	MR	Average melt rate on melting bands with snow, inches per degree-day.
B	RG	Runoff generated, inches.
C	TWATER	Moisture input, inches.
D	TTWATR	Period melt (from rain-melt and dry-melt), inches.
E*	TPET	Potential evapotranspiration rate, inches per day.

CODE:

F	TLIQD	Snow liquid water deficit inches.
G	ET	Evapotranspiration rate, inches per day.
H	WE	Water Equivalent of snow accumulation, inches.
I	SNOWLINE	Mid-point elevation of lowest band with non-zero WE, feet.
J	ROP	Average runoff percent.
K	TAMR	Reserved
L	TRGS	Input to surface runoff routing, inches/hour.
M	TRGSS	Input to subsurface runoff routing, inches/hour.
N	RGB	Input to baseflow runoff routing, inches/hour.
O*	RGLE	Input to lower-zone runoff routing, inches/hour.
P*	GMLT	GMLT inches/comppute period.
Q	LAPSE	Lapse rate: degrees/1000 ft.
R	TPP	
S	TBFP	
T	TPMR	

*Denotes parameters which are not available for depletion-basins (non-snowband).

PRINTER-PLOT OF INTEGRATED-SNOWBAND ELEVATION BAND RESULTS

	CONTINUE	FIELD	1st STATION		2nd STATION		3rd STATION		4th STATION		PLOT TIME CONTROL START HOUR	DAY	MO	YR	END HOUR	DAY	MO	YR	HOURS PER ABSCISSA POINT	MINIMUM	MAXIMUM
P	Z																				

Field Codes:

1 TA Band Temperature, Degrees F.
2 RAIN Precip on Band, Less Intercept (TINTA), Inches/Hour
3 WE Water Equivalent of Snow, Inches.
4 ATICC Cold Content ATI, Degree-Days.
5 CC Cold Content, Inches.
6 SLIQW Snow Liquid WAter Content, Inches.
7 ATIMR Melt Rate ATI, Degree-Days.
8 TINT Tree Interception.
9 SMI Soil Moisture Index, Inches.
A BII Baseflow Infiltration Index, Inches/Day.
B WATER Moisture Input, Inches.
C SMR Snowmelt Rate, Inches/Degree-Day.

Fields Codes:

D PMRE Percent Meltrate Effective
E RMELT Rain melt, Inches.
F DRYMELT Melt During Non-Rain Period, Inches.
G COLD Input to Cold-Content, Inches.
H CR Cold Rate, Inches/Degree-Days.
I RECH-WATER-RG, Inches.
J RG Runoff Generated, Inches.
K ROP Runoff Percent, Percent.
L BFP Baseflow Percent, Percent.
M RGS Input to Surface Runoff, Inches.
N RGSS Input to Subsurface Runoff, Inches.
O RGB Input to Baseflow Runoff, Inches.

Fields Codes:

P RGLZ Input to Lower Zone Runoff, Inches.
Q EKE ETP Effectiveness as Function of PP/Day, Ratio.
R DKE PET Effectiveness as Function of SMI, Ratio.
S TWATER = REMELT + DRYMELT, Total Melt, Inches.
T TINTMX Tree Interception Maximum, Inches.
U ETMO ETI Effectiveness as Function of Month, Ratio.
V ETI = ETP*EKE Evapotranspiration Index, Inches.
W ET Evapotranspiration, Inches.
X TINTA Tree Interception Input (Loss), Inches.
Y SLIQWD Snow Liquid Water Deficiency, Inches.
Z GMLT Groundmelt, Inches.

SAVE RIVER MODEL RESULTS AS TYPE-100 (REGULATION) RECORD

E = ELEVATIONS Q = FLOWS

		RIVER MODEL STATION	TYPE—100 STATION
S			

SAVE RIVER MODEL RESULTS BY MERGE INTO TYPE-100 AND TYPE-102

		RIVER MODEL STATION NAME	TYPE 100/102 STATION NAME	Q = SAVE FLOWS IN 100 RECORD	E = SAVE ELEVATIONS IN 102 RECORD
S	R				

TIME CONTROL

	1st PERIOD START TIME				HOURS PER PERIOD	2 TIME				3				4				5 (END OF 4)				INSTANTANEOUS CONDITION OUTPUT (HOURS FROM START OF RUN)				PROCESS
	HOUR	DAY	MO	YR		HOUR	DAY	MO	YR	HOURS PER PERIOD	HOUR	DAY	MO	YR	HOURS PER PERIOD	HOUR	DAY	MO	YR	HOURS PER PERIOD	HOUR	DAY	MO	YR	1	2	3	4	ALL	
T																														

COL 80: 2 = DO NOT PROCESS RIVER MODEL

3 = DO NOT PROCESS WATERSHEDS

4 = DO NOT PROCESS ANY MODELS

TELETYPE OUTPUT OF RIVER MODEL RESULTS

		START TIME (or T card)				NO. OF DAYS (or 7)	
		HOUR	DAY	MO	YR		
X	C						

TELETYPE OUTPUT TEXT LINE

		72 CHARACTERS TO BE OUTPUT DIRECTLY	
X	H		

TELETYPE OUTPUT STATION RETRIEVAL FROM RIVER MODEL RESULTS

		STATION		DATA CODE 2 = ELEV	STATION NAME (COL. 5 - 13 BLANK)	
					LINE DESCRIPTION	
X	S					

DEPLETION-CURVE BASIN INITIAL CONDITIONS

	STATION	TIME: HOUR	DAY	MO	YR	DAILY RAIN DISTRIBUTION	SMI (IN)	BII (IN)	ETI OR SNOW MELT DAILY DIST. TABLE	SNOW COVERED AREA %	INITIAL MELT RATE in/deg.-day			ACCUMULATED RUNOFF FROM RAINFALL	SNOW MELT ONLY: ACCUMULATED RUNOFF (INCH)	SNOW MELT ONLY: TOTAL SEASONAL RUNOFF (INCH)		INITIAL COND ADJUST Observed Q (CFS)
2B00																		

NOTE: IF DAILY DISTRIBUTION OF ETI IS USED, THE DAILY ETI DISTRIBUTION IS LOADED ON 5 CARDS.
AND THE DISTRIBUTION NAME FROM THE 5 CARD IS SHOWN IN COL. 38-41 ABOVE.

DEPLETION-CURVE BASIN INITIAL CONDITION OF ROUTING PHASES

	CODE (See note)	STATION	TIME: HOUR	DAY	MO	YR	0 or 1 = DISCHARGE, CFS 2 = ELEVATION, FEET (XXXXX.XX) PHASE 1	2	3	4	5	6	7	8
2B														

NOTE: CODE 2 = SURFACE
3 = SUBSURFACE
4 = BASEFLOW

LAKE/RESERVOIR INITIAL CONDITION

	STATION	HOUR	DAY	MO	YR	OUTFLOW (CFS)	MUTUALLY EXCLUSIVE: ELEVATION (FEET)	STORAGE (AC. - FT.)
2L								

NOTE: ELEVATION OR STORAGE MUST BE SPECIFIED, AS NON-ZERO

CHANNEL REACH INITIAL CONDITION

	STATION	INITIAL TIME: HOUR	DAY	MO	YR	CODE: 0 OR 1 = DISCHARGE (CFS), 2 = ELEVATION (XXXXX.XX ft.) INFLOW	INCREMENTAL DISCHARGES (CFS): 1	2	3	4	5	6	7
2R													

USGS DAILY PRECIPITATION DATA

	DATE (HR = 6AM) DD	MM	YY	STA-TION	DAILY PRECIPITATION SCALED XX.XX INCHES 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
3																					

CHANGE DEPLETION-CURVE BASIN INITIAL CONDITIONS

		STATION	TIME HOUR	DAILY RAIN DISTRIBUTION TABLE	SMI (IN)	BII (IN)	ETI OR SNOW MELT DAILY DIST. TABLE	SNOW COVERED AREA %	INITIAL MELT RATE in/sq.-day	PRINT CONTROL	SNOW MELT ONLY: ACCUMULATED RUNOFF (INCH)	SNOW MELT ONLY: TOTAL SEASONAL RUNOFF (INCH)	INITIAL COND ADJUST Observed Q (CFS)
3	B												

NOTE: THIS CARD IS USED TO CHANGE 2B00 CARD. ONLY NON-ZERO FIELDS ARE STORED.
PRINT CONTROL: IF NON-ZERO, CAUSES UNADJUSTED WATERSHED RESULTS TO PRINT AHEAD OF ADJUSTED RESULTS.

DEPLETION-CURVE BASIN ENDING OBSERVED FLOW

		STATION NAME	TIME HR	DD	MM	YY	OBSERVED FLOW CFS
3	F						

LAKE/RESERVOIR OBSERVED CONDITION

		STATION	HOUR	DAY	MO	YR	OUTFLOW (CFS)	MUTUALLY EXCLUSIVE: ELEVATION (FEET)	MUTUALLY EXCLUSIVE: STORAGE (AC. - FT.)
3	L								

NOTE: ELEVATION OR STORAGE MUST BE SPECIFIED, OUTFLOW MAY BE, VALUES MUST AGREE. ASSURE VALUES SPECIFIED ARE WITHIN LIMITS SPECIFIED IN CHARACTERISTICS CARDS.

CHANNEL REACH OBSERVED CONDITION

		STATION	TIME HOUR	DAY	MO	YR	OUTFLOW (CFS)	ELEVATION (FEET)
3	R							

HYDROMET DATA, EVENLY SPACED

	HOURS PER READING	STATION	NUMBER OF READINGS PER CARD					READINGS													
			FIRST TIME PERIOD				CODE														
			HOUR	DAY	MO	YR		1	2	3	4	5	6	7	8	9	10	11	12	13	14
4 D																					

CODE:
- 2 SNOWCOVERED AREA,% XXX.X
- 3 RAIN, INCHES XX.XX
- 4 AIR TEMPERATURE, °F. XXX.X
- 5 DEW POINT TEMP., °F. XXX.X, OR DAILY ETI INPUT (I.e., PAN EVPORATION DATA) IN IN/DAY, XX.XX
- 6 ALBEDO, % XXX.X OR LAPSE RATE XXX.X °F/1000
- 7 INSOLATION, LANGLEYS XXXX.
- 8 WIND SPEED, MPH XXX.X
- 9 SNOW MELT RATE, IN/DEG. DAY XXXX

DAILY SNOWLINE ELEVATIONS

	STATION	TIME FIRST VALUE					DAILY SNOWLINE ELEVATION READINGS							
		HOUR	DAY	MO	YR		1st	2	3	4	5	6	7	8
4 E						1								

HYDROMET DATA, WITHIN MONTH

	STATION	TIME FIRST VALUE				CODE	1st Reading	2nd			3rd			4th			5th		
		HOUR	DAY	MO	YR		VALUE	HOUR	DAY	VALUE	HOUR	DAY	VALUE	HOUR	DAY	VALUE	HOUR	DAY	VALUE
4 P																			

CODE:
- 1 SNOWLINE ELEVATION XXXX.
- 2 SNOWCOVERED AREA, % XXX.X
- 3 RAIN, INCHES XX.XX
- 4 AIR TEMPERATURE, °F. XXX.X
- 5 DEW POINT TEMP., °F. XXX.X
- 6 ALBEDO, /XXX.X OR LAPSE RATE XXX.XX°F/1000
- 7 INSOLATION, LANGLEYS XXXX.
- 8 WIND SPEED, MPH XXX.X
- 9 SNOW MELT RATE, IN/DEG.-DAY .XXXX

*NOTE: A DATA CODE 5 (WHEN SNOWMELT NOT BEING USED) IS USED TO INDICATE DAILY ETI INPUT (I.e. PAN EVAPORATION DATE) IN IN/DAY, XX.XX. ALSO THE C804 CARD MUST CONTAIN DATA CODE 5 FOLLOWED BY STATION NUMBER FROM THIS CARD, DISTROBUTION OF DAILY ETI IS LOADED ON 5 CARDS

DAILY DISTRIBUTION

	CARD NUMBER		DISTR. TABLE I. D.	START TIME HOUR BEGIN	DAY	MO	YR	SHIFT	1st DISTRIBUTION % PER PERIOD 1	2	3	4	5	6	7	8	2nd START DAY	MO	% PER PERIOD 1	2	3	4	5	6	7	8	3rd START DAY	MO	% PER PERIOD 1	2	3	4	5	6	7	8
5																																				

NOTE: IF COMPUTATION PERIODS ARE NOT 3 HOURS, YOU STILL USE 3 HOUR DISTRIBUTIONS
I.E. 3 HOUR % ARE ADDED TOGETHER IF 6 HOUR PERIODS WERE USED.
COL 24 - A 1 IN. COL. 24 ACTIVATES TIME SHIFT ADJUSTMENT, SHIFTS DISTR.
½ TIME PERIOD USED TO MINIMIZE ADJUSTMENTS OF PRECIPITATION.

REGULATION DATA

HOURS PER READING: 0 IN COL. 2 and BLANKS IN 3 and 4 FOR DAILY READINGS

		STATION	READINGS PER CARD HOUR	DAY	MO	YR	CODE	PERIOD READINGS 1	2	3	4	5	6	7	8
6															

CODES:
0 FREEFLOW
1 OUTFLOW, CFS
2 ELEVATION, FEET (XXXXX.XX)
3 STORAGE, 10 AC.-FT. (i.e., 1 = 10 AC.-FT.)
4 Δ STORAGE, CFS-DAYS
5 Δ ELEVATION PER DAY (XXXXX.XX)
6 Δ STORAGE PER DAY, 10 AC. - FT./DAY

REGULATION DATA

		STATION	TIME 1st VALUE HOUR	DAY	MO	YR	CODE	1 VALUE	2 HOUR	DAY	VALUE	3 HOUR	DAY	VALUE	4 HOUR	DAY	VALUE	5 HOUR	DAY	VALUE
6	P																			

REGULATION DATA, SPORADIC WITHIN YEAR

		STATION	1 TIME HOUR	DAY	MO	YR	CODE	VALUE	2 TIME HOUR	DAY	MO	CODE	VALUE	3 TIME HOUR	DAY	MO	CODE	VALUE	4 TIME HOUR	DAY	MO	CODE	VALUE
6	S																						

CODES: 0 FREEFLOW
1 OUTFLOW, CFS NOTE: ALL VALUES MUST BE IN SAME YEAR BUT MAY BE DIFFERENT MONTH, OR DIFFERENT DATA CODE
2 ELEVATION, FEET (XXXXX.XX)
3 STORAGE, 10 AC. - FT. (i.e., 1 = 10 AC. - FT.)
4 Δ STORAGE, CFS-DAYS
5 Δ ELEVATION PER DAY (XXXXX.XX)
6 Δ STORAGE PER DAY, 10 AC. - FT./DAY

THE INPUT STREAM

The SSARR Model program starts off by reading its first input from FORTRAN unit 5. What the program finds on unit 5 is dependent on the technique used for running the program. Two basic techniques are discussed in Appendix H; the "batch" and "interactive" techniques. Whatever method is selected, the user provides an input stream of card images. In the "interactive" mode, the keyboard of the user's terminal is assigned to unit 5.

The input stream does not have to be entirely on unit 5. There are two ways to include streams from other sources into the input: (a) by switching the input unit to another FORTRAN unit number with the "INU=" card format; (b) by including a stream of card images from the SSARR work file with a "GET" or "ZGET" card. In both cases, at the end of the included streams, the input unit automatically switches back to unit 5. When the end of unit 5 input is found ("end-of-file" signal on unit 5) the program stops and control returns to the host computer operating system.

SEQUENCE OF THE INPUT CARDS. SSARR program input card formats fall into processing groups. The positioning of these groups in relation to each other control the sequence of SSARR processing. Here are the names of the groups, and the card codes which are included in each group:

Group	Card Codes
Stream	GET, ZGET, INU=
Job	J
Characteristics	CB, CC, CF, CL, CP, CR, CT, C1, C2, C3, N, P(col.2=blank), ZC, ZH
Time	T
Time Data	H, Z1, Z2, Z4, Z6, Z7, Z8, 2, 3, 4, 5, 6
Displays	A, P(Col.2=alpha), S, X, ZA, ZS
Status	FEND, FILE, ZEND, ZFILE, ZBSTORE, ZLAPSE, ZLI, ZLIST, ZPUNCH, ZR, comment
End-of-Input	BY, END, end-of-file, J

Breaking the Sequence. The "IA" command may be any place in the input stream. When it is encountered, process control is tranferred to the interactive driver, breaking the "process cycle" shown in Figure B-1.

If the "RETURN" subcommand of "IA", or a "Z" card is entered as a subcommand of "IA", control returns to the "process cycle" position appropriate to process the next card.

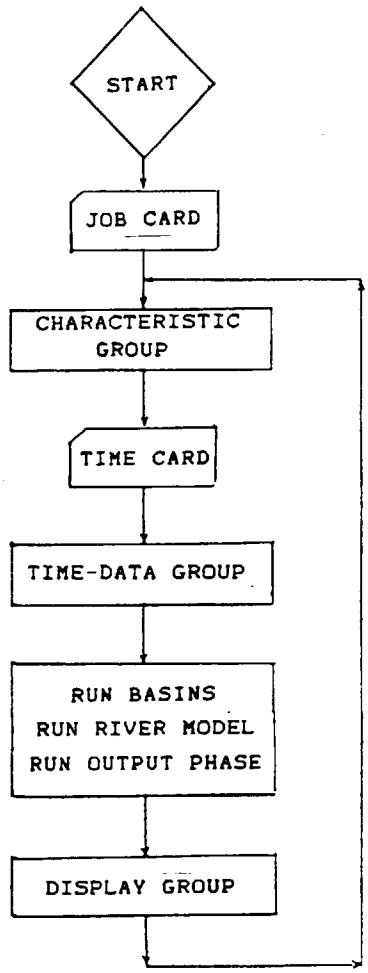


FIGURE B-1. SSARR MODEL AUTOMATIC PROCESSING CYCLE

This processing cycle is followed even when groups are missing. For example, if there are no Display Cards, the next step after processing the models is to see if the next card is from the characteristic group.

The groups are processed as follows:

Stream: This group contains the "INU=", "GET" and "ZGET" cards. These cards direct the program to go to a different source for the input stream. These cards do not themselves effect model characteristics, data, or processing; these cards only instruct the computer program as to where to get the next input cards.

Job: The input must begin with "J" card or "IA" command. When a "J" card is read in other than the beginning of input, it acts as an "END" group card of the preceding stream of input cards. It then becomes the "Job" group for the following cards.

Characteristics: These cards describe the model fixed-characteristics which are independent of time control. "Characteristic" group cards signal the beginning of a basic program cycle. Therefore, if "characteristics" follow a "time" or "time-data" group, the basic program cycle will process the models before beginning the next cycle.

Time: The only card in this group is the "T" time card. The "time" card signals that the models are to be queued, waiting to be processed when all the "time data" group is complete. When the next group following "time data" is encountered, the models are processed. For example, if two time cards are together, the first enqueues the models; the second signals there is no more "time data" for the first and the models are processed for the first "time" card. The program then continues the automatic cycle and returns to the "time" group block.

Time Data: Time dependent data such as daily precipitation, air temperatures, observed flows, daily distribution, and initial conditions are read into the SSARR work file via the Time Data group of card formats.

The date fields of these formats may be "relative dated," meaning that the effective date of the data is dependent on the currently active time control.

Watershed Models: In the program processing cycle, the models are automatically run following the input of a "Time" group and the completion of processing the "Time Data" group, if there is one. The watershed models are processed first. The currently active P-card list (identified by the "N" card) is searched for watersheds. When found, watersheds are processed through the time control range and computed discharges are saved in the SSARR work file in type 101 records.

River Model: Watershed results in type 101 records and regulation information in type 100 records are the time series input to the river model. The P-card list defines the station order and configuration of the river system. The river model produces a temporary file of results for the current time control range. To be usable, the results at key points in the river system must then be processed into reports and/or saved in the SSARR work file. This is accomplished by the automatic "Output Phase," and by the "Display" group card formats.

Output Phase: The characteristics of the stations in the P-card list are scanned for coding in column 21 of the CB01, CC01, CL01, and CR01 formats. This coding directs the Output Phase to include selected river model results in a printed report and on punched cards ("6" format).

Displays: This group of commands nearly all retrieve data from the river model temporary file. The one exception is the "PH" (plot hydromet) command which falls in the "Display" group because it is nearly always used with the other printer-plot commands ("PQ", etc).

The river model temporary file only contains the river model results for the current time range. This restricts the outputs produced by "PR", "X", "PQ", etc. cards to a single "T" card time range. Through the use of "SR", "A", and "ZA" formats, longer time series records may be accumulated in the SSARR work file from several program processing cycles (several "T" cards). These longer time-series may be displayed with the "HMLIST" subcommand of "IA".

Status: These card formats may be included within the "characteristic", "time data", and "display" groups. The current group identification is not changed when a "status" group card is encountered in the input stream. These cards set program status or do SSARR work file operations. The "FILE" and "ZFILE" cards cause the program to simply store (without looking at the contents) all cards following the "FILE"/"ZFILE" card. The storing continues until a "FEND" or "ZEND" card is encountered. The stored cards do not become SSARR input cards until included in the input stream with a "GET" or "ZGET" card.

The "IA" Card: This card causes program control to enter the interactive driver routine. The interactive driver has many subcommands for managing the contents of the SSARR work file including editing and display of time-series data and initial conditions.

Two subcommands of IA are "RUN" and "RETURN." Subcommands "RUN", "BASIN", and "RIVER" operate the watershed models and the river model independently from the "program processing cycle" of Figure B-1. The "Output Phase" is not operated by the "RUN" subcommand. When the models have completed storing their results, control returns to the interactive driver routine (IA).

Subcommand "RETURN" sends control to the program processing cycle shown in Figure B-1. Control is returned to the block in the cycle appropriate to the next card in the input stream.

NAMES OF STATIONS, TABLES, MODELS, AND LISTS. All names in the SSARR Model may be no more than 8 characters long. They may not contain embedded blanks. On some host computers, the program will allow special characters such as the pound sign (#) to be part of a name; but this is not universal so it is best to compose names from the ten digits (0-9) and 26 alphabetic characters.

There are two classes of input lines which may contain name fields. The first is the fixed-format cards in which a name must appear in certain card columns. The second class of input lines are in postional-free format, in which the fields vary in length and are separated by commas or blanks. This class includes "Z" formats and responses to prompts from the IA (interactive) processor.

The fixed-format cards for depletions-curve watershed characteristics and transfer point river model (CCO2 card) allow only four characters for table and hydromet gage names.

The fixed-format cards have four or eight character fields for names. A name which contains any alpha character may be positioned any place within that field; and may be as short as one character.

However, if a name is all numeric, special considerations apply. On the free-format "Z" cards, names are accepted just as they appear. For example, a card punched "ZC1 01230,..." will be interpreted as having the name "01230".

In fixed format name fields, any blanks in the field are filled in with zeroes (that is, if there are no alphabetic characters in the name, only numeric digits). For example, (using the symbol (^) for blank) the fixed format results are:

Card Columns 1-13	Resulting Name	
CB01^^01230^^	00123000	
CB01^^^^^^^^5	00000005	
CT^^^^^^^^^12	0012	(4 character field)

TECHNIQUES FOR MANAGING FIXED CHARACTERISTICS AND TABLES. Basin and river characteristics and tables are entered into the SSARR program with the card code "C" and "ZC" formats. They are processed by SSARR and stored in the SSARR work file. The processed records in the SSARR work file may be listed with the interactive processor via the "IA" command, subcommand "L,name,type". The record types for characteristic data are as follows:

Record Type	Record Contents
0	Characteristics of a basin, lake, reach, or transfer point. To list one of these characteristics, enter this subcommand of IA: "L, name, 0".
2	Model List. This record is produced by reading card code "N" followed by card code "P" (configure) cards describing a list of stations in a model and their streamflow relationship. The "EM" subcommand of IA may also be used to originate and edit Model lists. The "EM" subcommand is the only means available to list a type 2 record; the "L,name,2" command does not work with these records.

Model lists are also used to drive some of the subcommands of IA.

5 "FILE" Record. This record is produced by reading card code "FILE" or "ZFILE" followed by a group of SSARR input cards. The SSARR input card group is copied, in unprocessed form, into the type 5 record until a card code "FEND" or "ZEND" is read. The name of the type 5 record is the first field on the "FILE" or "ZFILE" card.

The "EF" subcommand of IA may also be used to originate and edit "FILE" records. The "EF" subcommand is the only means available to list a type 5 record; the "L,name,5" command does not work with these records.

10 Characteristic of a Gage. The type 10 record is produced by reading card code "CP" or "ZH" format into SSARR.

11 General relationship, usually in the form of a table. These records are produced by reading card formats "CT", "CF", "ZCT", and "ZCF".

Programming has not been done to write out the card images of the characteristics and table cards from the records stored in the SSARR work file. In addition, to make changes to characteristics and tables, it is necessary to reload the entire set of cards for a station; that is, there is not a card format for changing a single value. Therefore, it is usually necessary to maintain characteristics and tables in card image format outside of the SSARR work file.

The simplest and most practical technique for studies is to maintain a separate disk file of the study input stream. All characteristics, tables and data are read from this file by SSARR for each run of the simulation and the SSARR work file is a temporary file; each simulation begins with the SSARR work file empty. Changes to characteristics are made in the input stream file with the system editor .

For management of a permanent SSARR work file, the "INPUT" subcommand of "IA" is useful. A sequential file of characteristic and table cards is maintained with the computer system editor. This file is entirely read into SSARR only once, when the permanent file is first established. Changes to characteristics are made by; first, edit the sequential file; and second, use the "INPUT" subcommand to read only that corrected characteristic into SSARR to make the change in the SSARR work file.

TECHNIQUES FOR MANAGING TIME DEPENDENT DATA. As time-series data is read into the SSARR work file, it is organized into "records". These time-series records are the database for the watershed and river models. Data is input to SSARR in several forms and by a number of techniques, and the database "records" give the using programs a universally consistent way of accessing this data. For example, precipitation data for a gage may be input by card code "4D" cards, corrected by card code "Z7" cards, and further edited by the "L" subcommand of IA. This precipitation record may be used as the input by both the

Depletion-curve watershed model and the Integrated-Snowband Watershed Model, as well as plotted by the printer-plot "PH" card and output in "4D" card format by the "ZPUNCH" card. Central to all of these usages of this data is the precipitation record format in the SSARR work file (the "database"). This central representation of the data aids communications between the various computer programs necessary to perform these operations.

The type of data in the record defines the record "type". It would be more understandable if all references to data records were in terms of recognizable data names, such as precipitation, temperature, flow, etc. However, throughout this manual there are references to various record "types". This is often necessary because in some cases the data type does not uniquely define the record type, and conversely, the record type does not completely define the data. Also, many of the operations pertain to a group of record types (such as types 21-29, the hydromet data records). The following tabulation of the time-series record types may clarify this:

Record Type	Record Contents
21-29	Hydrometeorological Time-Series Records. When data is read in on card code "4D" cards, it is stored in this record type. The record type is derived by adding twenty to the code in Column 24 of the "4D" card. For example, precipitation is encoded with a "3" in Column 24. Therefore, the record type for precipitation data is 23.
61-69	Correction time-series to Override the type 21-29 record with the same name. This record type replaces data in the hydromet record for the same time period. For example, the type 63 record is a precipitation correction. When "Z7" cards are read (containing a "3" in the data code field, meaning "precip correction") the data code 3 is added to sixty to get record type 63. When the 63 record is complete, the SSARR work file is searched for a type 23 record with the same name. If found, the 23 record is corrected with the values from the 63 record.
100	Regulation Time-Series. In this record type, each value in the time-series has an associated "regulation data code". Reading card code "6" cards into SSARR produce this record type. The regulation data codes range in value from 0 to 6. For example, the reulation data codes are contained in Card Column 24 of the "6D" card, and Columns 24, 39, 54, and 69 of the "6S" format.
101	Basin Outflow Time-Series. This record is produced by the watershed models. It contains a value for each compute period, plus one at the start of time. It is mainly used as input to the river model. It can be listed with the IA subcommand "L name 101".

102 River Model Elevation Time-Series Record, produced only by the card code "SR" format. It cannot be used as input to the river model or "PR" report or "PQ" printer-plot. It can be listed with the IA subcommands "HMLIST" and "L name 102". The "SR" card accumulates data in the type 102 record for use by other programs independent of SSARR.

The type 102 record is needed because the type 100 record format can only contain one value at a point in time. Therefore, either flow or elevation from a reservoir can be saved in a type 100 record, but not both. This is pertinent when the computed reservoir conditions over a period of time are needed for other display and analysis programs.

108 Correction to Regulation Record. This record is produced by card code "Z8" and replaces data values in a type 100 record with the same name (similar function to the record type 61-69).

All of these time-series record types may be displayed with the "ZLIST" and "ZPUNCH" cards. All may also be saved into the Bulk file in time-series format with the "ZBSTORE" card. All but the type 101 may be retrieved from the bulk file with the "Z1" card.

The SSARR program has limited space for time-series data in the SSARR work file, so access to external files may be needed for some simulations. The SSARR work file records have a maximum capacity of 3900 data values for a gage for one data code (type 21-29 and 61-69 records). Regulation time-series (type 100 and 108 records) are limited to 2600 data values for a station.

External files addressable by SSARR are: sequential input stream files, the Bulk file, and CROHMS data base.

Time Specification. Dates may be specified completely, or relative to the current SSARR time control that has been set by a "T" card or the "T" subcommand of "IA". "Relative" dates are identified by a month number of zero. In this form, the day value is multiplied by 240 (tenths of hours per day) and added to the hour field (in 0.1 hour units); and this sum is added to SSARR start time to arrive at the given date. If the month number is zero, the year field is ignored

"Annual" relative dates are identified by a non-zero month number and a zero year number. In this form, the specified hour-day-month is to be within the 12-month period following SSARR start time.

Time is represented in the SSARR program as a single number of tenths of hours since the start of the century (Year 1900). This number is called "base-time". Leap year is accounted for correctly. However, there is no facility to represent "daylight" versus "standard" time shifts.

Hydromet Data. These time-series are in type 21-29 records in the SSARR work file. These records may be loaded directly by reading in card code "4" cards or "Z4" cards. They may also be loaded by the "Z1" card (retrieval from the Bulk File), and produced by the "ZLAPSE" card.

The record types and associated data codes are as follows:

Record Type	Data Code		Units Measure
21	1	Snowline elevation	feet
22	2	Snow-covered area	percent
23	3	Precipitation	inches
24	4	Air temperature	degrees
25	5	Dew point temperature	degrees
	or	Daily potential ET	in./day
26	6	Albedo	percent
	or	Lapse rate	degrees/1000 ft.
27	7	Insolation	langleys
28	8	Wind speed	miles/hour
29	9	Melt rate	in./degree-day

Corrections to type 21-29 records may be made by loading a type 61-69 record into the SSARR work file either by reading in "Z7" cards, or retrieving the type 61-69 record from the Bulk File with a "Z1" card. The "L" subcommand of "IA" may be used to edit and list hydromet records and the "CROHMS" subcommand may be used to retrieve and translate data from CROHMS data base for addition to a hydromet record.

Hydromet records may be listed by "IA" subcommands "HMLIST" and "L,name,2x". Output in "4" card format may be done with the "ZLIST" and "ZPUNCH" cards.

Regulation Data. The regulation time-series is in a type 100 record in the SSARR work file. The regulation record may be loaded directly by reading in card code "6" or "Z6" cards; it may also be loaded by the "Z1" card (retrieved from the Bulk File). A restriction on Bulk file operations is that regulation records are stored into bulk file time-series without the "regulation data code". Therefore, it is not possible to store regulation records (type 100 and type 108) that contain more than one "regulation data code". For example, true reservoir operation schedules may specify one kind of control (such as specified discharge) for a period of time, and then switch to another (such as change in storage) and these cannot be stored in the bulk file. However, flow records are often part of the input data to the SSARR models; these are stored in type 100 records and are appropriate data for management with the bulk file facility.

Corrections to a type 100 record may be made by loading a type 108 record into the SSARR work file either by reading in "Z8" cards, or retrieving a type 108 record from the Bulk file with a "Z1" card. The "IA" processor has several subcommands for dealing with regulation (type 100) records:

1. The subcommand "L,name,100" lists the contents. The "HMLIST" and "HMAINT" subcommands also will list type 100 records.

2. The subcommand "6,name..." sends control to the Regulation Editor.

3. The subcommand "SPECFLO" sends control the the SPECFLO program to interactively load a regulation record.

4. The subcommand "CROHMS" will retrieve and translate data from the CROHMS data base for addition to a regulation record.

Regulation records are also modified by card codes "A...", "S...", "ZA..." "ZR", "ZSQ", and "ZSE". These cards store river model results into type 100 records.

Output in "6" card format from type 100 records may be done with the "ZLIST" and "ZPUNCH" commands.

Initial Conditions. Each basin, lake/reservoir, and reach characteristic entered into SSARR produces both a characteristic record (type 0) and an initial condition record (type 1). The initial condition record has 20 positions, or "slots". Each position holds a set of initial conditions (IC) for one point in time, and there can only be one set at a point in time. When a new set of IC is stored, an old one is replaced.

IC may be input with the card code "2" formats. Integrated-snowband watershed model IC are input via card code "Z2" formats. In addition, the watershed and river models always save the computed IC at the end of simulation time, and may be instructed to save IC at intermediate times. The "IC" subcommand of IA may be used to manually input and change IC values for depletion-curve basins, lake/reservoirs, and reaches, but not for integrated-snowband basins.

Depletion-curve basin IC may be adjusted to observed conditions automatically at the end of simulation time, through the use of the card code "3F" format. A detailed description of the technique is to be found in Appendix C in the Section "Automatic Adjustment of Watershed".

Integrated-snowband basin IC can be automatically adjusted, at the end of simulation time through the use of the "ADJUST" subcommand of IA. This feature is only available on the Amdahl computer version of the program, and is documented in a separate report titled, "Automatic Adjustment of the Integrated-Snowband Model in Forecasting" by Speers and Davis, Corps of Engineers, NPD, December 1985.

Channel reach IC may be adjusted to observed conditions at the start of simulation time through the use of the card code "3R". A discussion of this usage may be found in Appendix F in the paragraph "Initial condition Adjustments".

The output of IC to screen/printer and files can be accomplished in several ways:

The "ZLI" card can display any of the 20 sets of IC for a station. It also has the option of storing the IC in card image form in a "FILE" record (type 5) in the SSARR file. Another option (the "EZ" option)outputs the IC at end of simulation time with zero in the date field, allowing the use of these images as input for "ESP" runs. A discussion of this can be found in Appendix F in the Section, "Seasonal Runoff Forecasts".

The "ZLIP" card is similar to the "ZLI" except that the output is directed to the "punch" unit, which can be allocated to a disk file.

The depletion-curve basin, lake/reservoir, and reach characteristics may be coded to cause IC to be output to the "punch" unit (like the "ZLIP" card does) at times specified on the time control ("T") card. This code is in card column 23 of the "CB01", "CL01", and "CR01" cards. The integrated-snowband basin model has no such coding option.

The entire IC record (type 1 record) may be stored in the bulk file with the "ZBSTORE" card, and retrieved with the "Z1" card. However, this capability is only a means of storing the 20 IC sets, intact, into the bulk file. When retrieved, the current IC record in the SSARR file (containing 20 new sets of IC) is replaced entirely with the record from the bulk file (with its 20 old sets of IC).

BULK FILE OPERATIONS

SSARR Model Program Facilities. The SSARR program inputs hydromet data organized in the form of time-series. The SSARR "Bulk File" was developed to assist the user in managing these time-series for studies covering long time periods.

In the SSARR program data processing, all hydromet time-series covering the range of a "time control" statement ("T" card) are assembled on the SSARR File for processing by the various SSARR models, analysis, and display subroutines. These time-series may be input via card code "4", "6", "Z4", "Z6", "Z7", and "Z8" formats, retrieved from the "Bulk File" via card code "Z1", retrieved from CROHMS Data Base via the "IA" (interactive) processor, and manually input and corrected via the "IA" processor. Discharges and elevations computed by the models may be put into the SSARR File as time-series via the card code "S" and "A" formats. Any time-series residing in the SSARR File may be merged into the "Bulk File" via the card code ZBSTORE format.

Bulk File Characteristics. The file was initially designed to accomodate 500 time series averaging 50 years of daily data. In fact, the length of the individual time-series is unlimited. The time spacing of data within the time-series is also not limited. The file directory has capacity for 2000 time-series.

A time-series is identified by an eight character name, and a numeric "bulk-code" record code.

Non time-series SSARR records may be stored/retrieved from the bulk file.

The bulk file is a large FORTRAN direct access file used in the same manner as a "partitioned dataset"; the total space allocation is fixed and the lower part contains data records while the upper part is free. When a data record is changed or added, free space is used and the old record space is lost until the file can be compressed by the "Bulk File Maintenance Program." For retrieval (Z1 commands) and updating (ZBSTORE command), the file may be concurrently shared by unlimited users in batch and/or TSO.

Z1 Command; Retrieve from "Bulk File". Retrieves data from the bulk file and stores it into the SSARR File.

When the Z1 is input, SSARR retrieves the requested data from the Bulk file and writes it into the SSARR File. An old record in the SSARR File with the identical name and code is replaced, even if no data is found in the Bulk File.

ZBSTORE Command; Store Data to the Bulk File. Merges time-series from SSARR File into Bulk file time-series, replacing all old data within the time range of the SSARR File time-series. SSARR File time-series' are limited to about 3900 values (2600 values in a type 100 record). Bulk file time-series are not limited in length.

Note: This command must be carefully used, since it stores to the Bulk file, replacing previous contents. The Bulk file is normally a "permanent" file, containing long-term historic time-series data.

The ZBSTORE command is freeform-positional and the words have the following meaning:

ZBSTORE, SSARRname, SSARRcode, Bulkname, Bulkcode

where:

SSARRname	SSARR File name; 8 character alphanumeric.
SSARRcode	SSARR File record code; number in the range 0-108. Codes 0-19 and 104 are SSARR fixed formats and are stored into Bulk file without alteration. Codes 20-102 and 108 are time-series and are merged into the Bulk file time-series record format.
Bulkname	Bulk file name; 8 character alphanumeric. If missing, SSARRname is used.
Bulkcode	Bulk file record code; number. If missing, SSARRcode is used. In the Bulk file, the Bulkcode has no meaning except to identify the record and may assume any value.

The ZBSTORE command is positioned in the SSARR input stream the same as the Z1 command. However, the Bulk file must have been previously unlocked for updating by a ZR command of the following content:

ZR BUPD

Independent Bulk File Programs. There are three programs independent of the SSARR program. These programs perform the following operations:

BULKINIT. The principle function of the program is to compress (reorganize) the Bulk file to recover lost space. The compression is into a new copy of the file, leaving the old uncompressed copy as backup.

BULKGET. Retrieves time-series data from the Bulk file and writes a sequential file containing one record per data value. The output format is suited for easy analysis by SAS procedures.

BULKTRAN. Copies records from one Bulk file to another. This program also has an extensive analysis capability for review of bulk file contents.

"Z" FORMAT CARD DESCRIPTIONS. All card formats with "Z" in column 1 are in the "positional-free" format. Words on the card formats have meaning according to their relative position on the card. Word position is counted from left to right. Individual word lengths are variable. Words are separated by one or more blanks (or a single comma; two commas together indicate a missing or null word). A word may represent a number, or an alpha-numeric string. (Such as the "basin description" field on ZC1 card). If the word is a number, a minus sign (indicating negative) may precede the first digit to the left, and a decimal point may be included if needed.

Note: The card identifier always begins in Column 1. Columns 3-80 may contain the positional-free form words. There is no provision for continuing an individual card to a second line of 80 columns. For example, all 16 fields provided by format "ZC2" must fit on the one 80-column card.

Comments are not allowed on the Z card formats. (Any card with column 1 blank is accepted as a comment card and has no effect on the model).

"ZA" Formats. The river model is composed from the current P-card (configuration) list. When the river model is run with the current time control, the flow (and elevation for stations with C1 tables) is computed for each station in the list for each time period. These results are held in the river model temporary work files for display with the plot (PQ, etc), print (PR), and other listing commands. Once the display processing is complete for a time period, these temporary work files are reused and the river model results discarded.

The "ZA" card provides the user the capability to save these river model results into a regulation time-series; a type 100 record in the SSARR work file. The "ZA" card will modify on existing type 100 record, replacing only the data values included within the time range of the current time control, the time control of the river model. If no old 100 record exists, a new one will be made.

ZAE source, target. Add elevations from "source" station in river model to "target" 100 record.

ZAQ source, target. Add flows from "source" station in river model to "target" 100 record.

Note: Other similar commands are card code "A" formats.

ZBSTORE. Store data from the SSARR file to the bulk file.

Note: This command must be carefully used, since it stores to the bulk file, replacing previous contents. The bulk file is normally a "permanent" file. ZBSTORE is only used during the initital file loading. Please see "Bulk File Operations", page B-25 for description of format and usage.

ZCA. Basin Percent-Area Per Band Table. Part of "Snowband Model" watershed characteristics. (There may be more than one ZCA card.)

Word	
1	Station
2	Percent of basin area contained in lowest band (Band number 1, if this is first ZCA card).
3	Percent of basin in next higher band.
4	Through end: Additional band percents.

See ZCE card for another way to specify bands.

ZCE. Basin Band Elevation Table. Part of "Snowband Model" watershed characteristics. (There may be more than one ZCE card.)

Word	
1	Station
2	Elevation (feet) of top of lowest band. If this is first ZCE card, this is top of band 1. Band 1 always starts at elevation of lowest point as given by ZCP table.
3	Elevation of top of next higher band. 4 through end: additional elevations of bands.

See ZCA card for another way to specify bands. If both ZCA and ZCE cards provided, ZCE is used.

ZCF. Three-dimension table for use as SMI, MI vs. ROP relation (word 2 of ZC4 card). This format may be used instead of CF format.

Each ZCF card always has 8 words:

Word	
1	Table name.
2	Value of 2nd independent variable (MI).
3	Value for 1st point of 1st independent variable (SMI).
4	Value for 1st point of dependent variable (ROP).
5	2nd value of SMI.
6	2nd value of ROP.
7	3rd value of SMI.
8	3rd value of ROP.

For example: relation 202 gives ROP as a function of MI and SMI as follows:

MI	SMI	ROP
0	0	10
0	4.5	60
0	9999	60
.04	0	10
.04	4.5	60
.04	9999	60
.08	0	50

.08	4.5	100
.08	9999	100
.25	0	100
.25	9999	100
.25	99999	100
999	0	100
999	9999	100

This relation is represented in ZCF format as follows:

ZCF	202	0	0	10	4.5	60	9999	60
ZCF	202	.04	0	10	4.5	60	9999	60
ZCF	202	.08	0	50	4.5	100	9999	100
ZCF	202	.25	0	100	9999	100	99999	100
ZCF	202	999	0	100	9999	100		

ZCH. Basin Hydromet Station List. Part of "Snowband Model" watershed characteristic. (There may be more than one ZCH card.)

Word	
1	Station name (of basin).
2	Hydromet station type; 3 = precipitation, 4 = temperature, 5 = ETI, 6 = lapse rate, 14 = temperature (missing values allowed).
3	Hydromet station name
4	Hydromet station weight; percent.
5,6,7	Type, name, weight for next Hydromet station, etc., 3 words per entry.

The entries on ZCH cards must be in the following order of Hydromet station type::

6	Lapse rate; must be the first entries on the first ZCH card.
4 or 14	Temperatures; must precede precipitation if catch deficiency (ZH card) is given.
3	Precipitation.

ZCP. Basin Table of Elevation vs. Percent of Area. Part of "Snowband Model" watershed characteristic. (More than one ZCP card may be used.)

Word	
1	Station
2	Elevation (feet) of lowest point.
3	Percent of basin area below elevation in word 2.
4-5	Elevation and percent-area-below of next higher point in table. Etc. Additional points.

ZCT. Two-dimension table or function. Relations may be loaded with either CT cards or the positional-freeform ZCT cards. (There may be more than one ZCT card for a table or relation.)

Word

1 Table name.

2 On 1st card of table, this word is the table format:

Word 2 = 2 Table is composed of two words per point (one independent and one dependent variable).

Word 2 = 3 Table is composed of three words per point (one independent and two dependent variables; for example, ATIMR vs. SMR and CR. See word 3 of ZC3 card).

Word 2 = 0 Power-series where word 3 is N, word 4 is A, word 5 is B, etc. in the following equation when X is the argument: Result = A*X + B*X**2 + ... The constant coefficient is in word (4+N).

3 - end Values of independent and dependent variables or coefficients in format given by word 2 of the first card.

For example:

Relation identified as "1234":

X	Y
0	10
1	25
5	35
9999	35

(From this table, we see that if X = 1, then Y = 25)

Codes in ZCT cards for table 1234 as:

```
ZCT  1234  2  0  10  1     25
ZCT  1234     5  35  9999  35
```

Relation identified as "ARC":

$Y = x + .015\ x^2 + 10$

ZCT ARC, 0, 2, 1, 0.015, 10

Relation identified as "0060":

Y = -123.456

ZCT 0060, 0, 0, -123.456

ZC1. Basin Description for Snowband Model Watershed.

Word 1 - Station name, maximum of 8 characters.

Word 2 - Basin Description. The next non-blank character following the station name is accepted as the beginning of a 44-column field. The contents of this field appear on listings as the basin description.

ZC2. Snowband Model Watershed Characteristics.

Word	
1	Station.
2	Basin area, square miles.
3	Number of snowbands (maximum: 20).
4	Number of surface routing phases.
5	Surface time-of-storage; hours, or name of flow vs. Ts relation.
6	Number of subsurface phases.
7	Subsurface time-of-storage; hours, or name of flow vs. Ts relation.
8	Number of baseflow phases.
9	Baseflow time-of storage; hours , or name of flow vs. Ts
10	Number of lower-zone phases.
11	Lower-zone time-of-storage; hours, or name of flow vs. Ts relation.
12 - BIITS:	Baseflow infiltration Index (BII) time-of-storage; hours.
13 - BIIMX:	BII maximum value; inches.
14 - BFLIM:	Baseflow input limit; inches/hour
15 - PBLZ:	Percent of baseflow input to lower-zone; percent. Default = 0.
16 - DGWLIM:	Lower-zone input limit; inches/hour. Default = 0.

ZC3. Snowband Model Watershed Characteristics.

Word	
1	Station.
2	Table name; Elevation (feet) vs. weighted precipitation (percent).
3 - SMR, CR:	Table name; ATIMR temperature index vs. melt rate, cold rate. Index in degree-days. Rates in inches/degree-days. (This table has two dependent variables; melt rate and cold rate).
4 - TIPMR:	Index parameter for ATIMR temperature index. Default = 0.98
5 - TIPM:	Index parameter for Cold Content ATI. Default = 0.84
6 - RMR:	Melt rate during a rain period. Default = 0.074 inches/degree-day.
7 - PLWHC:	Ratio of liquid water holding capacity of snow. Default = .03 (i.e.; 3%).

8 - SNETF:	Ratio of evapotranspiration over snow. Default = 0.9 (i.e.: 90%).
9 - ELINT:	Treeline elevation for interception; feet (default=100,000)
10	Basin lapse rate. Default = 3.3 degree/1000 feet.

ZC4. Snowband Model Watershed Characteristics.

Word

1	Station
2 - ROP:	Table name; SMI (inches) vs. ROP (runoff percent). If table missing, ROP = 100%. Table may be ZCF (or CF) if ROP is function of both SMI and Moisture Input (inches/hr)
3 - BFP:	Table name; BII (inches/day) vs. BFP (percent of runoff to baseflow). Operationally, table may contain BII vs. BFP and BFLIM (Baseflow Input Limit, inches/hour) overriding word 14 of ZC2.
4 - S/SS:	Table name; Input to S/SS (inches/hour) vs. input to surface (inches/hour). If table missing, 50% of input goes to each of surface and subsurface.
5 - EKE:	Table name; Rainfall intensity (inches/day) vs. EKE (percent effectiveness of ETI). If table missing, EKE = 100%.
6 - ETP:	Table name; Temperature vs. ETP (evapotranspiration index in inches/day). If table missing, ETP = 0.
7 - DKE:	Table name; SMI (inches) vs. DKE (Percent effective ETI). If table missing, DKE = 100%.
8 - ETMO:	Table name; month number vs. ETMO (Percent effective ETI). If table missing, ETMO = 100%.

ZC5. Snowband Model Watershed Characteristics.

Word

1	Station
2 - TINTMX:	Maximum precipitation interception (Default = .2 inches) or name of month vs. TINTMX relation.
3 - BASE:	Base temperature for snowmelt. Default = 32 degree Fahrenheit.
4 - PXTEMP:	Rain-freeze temperature. Default = 35 degree Fahrenheit.
5 - PMIN:	Minimum rain for rain-melt. Default = .017 inch/hour.
6 - PMAX:	Maximum snow for Cold Content ATI. Default = .0333 inch/hour.
7 - GMLT:	Groundmelt constant, inches/day, or name of month number vs. Groundmelt (inches/day) relation.
8 - ETIPCT:	Table name; Elevation (feet) vs. ETIPCT (Percent effective ETI). If table missing ETIPCT = 100%.
9 - WEMIN:	Minimum WE for unrestricted DRYMLT. Default = 2. inches.
10 - WEPCT:	Percentage/day of WE below WEMIN that can be melted. Default = 60%.
11 - WEMAX:	Maximum WE for DRYMLT restriction. Default = 0.4 inches.

ZC6. Snowband Model Watershed Characteristics.

Word

1	Station.
2	Table name; month number vs. MRPCT (Percent effective melt rate).
3	Station name of 6D cards containing basin observed discharges to print on basin summary printout.

ZFILE. File a group of cards.

ZEND. Terminate a group of ZFILE cards.

ZGET. Include a ZFILE Group in the input stream.

ZGETL. Include a ZFILE Group in the input stream and list it on ddname FT03F001.

Words

1 Name of group of cards.

Alternative: Words 1 and 2 may be numbers separated by one blank or comma, and spanning no more than 8 columns combined. The "File" name is made by the program with a "Z" replacing the separator. For example, the command "ZFILE 1, 2" is processed as if it had been entered as "ZFILE 1Z2". This is for compatability with the original version of the Snowband option of SSARR.

A ZFILE card must always eventually be followed by a ZEND card.

The ZEND card has no word fields.

A ZFILE, its group of cards to be filed, and its terminating ZEND may be located in the input stream along with characteristics, table, initial condition, or data cards.

Any kind of cards or interactive commands may be included within a ZFILE group.

ZGET cards may be located anyplace in the input stream. As the SSARR program processes the input stream, a ZGET card is replaced with the group of cards filed by the ZFILE with the same identification.

Alternative formats are "FILE", "FEND", and "GET".

ZH. Hydromet Station Characteristic. This card takes the place of SSARR format "CP" but provides some new information. The "weight-for-snow-events" is an adjustment for gage catch deficiency. The gage PX-temperature is used to separate rain events from snow events. If the weighted temperature at the gage is less than the gage PX-temperature, the precipitation for that compute period is multiplied by "weight-for-snow-events" divided by 100.

Word

1	Hydromet station name.
2	Elevation.
3	Weight for snow events.
4	PX temperature for this gage.

For example:

ZH FRCB 1300, 115, 35
Precipitation station FRCB at 1300 feet elevation. When temperature is below 35°, precipitation is multiplied by 115%.

ZLAPSE. Compute temperature lapse rates for each compute period. These command cards are positioned with the time dependent input data (rather than with PR (print) and PQ (plot) cards) in the input stream. The card contents are as follows:

ZLAPSE target low weight high weight

where:

"target" is hydromet station name of resulting type 26 record of lapse rates; (data code 6).

"low" is the low elevation temperature station number.

"weight": following "low" is the percentage weight to be multiplied with the temperatures for the "low" station.

"high" is the high elevation temperature station name.

"weight" following "high" is the percentage weight to be multiplied with the temperatures for the "high" station.

Elevations of the "high" and "low" stations are provided on CP or ZH cards and must precede the ZLAPSE card. Temperature data for the "high" and "low" stations are retrieved from type 24 records.

The results of the ZLAPSE card are stored in the file identified with "target" station name and record type 26 (as if the lapse rates had been read in on 4D cards with "target" in columns 10-13 and "6" in column 24).

The lapse rates may be listed or punched with the ZLIST and ZPUNCH command cards.

The lapse rates may be used in zone calculations by including type 6 and the "target" station number and appropriate weight on the ZCH card.

ZLI. List Snowband Initial Conditions (I.C.).

Word

1 Station name.

2 Time of I.C.; HHHMMDDYY, or codes "E" or "EZ." If word 2 (time) not provided, the I.C. at start time is listed. Code an E in place of time to cause end time I.C. to be displayed. Code EZ in place of time to cause ending I.C. to be displayed with 0 in the date field (for subsequent input to "ESP" run).

3 "FILE" name. If this field is included on the ZLI command, the IC card images are stored in the SSARR work file as a type 5 record (a "FILE" record). If a type 5 record already existed by the same name, it is replaced.

ZLIP. Punch Snowband Initial Conditions. (Same as ZLI card except "P" in column 4 causes IC to punch in Z2 format on FORTRAN unit 7).

ZLIST. List "4D" or "6D" cards from SSARR work file.

ZPUNCH. Same as "ZLIST" but output suitable for punching on 80 column device.

The command format:

ZLIST	station	type	unit
ZPUNCH	station	type	unit

where:

"station" is station name.

"type" is SSARR work file record type: for example, 23 (or 3) is precipitation and 24 (or 4) is temperature producing "4D" format. Type 100 is regulation record producing "6" format.

"unit" is FORTRAN unit number for output. If this field is not included on command card, ZLIST prints on unit 6 and ZPUNCH punches on unit 7.

ZR. Snowband Run Control. Words are read left to right. Command words and subcommand words have the following meaning:

L Causes individual snowband results to print. Subcommand words following the "L" are snowband numbers, ascending order, of those individual snowbands to be listed.

S Suppress basin printouts, both snowband and depletion curve models.

BUPD Open Bulk File to allow use of ZBSTORE commands.

For example:

ZR L 1 5 6 10

"L 1 5 6 10" Causes bands 1, 5, 6, 10 to be listed in detail.

The "S" code is not included so the basin summary printout will be made.

ZS. Statistic Request. This command card processes river model results in the same manner as PR (Print) or PQ (Plot) command cards and is in the same position in the input stream. The ZS command causes a specified set of monthly statistics to be printed.

Word

1 Computed station name.
2 Observed station name (or null).
3 Start date as DDMMYY or HHHDDMMYY or null.
4 End date; same format as Start date. Note: If a date is null (indicated by ,,), the date is taken from SSARR time control.
5 - End Codes identifying required statistics (see table below), or basin area with "A", and/or punch code "P".

If a word is coded A123.4, the number 123.4 is the drainage area. if no drainage area is provided and statistics 6, 7, 8, or 9 are requested, the characteristic record of the computed station is retrieved for the area.

Code table specifying statistics:

1	MAXIMUM	10	RELATIVE ERROR
2	DATE OF MAXIMUM	11	REL. ERR/MEAN
3	MINIMUM	12	ABSOLUTE ERROR
4	DATE OF MINIMUM	13	ABSOLUTE ERROR/MEAN
5	MEAN	14	STANDARD ERROR
6	VOLUME, INCHES	15	STANDARD ERROR/MEAN
7	ACCUM VOLUME, INCHES	16	SUM OF DIFFERENCES
8	(OBS. VOL.-COMP. VOL.)	17	SUM OF SQUARE OF DIFFERENCES
9	ACCUM (OBS. VOL-COMP.VOL)	18	SUM OF ABSOLUTE DIFFERENCES

If a code is "P", daily average discharges are computed for the "computed" and "observed" hydrographs named on this "ZS" card and punched on card format 6D.

For example: ZS, BONF,BOND,,,P,A210,5,6,8,9,15: station BONF (computed discharge is compared with station BOND (observed) discharge. Time range is same as preceding "T" card. Drainage area is 210 square mile. Average daily flows for stations BONF and BOND are punched. Statistics printed are monthly mean, monthly volume, difference between computed and observed volumes, accummulated difference in monthly volumes, and standard error divided by mean.

ZSE Source, Target. Save elevations.

ZSQ Source, Target. Save flows.

Save river model station named "source" into type 100 record named "target". Any old 100 record named "target" is over-written. See "SE" and "SQ" formats for alternatives and discussion.

Z1. Retrieve time series (or other record) from bulk file. See "Bulk File Operations" page B-23 for discussion of usage. The command is freeform-positional and the words have the following meaning:

Z1, SSARRname, SSARRcode, start, end, Bulkname, Bulkcode, type

where:

SSARRname — SSARR File name; 8 character alphanumeric. This is the target record name, into which data is transferred from the bulk file.

SSARRcode — SSARR File record type; number in the range 0-108 with fixed meanings:

Record Type	
0	Characteristic
1	Initial Condition
2	Model Structure P-Card List
5	File/Get List
10	Hydromet Characteristic
11	Table/Relation
13	Distribution
21	Snowline Elevation Time-Series
22	Snow Covered Area Time-Series
23	Precipitation Time-Series
24	Temperature Time-Series
25	Evapotranspiration Time-Series
26	Lapse Rate Time-Series
27	Insolation Time-Series
28	Wind Speed Time-Series
29	Melt Rate Time-Series
61-69	Corrections to Type 21-29 Time-Series
100	Reservoir Regulation Time-Series
101	Discharge Time-Series
102	Elevation Time-Series
104	Snowband Hydromet Summary
108	Reservoir Regulation Correct Time-Series

start — Start date to begin retrieval as a 6-digit number ddmmyy (day, month, year). If missing, start time from current SSARR time control is used.

end	End date to stop retrieval as a 6-digit number ddmmyy (day, month, year).If missing, end time from current SSARR time control is used.
Bulkname	Bulk file name; 8 character alphanumeric. If missing, SSARR name is used.
Bulkcode	Bulk file record code; number (9 digits or less). If missing, SSARR code is used. In the Bulk file, the Bulkcode has no meaning except to identify the record and may assume any value. The Bulk file records are identified by the ZBSTORE and Z1 command and the user must insure that records of a given SSARR code stored in the Bulk file are retrieved to SSARR with the correct SSARRcode.
type	When the SSARRcode is 100, the regulation data type is provided by this "type" variable, since the data type is not recorded in the Bulk file. (It may be recorded by the user within the Bulkcode via ZBSTORE command, but code 100 is ambiguous because the type 100 record includes a data type for every value. Therefore, type 100 records that are moved into and out of the Bulk File must contain data values of all the same data-code.) The code in word 7 identifies the datatype: 1 = flow, 2 = elevation, 3 = storage, etc. If word 7 is missing, data-type defaults to 1.

Z2B. Snowband Basin Baseflow Routing Components of Initial Conditions. This card format cannot be continued or repeated for the initial conditions for a given time. Values for all components of surface routing must be included on one 80 column card image.

Word

1 Station name.
2 Time-date; HHHDDMMYY. If date missing, start time from T card is used.
3 Thru end: Flow values for each routing phase; cfs. The number of phases is give on ZC2 card.

Z2LZ. Snowband basin Lower-Zone Routing Components of Initial Conditions. (Same as format Z2B).

Z2S. Snowband basin Surface Flow Routing Components of Initial Condition. (Same as format Z2B).

Z2SS. Snowband basin subsurface flow routing components of Initial Conditions. (same as format Z2B).

Z2nn. Snowband Initial Condition, Where nn is Band Number. The lowest band is 1. The number of bands is given by ZC2 card.

Word	
1	Station name.
2	Time-date of this initial condition in the form HHHDDMMYY where HHH is hour and tenths (for 6 AM, HHH is 060), DD is day, MM is month and YY is last two digits of year. There must be nine (9) digits in date word with no embedded blanks. Defaults to start-time from SSARR T (time) card.
3 - ROP:	Runoff percent. If this value is given, the equivalent SMI is gotten from CT or ZCT table (wd 2 of ZC4). (May not be used if ROP is function of CF of ZCF table).
4 - BFP:	Baseflow percent. If this value is given, the equivalent BII is gotten from the table (wd 3 of ZC4).
5 - CC:	Cold content; inches.
6 - SLIQW:	Snow liquid water held; inches.
7 - ATIMR:	Melt rate temperature index; degree-days.
8 - ATICC:	Cold content temperature index; degree-days.
9 - WE:	Snow water equivalent; inches.
10 - SMI:	Inches. If ROP provided in word 3, SMI is gotten from table and word 10 is ignored.
11 - BII:	Inches/day. If BFP provided in word 4, BII is gotten from table and word 11 is ignored.
12 - TINT:	Tree interception; inches.

Z4. Hydromet Input Data. A "freeform" version of the "4D" card.

"Z4" and "4D" formats cannot be mixed as formats for a single time-series.

The first two characters on the card are "Z4". The time increment between data values is specified beginning with the third character. The time increment control may be one of the following:

No entry	24 hours between values
D	(as in Z4D) 24 hours between values
24	(as in Z424) 24 hours between values
240	(as in Z4240) 24 hours between values.

12 or 120, 8 or 08 or 080, 6 or 06 or 060, 4, 04, 040, 3, 03, 030, 2, 02, 020, 1, 01, 010, 005, 002, or 001; if the hour field is one or two digits, it is hours; if the hour field is 3 digits, it is tenths-of-hours; only these values are accepted as valid time increments.

Word	Description
Card ID	"Z4" followed by time increment code (see description above).
1	Station name; should be no more than four characters long since card formats "4D", "CB04", and "PH" are limited to 4-character names.
2	Start time; gives the time-date of the first value (the value in word 4).
	The start time field may be in one of the following formats (determined by the number of digits in the field):

hhhddmmyy	(7, 8, or 9 digits) hhh is tenths-of-hours; ddmmyy is day-month-year.
ddmmyy	(5 or 6 digits) ddmmyy is day-month-year. Hour is picked up from the SSARR start time.
ddmm	(3 or 4 digits) day-month. Hour and year are gotten from the SSARR start time.
dd	(1 or 2 digits. May be preceded by minus sign) day relative to SSARR start time.
null	(,, following station name) use SSARR start time.

3 Data Code; this is the same code that appears in column 24 of the "4D" format (see below).

4 - end Values; The values are real numbers and may be preceded by a minus sign to indicate negative and include a decimal point. For example, the temperature -5.5 is entered just as it is written here. The units of measure are as follows:

Data Code

1	Snowline elevation, feet
2	Snowcovered area, percent
3	Precipitation, inches
4	Temperature, degrees Fahrenheit
5	Evapotranspiration index, inches/day; or dew point temperature, degrees F
6	Lapse rate, degrees F/1000 feet; or Albedo, percent
7	Insolation, langleys
8	Wind speed, mph
9	Snow meltrate, inches/degree-day

Z6. Regulation Input Data. A "freeform" version of the "6D" (and "6...") card. "Z6" and "6..." formats cannot be mixed as formats for a single time-series.

The first two characters on the card are "Z6". The time increment between data values is specified beginning with the third character. The time increment control may be one of the following:

No entry	24 hours between values
D	(as in Z6D) 24 hours between values
24	(as in Z624) 24 hours between values
240	(as in Z6240) 24 hours between values.

12 or 120, 8 or 08 or 080, 6 or 06 or 060, 4, 04, 040, 3, 03, 030, 2, 02, 020, 1, 01, 010, 005, 002, or 001; if the hour field is one or two digits, it is hours; if the hour field is 3 digits, it is tenths-of-hours; only these values are accepted as valid time increments.

Word	Description
Card ID	"Z6" followed by time-increment code (see description above).
1	Station name
2	Start time; gives the time-date of the first value (the value in word 4).

Syntax of time-date:

hhhddmmyy	(7, 8, or 9 digits) hhh is tenths-of-hours; ddmmyy is day-month-year.
ddmmyy	(5 or 6 digits) ddmmyy is day-month-year. Hour is picked up from the SSARR start time.
ddmm	(3 or 4 digits) day-month. Hour and year are gotten from the SSARR start time.
dd	(1 or 2 digits. May be preceded by minus sign) day relative to SSARR start time.
null	(,, following station name) use SSARR start time.

3	Data Code; this is the same code that appears in column 24 of the "6D" format (see below).
4 - end	Values; real numbers that may be preceded by a minus sign to indicate negative and include a decimal point. The units of measure are:

Data Code

0	Freeflow (value has no meaning, only time)
1	Discharge, cfs
2	Elevation, feet
3	Storage, acre-feet
4	Change in storage, cfs-days/day
5	Change in elevation, feet
6	Change in storage, AF/day

Z7. Corrections to a Hydromet Time-Series. Hydromet time-series may be loaded into the SSARR work file with "4D", "Z4", "Z1", and "L" and "CROHMS" subcommands of "IA".

The "Z7" card produces a SSARR work file record type in the range 61 through 69; the date code plus 60 is the record type. For example, precipitation is type 63. When a 60-series record is entered into the file, the 20-series record of the same data code (23 for precipitation in this example) with the same name as the correction record is retrieved. The corrections are applied to the 20-series record and it is stored back to replace the original version of the 20-series record in the file.

Values from the "Z7" correction record will replace values with equal times in the 20-series record, or merge into the 20-series record in time sequence. Values in the "Z7" record either before or after the 20-series record are ignored.

The first two characters of the card are "Z7". The time increment between values is specified beginning with the third character. The time increment control may be one of the following:

No entry	24 hours between values
D	(as in Z7D) 24 hours between values
24	(as in Z724) 24 hours between values
240	(as in Z7240) 24 hours between values.

12 or 120, 8 or 08 or 080, 6 or 06 or 060, 4, 04, 040, 3, 03, 030, 2, 02, 020, 1, 01, 010, 005, 002, or 001; if the hour field is one or two digits, it is hours; if the hour field is 3 digits, it is tenths-of-hours; only these values are accepted as valid spacing.

Word	Description
Card ID	"Z7" followed by time increment code (see description above).
1	Station name
2	Start time; gives the time-date of the first value (the value in word 4).
	hhhddmmyy (7, 8, or 9 digits) hhh is tenths-of-hours; ddmmyy is day-month-year.
	ddmmyy (5 or 6 digits) ddmmyy is day-month-year. Hour is picked up from the SSARR start time.
	ddmm (3 or 4 digits) day-month. Hour and year are gotten from the SSARR start time.
	dd (1 or 2 digits. May be preceded by minus sign) day relative to SSARR start time.
	null (,, following station name) use SSARR start time.
3	Data Code; this is the same code that appears in column 24 of the "4D" format (see below).
4 - end	Values; real numbers that may be preceded by a minus sign to indicate negative and include a decimal point. For example, the temperature -5.5 is entered just as it is written here. The units of measure are as follows:

Data Code

1	Snowline elevation, feet
2	Snowcovered area, percent
3	Precipitation, inches
4	Temperature, degrees Fahrenheit
5	Evapotranspiration index, inches/day; or Dew point temperature, degrees F
6	Lapse rate, degrees F/1000 feet; or Albedo, percent
7	Insolation, langleys
8	Wind speed, mph
9	Snow meltrate, inches/degree-day

Z8. Corrections to a Regulation Time-Series. Regulation time-series (a type 100 record) may be loaded into the SSARR work file with "Z6", "6D", "Z1", and subcommands of "IA" including "6", "SPECFL", and "CROHMS".

The "Z8" card produces a SSARR work file record type 108. When a 108 record is entered into the file, the type 100 record with the same name is retrieved. The corrections are applied to the 100 record and is it returned to the file.

Values from the "Z8" correction record replace values with equal times in the 100 record, or merge in time sequence. Values from the "Z8" record that are either before or after the 100 record are ignored; i.e., outside the 100 record time range.

The first two characters of the card are "Z8". The time increment between values is specified beginning with the third character. The time increment control may be one of the following:

No entry	24 hours between values
D	(as in Z8D) 24 hours between values
24	(as in Z824) 24 hours between values
240	(as in Z8240) 24 hours between values.

12 or 120, 8 or 08 or 080, 6 or 06 or 060, 4, 04, 040, 3, 03, 030, 2, 02, 020, 1, 01, 010, 005, 002, or 001; if the hour field is one or two digits, it is hours; if the hour field is 3 digits, it is tenths-of-hours; only these values are accepted as valid time increments.

Word	Description
Card ID	"Z8" followed by time increment code (see description above).
1	Station name
2	Start time; gives the time-date of the first value (the value in word 4). Syntax of time-date:
	hhhddmmyy (7, 8, or 9 digits) hhh is tenths-of-hours; ddmmyy is day-month-year.
	ddmmyy (5 or 6 digits) ddmmyy is day-month-year. Hour is picked up from the SSARR start time.
	ddmm (3 or 4 digits) day-month. Hour and year are gotten from the SSARR start time.
	dd (1 or 2 digits). May be preceded by minus sign) day <u>relative</u> to SSARR start time.
	null (,, following station name) use SSARR start time.
3	Data Code; this is the same code that appears in column 24 of the "6D" format (see below).

4 - end	Values; real numbers that may be preceded by a minus sign to indicate negative and include a decimal point. The units of measure are:

Data Code

0	Freeflow (value has no meaning, only time)
1	Discharge, cfs
2	Elevation, feet
3	Storage, acre-feet
4	Change in storage, cfs-days/day
5	Change in elevation, feet
6	Change in storage, AF/day

FIXED-FORMAT INPUT CARD DESCRIPTIONS

Input data to the SSARR program are prepared on specialized punched card formats. A specific group of card columns on a specific card format is set aside for each of the data words required by the program. Within the group of columns (called a "field"), the data word must be properly positioned to match the scaling expected by the program.

In most card formats, the decimal point position in fields designed for fractional values is fixed by the program. For instance, an elevation of 2.35 feet would be entered in the first elevation field of the "6D" card format (card columns 25-31) as "0000235" (the decimal point must not be punched into the card. Its position is fixed by the program. Also, the columns containing zeroes may be left blank).

"Blank", Comment Card: If card column 1 is blank, the card is listed in the input data list and does not affect processing. Column 2-80 may contain anything.

"A" Card Format: Add river model results into regulation time-series. The river model is composed from the current P-card (configuration) list. When the river model is run with the current time control, the flow (and elevation for stations with C1 tables) is computed for each station in the list for each time period. These results are held in temporary work files for display with the plot (PQ, et), print (PR), and other listing commands. Once the display processing is complete for a time period, these temporary work files are reused and the river model results discarded.

The "A" card provides the user the capability to save these river model results into a regulation time-series; a "100" record in the SSARR work file. ("100" records may also be built by reading card code 6 formats into the SSARR program.) The "A" card will modify an existing 100-record, replacing only the data values included within the time range of the current time control, the time control of the river model. If no old 100 record exists, a new one will be made.

Card Column:

1	Card Code A
2	"Q" or "E". If Column 2 contains "Q", flows are stored into the 100 record. If Column 2 contains "E", elevations are stored in 100 record. Elevations are data code 2; see Column 24 of the "6D" card format.
3-5	Not used.
6-13	Station name in river model.
16-23	Station name of 100 record to store into.

Note: See the "ZA" format for freeformat alternative. The SE, SQ, SR, ZSE, and ZSQ formats are other alternatives for saving river model results.

CB01 Card Format: "Depletion Curve" Watershed Characteristic. The simulation characteristics of a "depletion curve" watershed are described by the card formats CB01, CB02, CB03, CB04, C1 and C3. These cards for a single watershed must be all together in the input stream. The first card of the set must be the CB01.

Card Column

1-4 "CB01" card identification.

6-13 Station name.

19 Special Process Code: Snow band calculation. If Column 19 of CB01 card contains a "1", this watershed will be treated as an elevation band for the snowmelt computation. The C3 table determines the elevation range. The "snow cover depletion curve" (seasonal runoff vs. snow covered area) should yield 100% for all values of percent seasonal runoff. The "accumulated runoff" is treated as average snow water equivalent of snow pack over the band, and is accumulated or depleted according to temperature and precipitation data. Either the "temperature index" or "generalized snowmelt equation" may be used.

21 Watershed Printout-Suppress and River Model Output Code: The "Output" phase of SSARR can produce a printed report and punched cards. These outputs are produced as a result of the code in Column 21 of the CB01, CC01, CL01 and CR01 cards.

Output Codes:

Blank or zero - no output from "Output" phase.
1 - Print.
2 - Punch.
3 - Print and Punch.
8 - No output from "Output" phase. On CB01 card, do not print watershed model results.
9 - Punch, but do not print watershed model results.

Watershed printout may also be suppressed with "ZR" card. Watershed flows may also be output in "6" card format with "ZLIST" and "ZPUNCH" card formats.

23 Initial Condition Output Code: This column may contain either blank/zero, or a "2". Any other punch is invalid.

If a "2" is punched in Column 23 of CB01, initial condition cards will be punched at times determined by Column 62-77 of the "T" time control card or "ICOUT" subcommand of "IA".

31-72 Station name and description. Printed on all reports for this station.

73-80	Station name of the type 100 record containing the basin observed discharge. A type 100 record is the result of reading "6" or "Z6" format cards, or the "6", "SPECFLO", or "CROHMS" subcommands of IA. This name must be different than the basin name.

<u>CB02 Card Format:</u> Watershed characteristics second card.

<u>Card Column</u>

1-4	Card code "CB02".
6-13	Watershed station.
15-20	Drainage area. This is the watershed drainage area in square miles.
21	Number of surface routing phases.
22-25	Surface time of storage as xxx.x hours. This value is used only if the relation called "Outflow versus Surface Time of Storage" is not available (CB03, columns 15-18).
26	Number of subsurface phases.
27-31	Subsurface time of storage as xxxx.x hours.
32	Base flow routing phases.
33-37	Base flow time of storage as xxxx.x hours.
39-43	Base flow Infiltration Index time of storage for rising discharge as xxxx.x hours (TSBII).
44-47	Table ID of precipitation (inches/day) versus KE relation (or SMI vs. DKE with daily ETI). KE is the evapotranspiration percent effectiveness.
48-51	Table ID for the snow-depletion table (% Seasonal Runoff vs. % Snowcovered Area). If this table is not available, SSARR assumes there is <u>no</u> snowmelt simulation.
52-55	Hydromet station <u>name</u> of Snow Covered Area Percent. If this field contains a name, a type 22 record is written to the work file and only the snow covered area contributes to runoff. The type 22 record can be used as input by a rain-only watershed which lists this Hydromet station on its CB04 card, with a data code of 2. The weight should be 100% on the rain watershed entry. This way, the rain watershed becomes the non-snow area of the split-watershed option of the snow cover depletion method.
56-59	Table ID for Month vs. Evapotranspiration Index.
60-63	Table ID of Soil Moisture Index versus Runoff Percent relation.
64-68	Base Flow Infiltration Index time of storage (TSBII) for falling discharge as xxxx.x hours. If this field is non-zero, Columns 39-43 becomes BII time-of-storage for rising discharge.
75-80	Not processed, may be used for comments.

CB03 Card Format: Third Watershed Characteristic Card.

Card Column	
1-4	Card code "CB03".
6-13	Watershed station.
15-18	Table ID - Outflow versus Surface Time-of-Storage.
19-22	Table ID - Baseflow Infiltration Index (BII) versus Percent of Runoff to Baseflow (BFP).
23-27	Maximum BII xxx.xx inches/day.
28-31	Table ID - Surface-Subsurface Input versus Surface Component in inches/hour.
32-35	Coefficient (k') of shortwave radiation snowmelt term, as x.xxx (exposure ratio to radiation), required only when generalized snowmelt equation (GSE) is used. (GSE is used if meltrate table not available. See Columns 52-55).
36-39	Coefficient (k) of convection-condensation snowmelt term, as x.xxx (exposure ratio to wind), for GSE.
40-43	Effective Forest Cover Ratio, as x.xxx, for GSE.
44-47	Constant Wind Speed as xxx.x MPH (used if no Data Code 8 data available) for GSE.
48-51	Table ID - Air Temperature versus Dew Point Temperature. (Used if no Data Code 5 data supplied) for GSE.
52-55	Table ID - Percent season snowmelt runoff versus snowmelt rate. If this table is not available, GSE is used.
56-58	Percentage allowable error in adjustment procedure to meet observed discharge (xx.x%).
59-65	Allowable maximum error in discharge in adjustment procedure.

Note: Field 56-58 is multiplied by the observed discharge on the 2B00 card. The smaller of this product, and the maximum error in 59-65 is used as the tolerance.

66-68	Rain freeze temperature. If blank or zero, 35° is assumed. Scaled xx.x.
69-71	Base temperature for degree-day computation. If blank or zero, 40° is assumed. Scaled xx.x.
72-74	Lapse rate in °F/1000 feet as x.xx. If blank, 3.30° is assumed.
75-80	Not processed, may be used for comments.

CB04 Card Format: Watershed characteristics Hydromet station list. Use as many CB04 cards as needed. The program will accept a maximum of 30 Hydromet station entries in this list. Each entry includes a data code, which specifies the kind of hydromet data:

Data Code	Type of Data
1	Snowline elevation (feet)
2	Snow covered area (percent)
3	Precipitation (inches)
4	Air temperature (°F)

5	Dew point temperature (^{o}F), or Daily ETI (in/day) when snowmelt option not used.
6	Albedo ratio (percent)
7	Insolation (lanleys)
8	Wind speed (MPH)
9	Melt rate (inches/degree day)

The hydromet station and data code identify a type 2x record in the SSARR work file (where "x" is the data code; i.e., type 23 is precipitation). These records are loaded into the work file by reading in 4D or Z4 cards, or the "L" and "CROHMS" subcommands of IA. Several watersheds may refer to the same Hydromet station readings. Also a watershed may average the readings at several Hydromet stations. Therefore, each entry of Hydromet station-data code in the list has an associated weight. The final value of a data type used for a time period is computed as a weighted average of the readings available to the watershed as:

$$V_d = \sum_{i=1}^{n} \frac{(R_i * W_i)}{n}$$

where:

V_D	is the weighted average readings for one data code to be used in the period computations.
i	is Hydromet station entry in list with this data code.
n	is total number of Hydromet station entries in list with this data code.*
R_i	is reading from Hydromet station.
W_i	is weight from Hydromet station.

***Note:** For data code 3 readings (precipitation), n is the total number of Hydromet station entries that have precipitation records, whether there was any rain in this period or not.

For all other data codes, n is the total number of Hydromet station entries that have readings during this period. The SSARR program will not extrapolate readings from Hydromet data. It will interpolate, however, on data codes 6, 7, and 8 (Albedo, insolation, and wind speed).

Card Column

1-4	Card code CB04.
6-13	Watershed station.
19	Data code.
20-23	Hydromet station.
24-26	Weight in percent (xxx.).

Note: These three fields, the data code, the Hydromet station, and weight make up an entry for one Hydromet record. There is room for seven Hydromet record entries on a card. A maximum of thirty is allowed for any one watershed.

27	Data code for the second record.
28-31	Hydromet station.
32-34	Weight.
35	Data code for the third record.
36-39	Hydromet station.
40-42	Weight.
43	Data code for the fourth record.
44-47	Hydromet station.
48-50	Weight.
51	Data code for the fifth record.
52-55	Hydromet station.
56-58	Weight.
59	Data code for the sixth record.
60-63	Hydromet station.
64-66	Weight.
67	Data code for the seventh record.
68	Hydromet station.
72-74	Weight.
75-80	Not processed, may be used for comments.

CC01 Card Format: Transfer Point first card of characteristics. A transfer point may take several forms. It may be a summing point (a point of confluence in the river system). It may call for a local calculation. It may be an "adjacent" station, in which case its outflows are the function of some other station's outflow. It may generate discharges as a function of two control stations and a 3-variable table ("CF" or "ZCF" table).

The stage-discharge relation input on C1 card format may be used with this type of station. It allows the user the option of specifying outflows at this station in terms of elevation.

Card Column

1-4	"CC01" card identification
6-13	Station name.
21	River Model Output Code: The "Output" phase of SSARR can produce a printed report and punched cards. Output Codes: Blank or zero - no output from "Output" phase. 1 - Print. 2 - Punch. 3 - Print and Punch.
24-26	Data Codes for 3-Variable Transfer Point: Identify the Y, X, Z coordinates of the "CF" table as to flow or elevation (See Figure B-2, page B-61 and card format CF or ZCF):

Code "1", "0", or blank is flow.
Code "2" is elevation.
Column 24 is code for Transfer point result, the dependent variable (Y) in the CF table.
Column 25 is code for control-1 station, Columns 17-24 on CC02 card, (X) in the CF table.
Column 26 is code for control-2 station, Column 27-34 on CC02 card, (Z) in the CF table.

31-74 Station name and description. Printed on all reports for this station.

CC02 Card Format: Transfer point second characteristic card. This card is not necessary if the transfer point is simply a summing point.

Card Column

1-4 Card code "CC02".

6-13 Station name.

15 Sign reverse code. If column 15 is non-zero, computed outflows for this station are multiplied by -1.

17-24 Local station. If this field is non-zero, it is assumed that this local station has already been computed. The difference between the inflow and outflow at the local station is assumed to be contributed by this transfer point. For instance, if station 100 flows to station 200, and station 150 is a local inflow into station 200, this local inflow at station 150 would be computed in the following manner:

Configuration cards (P cards) would list the process sequence as station 100, station 200, station 150, and specify station 200 as being downstream from station 100. Outflows would be specified in type 100 records for both station 100 and station 200. Station 150 would be a transfer point with columns 17 to 24 of the CC02 card containing station 00000200 as the local station.

27-34 Adjacent station number. If this field is non-blank, the transfer point will have outflows dependent upon the adjacent station's outflow, which are assumed to have been already computed. Using the example described above, station 150 outflow could be a function of station 100 outflow. The CC02 card for station 150 would then contain 00000100 in column 27-34.

36-39 The adjacent station relation table ID. This relation allows the outflow at the transfer point (station 150) to be other than a constant percentage of the adjacent station outflow. The first word of each table point is adjacent station outflow, the second word is this station outflow (the dependent variable), in cfs.

If Columns 36-39 are blank, the transfer point outflow is the product of the adjacent station outflow and the percentage in Columns 40-43.

40-43 Adjacent relation percentage. This percentage is multiplied by the result from the adjacent relation. if no relation is provided this percentage is multiplied by the adjacent station outflow.

Three Variable Transfer Point: The station discharge or elevation (Column 24 of CC01 card) is a function of discharge (or elevation) of two control stations. The relationship is defined by a "CF" or "ZCF" table identified by Column 36-39 of "CC02" card. The first control station number is identified in Columns 17-24 of "CC02" card, corresponding to X coordinate of "CF" table. The second control station number is identified in Columns 27-34 of "CC02" card, corresponding to Z coordinate of "CF" table.

If any elevations are used (code "2" in Columns 24, 25, or 26 of CC01 card), the corresponding station must have a C1 (stage vs. discharge) table.

The computer program identifies the three-variable transfer point when it finds both the "local" and "adjacent" station names and the "adjacent relation" table ID filled in on the CC02 card.

CF Card Format: Family of Curves Table. This format is used to load three-dimensional curves for SMI and rainfall intensity versus runoff percent (SMI-RI vs. ROP) in the watershed simulation, and the three-variable mode of transfer point. An alternate "freeform" format is "ZCF".

The table gives the relationship of a dependent variable to two independent variables. The card format contains seven fields. The first field contains the value of the second independent variable for the card. The remaining six fields are pairs of values (first independent, dependent variable, respectively) describing three points on the second independent variable curve. For example, a family of curves is drawn on an X, Y coordinate grid. Each curve represents a different value of Z. Then Z is the second independent variable, X is the first independent variable, and Y is the dependent variable (See Figure B-2 on Page B-61).

The X, Y points on a card must be in ascending sequence of X values. The CF cards must be in ascending sequence of Z values. CF cards with the same Z values must be in ascending sequence of X values. All of the cards for a CF table must be together.

Card Column

1-2	Card code "CF".
3-4	Sequence number (not processed by program).
10-13	Table ID
19-26	"Z" value for card. In SMI-RI vs. ROP, this is RI in inches/hour. In three-variable transfer point, this is control-1 in CFS or feet.

27-34	X value of first point. In SMI-RI vs. ROP, this is SMI in inches. In three-variable transfer point, this is control-1 in CFS or feet.
35-42	Y value of first point. In SMI-RI vs. ROP, this is runoff percent. In three-variable transfer point, this is transfer point discharge (CFS) or elevation (feet).
43-50	X value of second popint.
51-58	Y value of second point.
59-66	X value of third point.
67-74	Y value of third point.
75-80	Not processed. May be used for comments.

Note: Decimals must be punched for fractional values for the SMI-RI vs. ROP relation. Decimals must not be punched in the three-variable transfer point; flow is automatically scaled xxxxxxx CFS, elevation is xxxxx.xx feet.

CL01 Card Format: First card of Lake/Reservoir characterstic. The lake/reservoir type station has several optional configurations:

1. Free-flow lake.
2. Reservoir with specified outflows, or pool elevation, or storage.
3. Backwater lake.

Lake characteristics must contain the elevation versus storage-content relationship. For a freeflow lake, it also must contain the elevation-discharge relationship. The time-of-storage is optional for a lake.

Card Column

1-4	"CL01" card identification
6-13	Station name.
21	River Model Output Code. The "Output" phase of SSARR can produce a printed report and punched cards. Output Codes: Blank or zero - no output from "Output" phase. 1 - Print. 2 - Punch. 3 - Print and Punch.
23	Initial Condition Output Code: This column may contain either blank/zero, or a "2". Any other punch is invalid. If a "2" is punched in Column 23, initial condition cards will be punched at times determined by Columns 62-77 of the "T" time control card or "ICOUT" subcommand of "IA".
31-74	Station name and description. Printed on all reports for this station.

CL02 Card Format: Lake/reservoir second characteristic card. This card must be included for a lake since it carries the lake pool upper and lower elevation limits.

Card Column	
1-4	Card code CL02.
6-13	Station name.
15	Backwater code. A one indicates the outflow of the controlling station is used for this station's backwater computation. A two means the elevation of the controlling station is the control. The backwater simulation requires the inclusion of a "C2" table with the CL and C1 cards.
17-24	Controlling station. This field is blank if this is not a backwater lake. The controlling station is that station whose outflow or elevation restricts the outflow at the backwater lake.
38-44	Maximum pool elevation (upper bound) as xxxxx.xx feet.
45-51	Minimum pool elevation (lower bound) as xxxxx.xx feet.

CP Card Format: Hydromet Gage Characteristic. Provides elevation for a temperature gage and gage catch deficiency information for precipitation gages used in the snowband model. See "ZH" format for freeformat alternative.

Card Column	
1-2	"CP" card identifier.
10-13	Hydromet station name.
15-18	Temperature of air as xxx.x when precipitation falls as snow at this precipitation gage. See "Precipitation" paragraph in Appendix D.
19-25	Hydromet station elevation as xxxxx.xx feet (do not punch decimal). This field is used as the basis for adjusting temperature data to average snow elevation during snowmelt computations. It is also used as precipitation station elevation for determining snow events and application of gage catch deficiency percent in Columns 26-29 in the Snowband model.
26-29	xxx.x percent of precipitation to be used for snow events. See "Precipitation" paragraphs in Appendix D.
30-79	Description. This alphabetic field is stored in SSARR work file and may be displayed by the "L,name,10" subcommand of "IA".

CR01 Card Format: First card Channel Reach characterstic.

Card Column	
1-4	"CR01" card identifier.
6-13	Station name.

19	Routing algorithm option. In the standard reach routing technique, inflow to this reach is computed once for each compute period. The program will subdivide the compute period if the computed time-of-storage falls below half the compute period length. however, the reach inflow is not recomputed for the subdivided periods. If a "1" is punched in Column 19, reach inflow is computed for each subdivided period. See Appendix E for more information.
21	River model output code. The "Output" phase of SSARR can produce a printed report and punched cards. Output Codes: Blank or zero - no output from "Output" phase. 1 - Print. 2 - Punch. 3 - Print and Punch.
23	Initial condition output code. This column may contain either blank/zero or a "2". Any other punch is invalid.
31-74	Station name and description. Printed on all reports for this station.

CR02 Card Format: This is the reach characteristic second card. If it is not input to the system, one routing phase is assumed and the routing time of storage will be extracted from the stage-discharge table if available.

Card Column	
1-4	Card code "CR02".
6-13	Station name.
26-27	Number of routing phases (must be greater than zero).
28-31	n value of KTS/Q^n computation as x.xxx. If n is zero, the time-of-storage is extracted from the stage-discharge table ("C1" table).
32-37	KTS value of time-of-storage calculation as xxxx.xx hours. (n non-zero).

An elevation-discharge-time of storage relation may be input to a reach characteristic record on the C1 card format. If the user provides this relation, initial phase values may be specified in terms of elevation instead of flow.

"CT" Card Format: Generalized table card format used for inputing relationships in several forms. Type 11 records in SSARR work file are built from this card format, seven words per card, in the order that the computer reads the cards. Each relationship has a specific format that must be followed in the preparation of the CT cards to load that relationship.

The first word (Columns 19-26) of the first CT card of the relation determines first if an equation or a table relationship will be read in on the card and secondly (if a table), the number of words per point in the table. Only a 2, 3 or zero may appear in this word.

If this first word is zero, the relationship is interpreted as a power series. The second word (Columns 27-34) is then the maximum exponent. For example, if the power series has a term with the argument squared, the second word of the first card will contain coefficient of the argument with an exponent of one; the next word is the coefficient of the argument squared (exponent of two); and so on, to the coefficient of the argument raised to the power noted in word 2. The next word after that is the constant term. The following two examples illustrate this:

```
result = argument + 0.015*(argument*argument) + 10.
CT       TABL     00000000 0000002 00001.0 0.01500 00010.0

result=123.4 (constant)
CT       TBL2     00000000 0000000 123.4
```

If the first word of the first card contains a two, the relation is interpreted as a table with two words per point. Words two and three of the first card are the independent and dependent variables, respectively, of the first point in the table. Words four and five, six and seven, and etc., are additional points in the table. A restriction is that the independent variable must be in ascending sequence, or descending sequence throughout the entire table.

The eight columns for each word are read through format F8.0. A decimal may be punched in the word, and the word may be made negative by inserting a minus sign preceding the first significant digit.

An alternative format is the "ZCT" free-format card.

Card Column of "CT"

1-2	Card code "CT".
3-4	Sequence number (not processed by program)
5-9	Must be blank.
10-13	Relationship Table ID.
14-18	Not used.
19-26	First word on card.
27-34	Second word on card.
35-42	Third word on card.
43-50	Fourth word on card.
51-58	Fifth word on card.
59-66	Sixth word on card.
67-74	Seventh word on card.
75-80	Not processed, may be used for comments.

The following list describes the relations loaded with CT cards. In each case, there is an independent variable, and one dependent variable. One exception is the BII vs. BFP-BFL table.

"CT" TABLE FORMATS (word 1 of first card is 2.0)

Independent Variable (First word of each point)		Dependent Variable (Second word of each point)
Month	vs	ETI-Evapotranspiration Index (Inches/Day)
BII-Baseflow Infiltration Index (Inches/Day)	vs	BFP-Baseflow percent
Adjacent Station Discharge (cfs)	vs	Surface Time of Storage (Hours)
SMI-Soil Moisture Index (Inches)	vs	ROP-Runoff percent
Precipitation (Inches/Day)	vs	KE percent (ETI effective)
Discharge at Adjacent Station (cfs)	vs	Discharge at this station (cfs)
Soil Moisture Index (Inches)	vs	DKE percent (Effective ETI)
Percent Total Accumulated Seasonal Runoff	vs	SCA-Snow Covered Area (percent)
Air Temperature (^{o}F)	vs	Dew Point Temperature (^{o}F)
Surface Plus Subsurface Input (Inches/Hour)	vs	Surface Input (Inches/Hour)

"CT" TABLE FORMAT (word 1 of first card is 3.0)

Independent Variable (1st word of each point)	First Dependent (2nd Word of each point)	Second Dependent (3rd word of each point)
Baseflow Infiltration Index (Inches/Day)	Base Flow Percent	Baseflow Input Limit (Inches/Hour)

Cl Card Code Format: Elevation-discharge-contents relation. The stage-discharge-contents relation must be in ascending elevation sequence. Each card contains two table points. The last point in the table should be an infinity point to serve as a search stopping point. An infinity point has the elevation, outflow and storage fields filled with nines. The table cannot exceed 50 points (25 cards).

The Cl table for a station must be with the other characteristic cards (CB,CC,CL,CR,etc.) for that station in the input stream.

Card Column of "Cl" Card

1-2	Card code "Cl".
3-4	Card number (not used).
6-13	Station.

First Point

17-23	Elevation as xxxxx.xx feet.
24-30	Discharge capacity in CFS.
31-36	Time of storage as xxxxx.x hours. Decimal point should be punched if less than 0.1 hour definition is desired.
37-45	Storage in acre-feet.

Second Point

46-52	Elevation.
53-59	Outflow capacity.
60-65	Time of Storage.
66-74	Storage.
75-80	Not processed, may be used for comments.

C2 Backwater Table. The backwater table is used for the backwater computations only. The backwater table is a series of points describing a three-dimensional surface. The three dimensions involved are the control parameter, the backwater lake elevation, and the backwater lake outflow. The control parameter may be either outflow, or elevation, and for purposes of table lookup, is considered to be the "first independent variable": The backwater lake elevation is the "second independent variable". The backwater lake outflow is the "dependent variable". Figure B-2 shows the typical backwater surface.

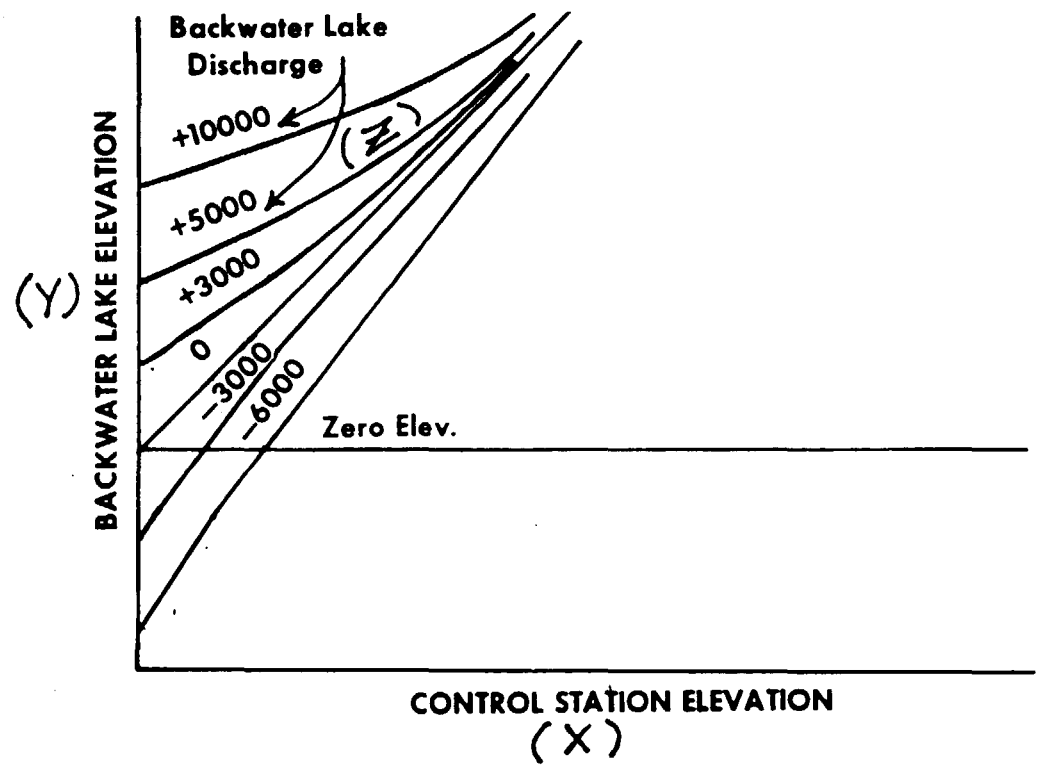


FIGURE B-2 HYPOTHETICAL BACKWATER RELATIONSHIPS

The points in the backwater table are arranged in ascending sequence of second independent variable (backwater lake elevation), within first independent variable (control parameter), and within backwater lake outflow. This scheme was designed for ease of representation of the graph with the first independent variable plotted as ordinate, the second independent variable plotted as abscissa, and the backwater lake outflows as single valued continous non-crossing curves with positive slopes. The first point in the backwater table would be the lowest pont in the lowest outflow curve. Points following the first point would have this same outflow value and continue on up that curve. They would be followed by the first point of the lowest elevation of the second outflow curve.

There must be at least two points in the table for every outflow value. The backwater surface must have a positive slope in all directions.

The last point in the table is identified by an outflow of -999999.

C2 Card Format:

Card Column	
1-2	Card code C2.
3-4	Card sequence number.
6-13	Station name.
17-23	Outflow of the first point in CFS.
24-30	Elevation of the backwater station (second independent variable) as xxxxx.xx feet.
39-45	Control parameter of the backwater control station (may be elevation, or outflow depending upon whether backwater parameter code on CL01 card (Column 15) is two or one, respectively.)
46-52	Outflow of second point.
53-59	Backwater station elevation of second point.
68-74	Control parameter at second point.
75-80	Not processed, may be used for comments.
Note:	Backwater table may contain no more than 200 points. (100 cards). The last point of the table is identified by an outflow of -999999.

C3 Card Format: Watershed Elevation versus Percent Area Table. This table is used for relating freezing level elevations to percent of snow covered area, and is required only for snowmelt computations in the "Depletion Curve" Watershed model; see CB01-CB04 card formats.

Card Column	
1-2	Card code "C3".
3-4	Not processed.
6-13	Station.
15-24	First table point on card.

15-21	Elevation as xxxxx.xx feet.
22-24	Percent of watershed drainage area below that elevation as xx.x%. (The table must be in ascending sequence in both elevation and percent-of-area).
25-34	Second point.
35-44	Third point.
45-54	Fourth point.
55-64	Fifth point.
65-74	Sixth point.
75-80	Not processed, may be used for comments.

Note: The table may contain a maximum of 100 points. The last point must be infinite elevation and 99.9%.

E Card Format: The "E" or "END" format terminates a run deck. It may be followed by a "J" or "IA" card beginning another run deck.

Card Column

1	"E" card identifier.
2-80	Not used.

FEND Card Format: Terminates a "FILE" or "ZFILE" stream. Same as "ZEND".

Card Column

1-4	"FEND" card identifier.

FILE Card Format: Signals beginning of a stream of card images to be stored intact in the SSARR work file. The cards following the "FILE" card are stored in sequence until the stream is stopped by a "FEND" or "ZEND" card. The stream is filed as a type 5 record with the name provided in Columns 6-13 of the "FILE" card. See "GET" and "ZGET" formats, and "EF" subcommand of "IA".

See "ZFILE" format for freeformat alternative.

Card Column

1-4	"FILE" card identifier
6-13	Name for type 5 record in SSARR work file.

GET Card Format: Causes a stream of card images to be included into the input stream in place of the "GET" command. The stream of card images must have previously been loaded into the SSARR work file with a "FILE" or "ZFILE" card, or with the "EF" subcommand of "IA". The stream of card images are SSARR input cards and commands.

For example, the same set of "PR" report control cards is used at the end of each year of simulation in a run of three years. The cards could be arranged as follows:

FILE PRCARDS	
PR...	Store "PR" cards to SSARR work file with
PRC...	name "PRCARDS".
PRC...	
FEND	
T...	Time control for first year of simulations. Initial conditions to start the three-year run. Time dependent data for three years.
GET PRCARDS	Include "PR" cards in input stream at this point.
T...	Time control for second year.
GET PRCARDS	Include same "PR" cards again.
T...	Time control for third year.
GET PRCARDS	Include same "PR" cards third time.

Card format ZGET is freeformat alternative. A GET or ZGET command may be used as SSARR input any place, including as a response to "IA" prompts.

Card Column

1-3	"GET" card identifier.
4	List code. If Column 4 is blank, card images included from the FILE record are not listed on FORTRAN unit 3, the user message printout. Punch "L" in Column 4 to cause card images included from the FILE record to be listed.
6-13	Name of FILE record on SSARR work file; record type 5.

H Card Format: Reload job heading (replaces job description loaded from "J" card). The job description appears in the report headings. The positioning of this card in the input stream is critical. This card is considered to be a time-dependent data card, like the IC and "4" and "6" cards. See "Sequence of Input Stream."

See "J, JOB, ..." subcommand of "IA" for another way to load a new job description.

Card Column

1	"H" card identifier.
41-80	Job description.

IA Card Format: Enter the "interactive" mode. This card may be the first card in the SSARR program input stream. (The other cards which may be first are the "J" card, or the "GET" or "ZGET" of a stream from the SSARR work file which begins with a "J" or "IA").

When "IA" is the first card input to SSARR, the program assumes it is running in interactive mode and prompts are issued for all input lines from the user; even "batch" input lines. See the "RETURN" and "J, BATCH"" sucommands of "IA".

Subcommands of "IA": In the interactive mode, the SSARR program requests instructions from the user by writing prompting messages to the user's terminal. See the section "Interactive Operations", Page B-89, for details of the capabilities available in this mode.

Card Column

1-2	"IA" card identifier.
3-80	Not used.

INU = Card Format: Switch input unit. The SSARR Model program starts off by reading it's first input from FORTRAN unit 5. When an "INU=n" command is read, the input unit is switched to n. That unit is read until end-of-line or another "INU=n" command is encountered.

To use this facility on IBM-MVS host software, the user must allocate the input stream data sets to FORTRAN ddnames for unit n, etc. before executing the SSARR program.

Card Column

1-4	Card code "INU="
5-6	FORTRAN unit number allocated to file containing input stream. The unit number may not be 3, 4, 6, or 15-22. Units 7, 8, and 9 are optional output units and should be avoided.

J Card Format: Job card. The "J" card marks the beginning of a run deck. A run deck must begin with a "J" card or an "IA" card (it may begin also with "GET" or "ZGET" but the first card included must be "J" or "IA").

If a "J" card is included within the SSARR input stream while in batch mode, it acts like an end-of-file following the card preceding the "J".

Run controls set by the "J" card may also be set or altered by the "J" subcommand of "IA".

Card Columns of "J"

1	Card code J.
2-4	Not processed. The card code is often punched "JOB" or "JSR" in Columns 1-3 for clarity.
5-13	Job Number. Printed in the heading of the various reports produced by SSARR.
14-19	Run Date. Printed in the SSARR report headings.
21	Trace code. This column is normally blank. It is used for program debugging. If non-zero, several of the SSARR subprograms print a message everytime they are executed so a programmer can trace the flow of control within the computer.

22 Heading code. If zero or blank, the report headings contain "NORTH PACIFIC DIVISION, CORPS OF ENGINEERS". If Column 22 contains a "1", the report headings contain "COLUMBIA RIVER FORECASTING SERVICE".

25 Unit of Measure. If blank or zero, this run will be made with English units; elevation in feet, flow in cubic feet per second, storage in acre-feet, precipitation in inches, etc.

If a "1" is punched, all data and calculations are in metric units.

26-29 River model hours per print line. If this field is left blank, each compute time period will be printed during the river model output phase. If a number of hours is specified (as xxx.x hours), only time periods separated by this number of hours are printed.

This field does not affect watershed printout spacing, or those reports generated by "PR" or "X" card formats. It controls the printout caused by punching codes 1 or 3, in Column 21 of the characterstic card codes CB01, CC01, CL01, or CR01. It also affects the plot spacing as generated by card codes PE, PH, PL, PQ, PM, PZ and PS.

30 River model printout control. If blank or zero, the watershed and river model reports all print on the same FORTRAN unit (unit 6) except for reports generated by specially coded PR cards.

If a "1" is punched, the watershed model reports print on FORTRAN unit 6, but all river model reports, including plots, print on FORTRAN unit 8.

31 Report page overflow at month-end. If blank or zero, watershed and river model reports skip to a new page at the beginning of each month.

32 Reserved. This column must be blank.

33 Special punched output code. If a "P" is punched, all punched flows generated by a code 2 or 3 of CB01, CC01, CL01 or CR01 card are in a special one-value-per-record format (described in Appendix E, River Model Output).

"H" causes "6hh" card format to punch including all computed values. (Hour spacing between values controlled by the "T" time control card). If Column 33 is not "H" or "P", 6D cards are punched. (24 hour spacing).

34	Print suppress code. If non-blank, run description printouts are suppressed. These include the station list and time control description.
35	0 = Melt only; 1 = melt plus runoff from rainfall used in "Depletion Curve" watershed model for calculation of percent seasonal runoff.
41-80	Job description. Printed in report headings.

N Card Format: Set current model name. If no "N" card has been read, the current model name is (by default) "AAARIVER". The "current model name" is the name of the "P" card (configuration card) list currently in control.

When "P" (configuration) cards are read into SSARR, they are stored as a list in the SSARR work file as record type 2 with "current model name" as the name. When, in the "batch" mode, all input data and time control is complete and the models are to be run, the "P" card configuration list for the current model name is retrieved from the SSARR work file. This "P" card list sets the order of processing and describes the flow of the river.

Card Column

1	"N" card identifier.
6-13	Model name.

P (With Column 2 Blank) Card Format: The sequence of processing the watersheds and river stations, and the relative positions of the river stations on the river tributaries are described in the computer program with the card code P card. The station sequence down the river tributaries is described by listing, for each station, the next downstream station. That is, the station which directly receives the outflows from this station. The computer program is designed to process the river stations in downstream order starting at the flow originating stations (watersheds, for instance) and proceeding downstream in such a way that all stations producing inflow to a station have been processed before this station is processed.

Each P card has a field or station name and six fields for listing the downstream station. Only the station immediately downstream is listed in these downstream stations, so normally, only the first downstream station field will ever be used. The additional five are provided to allow the user to use the same station's outflow as inflow to six different stations. This should be particularly useful in reconstitution work where several station models are to be evaluated with the same basic flow data. The order of P cards determines the process sequence, and also the order of the printout of the river model if the "OUTPUT" phase is used via codes in Column 21 of the CB01, CC01, CL01 and CR01 cards.

P card lists are also used to drive many of the subcommands of "IA". For example, the "IC" subcommand may reference a P card list; the program then displays the initial conditions of each station in the list for the user, one at a time, prompting for changes.

A P card list is stored in the SSARR work file with the "current model name" as determined by the currently active "N" card.

P card lists may also be entered and edited by the "EM" subcommand of "IA".

Card Column	
1	Card code "P".
2-4	Card sequence number (not processed).
6-13	Primary station name.
16-23	Station name of station receiving outflow from the primary station (the station which is immediately downstream from the primary station).
26-33	Station name of an additional station receiving the primary station outflow.
36-43	Second additional downstream station.
46-53	Third additional downstream station.
56-63	Fourth additional downstream station.
66-73	Fifth additional downstream station.

The six downstream station name fields must be used from left to right. The program looks at field 16-23 first, and if it is blank, assumes the rest of the card is unused.

There may not be more than one P card with the same station name in Columns 6-13 if this P card list is used to control the River Model.

PE, PH, PL, PM, PQ, PS PZ Card Formats: Printer-Plot commands.

Three plot capabilities are provided in the SSARR program. The first allows plotting of the Hydromet input data. The second is for plotting the computed discharge, elevation, or storage content values for the time span described on the immediately preceding T (time) card; i.e., the river model results. The third provides capability to plot variables from both watershed models, including individual snowband results from the Snow Band Model. Plot continuation cards allow up to 32 plots (7 continuation cards) on one graph. There is no restriction on the types of data or ordinate scales mixed together on one graph.

Printer Plot Time Control: The abscissa of the graph is time. The length and spacing of the abscissa is controlled by the first command card of the graph; the command card with blank Column 3.

a. If the first card is PE, PL, PM, PQ, PS or PZ, the values available to plot are controlled by the currently active time control; set by either the "T" batch mode card, or "T" subcommand of "IA". The time start, end, and spacing fields on the plot command can cause compute periods to not print; for example, the user could plot the last month of a 12-month run.

b. If the the first card is PH, the time start, end, and spacing fields may be used to exactly control the abscissa. If any of these fields are left blank, they default to currently active time control. **NOTE:** If plot continuations list any of the other plot commands (besides PH), values will plot only on the abscissa points that match compute-period-end times in the currently active time control.

The graph is structured in two ways, depending on the code in Column 22 of "J" card:

Column 22 of "J" = Blank or Zero: "Corps of Engineers" Heading on Reports. Plot headings, including plot identification and ordinate labels, appear at the top of the graph.

Column 22 of "J" = "1": "Columbia River Forecasting Service" Heading on Reports. Plot headings and ordinate labels appear at the bottom, or end of the graph.

Two columns of values are tabulated on the left margin of plots. These two columns are headed by their plotting characters. These two columns are the data values plotted by the first and second plot control fields of the first plot card for a graph.

For example: If a sequence of plot cards is as follows:

```
PQ^^^00000101* 00000100x
PZC100000100W200000100Y6
PZC100000101W200000100Y6
```

The PQ card is first of the set so flow for station 101 plots as * and its values are listed in the first column. Flow for station 100 plots as X and values list in second column. The second card of the set plots data type 1 for band 2 as W and band 6 as Y for station 100. Data type 1 is snowband temperature. See tabulation of "Snowband Calculation Result" following description of PZ n card.

Card Codes PE, PL, PM, PS Format: River station plot control. River station data computed for the time span described by the immediately preceding Time card may be plotted with this card. The second character in the card code determines the data type being plotted.

Card Column	
1-2	Card code: PL or PQ to plot discharge, PE to plot elevation, PS to plot storage content, PM to plot mean daily discharge.
3	Continuation code: Punch "C" if these plots to be on same graph as preceding control card. If "C" is punched, Column 4 and 45-66 on this card are ignored.
6-14	First plot control: 6-13 River station. 14 Plot character to be printed on the graph. Must not be blank if station is not blank.

16-24	Second plot control.
26-34	Third plot control.
36-44	Fourth plot control.
45-53	Plot start time as hhhddmmyy. If Column 3 contains "C", this field is ignored. if it is desired to start the plot at the first time period, the start time may be left blank.
54-62	Plot end time as hhhddmmyy. If Column 3 contains "C", this field is ignored. If left blank, the T-card end time is used.
63-66	Hours (in tenths) per abscissa ponit. This value must be an integral multiple of the period hours on the Time card.
67-73	Minimum ordinate value: (a decimal may be punched if desired). PL or PQ or PM card code: xxxxxxx. CFS. PE card code: xxxxxxx. feet. PS card code: xxxxxxx. 10's of acre-feet.
74-80	Maximum ordinate value scaled the same as Column 67-73.

Card Code PH Format: Hydromet data plot control. The plot control time span may be different than current model time control. See "Printer Plot Time Control" above.

Card Column

1-2	Card code, must contain "PH".
3	Continuation code - punch "C" if these plots to be on same graph as preceding control cad. If "C" is punched, Columns 45-66 of this card are ignored.
5-14	First plot control:

5-8	Hydromet station.
9	Data code (3 for precipitation, etc.)
10-13	Weight in percent. The Hydromet value is multiplied by this percentage before its ordinate position is calculated (see card columns 67-73, 74-80). This percentage can be the same as that on the CB04 card to match this plot with watershed printout.
14	Plot character. This is the character printed on the plot at the ordinate position. It cannot be blank if the Hydromet Station is not blank.

15-24	Second plot control.
25-34	Third plot control.
35-44	Fourth plot control.
45-53	Plot start time as hh.hddmmyy for hour, day, month, year, respectively. If "C" in Column 3 of this card, this field is ignored.
54-62	Plot end time as hh.hddmmyy. If "C" in Column 3 of this card, this field is ignored.
63-66	Hours per abscissa point in tenths of hours (that is, hours between plot lines).

67-73	Minimum scaled ordinate value as xxxxxx.x (it is not necessary to punch decimal; it is implied). Data code 3 (rain) is stored in inches. A minimum of 1.0 inch is punched "0000010".
74-80	Maximum scaled ordinate value as xxxxxx.x.

PZ Ø: Plot basin summary results (either snowband-basin or depletion-basin).

Card Columns for "PZ Ø":

1-2	"PZ" identifier.
3	Punch "C" to continue these plots on same graph as preceding card. If "C" punched, Columns 45-66 are ignored.
4	"Ø" or blank identifying this as plot of basin summary fields.
5-14	First plot control: 5-12 Basin name. 13 Plot character to print on graph. 14 Field to be plotted. See directory following this description.
15-24	Second plot control.
25-34	Third plot control.
35-44	Fourth plot control.
45-66	Time control, if "C" not punched in Column 3.
67-73	Minimum ordinate scale xxxxxx.x (discharge in cfs is also scaled this way on PZ Ø card which is different than all other plot control cards).
74-80	Maximum ordinate xxxxxx.x.
	Decimal may be punched in maximum and minimum fields, if needed.

Field codes for plotting snowband basin summary ("PZ Ø" card):

Code to punch in Column 14, 24, 34, or 44

Code	Field	Name on basin printout
1	PCPN	Period precipitation, at sea level, inches.
2	TA	Average temperature at sea level.
3	SURF	Discharge from surface component, cfs.
4	SUBSF	Discharge from subsurface component, cfs.
5	BASEF	Discharge from baseflow component, cfs.
6*	LOWERZ	Discharge from lower-zone compoenent, cfs.
7	TOTAL	Total basin discharge at end of compute period, cfs.
8	QOBS	Total basin observed discharge (CB01 card or ZC6 card).
9*	INT	Loss to tree interception, inches.
A	MR	Average melt rate on melting bands with snow, inches per degree-day.
B	RG	Runoff generated,, inches.

C	TWATER	Moisture input, inches.
D	TTWATR	Period melt (from rain-melt and dry-melt), inches.
E*	TPET	Potential evapotranspiration rate, inches per day.
F*	TLIQD	Snow Liquid water deficit, inches.
G	ET	Evapotranspiration rate, inches per day.
H	WE	Water Equivalent of snow accumulation, inches.
I	SNOWLINE	Mid-point elevation of lowest band with non-zero, WE, feet.
J	ROP	Average runoff percent.
K	SM1	SM1 at start of period.
L	TRGS	Input to surface runoff routing, inches/hour.
M	TRGSS	Input to subsurface runoff routine, inches/hour.
N	RGB	Input to baseflow runoff routing, inches/hour.
O*	RGLZ	Input to lower-zone runoff routing, inches/hour.
P*	GMLT	GMLT inches/compute period.
Q*	LAPSE	Lapse rate: degrees/1000 feet.
R	TPP	u TPRA
S	TBFP	v TSCA
T	TPMR	w TSMA

* Denotes parameters which are not available for "depletion" watersheds.

PZ: Plot Snowband calculation results. The data code is in Column 4 and affects the entire PZ card, and the snowband number is coded into Columns 14, 24, 34, and/or 44.

Card Columns

1-2	"PZ" identifier.
3	Punch a "C" to continue these plots on same graph as preceding card. If "C" is punched, Columns 45-66 are ignored.
4	Data Code. This code defines the data to be plotted by all four plot control fields. See "Data Code of Calculation Result" below.
5-14	First plot control.
	5-12 Snowband station name. 13 Plot character to print on graph. 14 Band Number: Punch 1 through 9 for bands 1 through 9; punch A through K for band 10 through 20.
15-24	Second plot control.
25-34	Third plot control.
35-44	Fourth plot control.
45-66	Time control, if "C" is not punched in Column 3.
67-73	Minimum ordinate scaled xxxxxx.x.
74-80	Maximum ordinate scaled xxxxxx.x.
	Decimal may be punched in Minimum and Maximum fields, if needed.

Snowband

Data Code of Calculation Result

1	TA Band Temperature, Degrees F.
2	RAIN Precipitation on Band Less Intercept (TINTA), Inches/Hour
3	WE Water Equivalent of Snow, Inches.
4	ATICC Cold Content ATI, Degree-Days.
5	CC Cold Content, Inches.
6	SLIQW Snow Liquid Water Content, Inches
7	ATIMR Melt Rate ATI, Degree-Days
8	TINT Tree Interception, Accumulation, Inches
9	SMI Soil Moisture Index, Inches
A	BII Baseflow Infiltration Index, Inches/Day.
B	WATER Moisutre Input, Inches/Hour
C	SMR Snowmelt Rate, Inches/Degree-Day.
D	PMRE Percent Meltrate Effectiveness, Percent
E	RMELT Rain Melt, Inches/Hour
F	DRYMLT Melt During Non-Rain Period, Inches/Hour
G	COLD Input to Cold-Content, Inches/Hour
H	CR Cold Rate, Inches/Degree-Days.
I	RECHG-WATER-RG, Inches/Hour
J	RG Runoff Generated, Inches/Hour
K	ROP Runoff Percent, Percent.
L	BFP Baseflow Percent, Percent.
M	RGS Input to Surface Runoff, Inches/Hour
N	RGSS Input to Subsurface Runoff, Inches/Hour
O	RGB Input to Baseflow Runoff, Inches/Hour
P	RGLZ Input to Lower Zone Runoff, Inches/Hour
Q	EKE ETP Effectiveness as Function of PP/Day, Ratio.
R	DKE PET Effectiveness as Function of SMI, Ratio.
S	TWATR=RMELT+DRYMLT, Total Melt, Inches/Hour
T	TINTMX Tree Interception Maximum, Inches
U	ETMO ETI-Effectiveness as Function of Month, Ratio.
V	ETP*EKE Evapotranspiration Index, Inches/hour
W	ET Evapotranspiration, Inches/Hour
X	TINTA Tree Interception Input (Loss), Inches.
Y	SLIQWD Snow Liquid Water Deficiency, Inches.
Z	GMLT Groundmelt, Inches per Compute Period

"PR" and "PT", Optional Printout of River Model: The PT card(s) should be immediately after the PR card(s) to which they pertain.

The report generated by "PR" and "PT" cards is not afected by Columns 26-29 of the "J" card, or coding in Column 21 of the CB01, CR01, CL01 and CC01 cards.

There is a maximum of 9 columns per printout page. Therefore, the combination of station codes cannot specify more than 9 columns.

PR Card Format

1-2	PR
3	"C" if continuation.
4	FORTRAN unit number report is to be written on. If blank or zero, report is written on same unit as printer-plots and OUTPUT report.
6-13	First station number.
14	First station code 1—flow (Q) 2—elev (E) or gage (lakes head the column with "ELEVATION", other types of stations head with "GAGE HEIGHT") 3—Q+E 4—storage (S) 5—Q+S 6—E+S 7—Q+E+S (default) 8—Mean Daily Q 9—Gives heading (only) of % capacity. For use with synethetic reservoir.
16-23	Second station.
24	Second code.
26-33	Third station.
34	Third code.
36-43	Fourth station.
44	Fourth code.
46-53	Fifth station.
54	Fifth code.
55-63	Beginning time in hour, day, month, year. (If blank, default is T card).
64-72	End time in hour, day, month, year. (If blank, default is T card).
73-76	Hour spacing - xxx.x.
77	Overflow code 0—no overflow (new month on new page). 1—overflow (continuous page despite month change).
78	0—date prints both sides. 1—no date on right side of page.

Note: On a continuation card, Columns 55-78 are ignored.

"PT" Card Format: PT cards are optional. If they aren't used, the titles come from the characteristic cards (first 16 characters of station name.)

Card Column

1-2	PT
3	"C" for continuation.
4	User sequence number; not processed.
5-20	Station description.
21	Number corresponding to position of station on PR card.

22-37	Station description.
38	Number.
39-54	Station description.
55	Number.
56-71	Station description.
72	Number.

"PU" Card Format: This card is in the same format as the "PR" card. The "PU" card causes "6D" cards to be punched on FORTRAN unit 7. The output codes in Columns 14, 24, 34, 44, and 54 can only be "8"-Mean Daily flows. There is no capability to punch other kinds of data, or other than 24 hours values.

SE and SQ Formats: The river model is composed from the current P-card (configuration) list. When the river model is run with the current time control, the flow (and elevation for stations with C1 tables) is computed for each station in the list for each time period. These results are held in temporary work files for display with the plot (PQ, etc), print (PR), and other listing commands. Once the display processing is complete for a time period, these temporary work files are reused and the river model results discarded.

The "SE" and "SQ" cards provide the user the capability to save these river model results into a regulation timeseries; a "100" record on the SSARR work file. "100" records may also be built by reading card code 6 formats into the SSARR program. The "SE" and "SQ" formats produce a new "100" record containing only the results of the most recent river model operation. If a "100" record already exists it is replaced and data outside the current time control is erased.

Card Column

1	Card Code "S".
2	"Q" or "E". If Column 2 contains "Q", flows are stored into the 100 record. If Column 2 contains "E", elevations are stored into 100 record. Elevations are data code 2; see Column 24 of the "6D" card format.
3-5	Not used.
6-13	Station name in river model.
16-23	Station name of 100 record to store into.

Note: See the "ZSE" and "ZSQ" formats for freeformat alternatives. The "A", "ZA", and "SR" formats will add current river model results to an old "100" record, rather than replace.

SR Card Format: The "SR" card provides the user the capability to save river model results into a regulation timeseries; "100" and "102" records in the SSARR workfile. The "SR" card will modify an existing 100-record and/or 102-record replacing only the data values included within the time range of the current time control, the time control of the river model. If no old time series record exists, a new one will be made.

Card Column

1-2	"SR" card code.
6-13	Station name in river model.
16-23	Station name of time-series records to store into. If blank, the name in Columns 6-13 is used.
24-25	If not blank, flows are saved into the 100 record (regulation record) with the name specified in Columns 16-23.
27-28	If not blank, elevations are saved into the 102 record with the name specified in Columns 16-23.

Notes: Other formats with similar functions are Card code "A", "SE", "SQ", "ZA", "ZSE", and "ZSQ".

In addition, type 100 records may be loaded into the SSARR work file by card code "6" cards, by retrieval from the BULK file with "Z1" cards, and with the "6", "SPECFL", and "CROHMS" subcommands of "IA".

Type "102" records may only be loaded with the "SR" and "Z1".

Type 100 and 102 records may be output in "6" format with "ZLIST" and "ZPUNCH" cards, and tabulated with the "HMLIST" and "L,name,100/102" subcommands of "IA".

"T" Card Format: The SSARR model simulates the passage of time with time increments or steps. Normally these time steps, called periods, are of equal length throughout the process time span. However, some applications demand that the length of the time period be changeable. Therefore, provision is made for a maximum of 3 changes in time period length. The number of periods defined by a "T" card is limited by the computer program memory capacity. Also, the time-dependent data records, such as precipitation and flow specifications, have maximum size restrictions. A practical limit for reconstitution work seems to be about one year of four periods per day. Some other practical ranges for a single "T" card are 5 years of 24 hour periods, and 2 months of 1-hour periods.

The T card format also has provision for instantaneous condition output control. The type of output is controlled by the code in Column 23 of the first characteristic card of each station (CB01, CR01, or CL01).

In "batch" mode, processing of watershed and river models may be suppressed by coding in Column 80 of the "T" card.

Card Column

1	Card Code T.
2	Must be blank.
5-16	This time, date, and hours per period specification are the run start time, and the first hours-per-period to be used in the run. The field is broken up as follows:

5-7	Hour of day in tenth of hours (6 a.m. is punched 060).
8-9	Day.
10-11	Month.
12-13	Year. This two digit year number is assumed to fall between 1901 and 1999.
14-16	Period: Hours per period in tenths of hours (12 hour period is punched 120).

17-28	Second date-period specification.
29-40	Third date-period specification.
41-52	Fourth date-period specification.

Note: The first date-period specification containing a period hours of zero is the run end-time.

53-61	Last date (if all hours-per-period fields are non-zero, this field must contain the run-end time).
62-65	Time from run-start time (Columns 5-13) of first Instantaneous Condition output, as xxxx. hours.
66-69	Time to second I.C. output.
70-73	Time to third I.C. output.
74-77	Time to fourth I.C. output.
78	Code: I.C. output at the end of all time periods if this code is non-blank.
80	River Model Suppress Code: If a "2" is punched in Column 80 of the "T" card, the river model (transfer points, lake/reservoir, and reach type stations) is not processed for the time described by this "T" card. Only the watershed models are processed. This is used in the forecasting procedures when it is not necessary to process the river model during the observed (backup) period.

If a "1" is punched, the river model is processed but the "OUTPUT" phase report is suppressed.

If a "3" is punched, the watershed models are not processed; the river model and "output" phase are processed.

If a "4" is punched; neither the watershed or river models are processed.

X Card Formats: The "X" card codes cause the printing of a specially formatted report for transmission via teletype. The printout line width is 72 columsn or less.

The card code "X" cards are similar in function to PR and plot control cards, and occupy the same relative position in the SSARR input data.

Capability is provided to read the "X" cards from a separate disk file so that the cards do not have to be handled in the SSARR input data.

The reports produced by "X" cards may be written to different FORTRAN units.

Reports Control Card, Code "XC": This card sets the controls for generation of a report. If the first "X" card in SSARR input data is not "XC", the default values are used. Therefore, the "XC" card is not normally reuqired.

"XC" Card Format:

Card Column	
1-2	Card code "XC".
3	Input unit number. If this column is blank or zero, the "X" cards for this report must follow the "XC" card in the SSARR input data. If this column is not blank or zero, it contains the FORTRAN unit number which points to the data set containing the "X" cards for this report.
4	Output unit number. If this column is blank or zero, this report will be written on FORTRAN unit 9. The text of the report is contained in 72 character lines. The first character of each line is not carriage control so the report should not be written on FORTRAN unit 6.
5-13	Hour and date (standard SSARR format) of start of report. The value for a station at this hour-date is written under the heading "TDY OBS" meaning "Today Observed". If this field is all blank or zero, the report is begun at run start time; that is, the first hour-date on the current "T" (time) card.
14-16	Number of days to output in the report. The first line output for a station contains the "TDY OBS" value plus 7 more days. If Column 14-16 contains a number higher than 7, additional lines will be output for a station with 7 days on each line. If Columns 14-16 is zero or blank, the report will contain 7 days.

Report Heading Line Card, Code "XH": The report is constructed, line by line, as a result of "XH" and "XS" cards in the SSARR input (or on disk and pointed to by an "XC" card in the SSARR input).

The "XH" card has a 72 column field which is copied to the report.

"XH" Card Format:

Card Column	
1-2	Card code "XH".
3-74	Character string to be copied into the report.

Report Heading Line Card, Code "XS": This card is in two formats, a station description card and a station line card. When the first "XS" is read by SSARR, either in the total SSARR input, or following an "XC" card, a report heading is output containing the report start hour-date and the day number for each column.

If the "XS" card is a description card, the 44 column name field is copied to the report.

If the "XS" card is a line card, the values requested by the card are extracted from river model result file and output in the report for the days requested on the "XC" card. An 8-column identification field is copied from the "XS" card at the beginning of the line of values.

"XS" Card Format:

Card Column

1-2	Card code "XS".

"Description Card" Format:

Card Column

3-24	Blank.
25-68	Station description.

"Line Card" Format:

Card Column

6-13	Station name (not blank).
24	Data Code: If Column 24 contains a "2" elevations are to be output. Otherwise, flows are to be output. Elevations are output to the nearest 0.1 foot (tenth of a foot). Flows are output to the nearest cfs but rounded to three significant digits.
25-32	Line identification: Copies to report at beginning of line of values.

2B00: Initial Condition First card for Depletion Curve Watershed Model.

Card Column

1-4	"2B00" card code.
6-13	Station name.
15-23	Time as, hhhddmmyy (if dates are left blank, the time will be the same as the start time on the T card).
24-27	Table identifier. Rain Daily Distribution (distribution is loaded on card code 5).
28-32	SMI. Soil Moisture Index as xxx.xx inches.
33-37	BII. Baseflow Infilitration Index as xxx.xx inches/day.
38-41	Table identifier. Snowmelt Daily Distribution or ETI Daily Distribution (distribution is loaded on card code 5).

42-45	Snow Covered Percent of Area as xxx.x%. Default is 100%.
46-49	Melt Rate as .xxxx inches per degree - day.
54-58	Accumulated Runoff from rainfall xxx.xx.
59-63	Accumulated Runoff of Snowmelt as xxx.xx inches (snowmelt only) for Snow Cover Depletion Option. For the Snow-Band Option of Depletion model, this field indicates the snow water equivalent on the band.
64-68	Total Seasonal Snowmelt Runoff as xxx.xx inches. If this field is zero, SSARR assumes there is no snow on this watershed, and ignores all snowmelt data.
74-80	Observed watershed discharge at time-end. If this value is non-zero the program recomputes the time range adjusting the rain and snow quantity to meet this observed discharge within tolerance specified on CB03 card.

2B02, 2B03, 2B04 Card Formats: Watershed Initial Condition Phase Values. Routing is done in three components: Surface, subsurface, and base flow. Each component may have up to eight phases. If an elevation-discharge relation (C1) cards) is provided, these initial condition phase values may be specified in terms of elevations instead of discharge.

The card codes for the three components are as follows:

2B02 — Surface component.
2B03 — Subsurface component.
2B04 — Base flow component.

Card Column

1-4	Card code 2B02, 2B03, or 2B04.
6-13	Station name.
15-23	Time of initial condition in hour, day, month, and year.
24	Flow-elevation code. If zero or one, phase values are specified in terms of flows. If column 24 is a two, phase values are specified in terms of elevations. Flows are in CFS, elevations are xxxxx.xx feet.
25-31	First phase.
32-38	Second phase.
39-45	Third phase.
46-52	Fourth phase.
53-59	Fifth phase.
60-66	Sixth phase.
67-73	Seventh phase.
74-80	Eighth phase.

The number of phase values stored in each of the three different card codes is determined by the number of phases specified on the CB02 card in Columns 21, 26, and 32, respectively.

2L01 Card Format: Lake/Reservoir Initial Condition. Since lakes have only one phase of routing, provide only the lake pool level and initial outflow to completely specify the initial condition.

Card Column

1-2	Card code "2L'.
6-13	Station name.
15-23	Time of initial condition in hour, day, month, and year.
25-31	Initial outflow in cfs.
32-38	Pool elevation as xxxxx.xx feet.
39-47	Storage volume in acre-feet.

Elevation and storage are mutually exclusive. If one is specified, it is not necessary to specify the other. Elevation versus storage relation (C1 cards) must be provided for a lake/reservoir type station.

If no "2L" card is provided for a lake, initial discharge is set equal to inflow, and initial elevation is set at elevation-lower-bound.

It is not possible to specify zero flow, elevation, or storage on "2L" card. SSARR treats zero or blank in these fields as "no specification".

2R01 Card Format: Reach Initial Conditions. The only information needed to specify reach initial conditions is the instantaneous inflow and the routing phase values. If the elevation-discharge relation is provided for the reach, the initial condition phase values may be specified in terms of elevation. If no initial condition phase values are input, the inflow to the reach will be computed at time zero and all phase values will be set equal to that inflow. If the user wishes to specify only the first and last phase values, he may leave the intermediate values equal to zero and the program will interpolate them on a straight line between the given values. The phase values may be adjusted to observed values through the use of the 3R card.

The number of 2R cards required is indicated by the phase count in Columns 26-27 of the CR02 card. Each 2R card holds eight phases. If 2R cards are omitted, the program assumes that the initial outflow is equal to inflow.

Decimals may not be punched in the phase values on the 2R card. The first value on the first 2R card is the inflow to the reach. The second value on the first card is the outflow of the first routing phase.

Flows are in cfs, elevations in xxxxx.xx feet.

Card Columns

1-2	Card Code 2R.
6-13	Station name.
15-23	Time of initial condition in hour, day, month and year.
24	Flow/elevation code. Zero or one indicates phase values are in terms of outflow. Two indicates phase values are in terms of elevations.
25-31	First value.
32-38	Second value.
39-45	Third value.
46-52	Fourth value.

53-59	Fifth value.
60-66	Sixth value.
67-73	Seventh value.
74-80	Eight value.

Note: If the number of phases specified on the CR02 card is N, then N+1 values must be include don the reach initial conditon cards (inflow to the reach is the first value of the first card.).

3 Card Format: USGS Daily Precipitation Data.

Card Column

1	"3" Card Code.
2-3	Blank; card code. (Column 2 must not contain alpha character).
4-5	Day of month. (Hour is assumed to be 6 a.m.).
6-7	Month of year.
8-9	Year.
10-12	Station number.
13-16	Precipitation for day in Columns 4-9. Scaled xx.xx inches (do not punch decimal).
17-20	Precipitation next day (Day 2).
21-24	Day 3.
25-28	Day 4.
29-32	Day 5.
33-36	day 6.
37-40	Day 8.
45-48	Day 9.
49-52	Day 10.
53-56	Day 11.
57-60	Day 12.
61-64	Day 13.
65-68	Day 14.
69-72	Day 15.
73-76	Day 16.
77-80	Day 17.

3B00 Depletion Curve Watershed Initial Condition Adjustments: This card is the same format as 2B00 with the exception of Column 53. Also, some of the fields are only used if they are non-zero. The 3B is used to update for daily forecasting operations.

Card Columns of "3B00"

1-4	Card code "3B00:.
6-13	Station name.
15-23	Time.
24-27	Rain Distribution ID - Used only if non-blank.
28-32	Soil Mositure Index - Used only if non-zero.
33-37	Baseflow Infiltration Index - Used only if non-zero.
38-41	Snow or ETI Distribution ID - Used only if non-blank.

42-45	Percent Snow Covered Area - Used only if non-zero.
46-49	Melt Rate - Used only if non-zero.
53	Code: If non-zero, print the unadjusted watershed results before printing the final adjusted results.
54-58	Accumulated Runoff from Rainfall.
59-63	Accumulated Runoff - Used only if non-zero.
64-68	Seasonal Runoff - Used only if non-zero.
74-80	Observed Discharge. If zero or blank, there will be no automatic watershed adjustment.

3F Depletion Curve Watershed Initial Condition Adjustment: Sets the observed discharge to control the automatic adjustment routine. See Appendix C, "Depletion Curve Watershed Model", "Automatic Adjustment of Watershed."

Card Column

1-2	"3F" card identification.
6-13	Station name.
15-23	Time - date of observed discharge.
25-31	Observed discharge in cfs.

3L Reservoir Initial Condition: Same as "2L" card.

3R01 Card Format: Reach Initial Condition Adjustment. When using the SSARR program for flow forecasting, initial conditions are output at the end of the forecast period and when requested by the user on the "T" card. When observed values are available for that same time, these observed values may be input to SSARR to adjust the computed initial conditions so that the model can be operated from that time forward without the necessity of manual preparation of all initial conditions. If the stage-discharge relation is provided for a reach, the observed stage of the river may be expressed in terms of elevation.

Card Column

1-4	Card Code 3R01.
6-13	Station name.
15-23	Time of initial condition in hour, day, month, and year.
25-31	Observed outflow.
32-38	Observed elevation.

4D Card Format: Hydromet data. This card format is used for entering up to 14 data values equally spaced in time. The data are assembled into a 20-series record in the SSARR work file. The record is identified by the hydromet station name and the data type. The "record type" is data type plus 20; for example, precipitation data type is 3, producing a SSARR work file record type 23.

Card codes 4D, 4E, and 4P may be mixed for any Hydromet station as long as the readings are in ascending time sequence and for the same data code.

Hydromet data 20-series records may also be input to the SSARR work file with "Z4" format. However, "Z4" formats may not be mixed with "4" formats to compose a hydromet record.

Card Column of "4D"

1-2	Card Code "4D".
5-7	Hours between values as xx.x. If zero, 24 hour spacing is assumed.
10-13	Hydromet station name.
14	Number of values on card. If zero or blank, 14 is assumed.
15-23	Time of the first reading in hour, day, month and year.
24	Data code (see below).
25-28	First value. This value is for the time recorded in Columns 15-23.
29-32	Second value.
33-80	Third through the 14th values (four columns per value).

No decimals should be punched in card code "4" formats. The scaling is implied by the data code (Column 24) as follows:

Data Code		Scaling
2		xxx.x % snow covered area.
3		xx.xx inches precipitation.
4		xxx.x °F air temperature.
5		xxx.x °F dew point temperature.
	or	xx.xx inches/day ETI.
6		xxx.x % Albedo.
	or	xxx.x Lapse rate, degrees/1000 feet.
7		xxxx. Langleys insolation.
8		xxx.x MPH wind speed.
9		.xxxx inches/degree-day melt rate.

Card Code 4E Card Format: Daily elevation readings at a Hydromet station. This format may be used for specifying snow-line elevations for snowmelt computations.

Card Column of "4E"

1-2	Card Code "4E".
10-13	Hydromet station name.
14	Number of values on card. If zero or blank, 8 is assumed.
15-23	Time of the first reading in hour, day, month, and year.
24	Data code (see below0
25-31	Value for first day.
32-38	Value for second day.
39-45	Value for third day.
46-52	Value for fourth day.
53-59	Value for fifth day.
60-66	Value for sixth day.
67-73	Value for seventh day.
74-80	Value for eighth day.

No decimals should be punched in card code "4" formats. The scaling is implied by the data code (Column 24) as follows:

Data Code	Scaling
1	xxxxx.xx feet snow line elevation.
2-9	same as 4D card.

4P Card Format: Periodic Hydromet Data. This card format is designed for the purpose of loading readings which do not occur in an orderly time spacing. all readings on each 4P card must be in the same month.

Card Column of "4P"

1-2	Card Code 4P.
10-13	Hydromet station name.
15-23	Time of the first value in hour, day, month, and year.
24	Data code.
26-32	The first value. This value corresponds to the time in Columns 15-23.
33-37	Time of the second value. This time is in hour and day as hhhdd for the month and year punched in Columns 20-23.
38-44	The second value.
45-49	Hour and day of the third value.
50-56	Third value.
57-61	Hour and day of the fourth value.
62-68	Fourth value.
69-73	Hour and day of fifth value.
74-80	Fifth value.

No decimal should be punched in card code "4" formats. The scaling is implied by the data code (Column 24) and is the same as 4E format.

"5" Card Format: Daily Distribution. This card is used for loading the eight-period daily distribution required for precipitation distribution and snowmelt distribution in watershed processing. The distribution record may contain distributions from more than one "5" card. Each 5 card has the capacity for three distributions. The program assumes that the last distribution input is in effect from its specified start time, to the end of the run. If the start time of the first distribution is later than the start of the run, no distribution will be used for that period of time from the beginning of the run to the start-time of the first distribution.

Card Column of "5"

1	Card Code "5".
2	Blank.
10-13	Distribution name. This is the name used in the 2B00 card in columns 24-27 or 38-41 which refers to this distribution.
15-23	Start time of the first distribution in hour, day, month and year.

24	Time shift code. Punch "1" if watershed adjustment procedure is to be allowed to shift this distribution forward or back one half a time period to match the observed discharge.
25-40	The first distribution. The distribution is made up of eight two-digit percentages which correspond to the first three hours, the second three hours, the third three hours, and so on to the eighth three hours of the day beginning with the start time of the distribution. For instance if the distribution start time is 1200, the first percentage of the 8-period distribution corresponds with the period 1200 to 1500. The 8th percentage corresponds to the time 900 to 1200.
41-44	Day to begin second distribtuion. These four columns contain the day and month. It is assumed that distribtuion begins at the same hour and year as recorded in the start time in columns 15-23.
45-60	Second distribution. Eight two-digit fields of whole percent.
61-64	Day to begin the third distribution.
65-80	Third distribution. Eight two-digit percent fields.

The dates of the distribution must be in ascending sequence. The eight percentages in a distribution normally add to a total of 100.

"6" or "6D" Card Format: The Daily Regulation Card. This card is used for loading daily values (or evenly spaced values) of regulation data, such as specified outflows, elevations, storage, or changes in storage. The regulation data are assembled into a type 100 record in the SSARR work file.

Each value is stored in the computer with its associated date and data code. The card formats 6, 6D, 6S and 6P may be intermixed as long as they are in date sequence. At a given time, there can be only one value and its data code for a station. It is not possible to specify both flow and elevation, for example, at the same point in time for a station. A straight-line interpolation is used to compute values at times in between those specified. The "Z6" format is another way to input regulation data. However, "Z6" cards cannot be mixed with "6" cards to compose a station's 100 record.

Card Column of "6"

1	Card code "6".
2-4	Hour spacing of values on card as xx.x hours. If Column 2 contains "D", or Column 2-4 is blank or zero, the hour spacing is set at 24 hours.
6-13	Station name.
14	Number of values on card. If zero or blank, 8 is assumed.
15-23	Time of the first value in hour, day, month, and year.
24	Data code of all values on card.
25-31	The reading for the first day corresponding to the time punched in Columns 15-23.
32-38	Second value.
39-45	Third value.

46-52	Fourth value.
53-59	Fifth value.
60-66	Sixth value.
67-73	Seventh value.
74-80	Eighth value.

No decimals should be punched in card code "6" formats. The scaling is implied by the data code (Column 24) as follows:

Data Code

0	Free flow.
1	Outflow specification as xxxxxxx. CFS.
2	Elevation specification as xxxxx.xx feet.
3	Storage volume specifications as xxxxxxx 10 acre-feet.
4	Change in storage in terms of flow rate (CFS-day).
5	Change in elevation per day as xxxxx.xx feet/day.
6	Change in storage volume per day as 10 acre-feet/day.

6P Card Format: Periodic Regulation Card. This card is used for specifying regulation readings which do not occur daily. All values must be in the same month. The regulation data are assembled into a type 100 record in the SSARR work file.

Card Column of "6P"

1-2	Card Code "6P".
6-13	River station name.
15-23	Time of the first value in hour, day, month and year.
24	Data code of all values on card.
26-32	First value.
33-37	Time of the second value in hour and day, as hhhdd. Month and year are the same as in Columns 20-23.
38-44	Second value.
45-49	The hour and day of the third value.
50-56	Third value.
57-61	The hour and day of the fourth value.
62-68	Fourth value.
69-73	The hour and day of the fifth value.
74-80	Fifth value.

No decimals should be punched in card code "6" formats. The scaling is implied by the data code (Column 24).

6S Card Format: The Sporadic Regulation Card. This card is used for loading regulation data at widely spaced times. Each field is preceded by a more complete date than the 6P card. Each value has its own data code. All values must be for same year.

Card Column of "6S"

1-2	Card Code "6S".
6-13	Station name.

15-23	Time of first value in hour, day, month, and year.
24	Data code for first value.
25-31	First value.
32-38	Time of second value in hour, day, month, as hhhddmm. The year is assumed to be same as Columns 22-23.
39	Data code for second value.
40-46	Second value.
47-61	Date, data code, and third value.
62-76	Date, data code, and fourth value.

Note: Dates must be in ascending order.

No decimal should be punched in card code "6S" formats. The scaling is implied by the data code with each value.

INTERACTIVE OPERATIONS

GETTING INTO THE INTERACTIVE MODE

The "IA" command will cause the interactive driver part of the SSARR program to take control. At the start of the interactive driver, an "*" is sent to the user terminal to indicate that the user should send one of the interactive commands. (See the "Subcommands" Section, below).

When the interactive driver and its subcommand processors are not in control, the SSARR program is processing fixed-format or Z-format cards. There are two ways to take control away from the interactive driver:

(1) The first command to SSARR when execution of the program is begun is a "J" card (not an "IA" card).

(2) While the interactive driver has control and has issued the "*" prompt to the user, the "RETURN" command is given by the user, or the user inputs any Z-format card.

PROMPTING IN "BATCH" AND "INTERACTIVE" MODES

The two modes "batch" and "interactive" only control the sending of prompting messages to the output device on FORTRAN unit 3. In the "batch" mode, the program assumes that the host processing computer is running SSARR in the batch mode with the input stream coming from a disk file rather than a keyboard; so most prompting messages are not sent; and the input stream is printed on the message unit (FORTRAN unit 3) as it is processed. In the "interactive" mode, the input stream is not printed and prompting messages are.

If the first command given to SSARR is a "J" card, the prompting mode is "batch"; if the first is "IA", the prompting mode is "interactive."

The prompting mode may be changed by the "J" subcommand of "IA".

INTERACTIVE COMMANDS

Commands to the interactive processor are free-format and the order of words from left to right determines their meaning in most cases. The main subcommands to "IA" begin with the command identifier. The meaning of additional words on the command line is different for each command.

When a word represents a name such as a station name, it may be all numeric digits, or it may include alphabetic characters. However it is composed, it must always be entered the same way; for exammple, the name "00000101" is not the same as "101" on interactive commands. (Name fields on fixed-format cards are interpreted with zeros in place of any blanks, if there are no alphabetic characters in the name. Therefore, all basin and river station names are eight digits long if they are all numeric. All numeric hydromet station names are four digits long. If there are any alphabetic characters in a name on fixed-format cards, blanks are left blank and the first blank or comma following the first character marks the end of the name).

Once a subcommand has been issued, the processing program for that subcommand takes control and begins prompting for the information it needs. Each subcommand processor has it's own unique prompting messages.

At any point in the dialog, as a response to any prompt, the user may send a "?" and a summary of the response options available to the user at this point will be printed (on FORTRAN unit 3).

SUBCOMMANDS OF "IA" (RESPONSES TO "*" PROMPT)

T Set Time Control. This command may be issued in two forms: (1) as simply a "T", for which the prompt is sent asking for the starting hour (in hours, not tenths) and the starting date; or (2) the T may be followed on the same line by the starting hour and starting date. For example, entering two lines thus:

```
T
6, 10485
```

will set the start time to 6 a.m., 1 April 1985. The same start time may be set by entering only one line:

```
T,6,10485
```

Once start time has been set, you are asked to declare the length of the run in days, and the hours per compute period. For example, the following response:

```
8,6
```

sets the run to eight days and the compute period to six hours per period. If you send a blank line instead of days and hours, run length and hours per period are not changed.

More complex time control must be set by the fixed-format "T" card. For example, if three days of 6-hour simulation followed by four days of 24-hour-per-period simulation is required:

```
RETURN
T^^^06001048506006004048524006008048 5
IA
```

sets start time at 0600, 1 Apr 85 and runs with 6-hour compute periods through 0600, 4 Apr 85. At that time, the run switches to 24-hour compute periods through 0600, 8 Apr 85.

ICOUT = hhh Set IC output time, where hhh is the number of hours after start time. This command accomplishes the same thing as columns 62-65 of the fixed-format "T" card. If more complex time control is needed, use the fixed-format "T" card as in the example above.

LT List the current time control.

IC name **Enter the Initial Condition Processor.**

3 name Enter the IC Processor for depletion basin observed discharge editing.

(If "name" is included, the entry command becomes an "action command".)

The IC processor provides the capability to list the times at which IC sets are available for a station. The user can set the time control within the IC processor and list and/or change the initial condition values.

One limitation is that the IC processor cannot change or input IC values for snowband watersheds; it can only list them. (Snowband IC can be input with "Z2" format cards.)

When the IC processor is entered, the current SSARR start-time is used as IC time. Use of the T and LT subcommands in response to the "IC COMMAND?" prompt do not effect the SSARR time.

Action Command. The action command is composed of four parts: (1) command, (2) name, (3) keywords, and (4) options.

(1) Command. The line may begin with "IC" command or "3" command; or the command may be left off so that the line begins with the name field. If the command is left off, the last command given has control. If the command is "IC", the standard prompts and displays are used. If the command is "3", processing a depletion watershed IC results in prompts and displays for editing observed basin discharge; reaches only prompt for reach observed discharge; and reach and lake prompts are not followed by the "=" (equal sign) prompt.

(2) Name. The name may be of a station IC (type 1 record) or a model list (type 2 record). The name may be preceded by "S=" if the name is to be interpreted as a station. It may be preceded by "M=" if it is to be interpreted as a model. If the name is not preceded by "S=" or "M=", the first search in the SSARR file is for a model by that name; if none is found, a station IC by that name is looked for.

If a model is specified, the effect is nearly the same as if the user had entered the action command for each station in the model p-card list. The difference when a model is specified is that after the user finishes with an IC, the program automatically steps to the next IC in the model list and prompts the user.

Model processing may be stopped by entering the command "Q", causing control to return to the "IC COMMAND?" prompt.

(3) **Keywords.** Initial Conditions for depletion watersheds contain 12 variables plus three components of phase values. Also, snow covered area may be referred to in terms of snowline elevation, and soil moisture index may be referred to in terms of runoff percent. The user designates which variables are listed and made candidates for positional input. The keywords are listed on the action command line following name. If no keywords are listed, the default list is used:

SMI MLAR RNAR SRO MRR MR SCR SCA SLIN MDST

The keyword meanings are:

QEND	Observed Discharge (the IC containing QEND is to be at end-of-runtime, not start time)
SMI	Soil Moisture Index. (See ROP also)
MLAR	Melt Accumulated Runoff
RNAR	Rain Accumulated Runoff
SRO	Seasonal Runoff
MRR	Melt Rate Ratio; ratio of current melt rate to theoretical melt rate (a function of % season runoff).
MR	Current Meltrate
SCR	Snow Cover Ratio; the ratio of current Snow Covered Area (SCA) to the theoretical SCA from the SCA vs %SRO curve.
SCA	Snow Covered Area Percent (See SLIN also)
SLIN	Snowline Elevation; derived from C3 table (elevation vs. percent area) with SCA as the argument. If the user specifies a new value for SLIN, the corresponding value of SCA is automatically computed.
MDST	Melt Daily Distribution Name. Distribution is loaded via card code "5" format.
RDST	Rain Daily Distribution Name
BII	Baseflow Infiltration Index
ROP	Runoff Percent; derived from SMI vs. ROP table with SMI as argument. If the user specifies a new value for ROP, the corresponding value of SMI is automatically computed.

(4) **Options.** Option codes are one letter each, and may appear on the action command any place following the name:

L	List the IC values but do not prompt for changes.
T	List the times for which IC sets are available.
P	List basin phase values, and prompt for changes if the "L" option is not given.
A	List/change both basin parameters and phase values.
C	Change a parameter for all basins in a model. When this option is included, the user is prompted for the change values: "ENTER MULTIPLIER AND ADDON AMOUNT"

For example, if the following commands are entered:

```
IC LIB8 SMI C
1., -2
```

The IC record for basin LIB8 at the current time will be retrieved. The SMI value will be multiplied by 1., and -2 added to the product.

If LIB8 were a model list, SMI for all basins in the list would be reduced by two inches.

OTHER COMMANDS TO THE INITIAL CONDITION PROCESSOR. There are two other commands in addition to the action command:

IC Initial Condition Processor (Continued)

T	Set IC time. The T command does not effect the SSARR start time.
T,hh,ddmmyy	Alternate form of T command which includes the IC hour as one number and the IC date as the second number. If the T command is entered without the hour and date, the user is prompted for them.
LT	List the current IC time.

L Enter the TEMP/PRECIP (Hydromet) Processor. The "L" command is given in response to the "*" prompt. The "L" command has no parameters (blank in Columns 2-80).

The Hydromet processor allows for listing and changing hydromet data in the SSARR file (type 21-29 records). When the hydromet processor is entered, the current SSARR start-time is used as the start of the hydromet time. Use of the T and LT subcommands in response to the "TEMP/PRECIP COMMAND?" prompt do not effect the SSARR time.

Action Command. The action command line is composed of three parts: (1) name, (2) parameter, and (3) options.

(1) Name. The name may be preceded by "M=" indicating it is a model list name. Otherwise, the name is of a hydromet record. When a model is specified, the program automatically steps to the next hydromet name in the list, lists the data, and (if there is no "L" option on the action command) prompts the user for changes.

Model processing may be stopped by entering the command "Q", causing control to return to the "TEMP/PRECIP COMMAND?" prompt.

(2) Parameter. Specifies the type of hydromet data and the default hour spacing; default hour spacing may be overridden by the "options" part of the action command.

Valid Parameters		Default Hour Spacing
T	Temperature	6
TX	Temperature	24
None	Precipitation	6
PP	Precipitation	24
1-9	Data Codes	SSARR Time Control

For example, the action command "KASB, 3" will cause a column heading for precipitation (data code 3) to print with the columns spaced at the number of hours in the currently set hours-per-period in SSARR time control.

If the action command were "KASB" (without the ",3" data code), the heading will be for precipitation and the columns spaced six hours apart, regardless of the SSARR time control.

In both action command examples, "KASB" is the name of the precipitation record (type 23 record) which will be retrieved from the SSARR file. If no old one is found, a new one will made.

The precipitation values for the time periods in the heading are retrieved from the record and printed. If the "L" option is not included in the action command, the user is prompted for changes to the data.

(3) **Options.** Three possible options, in any combination, may be included on the action command following the parameter:

L	List only, do not ask the user for changes to the data.
H=hh	Set the spacing between columns to hh hours, regardless of the parameter.
C=n	Set the number of columns in the display to n, where n must be at least 1 and no more than 24. The default is 15, which is the most that fit into 80 print positions. Once the number of columns is changed, it stays at the new value until changed again or control is returned to the interactive driver and "*" prompt.

Other Commands to the Hydromet Processor. There are three other commands in addition to the action command:

T	Set start time for the Hydromet Processor. The T command does not effect the SSARR start time.
T,hh,ddmmyy	Alternate form of T command which includes the start hour as one number and start date as the second number. If the T command is entered without the hour and date, the user is prompted for them.
LT	List the current Hydromet Processor start time (not necessarily the SSARR start time).
H	Start the next display resulting from an action command with a column heading. Normally, if action commands do not change the data code, number of columns, start time, or hour spacing, the column heading is not repeated.

SPECFLO. Enter the Project Regulations Input Processor. This program is designed to facilitate the input of reservoir regulation schedules (type 100 records in the SSARR file). The user gives a list of dates. He then enters a model name or station name. Then, the user is asked to enter the regulation data code followed by the values for each of the dates in the list. If a model was named, the user is automatically prompted for code and values for each station in the model list.

A type 100 record is orginated for each station in the list. Any old type 100 record in the SSARR file is replaced.

Start time in SPECFLO is initialized from SSARR start time and may be changed with the "T" or "R" commands. Use of these commands does not effect SSARR start time.

The list of dates is given by entering the number of days from SPECFLO start time to the dates, in response to the prompt.

For example, if SPECFLO start time is April 1, and regulation values are to be entered April 1, May 1, June 1, and July 1, the response to this prompt is "D000030061091". This "D..." command may contain a maximum of 15 three-digit numbers.

The "Hcccnnn" command sets up a sequence of equally spaced times. "ccc" is the number of hours between times, and "nnn" is the number of times.

"ENTER MODEL OR STATION NAME" prompt. After the date list is set, this prompt is given. If the user responds with a name, a model by that name is looked for in the SSARR file. If none is found, the name is taken as a station name and a 100 record is originated. The "model" or "station" interpretation can be forced by preceding the name with "M=" or "S=", respectively.

The other responses to this command are:

Q or blank line: leave SPECFLO, return to "*" prompt.
T or R: Prompt user for SPECFLO start time.
D or H: Prompt user for date list.
L name: List the existing type 100 record for station "name", or all stations in model "name".

"ENTER CODE AND VALUES FOR STATION" prompt. After a station or model name is entered, this prompt is sent. The response is one line for a station. The first number on the line is the regulation data code; 1 for flow, 2 for elevation, etc. (See card code 6 card, col. 24). Following the data code are the values, one for each date in the date list. The code and values are each separated by a comma, or one or more blanks.

6 Name. Regulation (Type 100) Record Editor. (If "name" is included on the "6" command, it becomes the first "action command".)

This program may be used to enter regulation schedules, edit and change old ones, and list them.

Action Command. The main prompt of the Regulation Editor program is:

"ENTER STATION/MODEL NAME OF REGULATION RECORDS:"

The user may respond to this prompt with a blank line to return to the "*" prompt.

6 Regulation Record Editor (Continued)

The only other response is "name, option". The "name" may be preceded by "M=" indicating it is a model list name. It may be preceded by "S=" indicating it is a station name. If not preceded by "M=" or "S=", the SSARR file is first searched for a model by that name; if none is found, it is taken as a station name.

The ",option" may be ",L" indicating that the entire 100 record is to be listed, and the user is not prompted for changes. If the option is ",R" only the values in the 100 record falling within the SSARR time control range are listed.

If a model name is specified in the action command, the effect is nearly the same as if the user had entered the action command for each station in the model p-card list. The difference when a model is specified is that after the user finishes with a Regulation record in the model list, the program automatically steps to the next Regulation record and prompts the user with the ":" prompt.

Model processing may be stopped by entering the command "Q" causing control to return to the main Regulation Editor prompt.

Responses to the ":" Prompt. Once a station name is given, either directly on the action command or automatically from a model list, the SSARR file is searched for regulation (type 100) record by that name. If no old record is found, a new one is prepared and the user is notified. Then the ":" prompt is displayed.

"Input" Response. The first "input" response determines whether the old 100 record is erased before the new entries are made. If the first "input" response begins with a date field (a number), the old record is erased. If the first "input" response is in the form "I,date,code,value", this (date,code,value) is merged into the old record.

After the first "input" response for a regulation record, it is not necessary to precede further "input" commands with the "I," for that regulation record.

"Q" Response. If the record has been modified or erased incorrectly through the "input" command but not yet saved back to the SSARR file, the "Q" command with return control to the main Regulation Editor prompt without saving this modified regulation record.

The "Q" command will also stop the automatic sequencing under model control.

"DELETE" Response. Delete all entrees in the regulation.

"L" Response. List the entire regulation record.

"R" Response. List that part of the regulation that falls within SSARR time control.

"Blank Line" Response. Saves the edited regulation to the SSARR file and, if under model control, proceeds to the next station in the list; when the list is finished, control returns to the main Regulation Editor prompt.

HMLIST General Data List Program for SSARR and CROHMS Time-Series. Lists observed and forecasted hydromet data in the format of one line per day, or one line per hour. Lines may contain up to sixteen columns of data values. Data is retrieved from CROHMS Data Base (CDB) or from the SSARR file. Optionally included are report headings, CROHMS/CBTT equivalent parameter codes, maximum/minimum/average of each column, and station descriptions.

Input Command Summary. The following example shows which commands affect the report parts: (See example on Page B-104 for commands to make this report.)

```
                                                          See Note
PROJECT-STREAMFLOW REPORT                                   (1)
NPD RESERVOIR CONTROL CENTER                                (2)

    BFEI                                                    (3)
    06GH       06Q                                          (4)
   HGZIZZ   QRZIZZ                                          (5)
DAY  1979  NOV                                              (6)
15    51.41     4.03                                        (7)
16    50.60     3.97

MAX   51.41     4.03                                        (8)
AVE   51.01     4.00
MIN   50.60     3.97

BFEI KOOTENAI R. AT BON FERRY                               (9)

         GCL                                                (3)
         QH
         QRZHZZ
HOUR   1979    NOV 17                                       (10)
 23   113.40
 24   109.30
HOUR   1979    NOV 18
  1   108.50

       LIBP                                                 (11)
       PRECIP PRECIP PRECIP PRECIP                          (12)
          6     12     18     24                           (13)
DAY 1985 APR                                                (6)
 1       0.00   0.00   0.20   0.50                         (14)
 2      0.20   0.00   0.00   0.00
 3       0.00   0.04   0.06   0.06
```

NOTES: The input commands which control this part of printout:

(1) PRINTOUT. This command causes headings to be printed. Headings may be stopped with NOPR command. P command forces new page to start.

(2) PRINTOUT command columns 9-72; if non-blank, replace this part of heading.

BMLIST (Continued)

(3) Data Request Command. Gives station and parameter codes for columns of report.

(4) Data Request Command. Parameters may be CBTT format (automatically translated to CDB format) or CDB format.

(5) PC command causes CDB parameter codes resulting from translation to be printed. NPC stops printing of this line.

(6) D command controls data range of report.

(7) Data request command controls retrieval of values from CDB. W command sets time window for retrieval.

(8) MX command causes printing of MAX/AVE/MIN for each column. NMX stops these lines from printing.

(9) N command causes station descriptions to print. NN command stops the printing of these lines.

(10) H command sets hourly format and sets time range.

(11) Data Request Command for SSARR time-series; gives station, record type, and hours for columns of report.

(12) Data Request Command record type.

(13) Data Request Command hours for columns of report.

(14) Data Request Command controls retrieval of values from SSARR time-series record. W command sets time window for retrieval.

Other Commands Available:

"Page Request" command calls command stream from the page description file.

C command cancels a report description without printing the report.

Blank line causes the accumulated report description to generate a report.

R pppppppp,u,z command causes CDB to operate with your password, units of measure, and/or time zone.

TR,MAIN,EXCEP change translate table names.

* command causes a stream of characters to copy to the printout.

$ command causes a CFDC command to copy to the printout.

? command causes a summary of user instructions to print.

Q command causes program to STOP.

COMMAND DESCRIPTIONS.

ssssssss,param,param.... CROHMS Data Base (CDB) data request command where ssssssss is station name and param,param... are parameter codes. One column is printed for each parameter code. As many data request commands may be used as needed, limited to 16 columns.

Station name must be at least 3 characters. At least one character in station name must be alpha.

Param formats are:

Q and QD: one or two alpha characters. CBTT code. Translates to CROHMS parameter. For daily format, retrieves hour 24 value within time window (see W command).

7Q,07Q,7QD,07QD: hour with one or two alpha characters. CBTT code. Translates to CROHMS parameter. Retrieves first value within time window (see W command) associated with given hour. Hour is ignored in hourly format.

QRIRAZ,QRIRA: CDB parameter code. First character is alpha; at least 5 characters long; 6th character defaults to "Z" if not furnished. For daily format, retrieves hour 24 value within time window (see W command).

7QRIRA,07QRIRA,...: CDB parameter code; hour with 5 or 6 character CDB code. Retrieves first value within time window (see W command) associated with given hour. Hour is ignored in hourly format.

ssssssss,type,hour,hour,.... SSARR work file data request command where "ssssssss" is record name, "type" is record type, and "hour,..." is the hour of the day for each column of the listing. Once column is printed for each "hour". If no "hour" fields are given, one column for hour 24 (midnight) is printed. As many data request commands may be used as needed, limited to 16 columns. CDB and SSARR data retrieval commands may be mixed.

Record name must be at least 3 characters.

"Type" codes of time-series records:

1 or 21	Snowline Elevation.
2 or 22	Snow Covered Area Percent
3 or 23	Precipitation
4 or 24	Temperature
5 or 25	Dew Point Temperature, or Potential ET
6 or 26	Albedo Percent, or Lapse Rate
7 or 27	Insolation
8 or 28	Wind Speed
9 or 29	Melt Rate

61-69	Correction Records for Same Types as 21-29.
100	Regulation Record (Flows, Elevations, etc).
101	Basin Computed Flows
102	River Model Computed Elevations (See "SR" card).
108	Correction Record for Regulation Record.

BLANK LINE COMMAND

Entering a blank line causes a report to be printed as described by the commands preceding the blank line. The report may be reprinted by entering another blank line. The time range (D command) may be changed, followed by a blank line to cause the same columns to print values for the different time period. All other control commands may also be used to change the format.

The columns are cleared when a data request command is entered following a blank line, or a C command is entered.

ppn

"Page Request" command. The page name (ppn) must be three characters long; two alpha, and a numeric digit.

Page descriptions are filed by program G07242OR and maintained by NWS-RFC. The page descriptions are simply a group of HMLIST commands (any commands except "page request") identified by a page name and stored into a special file by program 2OR. When HMLIST receives a "page request" command, the special file is searched. If a matching page description is found, the command stream identified as that page is processed.

Blank Line Command Following A Page Request.

The first two characters of the page name (pp) may identify a multi-page report. The last character (n) then identifies a page in that report. After the commands for a page have been processed, HMLIST prompts the user for his next command. If a blank line is entered, the next page of this report (pp) is processed.

*** Text**

Columns 2 through 72 of a command with an asterisk (*) in Column 1 are copied directly to the output. This is used for special heading lines and control sequences in the report text.

$ Text

Columns 1 through 72 of a command with a dollar sign ($) in Column 1 are copied directly to the output. This is used for imbedding CFDC commands in the output report, to cause the report to be stored in CFDC Report file.

?

This command causes a summary of HMLIST commands to be written out. Useful for interactive users of the program.

C

Cancel Command. During interactive use, a sequence of Data Request commands may have been entered. If you enter a blank line, the described report will print. If you enter a "C", the report will not be printed but will be cancelled allowing you to enter a new set of Data Request commands.

Dnn,ddmmyy

Date Command In Original (SSARR) Format. See field descriptions following DC command. D and DC command produce the same results (Daily format reports).

DCnnyymmdd

Date command in CROHMS format. D and DC commands produce the same results (Daily format reports).

The "DC" command is in fixed format; i.e., the fields appear in specific columns:

	DC Command Columns	
nn	3-4	Number of days in report. Report will contain nn+1 data lines.
mm	7-8	Month of report end.
yy	5-6	Year of report end.
dd	9-10	Day report is to end on.

Dnn-d,Dnn-dd, or Dnn-ddd

nn is number of days in report; report is in daily (one line per day) format; ending date of report is tomorrow's date minus d days. For example, D03-1 results in three day report ending today.

Dnn+d,Dnn+dd, or Dnn+ddd

The plus sign indicates that report end is tomorrow plus d days. D03+0 is valid.

Hnnddmmhh

Produce reports in hourly format; one line per hour. Lists nn hours ending in current year on day dd, month mm, and hour hh. The time window in the hourly format is fixed at -30.0 (15 minutes before to 15 minutes after the hour).

Hnn-1

Produce hourly report containing nn hours ending at current system clock hour.

If no D or DC is entered, HMLIST defaults to D03-1.

MX

Causes MAX/AVE/MIN lines to be added to printout.

N

Causes Station Description lines to be added to printout. "PRINTOUT" command also causes Station Description lines to be printed.

NMX

Stop printing of MAX/AVE/MIN lines. This is the default.

NN

Stop printing of Station Description lines. This command may be used following the "PRINTOUT" command to stop Station Description from printing even through headings are being printed.

NPC

Stop printing CDB equivalent parameter codes. These codes are the result of translation when CBTT parameter codes are used on Data Request commands. (see PC).

NOPR

Stop printing headings and resume "prompting" (See PRINTOUT).

P

Page Start Command. When "PRINTOUT" command has been entered, HMLIST counts lines of print and starts a new page when the previous page is full. The P command is used to start a new page regardless of contents of previous page.

PC

Print CDB-equivalent parameter codes below the CBTT codes used on the Data Request command. (Default)

PRINTOUT tttt...

Causes heading lines at page overflow to be added to the report. Meant for use of HMLIST where printout will be produced by a line printer (rather than remote terminal).

HMLIST (Continued)

Columns of 9-72 of the command may contain text for the second line of the heading. If Columns 9-72 are blank, the second line will not change from its previous contents. HMLIST defaults second line to "NPD RESERVOIR CONTROL CENTER".

This command causes HMLIST to print station descriptions (as if N command given) and CDB parameter codes to print (as if PC command given).

Q

Causes HMLIST to stop; returns control to the interactive driver and the "*" prompt.

R pppppppp u t

Command to set new password, units, and time zone for CDB access. pppppppp is your CDB password, u is units of measure (either "E" for english or "M" for metric), and Z is time zone ("P" for Pacific, "M" for mountain, "Z" for Zulu time).

The program defaults to password "CROHMS", unit "E", and zone "P" if no R card is entered.

TR main, exception

The default translate tables for getting from CBTT codes to CROHMS codes are named "CBTT" for both main and exceptions tables. If other tables are available and you wish to use them, the TR command will cause all following data request commands to use the new tables.

W mm

The window command sets the time window for data retrievals for daily format reports. mm is in minutes. If mm is negative, the window is centered on the hour; i.e., the window starts at mm/2 minutes before the hour and goes to mm/2 minutes after the hour. The window defaults to 30 minutes (positive).

If the window mm is positive, it is subtracted from the hour of each column.

For example, if the time series contained values at the following times:

Time	Value for Station BFEI, parameter GH
05:40	52.03
06:11	51.41
06:20	51.12

If W=-30, retrieval of 06GH results in the 06:11 value of 51.41 because it is closest value in the 30-minute period from 0545 to 0615.

If W=30, retrieval of 06GH results in the 05:40 value of 52.03 because it is closest value in the 30-minute period from 0530 to 0600.

Sample Command Stream (See printout result on Page B-97)

```
PRINTOUT
D1,161179
BFEI 06GH 06Q
blank line
H02181101
GCL QH
blank line
D2,030485
LIBP,3,6,12,18,24
blank line
```

CROHMS **Enter the CROHMS Data Retrieval Processor;** this program will retrieve and translate data from the CROHMS database and add it to a time-series record in the SSARR file.

Time control for the retrieval defaults to SSARR time control. The "T..." subcommand of CROHMS does not effect SSARR time control.

The data retrieval from CROHMS may be from several CROHMS time-series, each with it's own window and translation controls. The user provides a list of CROHMS time-series; for each time point in the time range, the first entry in the time range, the first entry in the list is checked. If no value is available, the next entry in list is checked, and so on. In this way, a retrieval of the best available data for a time-series can be assembled. This facility can be useful if the time-series of estimated values is in CROHMS separate from the observed values; if the observed value for a period is missing, the estimated can be put into the SSARR target time-series in place of the observed.

Subcommands of CROHMS

"T,hhhddmmyy,pp,hhhddmmyyysss"

Set Retrieval Time Control. The first hour-date field is retrieval start time; pp is hours between retrieval points; the second hour-date field is retrieval and time; and sss is hours to shift CROHMS-time.

The "T..." command is fixed-format; each field must be in the correct columns.

The sss field may include a minus sign in the 3 columns. For example, "-24" will result in 24 hours being subtracted from CROHMS time to get SSARR time (in fact, the "T..." command sets the SSARR time-series retrieval times; CROHMS time is computed from that. A retrieval for hour 0600, 1 April 1985 for SSARR, with sss=-24 will cause the retrieval in CROHMS to be at 0600, 2 April 1985.

"4,station,type,code"

The "4,..." command sets up to retrieve for a SSARR hydromet record (type 21-29). The "station" is the SSARR record name; hydromet records usually have 4-character names because of the fixed-format card code "4" and "CB04" cards.

If an old SSARR time-series for this station, type is found, the old values for the retrieval time range are erased.

The "type" is the hydromet data type; i.e., 3 is precipitation, 4 is temperature, etc.

The "code" indicates the disposition of missing values during the retrieval from CROHMS. Valid "codes" are:

"P" Propogate previous values to fill in for a missing value.

"I" Interpolate missing values as a function of time.

"0" Leave missing values out of the target time-series in SSARR file. Times on values copied to SSARR are set from "T" command. Values are selected from CROHMS within time window on retrieval command.

"C" Copy values from CROHMS Database to SSARR with times from CROHMS. The other options ("P", "I", and "0") all get the times for the values in the resulting SSARR time-series from the "T" subcommand. The retrieval selects the CROHMS value within the retrieval time window and closest to the SSARR time, and stores the value in SSARR with the SSARR time. The "C" option stores the value in SSARR with the CROHMS time.

"6,station,data,code"

The "6,..." command sets up to retrieve for a SSARR regulation record (type 100).

The "station" and "code" fields are the same as for the "4,..." command. The "data" field sets the regulation data code, as used in Column 24 of the fixed-format "6" card.

Retrieval

When a "4,..." or "6,..." command is entered the program sends the prompt asking for the list of CROHMS time-series to use as the source:

"SOURCE: STA,PCDTSE,WINDOW,SCALE,ADDON"

The user response is "station,parameter,window,scale,addon":

"station" is the CROHMS station name.

"parameter" is the CROHMS parameter code.

"window" is the retrieval time window in minutes. The maximum value is 1440 minutes (24 hours). If the window is negative, it is centered on the retrieval time. If the window is positive, it is subtracted from the retrieval time. In either case, the value in the CROHMS time-series within the window and closest to the retrieval time is selected.

If "window" is not specified, it defaults to -122, 61 minutes eaach way from retrieval time.

"scale" is scale factor, multiplied with CROHMS value to get SSARR value. If "scale" is not specified, it defaults to 1.0.

"addon" is constant to add to the target value, after scaling. "addon" defaults to zero.

A maximum of nine "station,parametric,..." responses are allowed. Nine alternative CROHMS time-series from which to retrieve each target value.

Action Command. When the user enters a blank line, the program is signalled that there are no more CROHMS time-series to be added to the list, and retrieval begins. As data is retrieval, it is listed at the terminal. Each line begins with the time-date of the first value, this is followed by the values, spaced as dictated by the retrieval time control. Each value is followed by a code in parenthesis; this code shows the source of the value, either the position of the CROHMS time-series in the list, or a (P) indicating the value is the same as the previous value, or an (I) meaning this value was interpoloated.

After retrieval is complete and the SSARR target times series has been updated and returned to the SSARR file, control returns to the main CROHMS Data Retrieval Processor prompt.

Enter a blank line to return to the "*" prompt.

INPUT **Enter characteristic File Processor.** The main prompt is:

"CHARAC FILE COMMAND?:"

This program will search a sequential file of SSARR format card images for the first occurance of the argument name; it then reads those images for that name into SSARR for processing into the SSARR file.

This facility is used in the forecast environment to help maintain a backup file of characteristic, table, and configuration cards. These card images are read by SSARR normally only once at the beginning of the season. If a characteristic is changed, it is only necessary to reread that one, not the entire file of characteristics; so the characteristic File Processor allows the user to direct SSARR to scan the backup file of card images and process only those needed.

The action command may specify the FORTRAN unit to be scanned ("U=nn" option). The default units are 15 and 16; unit 15 defaults to the file of fixed-format and Z-format cards which contain the identifying station number in each card image, allowing the retrieval to be for all card images for a given station.

Unit 16 defaults to the file which contains finder cards. Finder cards contain a semi-colon in card column 1 and preceed a group of SSARR card images; this is used to load "N" and "P" card model lists, as well as "FILE" groups. The finder card format is: Column 1 contains a semi-colon (";") and the search name is in Column 2-80, 8 columns or less. All cards between this finder card and the next are the group associated with this finder.

Action Command. "name,options"

"name" is the name which will be used to search the sequential file.

"options":

u=xx	Overrides the default unit assignments and causes the search to be done on unit xx.
N	Causes search to ignore finder cards and look for SSARR format cards with the search name on unit 15, unless overridden. When one is found, card images are read from the sequential file until an image is found that does not have the search name.
F	Causes search to look for finder cards on unit 16 unless overridden by "U=xx" option.

If no options are given, "N" is assummed.

HMAINT SSARR File Maintenance Program. This program provides some useful file analysis tools, as well as facilities for SSARR program testing and maintenance. The program is particularly useful for listing the names of the various record types currently in the SSARR file. There are two forms of the list command:

L,,nn List the names of all records of type nn.
L,name List the record types currently in the SSARR file for station "name".

The remainder of the functions of the Maintenance Program are provided for SSARR program maintenance and file maintenance for the programming staff. A password is built into the program. The file change functions of the program cannot be used without first entering the password.

RETURN Leave the interactive processor and enter the fixed-format and Z-format processors.

Z...Any Z-format entry in response to the "*" prompt will cause control to transfer to the Z-format processor. To get back to the interactive processor, you must enter "IA".

J Interactive Job Control Settings. The options on this command set some of the same controls as the card code "J" fixed-format card. The options may be entered one per line, or combined onto one line with blanks or a comma separating them. The options are as follows:

?	List a summary of the options.
L	List the current setting of the job control options.
ENGLISH	(default) All data are assumed to be in english units of measure, and all calculations are done in english units. Report headings reflect english units.
METRIC	(opposite of ENGLISH) All data are assumed to be in metric units of measure, and all calculations are done in metric units. Report headings reflect metric units.
M	(default) Accumulate melt only for "accumulated total runoff" in the depletion-curve watershed model. Same control as col. 35 of "J" card).
MPLUSR	(opposite of M) Accumulate both rain and melt for "accumulated total runoff".
IA	set "Interactive" mode of operation. If the first command to SSARR is "IA" rather than a "J" card, the "interactive" mode is set. The effect is to limit the depletion-curve watershed model to 79-column printout. Also, when processing card formats (when not under interactive processor control), prompting messages are sent to the user when card input is required, and the input cards are not printed.
BATCH	(opposite of IA) set "Batch" mode of operation. Depletion-curve model printouts are 133 columns wide, there is no prompting when processing card formats, and the input card formats are listed.
FCST	(default) Same control as col. 34 of "J" card. Causes the river model to suppress the printout of stations in the model, and the printout of time control parameters.
NOFCST	(opposite of FCST) Causes the river model to print the stations in the model list and the time control parameters.
NOPLOT	(default) Depletion-curve model printout is all tabular.
PLOT	(opposite of NOPLOT) Depletion-curve watershed model printout is part tabular and part printer-plot. The printer-plot portion of the report includes temperature, precipitation, observed discharge, and total computed discharge as well as surface, subsurface, and baseflow components of discharge.

NOTE: This option is only available on the NPD mainframe version of the SSARR program.

NOTRACE (default) Same function as col. 21 of "J" card.

TRACE (opposite of NOTRACE) Turns on printouts from various parts of the program to assist in tracking the subroutines of the SSARR program during program testing.

PRT= Equal-sign is followed by hours per printline. Same function as cols. 26-29 of the "J" card.

JOB= Equal-sign is followed by agency title for report headings. This agency title overrides the title setup by col. 22 of the "J" card. If the SSARR run is begun with an IA command, the agency title defaults to "Columbia River Forecasting Service".

blank-line When the user replies to the "MORE KEYWORDS?" prompt with a blank line, control returns to the interactive processor and the "*" prompt.

Several controls on the card code "J" card cannot be changed by the options of the "J" subcommand of IA. These are the functions of the "J" card in cols. 5-19, 30, 31, and 33. Also, the functions of the "ZR" card can only be set by the "ZR" card.

L,name,type List SSARR Work File Record. This command is identified by the "L" command followed by a name. (The "L" command with no other words is the entry to the Hydromet editor.)

If type is left off, type=0 is assumed.

Types which may be listed are 0,10,11,13,21-102, and 108. Type 1 (initial condition) may be listed with "IC" command; type 2 with "EM", type 5 with "EF"; type 104 may not be listed except with "HMAINT".

EM,name Edit Model Record (Type 2). A "model" is a "P"-card list named with a fixed format "N" card. A model may be listed, changed, copied, and originated with the "EM" command. In addition to driving the watershed and river model processors, "model" P-card lists may be used drive some of the interactive processors (Initial Conditiion, Hydromet Editor, Regulation Editor, and the "INPUT" command processor).

With the "EM" command lines in the P-card list may be changed with the "*" and inserted with the "I" commands. Columns 3-80 of these commands is equivalent to a P (configuration) card; the first word is the primary station name; and the 2nd is the downstream station. Four additional "downstream" stations may be included.

The editor maintains a current-line pointer as you move around in the model P-card list.

The * command will replace the current line with Columns 3-80 of the * line. If Columns 3-80 are blank, the current line is erased and the current-line point is moved to the previous line. The I command will insert a new line following the current line, and move the current line pointer to the new line; the new line is from Columns 3-80 of the I command.

The UP,D, and L commands display a line or lines and move the current-line pointer to the last line displayed.

The "S,name" command saves the P-card list in its current form to the SSARR file with "name" as a new model name.

The Q command causes control to return to the interactive driver and the "*" prompt without saving the edited version of this model.

Sending a blank line causes the editorial version of the model to replace the old version,a nd control to return to the "*" prompt.

EF,name Edit File Record (Type 5). A FILE record may be loaded into the SSARR file by processing the fixed-format "FILE" card or Z-format "ZFILE" card. A FILE record may be listed, changed, copied, and originated withe the "EF" command. FILE records are included into the input stream with GET and ZGET commands.

With the "EF" command, lines in a FILE record may be changed with the "*" and inserted with the "I" commands. Columns 3-80 of these commands contains the new line, shifted to Columns 1-78. It is not possible to enter data into Columns 79-80 with the "EF" edit program.

The editor maintains a current-line point as you move through the lines of the FILE record.

The "*" command will replace the current line with Columns 3-80 of the command. If Columns 3-80 are blank, the current line is erased and the current-line point is moved up to the previous line.

The "I" command will insert a new line following the current line, and move the current line pointer to the new line; the new line is from Columns 3-80 of the "I" command, and may be blank resulting in a blank line in the FILE record.

The UP, D, and L commands display a line or lines and move the current-line pointer to the last line displayed.

The "S,name" command saves the edited FILE record to the SSARR file as a new FILE record with "name" from the S command.

The Q command causes control to return to the interactive driver and the "*"prompt without saving the edited FILE record in place of the original.

Sending a blank line as command to the "EF" processor causes the edited version of the FILE record to replace the original version, and control to return to the interactive driver and the "*" prompt.

BY STOP the SSARR program; return to the host computer operating system.

BASIN,name Process watershed model. ",name" in the command may be a basin name or a model name. If it is a model name, all basins in the model list are processed.

BASIN. If no ",name" field is provided, the BASIN option of the RUN command is set.

RIVER,model Process the river model. ",model" is the name of a model list.

RIVER. If no ",model" field is provided, the RIVER option of the RUN command is set.

RUN,name Process either watersheds or a river model. If no "BASIN" or "RIVER" command has been given, the default is "BASIN".

After the RUN command has been processed and the model results are complete, control returns to the interactive processor and the "*" prompt.

When watershed models are processed with the "RUN" command, the basin printouts go to FORTRAN unit 6 during the computations. Basin summary results are left in the FORTRAN unit 19 workfile and basin discharges are stored in the SSARR file in type 101 records.

There is no difference in output options between processing watersheds by the "RUN" command, or processing with fixed-format card input stream (the batch processing technique).

The type 101 records become input to the river model.

The basin summary data on unit 19 may be plotted with the "PZ" card. The following sequence of commands demonstrates this:

```
BASIN
RUN  BASIN1
RETURN
PZ 0BASIN1...
IA
```

When a river model is processed by the "RUN" command, the only direct printout during processing is the display of river configuration and time control, which can be suppressed with Column 34 of the "J" card. When the model process is finished, the message "FINAL FILE OF TIME RECORDS IS ON UNIT 21" (or "UNIT 22") is printed on FORTRAN unit 3 and control returns to the interactive processor and the "*" prompt.

River model results are left on the temporary files (21 or 22) as the "FINAL FILE..." message indicates. River model reports may be printed and results saved in the SSARR file by entering a "RETURN" command followed by the desired "PR", "PQ", "X", "SR" etc. card formats.

APPENDIX C

"DEPLETION CURVE" WATERSHED MODEL

APPLICATIION AND EXAMPLES

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APPENDIX C

"DEPLETION CURVE" WATERSHED MODEL

This section illustrates applicatiions of the SSARR Model for several "depletion" watersheds with a variety of hydrologic characteristics. Various uses of the model, available program options, and useful techniques will be discussed and illustrated in detail. The intent is to provide a guide for the user and also to demonstrate the versatility of the model. This section relies heavily on the detailed card formats and related information contained in Appendix B.

Initially, the effects of watershed parameters on synthesized streamflow are discussed. Streamflow syntheses from historical rainfall and snowmelt events are then described.

Application. The successful use of the SSARR Model to synthesize streamflow from a watershed is determined largely by the quantity and quality of data, hydrologic experience of the user, and his familiarity with the program. The program allows the user considerable flexibility to model hydrologically different watersheds. However, good judgement and logic are essential to properly develop parameter relationships.

A basic understanding of the watershed parameters and their effects on streamflow should be gained before attempting to apply the model. The following section describes the effect sof watershed parameters in detail. Subsequent sections illustrate several program options and discuss their applications for the watershed portion of the model.

Effects of Parameter Modifications. The applications of the SSARR Model to any particular watershed depends largely on the development of parameter relationships. Parameter relationships are usually established by reconstituting historical streamflow records often with sparse input data.

a. Precipitation Weighting Factor. The first objective with streamflow reconstitution is usually to get computed volumes approximately equal to observed volumes. The precipitation weighting factor should be one of the first parameters manipulated to "rough in" the computed volumes. Initial weighting values for precipitation are usually estimated with the Thiessen method or from a ratio of normal

station to normal watershed precipitation. Consistent over or under computation of streamflow volumes should dictate changes in the precipitation weighting factor to attain a more representative estimate of basin precipitation.

The effects of four different weighting factors for a two-inch rain on a 2300 square mile watershed are illustrated in Figure 8.1. These rather drastic weighting factors indicate that the respective peak flows do not differ in the same magnitudes as the percentage differences in precipitation input. With higher precipitation rates, a greater proportion of the moisture input becomes surface runoff and a higher peak results. For example, hydrograph 4777 has 50 percent more rain than hydrograph 4778, however, its runoff peak is 63 percent higher than that for hydrograph 4778.

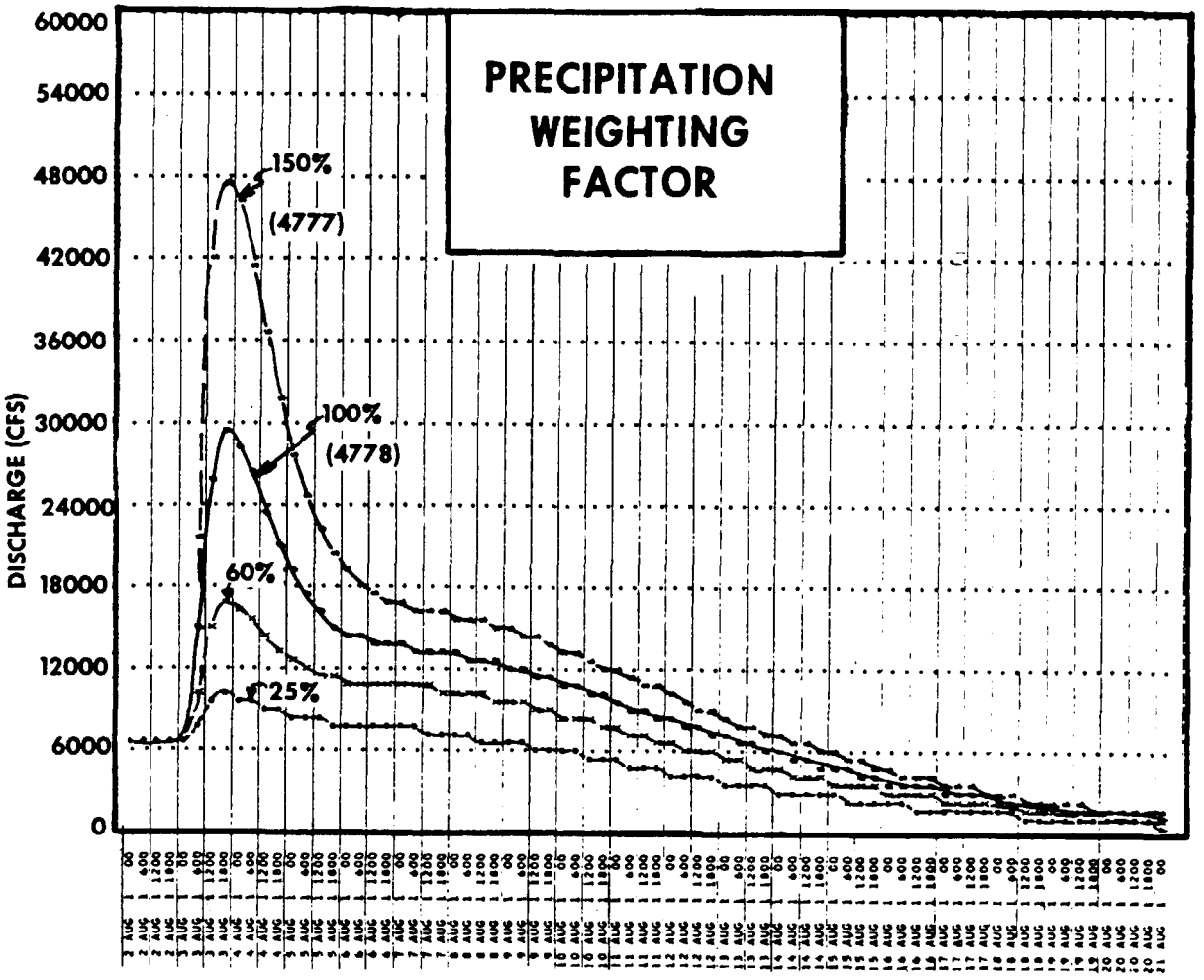

Figure 8.1 Effects of the Precipitation Weighting Factor on Runoff

b. Soil Moisture Index. One of the most important parameters that affect the runoff hydrograph is the Soil Moisture Index (SMI) - Runoff Percent (ROP) relationship. This relationship determines, to a large extent, the volume of runoff and also affects the shape of the hydrograph. To demonstrate the effects of the two-variable SMI-ROP relationship, four different SMI curves were tested. The resultant outflow hydrograph for each relationship is illustrated in Figure 8.2.

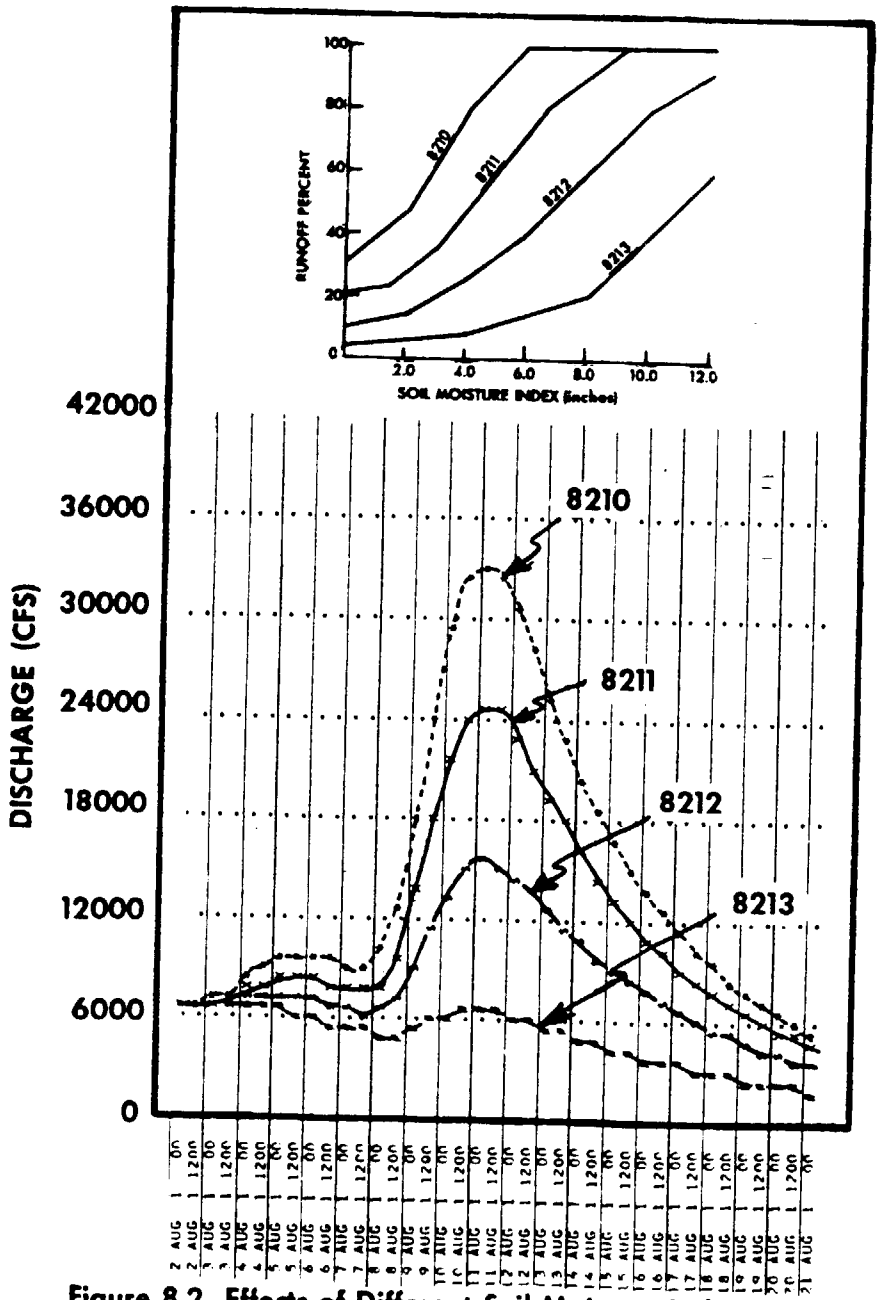

Figure 8.2 Effects of Different Soil Moisture Index - Runoff Percent Relationships on Streamflow

As one would expect, curve 8210 yielded the most runoff, whereas curve 8213 yielded practically none. Curve 8210 might represent the response of a "flashy" type stream perhaps fed by a watershed with steep slopes and shallow soil. The runoff characteristics of curve 8213, on the other hand, would require several successive storms before runoff percent could exceed 20-30 percent. This curve might characterize a watershed with little topographic relief and a deep soil.

If desired, a three-variable SMI-Rainfall Intensity (inches/hour) - ROP relationship may be used for any watershed. The higher rainfall intensities would yield a higher percentage of runoff for a given SMI value (as with curves 8211 and 8210). This three-variable relationship is more difficult to establish, however, since the user must develop a family of curves.

c. Evapotranspiration Index. Seasonal differences between observed and computed streamflow volumes can usually be adjusted by manipulating the Evapotranspiration Index (ETI). When monthly ETI is used, the ETI values themselves can often be changed. For example, if computed volumes exceed observed volumes during the spring and early summer, the corresponding ETI values can be increased. This adjustment may reflect higher transpiration rates of plants during these seasons and consequently lower soil moisture content and less runoff. Adjustments of monthly ETI for any month can be made when a definite bias exists with streamflow reconstituions. The ETI, however, should not be changed to unreasonable magnitudes. Further modifications of the ETI effects can be made indirectly by altering the KE relationship. Low KE values (percent effective ETI) would characterize areas with predominantly frontal-type storm systems, whereas larger KE values may be characteristic for warmer areas with short-duration, high intensity rainfall.

When daily pan evaporation data are used, a weighting coefficient for daily ETI is provided to compensate for the pan coefficient. In addition, the actual evapotranspiration can be more closely estimated by developing a DKE-SMI relationship to lower the ETI when soil water becomes limited. The effects of ETI, KE, or DKE on any individual storm are often slight. These factors become important when the user attempts to model watersheds where antecedent soil moisture conditions fluctuate significantly and long term simulations are desired.

d. Baseflow Infiltration Index. After observed streamflow volumes are approximated, the next step usually is to correctly separate flow into its three components. An approximate base flow relationship can often be determined on the basis of experience. The effects of four different BII - Baseflow Percent curves are illustrated in Figure 8.3. Again, all other factors such as SMI and ETI, were the same for each hydrograph. As illustrated, the volumes of runoff were not affected by the BII, however, the magnitude of baseflow with curve 8308 was substantially greater than with 8311.

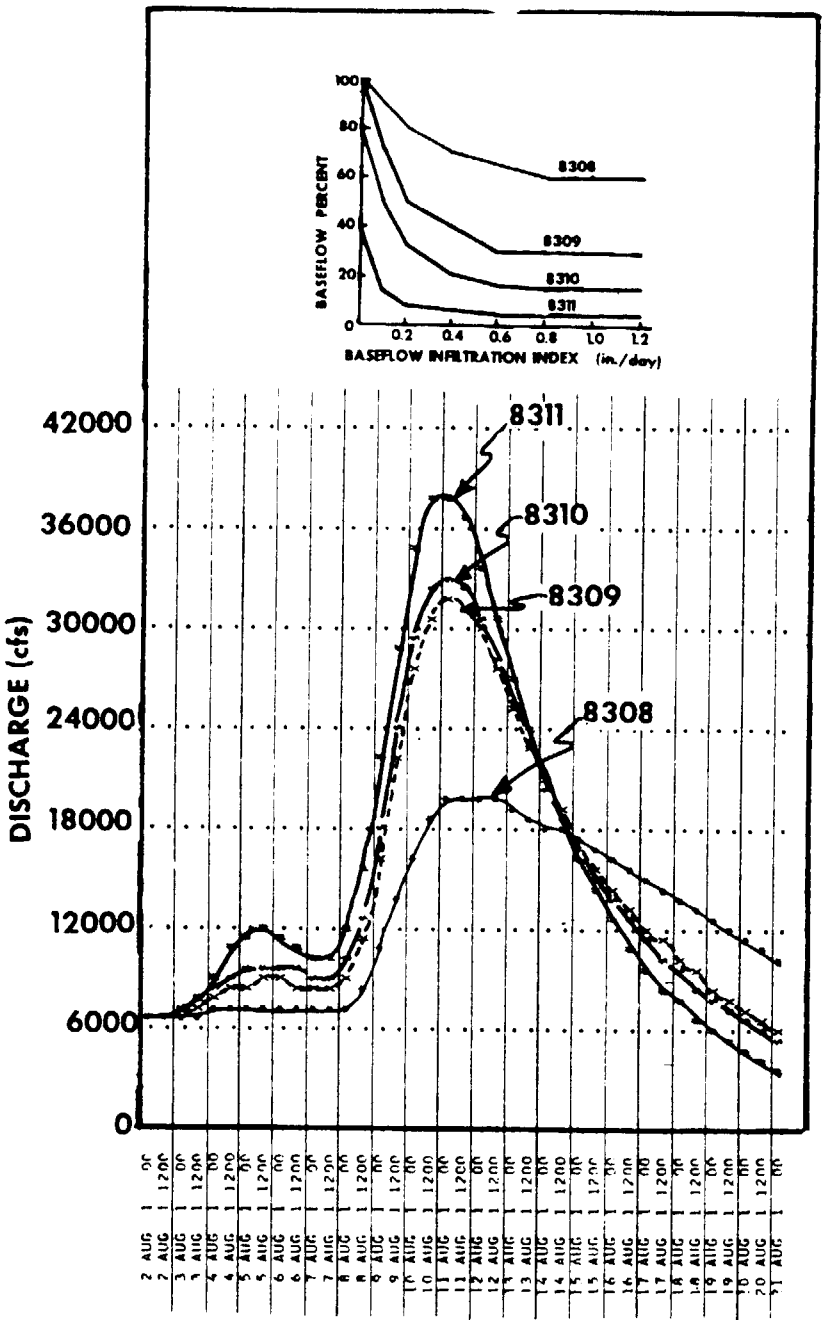

Figure 8.3 Resultant Streamflow from Various Baseflow Infiltration Index Relationships

e. Surface-Subsurface Separation. Further breakdown of the runoff into surface and subsurface components is illustrated in Figure 8.4. Here the SMI, BII, etc., were the same for each hydrograph. Curve 8010 yielded more surface runoff and an earlier peak (more flashy streams) than the other curves. The surface-subsurface relationships are developed so that the surface component of flow becomes larger with higher moisture input rates.

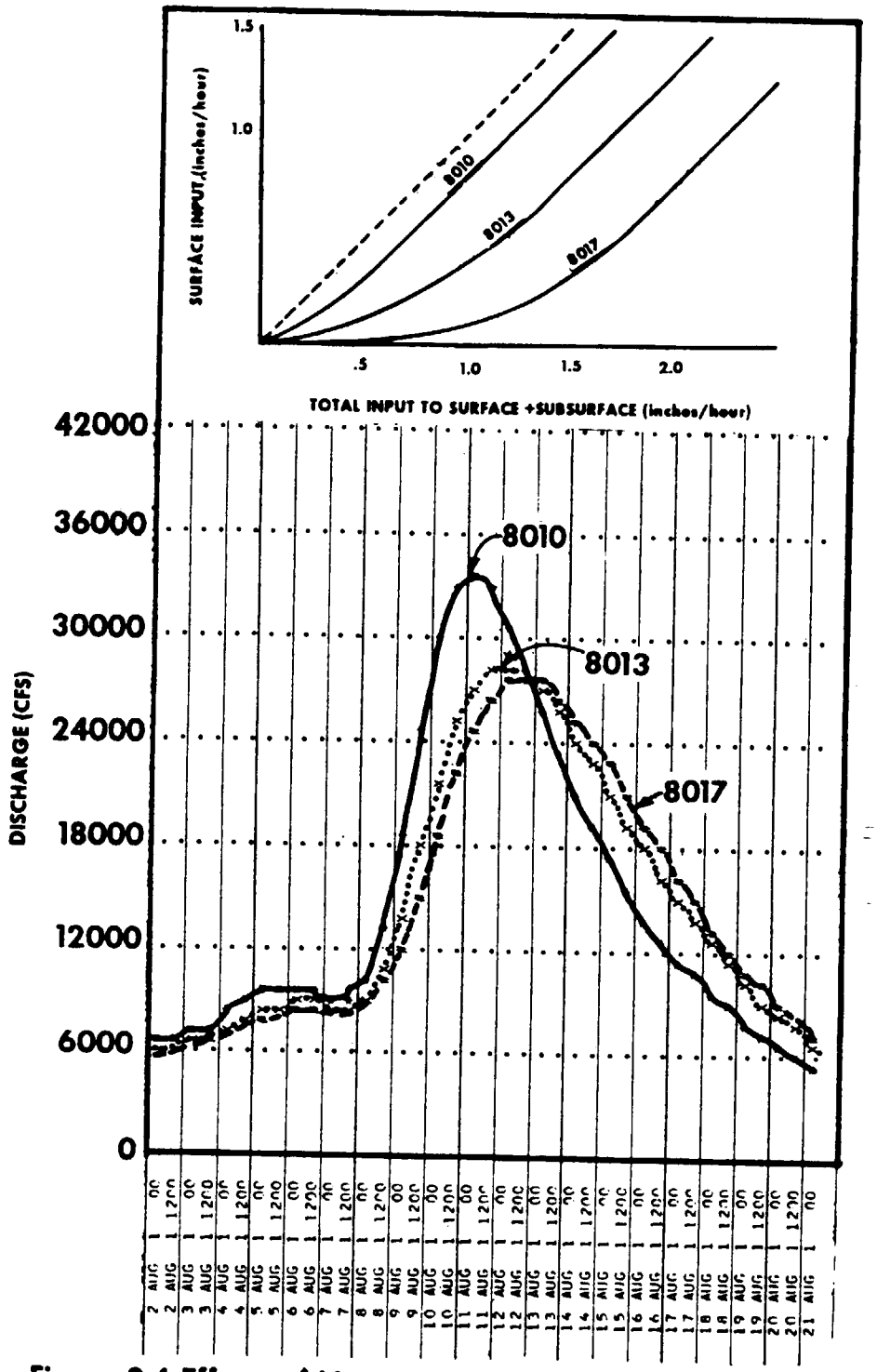

Figure 8.4 Effects of Varying Surface - Subsurface Separation Relationships on Streamflow

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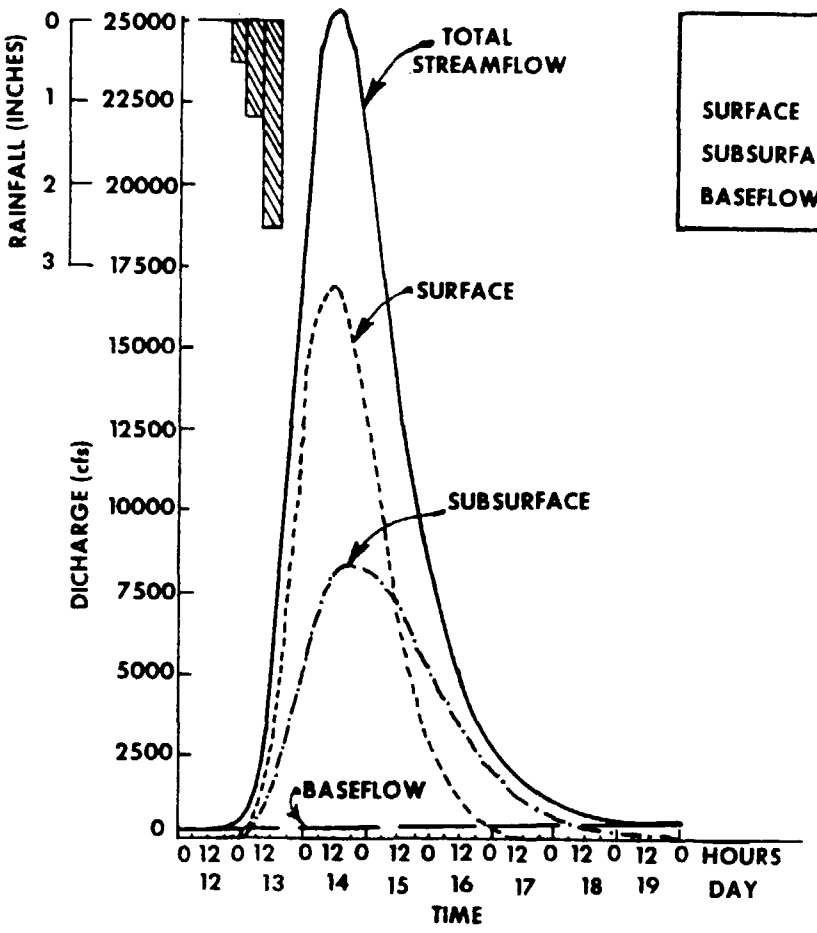
f. Watershed Routing Parameters. The outflow hydrograph shape and timing response are affected by the number of routing phases for each component of flow and the time of storage per phase. The three components of watershed outflow for a specified number of routing phases and time of storage (T_s) per phase are illustrated in Figure 8.5. The subsurface peak lagged the surface peak only slightly in this case, and created a higher outflow peak. Since T_s values for baseflow are usually large, routing characteristics for the baseflow component have little effect on the outflow hydrograph. Thus, the following examples illustrate only the effects of changing routing characteristics for surface and subsurface components.



	No. PHASES	Ts per PHASE (hours)
SURFACE	5	7.7
SUBSURFACE	4	13.0
BASEFLOW	2	250.0

FIGURE 8.5 WATERSHED ROUTING CHARACTERISTICS AND RESULTANT HYDROGRAPH

The following examples of parameter modifications are for illustrative purposes only and do not necessarily represent realistic values for any given watershed. For the first example, all routing coefficients were constant except for the number of routing phases for surface flow (see Figure 8.6). The time of storage per phase (T_s) for each station was 25 and 50 hours for surface and subsurface components, respectively. Since T_s values were not changed to obtain the same total time of storage, the increased number of surface phases caused a greater total time of storage and a reduction in the peak. Rather extreme changes in the number of routing phases for surface and subsurface flow are shown in Figure 8.7. Again, the time of storage is greater for hydrograph 4778 than 4777, etc. In all of these examples the total volume of runoff was the same.

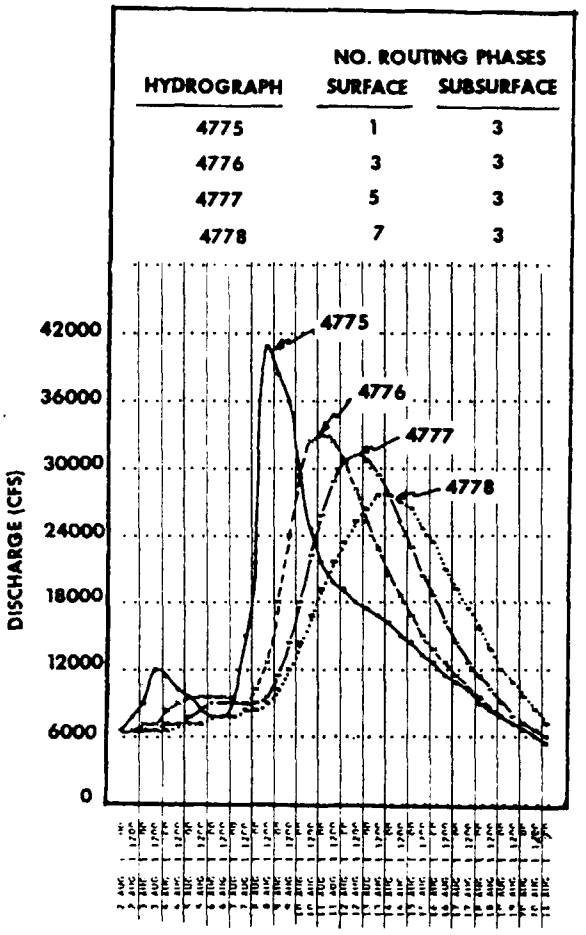


Figure 8.6 Effects of Varying the Number of Surface Routing Phases on Streamflow

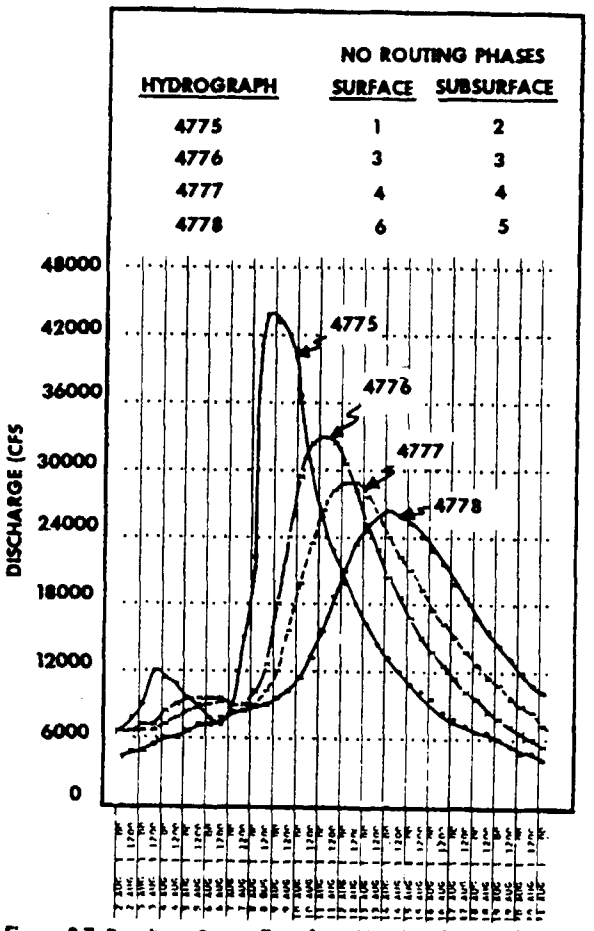


Figure 8.7 Resultant Streamflow from Varying the Number of Surface and Subsurface Routing Phases

Adjustments in time of storage per phase (T_s) can also result in significant changes in timing and hydrograph characteristics. Increased T_s for surface components with three phases for each component, resulted in a greater lag time and lowered peaks (see Figure 8.8). When surface T_s values were constant, and T_s for subsurface increased, the peaks were lowered significantly, however, the total lag time of the peaks was only slightly affected (Figure 8.9). The effects of increasing time of

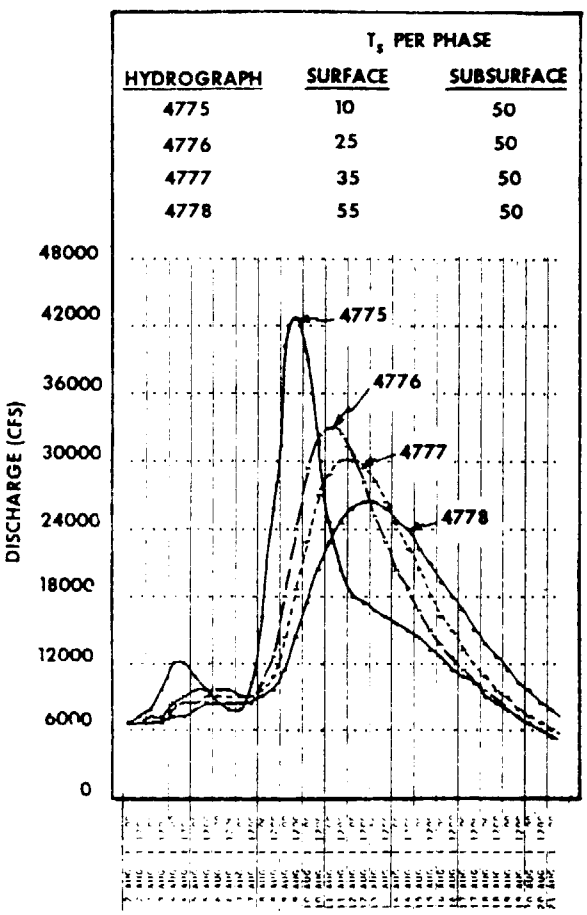


Figure 8.8 Effects of Surface Time of Storage on Streamflow

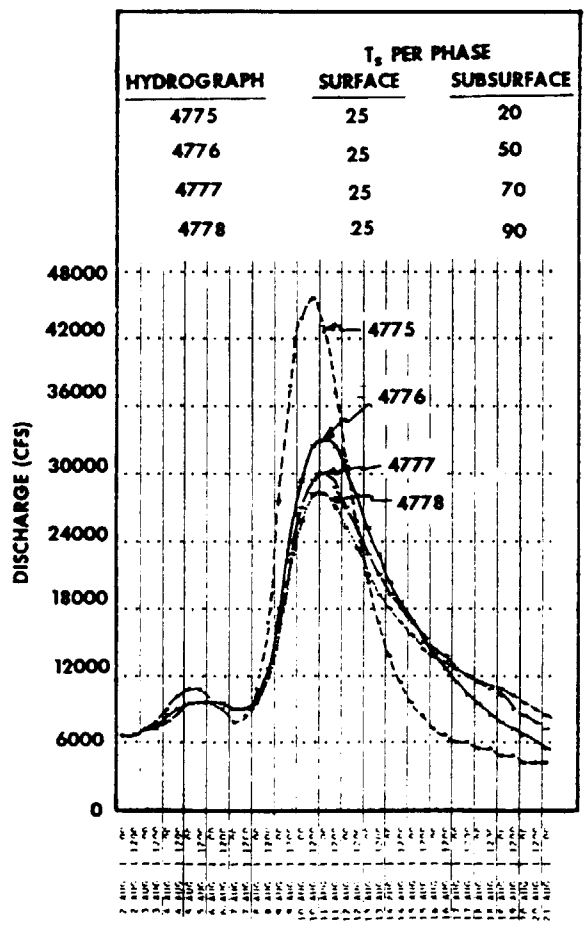


Figure 8.9 Effects of Subsurface Time of Storage on Streamflow

storage per phase for each of three phases of surface and subsurface flow were even more pronounced (Figure 8.10). Again, total time of storage was much greater for hydrograph 4778 than for 4775.

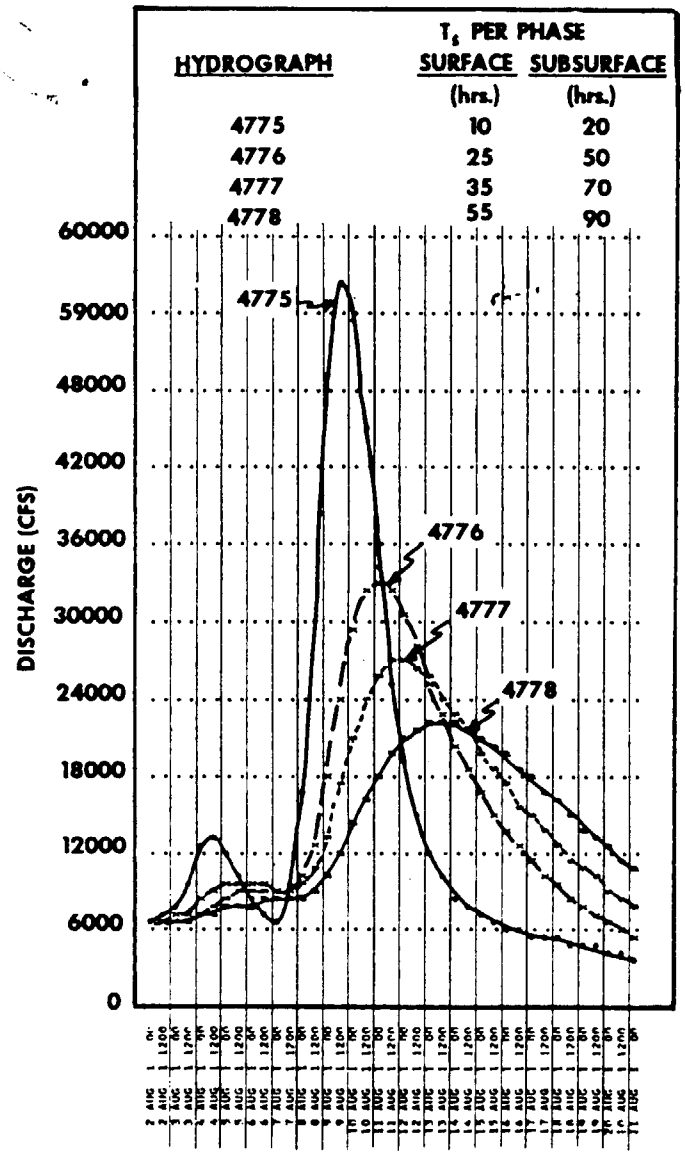


Figure 8.10 Resultant Streamflow from Increasing Surface and Subsurface Time of Storage

In Figure 8.11 hydrograph 4776 represents the control. The routing characteristics of the other hydrographs were changed with specific modifications in mind. Hydrograph 4775 shows the effects of altering surface routing to increase peak discharge without affecting the timing of the peak. The effect of increasing only the subsurface peak on the hydrograph is illustrated by hydrograph 4777.

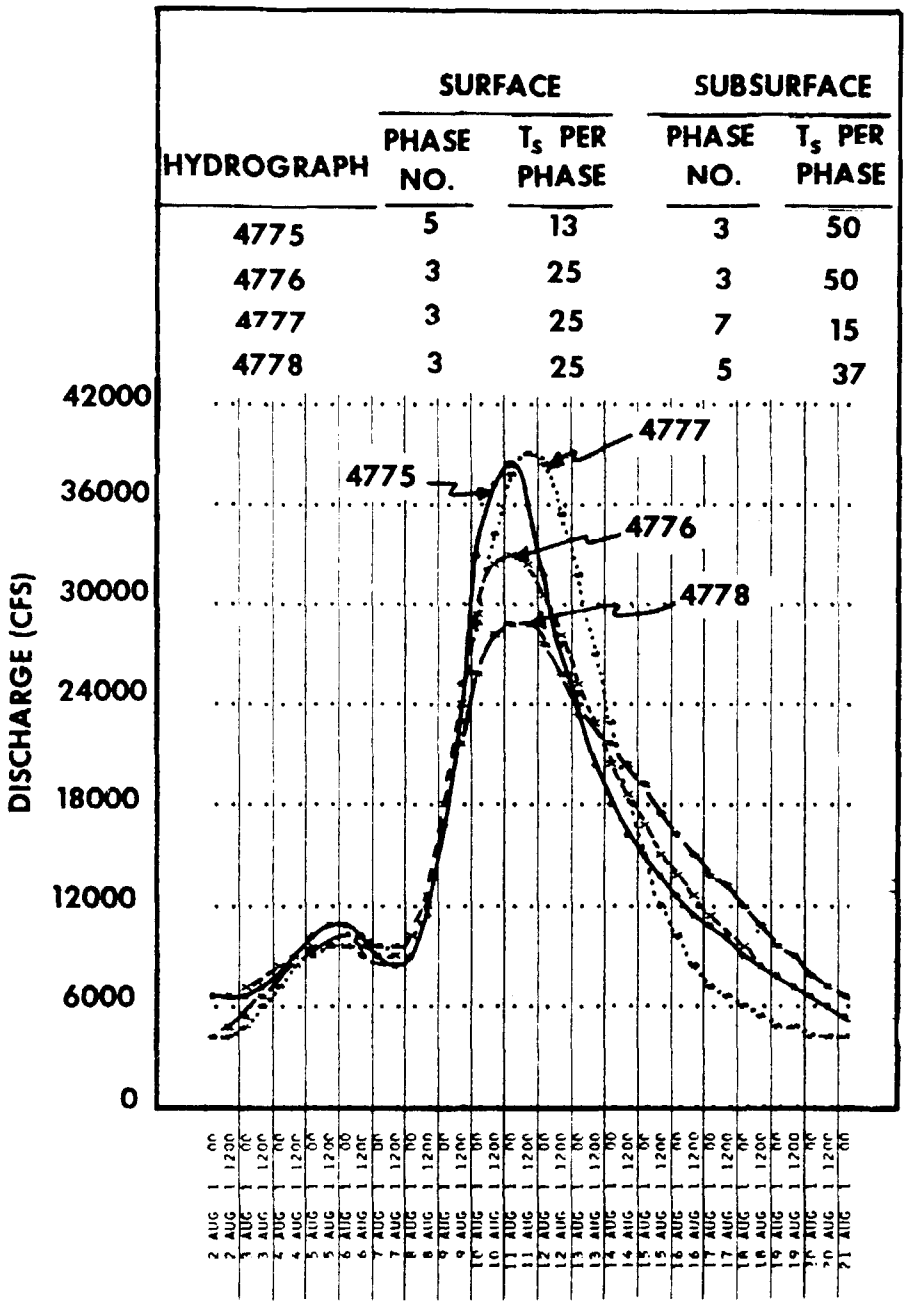


Figure 8.11 Effects of Changing Watershed Routing Characteristics on Streamflow

This created a broadened peak with an increase lag time for the total discharge due strictly to the increased time of the subsurface peak. The total time of storage for subsurface flow was increased for station 4778 and resulted in a lower, more broadened peak with an increase lag time for the total discharge due strictly to the increased time of subsurface peak. The total time of storage for subsurface flow was increased for station 4778 and resulted in a lower, more broadened peak, with a considerably higher recession limb.

g. TSBII. The TSBII parameter, which corresponds to a depression time of storage, does not affect runoff as markedly as the before mentioned parameters. As TSBII increases, the changes in BII from one period to the next decrease, and the result is a higher percentage of baseflow (Figure 8.12). The TSBII affects the peak to a slight degree, however, it has a rather significant effect on the slope of the recession limb of the hydrograph. Large values of TSBII maintain a significant baseflow over extended periods of time.

$$BII_2 = BII_1 + (24 \times RG - BII_1)\left[\frac{PH}{TSBII + PH/2}\right]$$

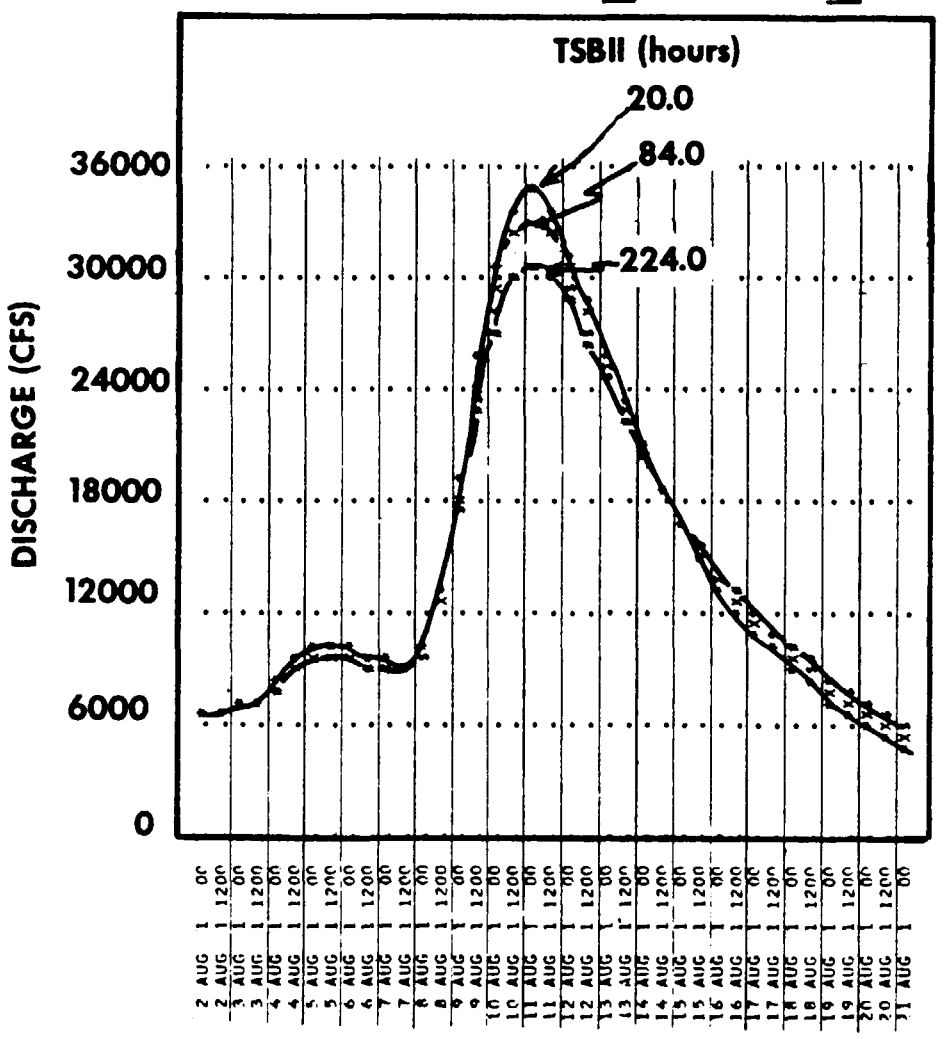


Figure 8.12 Effects of Varying TSBII Parameter on Streamflow

Single Watershed - Rain Only. The application of the model to a particular watershed should begin with the derivation of basic rainfall-runoff relationships. Initial estimates of the parameters can usually be obtained from similar basins previously modeled, or from basic hydrologic knowledge of the area. Streamflow reconstitutions are then made to establish parameter relationships by manipulating one parameter at a time until the computed hydrograph approximates observed streamflow. After the model is "calibrated" by reconstitutions, the parameter relationships should be verified with independent data. Once verified, the parameters can be considered representative, and the model can then be applied for such purposes as design flood derivations, or streamflow forecasting.

Two watersheds with different climatic and hydrologic characteristics were selected to illustrate the versatility of the model with regard to runoff synthesis from rainfall.

a. South Yamhill Basin. The first example illustrates the use of the model for streamflow synthesis from the South Yamhill River Basin on the east slope of the Coast Range in Oregon. Snow accumulation and melt are negligible on this 502 square-mile basin which has a mild, humid climate. Frontal-type storms prevail in this area with annual precipitation averaging 45 inches at the valley floor, and over 170 inches at the upper elevations of the basin. High intensity rainfall is infrequent over the basin, so that a single Soil Moisture Index (SMI)-Runoff Percent (ROP) relationship was used. Since evapotranspiration losses are small compared to basin precipitation, estimates of the Evapotranspiration Index (ETI) on a monthly basis were considered adequate. The ETI and corresponding KE factors have little effect on the total volume of runoff in this area, because soil moisture does not fluctuate greatly during the rainy season. Runoff is usually negligible during the summer months when evapotranspiration losses are greatest.

Initially, "high effect" parameters such as precipitation weighting factors and SMI-ROP relationships were adjusted until computed volumes approximated those observed. The remaining parameters, BII, surface-subsurface relationships, basin routing phases and time of storage per phase, and TSBII were then adjusted to improve the hydrograph shape and timing response. The parameters and table relationships derived for the South Yamhill Basin are illustrated in Figure 8.13. Some of the reconstitutions based on these parameters are illustrated in Figure 8.14. The computed and observed streamflow are represented by the dashed and solid lines, respectively. Once adequate reconstitutions were obtained, the parameters and table relationships were not changed. The only input changes for daily operational use would be time specifications, initial conditions, and hydrometeorological data.

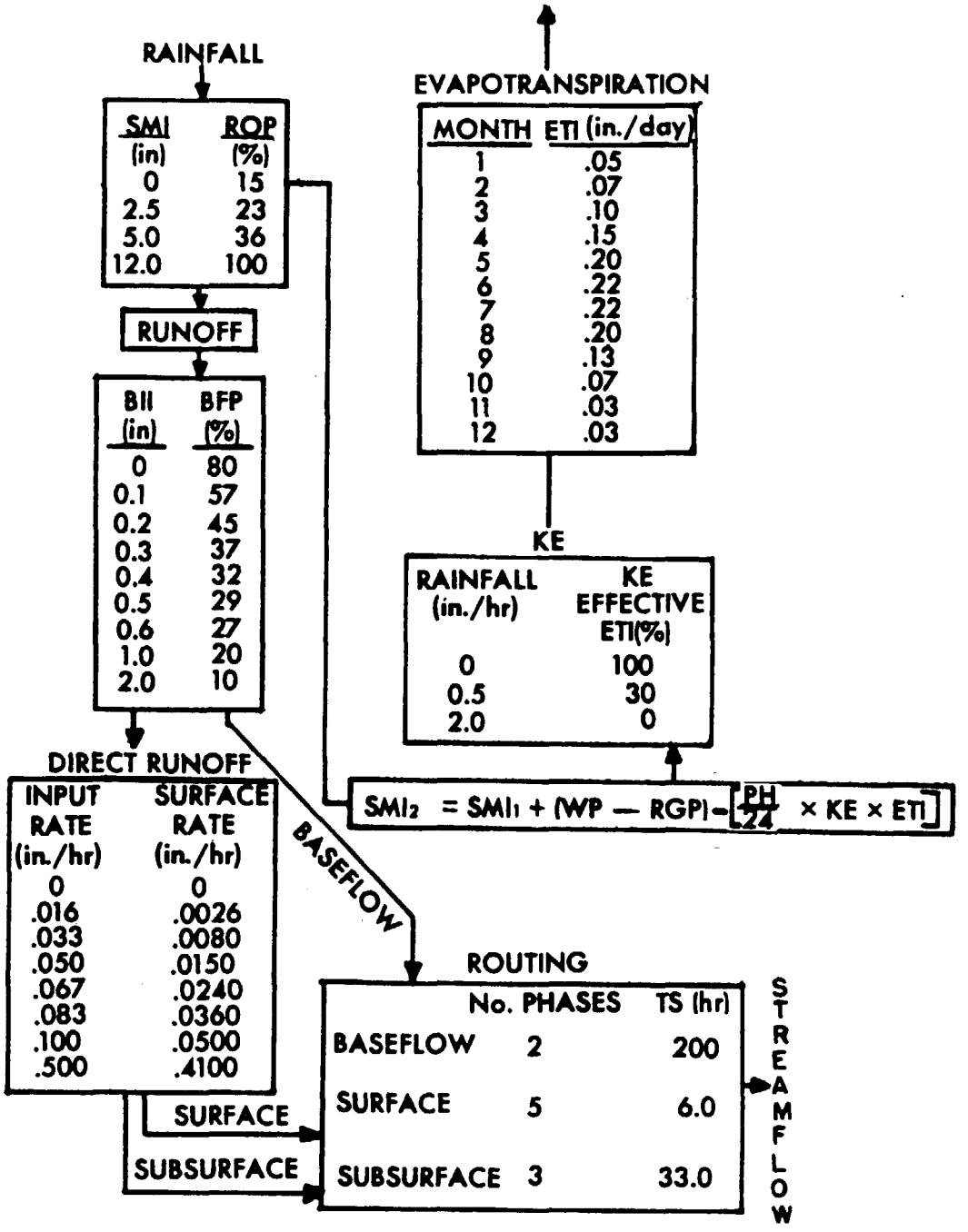


FIGURE 8.13 TABLE VALUES AND PARAMETERS USED WITH SSARR FOR SOUTH YAMHILL RIVER BASIN, OREGON

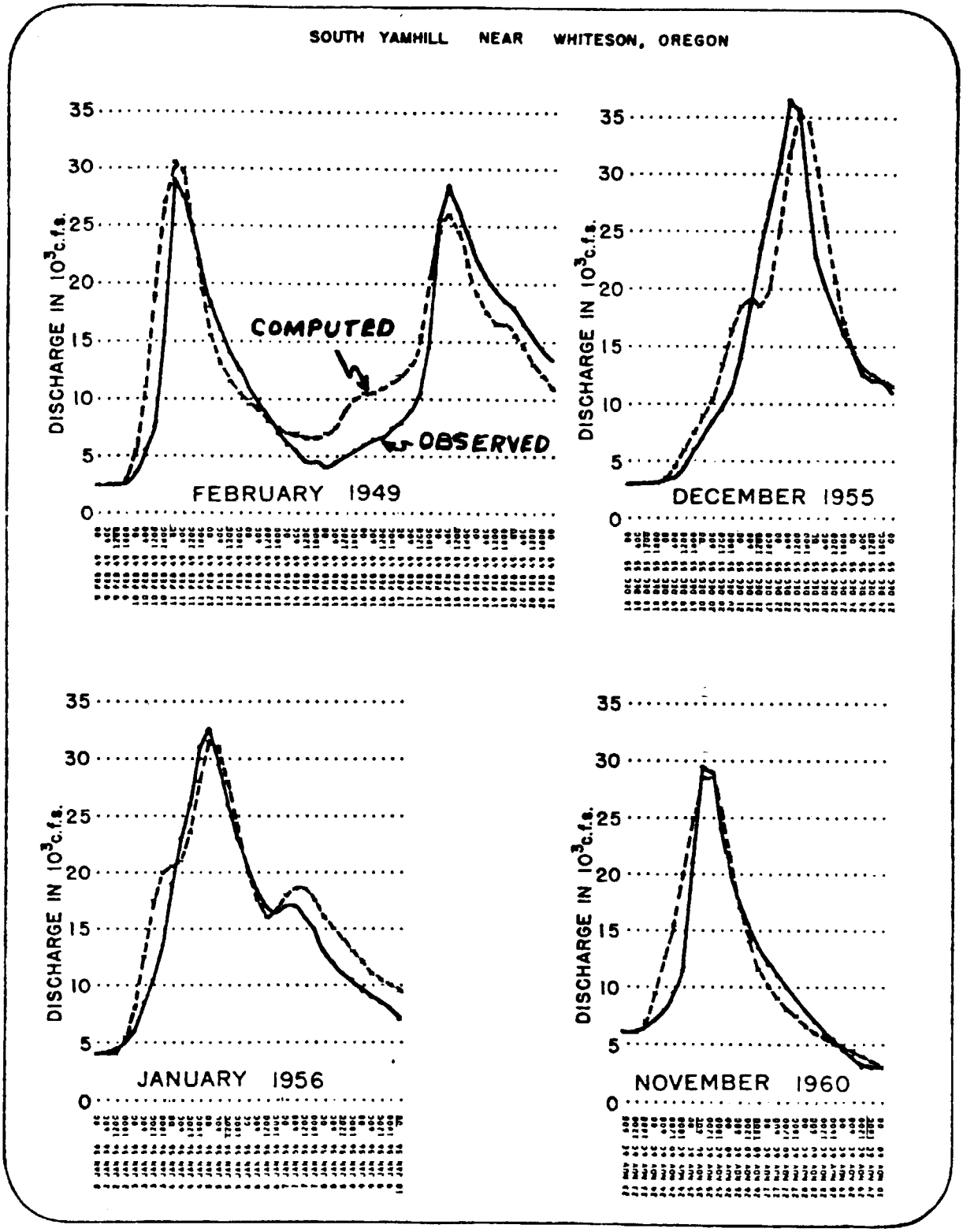


FIGURE 8.14 STREAMFLOW RECONSTITUTIONS FOR THE SOUTH YAMHILL RIVER BASIN, OREGON (7)

b. Bird Creek Basin. The second example illustrates the use of the model to synthesize streamflow from the semi-arid Bird Creek Basin near Sperry, Oklahoma. As opposed to the South Yamhill Basin, this basin is characterized by hot summer temperatures, long dry periods, high evapotranspiration rates, and high intensity, short-duration rainfall. Snowmelt contributions to streamflow are negligible.

The soil-water content fluctuates more radically in this basin than in the preceding example. Because of the significant effects of antecedant soil moisture on runoff, accurate accounting of soil moisture changes was required. Therefore, the following program options were used:

(1) The three-variable SMI relationship was used to account for rainfall intensity effects on runoff. With the single SMI-ROP curve streamflow reconstitutions were, on the average, too high for low intensity rainfall and too low for high intensity rainfall. The SMI-Rainfall Intensity-ROP curves in Figure 8.15 were developed by trial and error, and improved streamflow reconstitutions considerably.

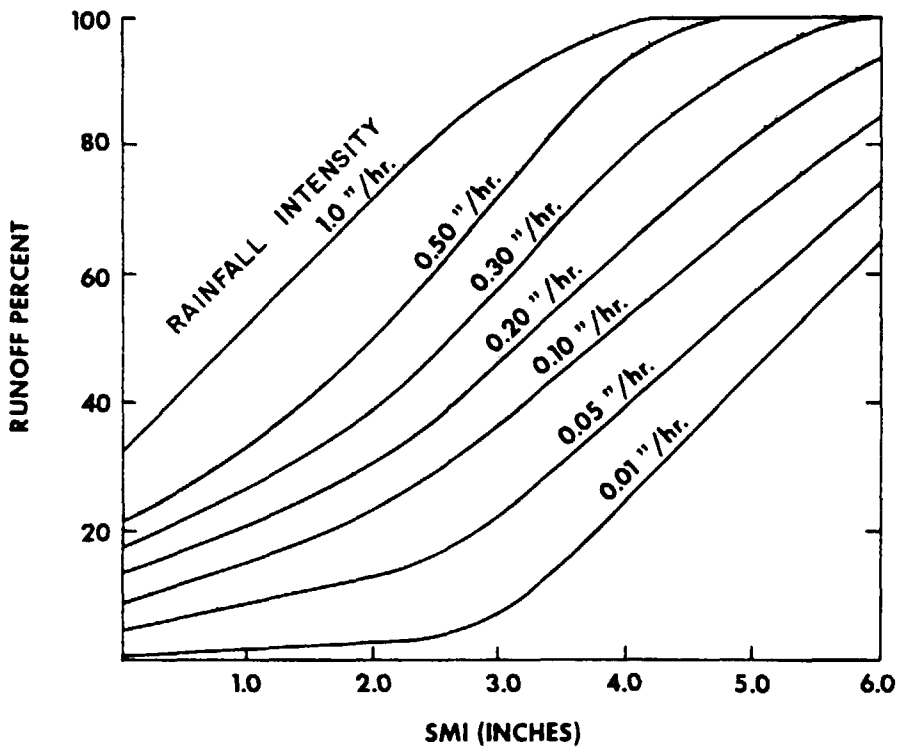


FIGURE 8.15 THREE VARIABLE SOIL MOISTURE INDEX RELATIONSHIPS DEVELOPED FOR BIRD CREEK. SMI (INCHES) vs. RAINFALL INTENSITY (INCHES PER HOUR) vs. RUNOFF PERCENT

Revised June 1975

(2) Daily pan evaporation data were used to estimate daily changes in the Evapotranspiration Index (ETI) to improve the sensitivity of the SMI relationship. Two pan evaporation stations near the basin were weighted 80 percent and averaged to estimate daily ETI for the basin. A corresponding DKE versus SMI relationship was also developed by trial and error for Bird Creek (See Figure 8.16). The DKE-SMI relationship

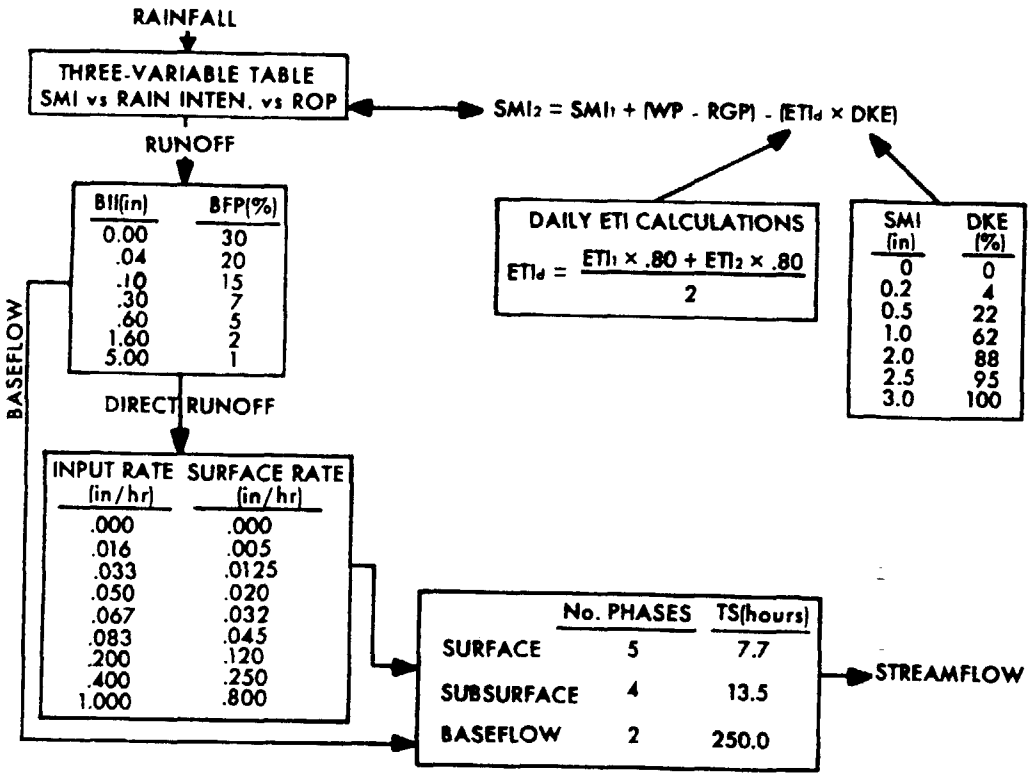


FIGURE 8.16 WATERSHED PARAMETERS DEVELOPED FOR BIRD CREEK

enabled a more realistic estimate of ETI than did average monthly values since actual evapotranspiration does not proceed at a constant, potential rate at all times.

Ten years of Bird Creek streamflow records were reconstituted to develop the parameter relationships illustrated in Figure 8.16. An example of the input listing is presented in Figure 8.17. Six-hour computational periods were designated throughout with the T card. The Hydrometeorological input consisted of 6-hourly basin-averaged rainfall and daily pan evaporation data.

```
1********10********20********30********40********50********60********70********80
JOB 04331601          0 120  6                BIRD  CREEK
    ****  3 VARIABLE SMI  TESTED  28-29 SEPT.  *****
CF01   1000              0       0       0      99       0
CF02   1000            .01       0       0     2.5       3     3.0       5 FINAL
CF03   1000            .01     4.0      25     5.0      45     6.0      65 SMI
CF04   1000            .01     8.0      75    10.0      90     999     100 BIRD
CF05   1000            .05       0       4    2.75      17     3.0      77 CR
CF06   1000            .05     3.8      37     5.0      58     6.0      71
CF07   1000            .05     8.0      80    10.0     100     999     100
CF08   1000            .10       0       8    2.25      25     2.5      30
CF09   1000            .10     2.8      34     3.5      48    3.75      48
CF10   1000            .10     4.5      60     5.5      78     9.0     100
CF11   1000            .20       0      13     1.5      24     2.2      34
CF12   1000            .20     2.6      39     3.5      56    4.25      70
CF13   1000            .20     5.5      90     6.5      95     7.5     100
CF14   1000            .30       0      18     2.0      37     3.0      57
CF15   1000            .30    3.75      76    4.75      94     6.0     100
CF16   1000            .50       0      21     2.0      50     3.0      72
CF17   1000            .50     4.0      93    4.75     100     999     100
CF18   1000            1.0       0      33     2.0      90     4.0     100
CF19   1000            1.0     999     100
    ******  *  3RD  811   INTERMEDIATE  NFP  *******
CT01   2000              2       0      30     .04      70      .1      15 RIZ
CT 2   2000            .14      10      .3       7      .6       5     1.0
CT 3   2000              4     1.6       2      5.       1     10.     .05
CT 4   2000            999     .05
CT01   3000              2       0       0     .016    .0050    .033   .0125 S/SS
CT02   3000            .05    .020    .067    .032    .083    .045    .200
CT03   3000            .12      .4     .25     .76     .58     1.0      .8
CT 4   3000            1.5     1.3     1.6     1.4     999     999      ETI
CT01   4111              7       1     .03       2     .11       3     .16
CT02   4111              4     .24       5     .25       6     .31       7 (MONTHLY)
CT03   4111            .33       8     .33       9     .28      10     .19
CT04   4111             11     .12      12     .08
CT01   5000              2       0       0    0.20       4     0.5      22
CT02   5000            1.0      62     2.0      88     2.5      95     3.0
CT03   5000            100     999     100
  *  *  *   CHARACTERISTICS   *  *  *  *  RAIN ONLY  *  *
CB01     20              2       BIRD  CREEK
CB 2     20           9055   774  1352  750   100  5000      99991111000
CB 3     20           2000   2  3000
CB 4     20           31775100 54000 8054002 80
CC 1     21                       SUMMING PT.   MEAN DAILY FLOW
CC 1   1775              8            OBSERVED Q
CC01   1971              8            SIGN  CHANGE
CC02   1971 1
CL01     25              8 1          DEVIATION
CL02     25                                9     -9
C110     25            -10                     -4R2666    10                    4R2666
  *  *  CONFIGURATION  *  *
F      1775           1971
P      1971             25
P        20             21
P        21             25
****EOF****
****EOF*****  *TIME CONTROL  **
T    6  11055 6 24 30 956
?BOC     20 06 011055        25      05550
2B04     20  6  11055        0       0
2L 1     25                                  1
T        5550 00 011055   0 010203030 1000
T        5550 00 011056   0 010203030 1000
    ****  WATER  YEAR  56      BIRD  CREEK  ****
    ***  OCT 55 TO OCT 56   PRECIP  ***
4D   6   1775  6 0110553  01  21   0   0   0 153  10  04  04   0  09  01
4D   6   1775  6 0410553  18 129  24  17  36
4D   6   1775  6 2510553                                                01
4D   6   1775  6 3011553                  09  13  03
4D   6   1775  6 1601563                          01  01  01
4D   6   1775  6 1901563              01  01  01
4D   6   1775  6 2201563  07  04  03  06  04  06          03  03
4D   6   1775  6 2801563                  06  01
4D   6   1775  6 3101563                  02  09  21  13                  01
4D   6   1775  6 0302563              03  04                  05
4D   6   1775  6 0602563                                      04  08
4D   6   1775  6 1702563  01
4D   6   1775  6 1303563                  02                          02  06
4D   6   1775  6 2003563                  15  30  73  03
          HULAH DAM ETI FOR WK 39
4D     4000  00 110555  27                      23  22  17  23  18  19  20  25  25
4D     4000  001510555  20  16  21  32  14  21  25  18  20  27  17  23  28  33
4D     4000  002910555  17  20  13  27  20  16  14  29  18  13   9  11  11  10
4D     4000  001211555  19  12  15  14   2   2   2   3   6  12  30  18  18  20
4D     4000  002611555   7   5   6   6   6   8   8   8   8   8   8   8   8   8
4D     4000  001012555   4   4   4   4   8   5   4   5   5  17   6   6   1   5
4D     4000  002412555  11  12  12   9  10  12   3   3   3  14  10   9  11  16
4D     4000  000701565  11   9   8   4   6   5   6   6  15   2   2   3   2   2
4D     4000  002101565   3   2   2   1   4   5   6   7   5   5   6   6   6   6
4D     4000  00 502565   6   6   6   6   6   6   6   6   6   6   6   4   4   6
4D     4000  001902565   9  11  10   8  12  40  75   6  27   9  40  22  30  16
4D     4000  00 503565  35  50  35  28  10  45  50  16   3   3   3   9  23  10
4D     4000  001903565  36  30   2   2  11  20   7  49  40  38  32  28  23  37
4D     4000  00 204565  28  28  30  19  27  36  26  27  00  10  13  20  28  42
4D     4000  001604565  30  22  24  28  23  26  43  23  12   9  31  46  56  21
4D     4000  003004565  17   7   2   2  28  24  44  34  29  31  51  49  47  60
4D     4000  001405565  54  14  37  40  24  58  39  47  64  45  24   7  15  16
4D     4000  002805565  17  35  40  25  25  46  33   7  34  16  32  30  31  38
6D     1775 12 0910551   80   50   30   21   16   13    9    7
6D     1775 12 1710551    6    5    4    3    2    2    2    1
6D     1775 12 2510551    1    1    1    1    1    1    1    1
6D     1775 12 0211551    1    1    1    0
6D     1775 12 1011551
6D     1775 12 1811551
6D     1775 12 2611551
6D     1775 12 0412551
6D     1775 12 1212551
6D     1775 12 3012551
  *  PLOT CONTROL  *
PO     17750                    06 01105524 300956 24    0   25000
FINAL FILE OF TIME RECORDS FOR OUTPUT AND PLOT IS ON UNIT 21
PRC      20*                                              0   25000
PEC      25X                                             -10     10
PHC 17753 100*                                            10
PR 1  .   218      253     17758                                   1
PTC  MEAN Q CALC.   1 MEAN Q OBSERV. 2
END
```

3 - VARIABLE SMI TABLE

NOTE: NOT ALL DATA FOR THIS RUN IS GIVEN ON THIS EXAMPLE, THE WAVY LINE DENOTES PLACES WHERE DATA HAS BEEN LEFT OUT.

NOT USED WHEN DAILY PAN EVAPORATION RATES ARE INPUT ON 4D CARDS.

KE (%) vs. SMI (INCHES) FOR DAILY ETI

For Daily ETI

SIGN CHANGE AND SYNTHETIC

RESERVOIR FOR DEVIATION PLOT

INITIAL CONDITIONS

DAILY DISTRIBUTION OF ETI

PRECIPITATION DATA

DAILY PAN EVAPORATION DATA

(STATION 4000) FOR ETI COMPUTATIONS

OBSERVED STREAMFLOW

MEAN DAILY STREAMFLOW PLOT

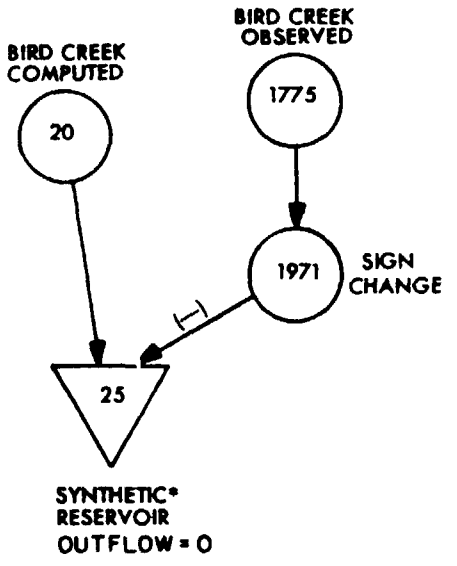
MEAN DAILY STREAMFLOW CALCULATIONS

FIGURE 8.17 EXAMPLE OF INPUT LISTING FOR BIRD CREEK

REVISED JUNE 1975

The SMI equation used with the daily ETI option differs slightly from the one used with the tabled ETI input for the South Yamhill Basin. The daily ETI values were distributed throughout each day as defined in "5" cards so that the highest evapotranspiration losses occurred in mid afternoon. The BII and surface-subsurface parameters developed for Bird Creek were characterized by smaller percentages of baseflow and a larger percentage of surface runoff than with South Yamhill.

A useful technique was employed with Bird Creek reconstitutions to derive the best parameter values and relationships. A synthetic reservoir was inserted at the basin outflow point (see Figure 8.18), with



* 1 Foot of pool elevation = 1 inch of basin runoff

FIGURE 8.18 CONFIGURATION FOR THE SYNTHETIC RESERVOIR USED TO DETERMINE DIFFERENCES BETWEEN COMPUTED AND OBSERVED STREAMFLOW

inflow consisting of the sum of the positive computed streamflow and the negative observed streamflow. The reservoir characteristics were specified so that; one inch of basin runoff equalled one foot elevation of the pool; reservoir outflow equalled zero; and the upper and lower bounds were set to allow adequate "pool" fluctuation. If the initial elevation is set equal to "0" then the deviation of the hypothetical pool elevation represents the difference in inches of basin runoff between computed and observed hydrographs. This pool elevation, computed and observed hydrographs, and rainfall are plotted in Figure 8.19A. In this example, the streamflow was overcomputed,

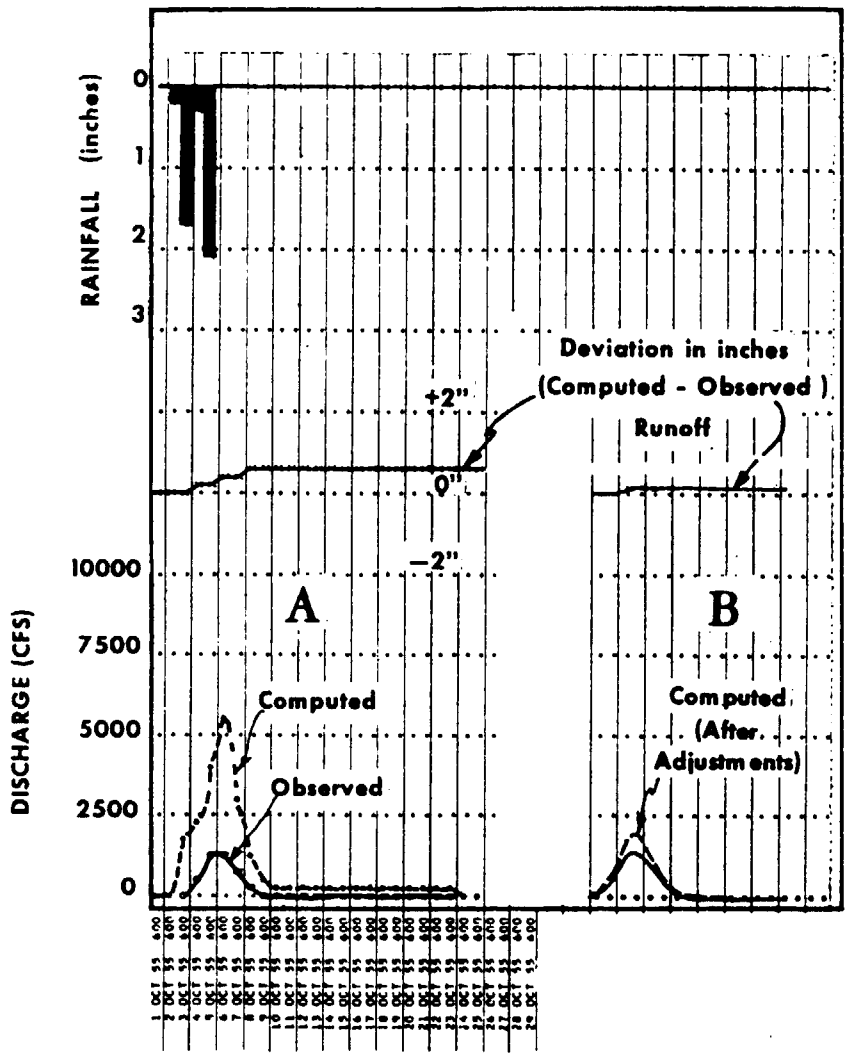


Figure 8.19 Example of Plotting Capabilities of SSARR: Reconstituted Streamflow of Bird Creek

denoted by the positive deviation of the reservoir of approximately 0.7 inches of basin runoff. The deviation at the end of the computation period represents the accumulated difference between computed and observed streamflow. Adjustments were made with the SMI, weighting coefficients, BII, etc., to get the minimal deviation from the "0" line as shown in Figure 8.19B.

A sample of the output listing of the watershed characteristics is illustrated in Figure 8.20.

BASIN RESULTS - STATION 2.0 BIRD CREEK

RUN DATE	RUN NO.	INITIAL DATE, HOUR	JOB DESCRIPTION	
	0	1 OCT 1955 600	43316010 BIRD CREEK	N.P.D., CORPS OF ENGINEERS

ETI = 0.19 IN./DAY, MELT RATE = 0.0 IN./DEGREE-DAY, AREA = 905.0 SQ. MI.

DAY	HOUR	PCPN	%RA	RN-AR	ML-AR	%AR	ELEV	SCA	D-DY	%MA	MELT	MI	ETI	SMI	ROP	RGP	BII	BFP	BASEF	SUBSF	SURF	DISCH	HOUR	DAY
OCT 1955																							OCT 1955	
1	600	0.0	0	0.0	0.0	0	0	0	0.0	0	0.0	0.0	21.01	0.25	0	0.0	0.0	0	0	0	0	0	600	1
1	1200	0.21	100	0.01	0.0	0	0	0	0.0	0	0.0	0.21	0.02	0.25	3	0.01	0.00	30	0	0	0	1	1200	1
1	1800	0.0	100	0.01	0.0	0	0	0	0.0	0	0.0	0.0	0.03	0.45	0	0.0	0.00	30	0	3	3	7	1800	1
2	00	0.0	100	0.01	0.0	0	0	0	0.0	0	0.0	0.0	0.01	0.45	0	0.0	0.00	30	0	10	9	20	00	2
2	600	0.0	100	0.01	0.0	0	0	0	0.0	0	0.0	0.0	0.0	0.44	0	0.0	0.00	30	0	18	16	36	600	2
2	1200	1.53	100	0.31	0.0	0	0	0	0.0	0	0.0	1.53	0.02	0.44	20	0.30	0.07	30	2	53	48	105	1200	2
2	1800	0.10	100	0.31	0.0	0	0	0	0.0	0	0.0	0.10	0.04	1.67	4	0.00	0.07	17	7	184	191	383	1800	2
3	00	0.04	100	0.31	0.0	0	0	0	0.0	0	0.0	0.04	0.01	1.73	1	0.00	0.06	18	12	441	502	956	00	3
3	600	0.04	100	0.31	0.0	0	0	0	0.0	0	0.0	0.04	0.0	1.77	1	0.00	0.06	18	16	756	883	1657	600	3
3	1200	0.0	100	0.31	0.0	0	0	0	0.0	0	0.0	0.0	0.02	1.81	0	0.0	0.06	18	21	1035	1153	2210	1200	3
3	1800	0.09	100	0.31	0.0	0	0	0	0.0	0	0.0	0.09	0.04	1.79	3	0.00	0.05	19	25	1222	1220	2468	1800	3
4	00	0.01	100	0.31	0.0	0	0	0	0.0	0	0.0	0.01	0.01	1.85	0	0.00	0.05	19	28	1305	1114	2449	00	4
4	600	0.18	100	0.33	0.0	0	0	0	0.0	0	0.0	0.18	0.0	1.85	7	0.01	0.05	19	32	1297	917	2248	600	4
4	1200	1.29	100	0.74	0.0	0	0	0	0.0	0	0.0	1.29	0.02	2.02	32	0.41	0.14	19	38	1267	751	2058	1200	4
4	1800	0.24	100	0.77	0.0	0	0	0	0.0	0	0.0	0.24	0.03	2.89	16	0.04	0.14	10	45	1349	819	2215	1800	4
5	00	0.17	100	0.80	0.0	0	0	0	0.0	0	0.0	0.17	0.01	3.06	14	0.02	0.14	10	53	1618	1248	2920	00	5
5	600	0.36	100	0.90	0.0	0	0	0	0.0	0	0.0	0.36	0.0	3.20	28	0.10	0.16	10	60	2013	1877	3952	600	5
5	1200	0.0	100	0.90	0.0	0	0	0	0.0	0	0.0	0.0	0.06	3.46	0	0.0	0.15	10	68	2430	2399	4898	1200	5
5	1800	0.0	100	0.90	0.0	0	0	0	0.0	0	0.0	0.0	0.11	3.40	0	0.0	0.14	10	75	2785	2636	5496	1800	5
6	00	0.0	100	0.90	0.0	0	0	0	0.0	0	0.0	0.0	0.02	3.29	0	0.0	0.13	10	81	3007	2573	5662	00	6
6	600	0.0	100	0.90	0.0	0	0	0	0.0	0	0.0	0.0	0.0	3.27	0	0.0	0.12	11	87	3063	2279	5430	600	6
6	1200	0.0	100	0.90	0.0	0	0	0	0.0	0	0.0	0.0	0.06	3.27	0	0.0	0.12	12	93	2962	1859	4916	1200	6
6	1800	0.0	100	0.90	0.0	0	0	0	0.0	0	0.0	0.0	0.13	3.21	0	0.0	0.11	13	99	2741	1415	4256	1800	6
7	00	0.0	100	0.90	0.0	0	0	0	0.0	0	0.0	0.0	0.02	3.08	0	0.0	0.10	14	104	2443	1017	3565	00	7
7	600	0.0	100	0.90	0.0	0	0	0	0.0	0	0.0	0.0	0.0	3.06	0	0.0	0.10	15	109	2111	696	2917	600	7
7	1200	0.0	100	0.90	0.0	0	0	0	0.0	0	0.0	0.0	0.04	3.06	0	0.0	0.09	15	113	1777	457	2349	1200	7
7	1800	0.0	100	0.90	0.0	0	0	0	0.0	0	0.0	0.0	0.08	3.02	0	0.0	0.09	16	118	1462	290	1871	1800	7
8	00	0.0	100	0.90	0.0	0	0	0	0.0	0	0.0	0.0	0.01	2.94	0	0.0	0.08	16	122	1180	179	1482	00	8
8	600	0.0	100	0.90	0.0	0	0	0	0.0	0	0.0	0.0	0.0	2.93	0	0.0	0.08	17	126	936	107	1171	600	8

PCPN = Weighted Rainfall in inches
% RA = Percent Rain Area, 100% for Rain-only Computations
RN-AR = Accumulated Runoff in inches
ML AR = N/A Snow Option Only
% AR = N/A Snow Option Only
ELEV = N/A Snow Option Only
SCA = N/A Snow Option Only
D-DY = N/A Snow Option Only
% MA = N/A Snow Option Only
MELT = N/A Snow Option Only
MI = Moisture Input in inches

ETI = Evapotranspiration Index in inches, Period values from Daily Input
SMI = Soil Moisture Index in inches
ROP = Runoff Percent
RGP = Runoff Generated in the Period
BII = Base Flow Infiltration Index
BFP = Base Flow Percent
BASEF = Baseflow Component of Flow (cfs)
SUBSF = Subsurface Component of Flow (cfs)
SURF = Surface Component of Flow (cfs)
DISCH = Stream Discharge (cfs)

8.20 EXAMPLE OF OUTPUT LISTING FOR BIRD CREEK

Snowmelt Runoff. The SSARR Model has several options available to synthesize streamflow from snowmelt, and can be tailored somewhat to the user's needs, data availability, and physical characteristics of the watershed. Operational requirements often dictate the more simplified procedures which require a minimum of data handling. One such example would be the snow cover depletion (SCD) option using the temperature index to compute melt. Conversely, design studies may require the more detailed snow band option using the generalized snowmelt equation.

Certain input specifications and data are required to obtain the desired snowmelt options. A schematic of the various snow options is illustrated in Figure 8.21. This simplified flow chart can be used as a guide to indicate the necessary input for each option. The various options and their application are discussed in the following examples:

a. Snow Cover Depletion Option. The snow cover depletion approach is applied to many of the Columbia Basin tributaries for operational streamflow forecasting during the active melt season. During this period, runoff from rainfall on snow free areas is negligible and new snow accumulations are usually not significant. When rainfall-runoff on snow free areas is substantial, the split-watershed approach, described later, is preferable.

The Willamette Basin Snow Laboratory (WBSL) was selected to illustrate the use of the snow cover depletion option and temperature index method on a single watershed (11.5 square miles). This watershed is rather unique because there are good estimates of melt rates and other snowmelt-runoff relationships due to extensive snow hydrology research previously conducted. Snow accumulation during the melt season is usually not hydrologically important, however, if significant snowfall occurs, manual adjustments can be made with the snow cover depletion relationship. This adjustment may simply involve the specification of a higher snow covered area percent at the time of snowfall.

The watershed characteristics and parameter relationships for the single SCD and split-watershed SCD options are shown in Figure 8.22. The departures from the "rain-only" examples include:

(1) A snow cover depletion relationship (Table CT 85Ø1) of snow covered area (percent versus accumulated runoff in percent of the seasonal total.

(2) Melt rate specifications (Table CT 87ØØ) from which melt rates are determined as a function of percent seasonal accumulated runoff.

(3) Temperature data specification on CBØ4 card (Data Code 4) with station elevation (4240 feet) specified on the CP card. The corresponding 4D cards with temperature and precipitation data are not shown.

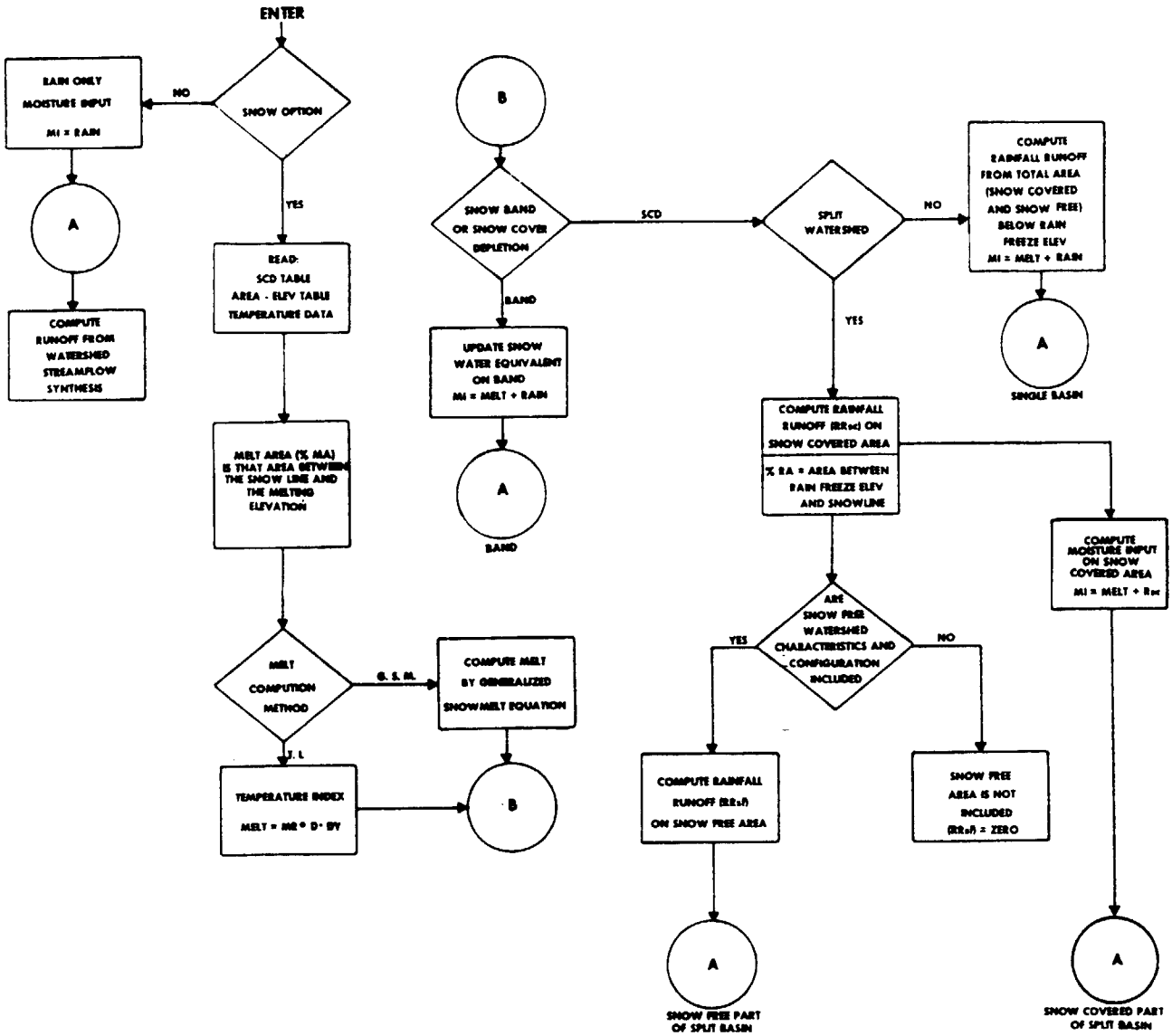


FIGURE 8.21 SCHEMATIC DIAGRAM OF SNOWMELT OPTIONS

```
1*******10********20********30********40********50********60********70********80
JOB      09424        0 120  6  1          SNOW COVERED BASINS

    * * RELATIONSHIPS        * *

CP          1       4240
CT 1      8000            2        0        0      999      999
CT 1      8006            2        0        0     0.01  0.00133     0.02  0.00333   S-SS
CT 2      8006         0.03    0.006     0.06    0.018     0.09    0.036     0.12   S-SS
CT 3      8006         0.06   999.12   999.06                                        S-SS
CT 1      8105            2        1      .05        2      .07        3      .10    ETI
CT 2      8105            4      .15        5      .20        6      .25        7    ETI
CT 3      8105          .25        8      .20        9      .13       10      .08    ETI
CT 4      8105           11      .03       12      .03                              ETI
CT 1      8200            2        0      100    99999      100                      SMI
CT 1      8207            2        0       10      5.0       20      8.0       36    SMI
CT 2      8207           11      100       15      100      999      100            SMI
CT 1      8300            2        0        0      999        0
CT 1      8309            2        0       80      0.1       60      0.3       40    BII
CT 2      8309          0.5       30      999       30                              BII
CT 1      8400            2        0      100       .5       30      1.0       10    KE
CT 2      8400        99999       10                                                 KE
CT 1      8500            2        0      100      100      100     9999     9999    SCD
CT 1      8501            2        0      100       10       95       20       88    SCD
CT 2      8501           30       79       40       67       50       56       60    SCD
CT 3      8501           44       70       31       80       19       90        7    SCD
CT 4      8501          100        0     9999        0                              SCD
CT 1      8700            2        0     .200      100     .200     9999            M R
CT 1      8701            2        0     .050      100     .050     9999            M R

    * * CHARACTERISTICS      * *

CB 1        50          2        TWO BASIN (SNOW)
CB 2        50    11.54  3 4  10 2 300     36 84008501   9981058207
CB 3        50      8309  1  8006                      8700          33 32 2
CB 4        50      3   11104   1100
C3 1        50   1959       2500   8  2800  20  3000  28  3228  40  3500  54
C3 2        50   3620  60  4030  80  4330  90  4900  996 5364  9999999999999
CB 1        51          2        TWO BASIN (RAIN)
CB 2        51    11.54  3 4  10 2 300     36 8400        81058207
CB 3        51      8309  1  8006
CB 4        51      3   11102  99100
CC 1        52                 SUM OF TWO BASINS (SCD)
CB 1        70          2        ONE BASIN DEPLETION OPTION RAIN ON SNOW FREE
CB 2        70    11.54  3 4  10 2 300     36 84008501    81058207
CB 3        70      8309  1  8006                      8700          33 32 2
CB 4        70      3   11104   1100
C3 1        70   1959       2500   8  2800  20  3000  28  3228  40  3500  54
C3 2        70   3620  60  4030  80  4330  90  4900  996 5364  9999999999999

    * * CONFIGURATION        * *

P           50         52
P           51         52
P           52
P           70

    * * TIME CONTROL         * *

T    18 261050 3  6  61150

    * * INITIAL CONDITIONS * *

2800        50    0241050   0 1000   20   0 6002000              0 0400
2B 4        50    02410501     39     40
2800        51    0241050   0 1000   20
2800        70    0241050   0 1000   20   0 6002000              0  400
2B 4        70    02410501     39     40
```

FIGURE NO. 8.22 INPUT LISTING
RUNOFF FROM SNOWFALL ON SINGLE AND SPLIT BASIN

(4) Area-elevation relationships (C3 cards) for the watershed used by the model to lapse temperatures from the station elevation to the snow covered area. The highest elevation at which snowmelt begins is determined by base temperature (32°F) and lapse rate (2°F per 1000 feet elevation) specified in the CBØ3 card. The rain-freeze temperature of 33°F (CBØ3) has provided good results in determining the areas which contribute runoff from rainfall from WBSL.

(5) The initial condition specifications of 0.20 inches per degree day melt rate, 60 percent snow covered area, "0" accumulated runoff with 4 inches total seasonal runoff. The example presented herein is for a short time period (26 October-6 November). The melt rate is very high and does not vary with accumulated seasonal runoff in this case.

When the single watershed SCD option is used, single watershed values of SMI, BII, etc., are maintained. If the runoff conditions for the snow free area differ substantially from the snow covered area, an adjustment can be made to split the watershed. Note that when the split-watershed option is used, the two areas are handled as two separate watersheds, each with its own characteristics and initial condition specifications. The split-watershed option is specified in this example by a number (99 in this case) in columns 52-55 of the CBØ2 card for station 50, and in columns 28-31 of the CBØ4 card for station 51. The snow cover depletion table and snowmelt parameters are specified only for watershed 50. The program determines the snow covered and snow free areas from the snow cover depletion curve. Thus, as the melt season progresses, the snow free area becomes larger.

A portion of the output from the above input specifications is illustrated in Figures 8.23, 8.24, and 8.25. The column headings are identical to those of the Bird Creek listing previously illustrated (Figure 8.20). The listing for the WBSL, however, lists computed values for the various snowmelt parameters as opposed to zeros in the Bird Creek listing. To describe the output listing and types of computations required, it is instructive to go through one row of calculations manually. For an example of areal contribution and computation of runoff from rainfall and snowmelt, refer to the output listings, Figures 8.23, 8.24, and 8.25 for 0900 hours on 29 October 1950. (1) Temperature at the base station (Elev. 4,240 feet) was 32°F; (2) The snow line elevation (with depletion from melt in preceding period) is 3,337 feet; (3) The corresponding snow covered area is 54%; (4) Rain freeze temperature is 33°; (5) Base temperature is 32°; (6) Lapse rate is 2°F per 1,000 feet.

Computed values are as follows:

(1) Rain-Freeze Elevation = 4240' + (32° -33°)/(2°/1000') = 3740'

(2) Area below Rain-Freeze Elevation = 66% (See basin 70)

(3) Percentage of snow covered area below Rain-Freeze Elevation = 20% (54% -(100%-66%) See basin 50)

(4) % RA on snow free area = 46% (See basin 51; this is the entire snow free area)

(5) Base-Temperature Elevation = 4240' + (32° -32°)/(2°/1000')
= 4240'

(6) Area below 4240' = 87%

(7) % MA = (54 -(100 -87)) = 41%

(8) Mean elevation and temperature of melting snowpack as determined from the area-elevation table:
46% + (41%/2) = 66.5%

(9) Elevation at 66.5% = 3753'

(10) Temperature at 3753' = 32° -(3753' - 4240')(2°/1000') = 32.97^{o}F

(11) Degree Days (D-DY) = (32.97^{o} - 32.00^{o}F)*$\left[\frac{3}{24}\right]$ = 0.121 D-DY for 3-hour period.

(12) Melt = 0.121 D-DY * 0.20 in/D-DY = 0.02 in.

(13) Generated Runoff (RGP):

Basin 70:	Rain = .41 in. * .66 (%RA)	=	0.27 in.	
	Melt = .02 in. * .41 (%MA)	=	0.01 in.	
	MI	=	0.28 in.	
	RGP = 0.28 in.* .97 (ROP)	=	.27 in.	
Basin 50:	Rain = .41 in. * .20 (%RA)	=	0.08 in.	
	Melt = .02 in. * .41 (%MA)	=	0.01 in.	
	MI	=	0.09 in.	
	RGP = 0.09 in.* .96 (ROP)	=	0.09 in.	
Basin 51:	Rain = .41 in. * .46 (%RA)	=	.19 in.	(MI)
	RGP == .19 in. * .57 (ROP)	=	.11 in.	

A separate accounting of parameters is maintained for the snow free and snow covered areas which in this case causes less generated runoff than with the single basin (70). Runoff from the two areas (50 and 51) is summed at station 52 which represents the total discharge from the watershed. The difference in discharge between the single and split watershed for the same input data is illustrated in Figure 8.26.

In some regions, rainfall-runoff from snow free areas during the active melt season is insignificant because of rapidly drying soil. A simplified procedure can be used with the model to specify no runoff from the snow free area without setting up the split watershed option. This is accomplished by simply punching "dummy" digits in columns 52-55 of the CBØ2 card for the single SCD option. This procedure tells the computer that a split watershed is to be used, however, no characteristic cards are present for the snow free area. Thus, runoff is computed only for the snow covered area.

BASIN RESULTS - STATION 5.0 TWO BASIN (SNOW)

RUN DATE	RUN NO.	INITIAL DATE, HOUR	JOB DESCRIPTION	
	0	26 OCT 1950 1800	9424 SNOW COVERED BASINS	N.P.D., CORPS OF ENGINEERS

FTI = 0.08 IN./DAY, MELT RATE = 0.200 IN./DEGREE-DAY, AREA = 11.5 SQ. MI.

DAY	HOUR	PCPN	%RA	RN-AR	ML-AR	%AR	ELEV	SCA	D-DY	%MA	MELT	MI	FTI	SMI	ROP	RGP	RII	RFP	BASEF	SUBSF	SURF	DISCH	HOUR	DAY
OCT 1950																							OCT 1950	
26	1800	0.0	0	0.0	0.0	0	0	60	0.0	0	0.0	0.0	0.03	10.00	0	0.0	0.20	0	40	0	0	40	1800	26
26	2100	0.14	59	0.07	0.10	3	3228	59	8.8	60	0.22	0.22	0.08	10.00	79	0.17	0.37	50	39	0	1	42	2100	26
27	00	0.46	59	0.28	0.18	5	3243	59	6.8	59	0.17	0.37	0.08	10.08	80	0.30	0.66	37	40	0	11	52	00	27
27	300	0.47	58	0.51	0.23	6	3255	58	3.8	59	0.10	0.33	0.08	10.20	83	0.27	0.91	30	40	2	40	83	300	27
27	600	0.32	45	0.63	0.25	6	3262	58	1.9	55	0.05	0.17	0.08	10.30	85	0.14	1.00	30	40	6	82	129	600	27
27	900	0.18	0	0.63	0.25	6	3265	58	0.0	0	0.0	0.0	0.08	10.34	86	0.0	0.97	30	40	12	113	166	900	27
27	1200	0.16	0	0.63	0.25	6	3265	58	0.0	0	0.0	0.0	0.08	10.34	86	0.0	0.84	30	40	20	114	175	1200	27
27	1500	0.24	0	0.63	0.26	6	3265	58	0.5	24	0.01	0.00	0.08	10.34	86	0.00	0.78	30	40	29	90	160	1500	27
27	1800	0.69	0	0.63	0.26	6	3265	58	0.5	24	0.01	0.00	0.08	10.34	86	0.00	0.72	30	40	37	60	139	1800	27
27	2100	0.41	0	0.63	0.26	7	3266	58	0.5	24	0.01	0.00	0.08	10.34	86	0.00	0.67	30	40	44	36	121	2100	27
28	00	0.52	0	0.63	0.26	7	3266	58	0.5	24	0.01	0.00	0.08	10.34	86	0.00	0.61	30	40	49	20	110	00	28
28	300	0.46	0	0.63	0.27	7	3266	58	0.5	24	0.01	0.00	0.08	10.34	86	0.00	0.57	30	40	53	11	104	300	28
28	600	0.70	0	0.63	0.27	7	3267	58	0.5	24	0.01	0.00	0.08	10.34	86	0.00	0.53	30	40	54	6	101	600	28
28	900	1.15	55	1.18	0.30	8	3267	58	2.8	58	0.07	0.67	0.08	10.34	86	0.58	1.00	30	40	54	27	117	900	28
28	1200	1.10	54	1.71	0.34	8	3272	57	2.8	58	0.07	0.64	0.08	10.50	89	0.57	1.00	30	40	53	101	195	1200	28
28	1500	0.58	57	2.01	0.39	10	3277	57	3.8	57	0.09	0.39	0.08	10.62	92	0.35	1.00	30	40	53	241	335	1500	28
28	1800	0.44	56	2.24	0.45	11	3285	56	4.8	57	0.12	0.32	0.08	10.67	93	0.29	1.00	30	40	54	363	459	1800	28
28	2100	0.57	56	2.54	0.51	13	3297	56	4.8	56	0.12	0.39	0.08	10.71	94	0.36	1.00	30	40	58	412	512	2100	28
29	00	0.38	55	2.74	0.58	14	3310	55	4.7	56	0.12	0.28	0.08	10.75	95	0.26	1.00	30	40	64	403	509	00	29
29	300	0.38	52	2.93	0.61	15	3322	55	2.7	55	0.07	0.24	0.08	10.78	95	0.23	1.00	30	41	73	368	483	300	29
29	600	0.51	51	3.18	0.65	16	3330	54	2.7	55	0.07	0.30	0.08	10.80	96	0.28	1.00	30	41	84	323	449	600	29
→ 29	900	0.41	20	3.26	0.66	16	3337	54	1.0	41	0.02	0.09	0.08	10.82	96	0.09	1.00	30	41	96	279	417	900	29
29	1200	0.35	41	3.40	0.68	17	3339	54	1.8	51	0.04	0.17	0.08	10.82	96	0.16	1.00	30	41	108	237	388	1200	29
29	1500	0.20	20	3.44	0.69	17	3343	54	1.0	41	0.02	0.05	0.08	10.84	96	0.05	0.98	30	41	119	194	356	1500	29
29	1800	0.01	20	3.44	0.70	17	3345	54	1.0	41	0.02	0.01	0.08	10.84	97	0.01	0.91	30	42	129	149	321	1800	29
29	2100	0.03	0	3.44	0.70	18	3347	54	0.4	20	0.01	0.00	0.08	10.83	96	0.00	0.84	30	42	137	106	286	2100	29
30	00	0.02	0	3.44	0.70	18	3348	54	0.4	20	0.01	0.00	0.08	10.82	96	0.00	0.78	30	42	142	68	253	00	30
30	300	0.11	0	3.44	0.70	18	3348	54	0.4	20	0.01	0.00	0.08	10.82	96	0.00	0.72	30	42	143	40	227	300	30
30	600	0.20	0	3.44	0.70	18	3348	54	0.0	0	0.0	0.0	0.08	10.81	96	0.0	0.66	30	42	142	22	208	600	30
30	900	0.18	0	3.44	0.70	18	3348	54	0.0	0	0.0	0.0	0.08	10.81	96	0.0	0.61	30	42	138	11	193	900	30
30	1200	0.13	0	3.44	0.70	18	3348	54	0.0	0	0.0	0.0	0.08	10.81	96	0.0	0.56	30	42	131	5	181	1200	30
30	1500	0.22	0	3.44	0.71	18	3348	54	0.4	20	0.01	0.00	0.08	10.81	96	0.00	0.52	30	43	123	2	169	1500	30
30	1800	0.16	0	3.44	0.71	18	3349	54	0.0	0	0.0	0.0	0.08	10.81	96	0.0	0.47	30	43	113	1	159	1800	30
30	2100	0.10	0	3.44	0.71	18	3349	54	0.0	0	0.0	0.0	0.08	10.81	96	0.0	0.44	31	43	103	0	148	2100	30
31	00	0.18	0	3.44	0.71	18	3349	54	0.0	0	0.0	0.0	0.08	10.81	96	0.0	0.40	33	43	93	0	137	00	31
31	300	0.0	0	3.44	0.71	18	3349	54	0.0	0	0.0	0.0	0.08	10.81	96	0.0	0.37	35	43	83	0	127	300	31
31	600	0.0	0	3.44	0.71	18	3349	54	0.0	0	0.0	0.0	0.08	10.80	96	0.0	0.34	37	43	73	0	117	600	31
31	900	0.0	0	3.44	0.71	18	3349	54	0.0	0	0.0	0.0	0.08	10.79	95	0.0	0.31	38	43	63	0	108	900	31
31	1200	0.0	0	3.44	0.71	18	3349	54	0.0	0	0.0	0.0	0.08	10.78	95	0.0	0.29	39	43	55	0	99	1200	31
31	1500	0.0	0	3.44	0.71	18	3349	54	0.0	0	0.0	0.0	0.08	10.77	95	0.0	0.26	41	43	47	0	92	1500	31
31	1800	0.0	0	3.44	0.71	18	3349	54	0.4	20	0.01	0.00	0.08	10.76	95	0.00	0.25	44	43	40	0	85	1800	31
31	2100	0.0	0	3.44	0.71	18	3349	54	0.4	20	0.01	0.00	0.08	10.75	95	0.00	0.23	45	43	34	0	79	2100	31
NOV 1950																							NOV 1950	
1	00	0.0	0	3.44	0.71	18	3350	54	0.4	20	0.01	0.00	0.08	10.74	94	0.00	0.21	47	44	29	0	73	00	1
1	300	0.07	41	3.47	0.73	18	3350	54	1.8	51	0.04	0.05	0.03	10.73	94	0.05	0.25	49	44	24	0	69	300	1
1	600	0.48	52	3.70	0.82	20	3354	53	6.7	53	0.17	0.34	0.03	10.73	94	0.32	0.62	45	44	20	6	71	600	1
1	900	0.41	51	3.90	0.91	23	3372	51	7.7	52	0.19	0.31	0.03	10.77	95	0.29	0.94	30	44	18	31	94	900	1
1	1200	0.73	50	4.25	0.99	25	3398	50	6.7	51	0.17	0.45	0.03	10.80	96	0.43	1.00	30	44	18	87	150	1200	1
1	1500	0.80	49	4.63	1.10	27	3419	49	8.6	50	0.22	0.50	0.03	10.84	97	0.48	1.00	30	44	21	175	242	1500	1
1	1800	0.89	47	5.04	1.21	30	3446	47	9.6	49	0.24	0.54	0.03	10.87	97	0.52	1.00	30	44	26	288	360	1800	1
1	2100	0.86	44	5.41	1.37	34	3477	44	13.6	47	0.34	0.54	0.03	10.90	98	0.53	1.00	30	44	35	407	488	2100	1
2	00	0.35	42	5.55	1.52	38	3533	42	13.5	44	0.34	0.30	0.03	10.93	98	0.29	1.00	30	45	45	503	594	00	2
2	300	0.24	40	5.65	1.63	41	3586	40	11.5	42	0.29	0.21	0.03	10.94	99	0.21	1.00	30	45	57	537	641	300	2
2	600	0.11	38	5.69	1.75	44	3627	38	11.4	40	0.29	0.15	0.03	10.94	99	0.15	1.00	30	45	70	495	611	600	2
2	900	0.07	36	5.71	1.85	46	3665	36	11.4	38	0.28	0.13	0.03	10.95	99	0.13	1.00	30	45	83	403	532	900	2
2	1200	0.0	34	5.71	1.98	49	3701	34	14.3	36	0.36	0.13	0.03	10.95	99	0.13	1.00	30	46	95	301	443	1200	2
2	1500	0.02	32	5.73	2.11	53	3744	32	15.2	34	0.38	0.15	0.03	10.95	99	0.15	1.00	30	46	106	218	371	1500	2
2	1800	0.09	29	5.76	2.22	56	3790	30	15.2	32	0.38	0.15	0.03	10.96	99	0.14	1.00	30	46	116	163	326	1800	2
2	2100	0.02	28	5.76	2.32	58	3834	28	13.1	29	0.33	0.10	0.03	10.96	99	0.10	1.00	30	46	124	132	304	2100	2
3	00	0.0	26	5.76	2.41	60	3869	26	13.1	28	0.33	0.09	0.03	10.96	99	0.09	1.00	30	46	131	114	293	00	3
3	300	0.0	25	5.76	2.49	62	3903	25	12.0	26	0.30	0.08	0.03	10.96	99	0.08	1.00	30	47	135	98	282	300	3
3	600	0.0	23	5.76	2.57	64	3934	23	13.0	25	0.32	0.08	0.03	10.96	99	0.08	1.00	30	47	138	83	270	600	3
3	900	0.0	21	5.76	2.65	66	3966	22	13.9	23	0.35	0.08	0.03	10.96	99	0.08	1.00	30	47	140	70	258	900	3
3	1200	0.0	20	5.76	2.75	69	3997	20	18.9	21	0.47	0.10	0.03	10.96	99	0.10	1.00	30	47	140	62	250	1200	3
3	1500	0.0	18	5.76	2.83	71	4041	18	16.8	20	0.42	0.08	0.03	10.96	99	0.08	1.00	30	48	138	58	247	1500	3
3	1800	0.0	16	5.76	2.93	73	4087	16	22.7	18	0.57	0.10	0.03	10.96	99	0.10	1.00	30	48	136	61	246	1800	3
3	2100	0.0	15	5.76	3.01	75	4142	15	15.6	16	0.49	0.08	0.03	10.96	99	0.08	1.00	30	48	133	65	248	2100	3
4	00	0.0	13	5.76	3.08	77	4184	14	19.5	15	0.49	0.07	0.03	10.96	99	0.07	1.00	30	48	129	69	248	00	4
4	300	0.0	12	5.76	3.15	79	4223	12	20.4	13	0.51	0.07	0.03	10.96	99	0.07	1.00	30	49	125	70	245	300	4
4	600	0.0	11	5.76	3.21	80	4260	11	19.4	12	0.48	0.06	0.03	10.96	99	0.06	1.00	30	49	120	68	238	600	4
4	900	0.0	10	5.76	3.25	81	4292	11	15.1	11	0.38	0.04	0.03	10.96	99	0.04	1.00	30	49	116	63	229	900	4
4	1200	0.0	9	5.76	3.30	83	4314	10	20.3	10	0.51	0.05	0.03	10.96	99	0.05	1.00	30	49	111	57	218	1200	4
4	1500	0.0	9	5.76	3.34	84	4355	9	18.7	9	0.46	0.04	0.03	10.96	99	0.04	1.00	30	49	106	50	207	1500	4
4	1800	0.0	8	5.76	3.37	84	4401	8	11.2	9	0.28	0.02	0.03	10.96	99	0.02	1.00	30	49	101	44	196	1800	4
4	2100	0.0	8	5.76	3.39	85	4427	8	10.1	8	0.25	0.02	0.03	10.96	99	0.02	1.00	30	50	95	38	185	2100	4
5	00	0.0	8	5.76	3.41	85	4449	8	10.1	8	0.25	0.02	0.03	10.96	99	0.02	1.00	30	50	90	31	172	00	5
5	300	0.0	7	5.76	3.43	86	4470	7	9.1	8	0.23	0.07	0.03	10.96	99	0.02	1.00	30	50	85	24	160	300	5
5	600	0.0	7	5.76	3.44	86	4488	7	7.1	7	0.18	0.01	0.03	10.96	99	0.01	1.00	30	50	79	18	149	600	5
5	900	0.0	7	5.76	3.45	86	4502	7	7.1	7	0.18	0.01	0.03	10.95	99	0.01	1.00	30	50	74	13	139	900	5
5	1200	0.0	7	5.76	3.47	87	4515	7	9.0	7	0.23	0.02	0.03	10.95	99	0.02	1.00	30	50	69	10	131	1200	5
5	1500	0.0	6	5.76	3.49	87	4531	6	12.0	7	0.30	0.02	0.03	10.95	99	0.02	1.00	30	51	64	8	124	1500	5
5	1800	0.0	6	5.76	3.50	88	4542	6	10.0	6	0.25	0.02	0.03	10.95	99	0.07	1.00	30	51	59	8	119	1800	5
5	2100	0.0	6	5.76	3.51	88	4568	6	8.0	6	0.20	0.01	0.03	10.95	99	0.01	1.00	30	51	54	8	114	2100	5
6	00	0.0	6	5.76	3.52	88	4581	6	7.0	6	0.17	0.01	0.03	10.95	99	0.01	1.00	30	51	50	7	110	00	6
6	300	0.0	5	5.76	3.53	88	4591	5	5.0	6	0.12	0.01	0.03	10.95	99	0.01	1.00	30	51	46	7	105	300	6
6	600	0.0	5	5.76	3.53	88	4598	5	3.0	5	0.07	0.00	0.03	10.94	99	0.00	0.97	30	51	42	6	100	600	6

SNOW MELT OPTIONS ARE MELT INDEX, DEPL. CURVE, LAPSE=Y, RUNOFF FROM SNOW COVERED AREA ONLY (SPLIT BASIN)

PCPN = Weighted Precipitation, in Inches
% RA = Percent Rain Area
RN-AR = Accumulated Runoff from Rainfall, in Inches
ML-AR = Accumulated Runoff from Snowmelt, in Inches
% AR = Percent of Accumulated Seasonal Runoff (for SCD Function)
ELEV = Elevation of Snowline, in feet
SCA = Snow Covered Area in percent (From SCD Table)
D-DY = Degree-Days
% MA = Percent of Area Contributing Melt
MELT = Total Melt for the Period, in Inches
MI = Total Moisture Input from Rain and Snow, in Inches

* The remaining column headings are the same as with the Bird Creek listing.

FIGURE 8.23 OUTPUT LISTING – RUNOFF FROM SNOWMELT AND RAIN ON SNOW COVERED PART OF SPLIT BASIN (50)

BASIN RESULTS - STATION 5.1 TWO BASIN (RAIN)

RUN DATE	RUN NO.	INITIAL DATE, HOUR	JOB DESCRIPTION	
	0	26 OCT 1950 1600	9424 SNOW COVERED BASINS	N.P.D., CORPS OF ENGINEERS

ETI = 0.08 IN./DAY, MELT RATE = 0.0 IN./DEGREE-DAY, AREA = 11.5 SQ. MI.

DAY	HOUR	PCPN	%RA	AN-AR	ML-AR	%AR	ELEV	SCA	D-DY	%MA	MELT	MI	ETI	SMI	ROP	RGP	BII	BFP	BASEF	SUBSF	SURF	DISCH	HOUR	DAY
OCT 1950																								OCT 1950
26	1800	0.0	0	0.0	0.0	0	0	0	0.0	0	0.0	0.0	0.03	9.00	0	0.0	0.20	0	0	0	0	0	1800	26
26	2100	0.14	41	0.02	0.0	0	0	0	0.0	0	0.0	0.06	0.08	9.00	41	0.02	0.22	50	0	0	0	0	2100	26
27	00	0.46	41	0.10	0.0	0	0	0	0.0	0	0.0	0.19	0.08	9.08	41	0.08	0.32	48	0	0	0	1	00	27
27	300	0.47	42	0.19	0.0	0	0	0	0.0	0	0.0	0.20	0.08	9.36	42	0.08	0.43	39	0	0	3	5	300	27
27	600	0.32	42	0.24	0.0	0	0	0	0.0	0	0.0	0.13	0.08	9.63	44	0.06	0.48	34	0	1	9	11	600	27
27	900	0.18	18	0.26	0.0	0	0	0	0.0	0	0.0	0.03	0.08	9.81	44	0.01	0.49	31	0	3	14	18	900	27
27	1200	0.16	18	0.27	0.0	0	0	0	0.0	0	0.0	0.03	0.08	9.90	45	0.01	0.50	30	0	6	16	22	1200	27
27	1500	0.24	41	0.32	0.0	0	0	0	0.0	0	0.0	0.10	0.08	9.99	45	0.04	0.53	30	0	9	14	24	1500	27
27	1800	0.69	41	0.44	0.0	0	0	0	0.0	0	0.0	0.28	0.08	10.12	46	0.13	0.69	30	0	12	14	27	1800	27
27	2100	0.41	41	0.52	0.0	0	0	0	0.0	0	0.0	0.17	0.08	10.50	48	0.08	0.76	30	0	16	19	36	2100	27
28	00	0.52	41	0.63	0.0	0	0	0	0.0	0	0.0	0.21	0.08	10.71	49	0.10	0.86	30	0	20	28	50	00	28
28	300	0.46	41	0.72	0.0	0	0	0	0.0	0	0.0	0.19	0.08	10.97	50	0.09	0.94	30	0	25	36	63	300	28
28	600	0.70	41	0.86	0.0	0	0	0	0.0	0	0.0	0.29	0.08	11.20	51	0.14	1.00	30	0	31	43	75	600	28
28	900	1.15	42	1.11	0.0	0	0	0	0.0	0	0.0	0.49	0.08	11.55	51	0.25	1.00	30	0	37	55	93	900	28
28	1200	1.10	43	1.36	0.0	0	0	0	0.0	0	0.0	0.47	0.08	12.11	53	0.25	1.00	30	0	44	82	127	1200	28
28	1500	0.58	43	1.50	0.0	0	0	0	0.0	0	0.0	0.25	0.08	12.63	54	0.14	1.00	30	0	51	119	171	1500	28
28	1800	0.44	44	1.60	0.0	0	0	0	0.0	0	0.0	0.19	0.08	12.90	55	0.10	1.00	30	0	60	142	204	1800	28
28	2100	0.57	44	1.74	0.0	0	0	0	0.0	0	0.0	0.25	0.08	13.10	55	0.14	1.00	30	0	68	140	210	2100	28
29	00	0.38	45	1.84	0.0	0	0	0	0.0	0	0.0	0.17	0.08	13.35	56	0.10	1.00	30	0	77	122	201	00	29
29	300	0.38	45	1.94	0.0	0	0	0	0.0	0	0.0	0.17	0.08	13.52	56	0.10	1.00	30	1	85	101	189	300	29
29	600	0.51	46	2.07	0.0	0	0	0	0.0	0	0.0	0.23	0.08	13.69	57	0.13	1.00	30	1	93	83	179	600	29
29	900	0.41	46	2.17	0.0	0	0	0	0.0	0	0.0	0.19	0.08	13.91	57	0.11	1.00	30	1	100	72	174	900	29
29	1200	0.35	46	2.27	0.0	0	0	0	0.0	0	0.0	0.16	0.08	14.08	58	0.09	1.00	30	1	106	65	174	1200	29
29	1500	0.20	46	2.32	0.0	0	0	0	0.0	0	0.0	0.09	0.08	14.23	58	0.05	0.99	30	1	112	59	174	1500	29
29	1800	0.01	46	2.32	0.0	0	0	0	0.0	0	0.0	0.01	0.08	14.31	58	0.00	0.92	30	1	116	51	170	1800	29
29	2100	0.03	41	2.33	0.0	0	0	0	0.0	0	0.0	0.01	0.08	14.30	58	0.01	0.86	30	1	118	40	161	2100	29
30	00	0.02	41	2.34	0.0	0	0	0	0.0	0	0.0	0.01	0.08	14.31	58	0.01	0.80	30	2	119	28	150	00	30
30	300	0.11	41	2.36	0.0	0	0	0	0.0	0	0.0	0.04	0.08	14.31	58	0.03	0.77	30	2	119	17	139	300	30
30	600	0.20	18	2.38	0.0	0	0	0	0.0	0	0.0	0.03	0.08	14.36	58	0.02	0.79	30	2	116	11	130	600	30
30	900	0.18	18	2.40	0.0	0	0	0	0.0	0	0.0	0.03	0.08	14.44	59	0.02	0.79	30	2	112	7	123	900	30
30	1200	0.13	18	2.41	0.0	0	0	0	0.0	0	0.0	0.02	0.08	14.51	59	0.01	0.78	30	2	106	6	116	1200	30
30	1500	0.22	41	2.47	0.0	0	0	0	0.0	0	0.0	0.09	0.08	14.56	59	0.05	0.80	30	2	100	6	110	1500	30
30	1800	0.16	4	2.47	0.0	0	0	0	0.0	0	0.0	0.01	0.08	14.65	59	0.00	0.80	30	2	94	6	104	1800	30
30	2100	0.10	0	2.47	0.0	0	0	0	0.0	0	0.0	0.0	0.08	14.72	59	0.0	0.73	30	2	87	7	98	2100	30
31	00	0.18	0	2.47	0.0	0	0	0	0.0	0	0.0	0.0	0.08	14.72	59	0.0	0.67	30	3	80	6	91	00	31
31	300	0.0	0	2.47	0.0	0	0	0	0.0	0	0.0	0.0	0.08	14.72	59	0.0	0.62	30	3	74	4	83	300	31
31	600	0.0	0	2.47	0.0	0	0	0	0.0	0	0.0	0.0	0.08	14.71	59	0.0	0.57	30	3	68	3	75	600	31
31	900	0.0	0	2.47	0.0	0	0	0	0.0	0	0.0	0.0	0.08	14.70	59	0.0	0.52	30	3	61	1	67	900	31
31	1200	0.0	4	2.47	0.0	0	0	0	0.0	0	0.0	0.0	0.08	14.69	59	0.0	0.48	30	3	55	0	60	1200	31
31	1500	0.0	18	2.47	0.0	0	0	0	0.0	0	0.0	0.0	0.08	14.68	59	0.0	0.44	31	3	49	0	54	1500	31
31	1800	0.0	41	2.47	0.0	0	0	0	0.0	0	0.0	0.0	0.08	14.67	59	0.0	0.41	33	3	44	0	48	1800	31
31	2100	0.0	41	2.47	0.0	0	0	0	0.0	0	0.0	0.0	0.08	14.66	59	0.0	0.38	35	3	39	0	43	2100	31
NOV 1950																								NOV 1950
1	00	0.0	41	2.47	0.0	0	0	0	0.0	0	0.0	0.0	0.08	14.65	59	0.0	0.35	36	4	36	0	38	00	1
1	300	0.07	46	2.49	0.0	0	0	0	0.0	0	0.0	0.03	0.03	14.64	59	0.02	0.34	38	4	29	0	34	300	1
1	600	0.48	47	2.62	0.0	0	0	0	0.0	0	0.0	0.23	0.03	14.66	59	0.14	0.50	38	4	25	1	32	600	1
1	900	0.41	49	2.74	0.0	0	0	0	0.0	0	0.0	0.20	0.03	14.86	60	0.12	0.61	30	4	22	8	36	900	1
1	1200	0.73	50	2.96	0.0	0	0	0	0.0	0	0.0	0.36	0.03	15.02	60	0.22	0.86	30	4	21	23	50	1200	1
1	1500	0.80	51	3.21	0.0	0	0	0	0.0	0	0.0	0.41	0.03	15.31	60	0.25	1.00	30	4	21	49	76	1500	1
1	1800	0.89	53	3.49	0.0	0	0	0	0.0	0	0.0	0.47	0.03	15.63	60	0.28	1.00	30	4	24	86	117	1800	1
1	2100	0.66	56	3.78	0.0	0	0	0	0.0	0	0.0	0.48	0.03	15.99	60	0.29	1.00	30	4	30	130	166	2100	1
2	00	0.35	58	3.90	0.0	0	0	0	0.0	0	0.0	0.21	0.03	16.33	60	0.12	1.00	30	5	38	166	211	00	2
2	300	0.24	60	3.99	0.0	0	0	0	0.0	0	0.0	0.15	0.03	16.47	60	0.09	1.00	30	5	49	177	232	300	2
2	600	0.11	62	4.03	0.0	0	0	0	0.0	0	0.0	0.07	0.03	16.57	60	0.04	0.96	30	5	60	157	226	600	2
2	900	0.07	64	4.05	0.0	0	0	0	0.0	0	0.0	0.04	0.03	16.61	60	0.03	0.91	30	5	72	119	197	900	2
2	1200	0.0	66	4.05	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.64	60	0.0	0.84	30	5	82	80	169	1200	2
2	1500	0.07	68	4.08	0.0	0	0	0	0.0	0	0.0	0.05	0.03	16.63	60	0.03	0.80	30	6	91	49	147	1500	2
2	1800	0.09	70	4.12	0.0	0	0	0	0.0	0	0.0	0.06	0.03	16.66	60	0.04	0.77	30	6	97	29	133	1800	2
2	2100	0.02	72	4.13	0.0	0	0	0	0.0	0	0.0	0.02	0.03	16.69	60	0.01	0.71	30	6	101	17	125	2100	2
3	00	0.0	74	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.70	60	0.0	0.66	30	6	102	11	120	00	3
3	300	0.0	75	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.70	60	0.0	0.60	30	6	101	7	116	300	3
3	600	0.0	77	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.69	60	0.0	0.56	30	6	98	4	110	600	3
3	900	0.0	78	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.69	60	0.0	0.51	30	7	94	2	104	900	3
3	1200	0.0	80	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.69	60	0.0	0.47	30	7	88	1	97	1200	3
3	1500	0.0	82	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.68	60	0.0	0.43	31	7	81	0	90	1500	3
3	1800	0.0	84	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.68	60	0.0	0.40	33	7	74	0	83	1800	3
3	2100	0.0	85	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.67	60	0.0	0.37	35	7	67	0	75	2100	3
4	00	0.0	86	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.67	60	0.0	0.34	37	7	60	0	68	00	4
4	300	0.0	88	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.67	60	0.0	0.31	38	7	53	0	61	300	4
4	600	0.0	89	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.66	60	0.0	0.29	40	8	46	0	55	600	4
4	900	0.0	89	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.66	60	0.0	0.26	41	8	40	0	49	900	4
4	1200	0.0	90	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.65	60	0.0	0.24	44	8	35	0	43	1200	4
4	1500	0.0	91	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.65	60	0.0	0.22	46	8	30	0	39	1500	4
4	1800	0.0	92	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.65	60	0.0	0.20	48	8	25	0	34	1800	4
4	2100	0.0	92	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.64	60	0.0	0.19	50	8	21	0	30	2100	4
5	00	0.0	92	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.64	60	0.0	0.17	51	8	18	0	27	00	5
5	300	0.0	93	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.64	60	0.0	0.16	53	8	15	0	24	300	5
5	600	0.0	93	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.63	60	0.0	0.15	54	9	12	0	22	600	5
5	900	0.0	93	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.63	60	0.0	0.13	55	9	10	0	20	900	5
5	1200	0.0	93	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.62	60	0.0	0.12	57	9	8	0	18	1200	5
5	1500	0.0	94	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.62	60	0.0	0.11	58	9	7	0	17	1500	5
5	1800	0.0	94	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.62	60	0.0	0.10	59	9	5	0	15	1800	5
5	2100	0.0	94	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.61	60	0.0	0.10	60	9	4	0	14	2100	5
6	00	0.0	94	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.61	60	0.0	0.09	61	9	3	0	14	00	6
6	300	0.0	95	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.61	60	0.0	0.08	62	9	3	0	13	300	6
6	600	0.0	95	4.13	0.0	0	0	0	0.0	0	0.0	0.0	0.03	16.60	60	0.0	0.08	64	9	2	0	12	600	6

FIGURE 8.24 OUTPUT LISTING – RUNOFF FROM RAIN ON SNOWFREE PART OF SPLIT BASIN (51)

BASIN RESULTS - STATION   7.0 ONE BASIN DEPLETION OPTION RAIN ON SNOW FREE

RUN DATE   RUN NO.   INITIAL DATE, HOUR   JOB DESCRIPTION

0   26 OCT 1950   1800   9474   SNOW COVERED BASINS   N.P.D., CORPS OF ENGINEERS

ETI = 0.08 IN./DAY, MELT RATE = 0.200 IN./DEGREE-DAY, AREA = 11.5 SQ. MI.

DAY	HOUR	PCPN	%RA	RN-AP	ML-AR	%AR	ELEV	SCA	D-DY	%MA	MELT	MI	ETI	SMI	ROP	RGP	BII	RFP	BASEF	SUBSF	SURF	DISCH	HOUR	DAY
OCT 1950																							OCT 1950	
26	1800	0.0	0	0.0	0.0	0	0	60	0.0	0	0.0	0.0	0.03	10.00	0	0.0	0.20	0	40	0	0	40	1800	26
26	2100	0.14	100	0.11	0.10	3	3228	59	8.8	60	0.22	0.28	0.08	10.00	79	0.22	0.37	50	40	0	1	42	2100	26
27	00	0.46	100	0.48	0.18	5	3243	59	6.8	59	0.17	0.56	0.08	10.08	80	0.45	0.66	37	40	0	15	57	00	27
27	300	0.47	100	0.87	0.23	6	3255	58	3.8	59	0.10	0.53	0.08	10.20	83	0.44	0.91	30	40	3	58	102	300	27
27	600	0.32	87	1.11	0.25	6	3262	58	1.9	55	0.05	0.30	0.08	10.30	85	0.26	1.00	30	40	9	124	174	600	27
27	900	0.18	18	1.14	0.25	6	3265	58	0.0	0	0.0	0.03	0.08	10.34	86	0.03	0.94	30	40	18	175	235	900	27
27	1200	0.16	18	1.16	0.25	6	3265	58	0.0	0	0.0	0.03	0.08	10.35	86	0.02	0.88	30	40	31	181	253	1200	27
27	1500	0.24	41	1.25	0.26	6	3265	58	0.5	24	0.01	0.10	0.08	10.35	86	0.09	0.86	30	40	45	168	234	1500	27
27	1800	0.69	41	1.49	0.26	6	3265	58	0.5	24	0.01	0.28	0.08	10.36	86	0.25	0.95	30	40	58	112	212	1800	27
27	2100	0.41	41	1.63	0.26	7	3266	58	0.5	24	0.01	0.17	0.08	10.40	87	0.15	0.97	30	40	71	99	212	2100	27
28	00	0.52	41	1.87	0.26	7	3266	58	0.5	24	0.01	0.21	0.08	10.42	88	0.19	1.00	30	40	83	107	232	00	28
28	300	0.46	41	1.98	0.27	7	3266	58	0.5	24	0.01	0.19	0.08	10.45	88	0.17	1.00	30	40	93	119	255	300	28
28	600	0.70	41	2.24	0.27	7	3267	58	0.5	24	0.01	0.29	0.08	10.47	89	0.26	1.00	30	40	103	130	275	600	28
28	900	1.15	97	3.24	0.30	8	3267	58	2.8	58	0.07	1.16	0.08	10.50	89	1.04	1.00	30	41	111	175	328	900	28
28	1200	1.10	97	4.22	0.34	9	3272	57	2.8	58	0.07	1.11	0.08	10.63	92	1.02	1.00	30	41	119	320	482	1200	28
28	1500	0.58	100	4.77	0.39	10	3278	57	3.8	57	0.09	0.64	0.08	10.72	94	0.60	1.00	30	41	128	551	722	1500	28
28	1800	0.44	100	5.18	0.46	11	3285	56	4.8	57	0.12	0.51	0.08	10.76	95	0.48	1.00	30	41	130	735	917	1800	28
28	2100	0.57	100	5.73	0.52	13	3298	56	4.8	56	0.12	0.64	0.08	10.78	95	0.61	1.00	30	42	152	784	980	2100	28
29	00	0.38	100	6.10	0.58	15	3311	55	4.7	56	0.12	0.45	0.08	10.82	96	0.43	1.00	30	42	167	737	948	00	29
29	300	0.38	97	6.46	0.62	15	3324	55	2.7	55	0.07	0.41	0.08	10.83	96	0.40	1.00	30	43	184	654	882	300	29
29	600	0.51	97	6.93	0.66	16	3331	54	2.7	55	0.07	0.53	0.08	10.85	97	0.51	1.00	30	43	202	565	811	600	29
→ 29	900	0.41	66	7.19	0.67	17	3338	54	1.0	41	0.02	0.28	0.08	10.87	97	0.27	1.00	30	43	220	488	754	900	29
29	1200	0.35	87	7.49	0.69	17	3340	54	1.8	51	0.04	0.33	0.08	10.87	97	0.32	1.00	30	44	238	425	709	1200	29
29	1500	0.20	66	7.62	0.70	17	3345	54	1.0	41	0.02	0.14	0.08	10.88	97	0.14	1.00	30	44	255	367	663	1500	29
29	1800	0.01	66	7.62	0.71	18	3347	54	1.0	41	0.02	0.02	0.08	10.88	98	0.02	0.94	30	45	269	291	606	1800	29
29	2100	0.03	41	7.64	0.71	18	3349	54	0.4	20	0.01	0.02	0.08	10.88	97	0.01	0.87	30	45	280	214	541	2100	29
30	00	0.02	41	7.65	0.71	18	3349	54	0.4	20	0.01	0.01	0.08	10.87	97	0.01	0.81	30	45	287	142	476	00	30
30	300	0.11	41	7.69	0.71	18	3350	54	0.4	20	0.01	0.05	0.08	10.86	97	0.05	0.78	30	46	288	86	421	300	30
30	600	0.20	18	7.72	0.71	18	3350	54	0.0	0	0.0	0.03	0.08	10.86	97	0.03	0.73	30	46	284	50	381	600	30
30	900	0.18	18	7.75	0.71	18	3350	54	0.0	0	0.0	0.03	0.08	10.86	97	0.03	0.70	30	47	275	30	353	900	30
30	1200	0.13	18	7.78	0.71	18	3350	54	0.0	0	0.0	0.02	0.08	10.86	97	0.02	0.65	30	47	263	20	332	1200	30
30	1500	0.22	41	7.86	0.71	18	3350	54	0.4	20	0.01	0.09	0.08	10.86	97	0.09	0.66	30	47	248	16	313	1500	30
30	1800	0.16	4	7.87	0.71	18	3350	54	0.0	0	0.0	0.01	0.08	10.86	97	0.01	0.61	30	48	231	16	296	1800	30
30	2100	0.10	0	7.87	0.71	18	3350	54	0.0	0	0.0	0.0	0.08	10.86	97	0.0	0.56	30	48	214	17	280	2100	30
31	00	0.18	0	7.87	0.71	18	3350	54	0.0	0	0.0	0.0	0.08	10.86	97	0.0	0.52	30	48	196	15	261	00	31
31	300	0.0	0	7.87	0.71	18	3350	54	0.0	0	0.0	0.0	0.08	10.86	97	0.0	0.48	30	49	178	11	239	300	31
31	600	0.0	0	7.87	0.71	18	3350	54	0.0	0	0.0	0.0	0.08	10.85	97	0.0	0.44	31	49	161	7	218	600	31
31	900	0.0	0	7.87	0.71	18	3350	54	0.0	0	0.0	0.0	0.08	10.84	97	0.0	0.40	33	49	144	4	199	900	31
31	1200	0.0	4	7.87	0.71	18	3350	54	0.0	0	0.0	0.0	0.08	10.83	96	0.0	0.37	35	50	129	2	181	1200	31
31	1500	0.0	18	7.87	0.71	18	3350	54	0.0	0	0.0	0.0	0.08	10.82	96	0.0	0.34	36	50	114	1	165	1500	31
31	1800	0.0	41	7.87	0.72	18	3350	54	0.4	20	0.01	0.00	0.08	10.81	96	0.00	0.32	38	50	100	0	151	1800	31
31	2100	0.0	41	7.87	0.72	18	3351	54	0.4	20	0.01	0.00	0.08	10.80	96	0.00	0.29	39	50	87	0	138	2100	31
NOV 1950																							NOV 1950	
1	00	0.0	41	7.87	0.72	18	3351	54	0.4	20	0.01	0.00	0.08	10.79	96	0.00	0.27	41	51	75	0	127	00	1
1	300	0.07	87	7.92	0.74	19	3352	53	1.8	51	0.04	0.08	0.03	10.78	95	0.08	0.31	43	51	65	0	117	300	1
1	600	0.48	100	8.38	0.83	21	3356	52	6.7	53	0.17	0.57	0.03	10.78	95	0.55	0.68	39	51	56	17	121	600	1
1	900	0.41	100	8.78	0.92	23	3375	51	7.7	52	0.19	0.51	0.03	10.81	96	0.49	1.00	30	51	49	60	163	900	1
1	1200	0.73	100	9.48	1.00	25	3400	50	6.7	51	0.17	0.81	0.03	10.84	97	0.78	1.00	30	52	47	162	263	1200	1
1	1500	0.80	100	10.25	1.11	28	3422	49	8.6	50	0.22	0.91	0.03	10.87	97	0.88	1.00	30	52	50	321	424	1500	1
1	1800	0.99	100	11.13	1.22	31	3449	47	9.6	49	0.24	1.01	0.03	10.90	98	0.98	1.00	30	53	57	527	638	1800	1
1	2100	0.86	100	11.97	1.38	34	3481	44	13.6	47	0.34	1.02	0.03	10.92	98	1.00	1.00	30	53	70	750	874	2100	1
2	00	0.35	100	12.32	1.53	38	3537	42	13.5	44	0.34	0.50	0.03	10.94	99	0.49	1.00	30	54	87	932	1074	00	2
2	300	0.24	100	12.55	1.64	41	3590	39	11.5	41	0.29	0.36	0.03	10.95	99	0.36	1.00	30	54	108	996	1159	300	2
2	600	0.11	100	12.66	1.76	44	3631	38	11.4	39	0.29	0.22	0.03	10.96	99	0.22	1.00	30	55	129	912	1097	600	2
2	900	0.07	100	12.73	1.86	47	3668	36	11.4	38	0.28	0.17	0.03	10.96	99	0.17	1.00	30	55	151	730	938	900	2
2	1200	0.0	100	12.73	1.90	50	3704	34	14.3	36	0.36	0.13	0.03	10.96	99	0.13	1.00	30	56	172	532	761	1200	2
2	1500	0.07	100	12.79	2.12	53	3747	32	15.2	34	0.38	0.19	0.03	10.96	99	0.19	1.00	30	56	190	367	615	1500	2
2	1800	0.09	100	12.89	2.23	56	3794	29	15.2	31	0.38	0.21	0.03	10.96	99	0.21	1.00	30	57	205	256	519	1800	2
2	2100	0.02	100	12.90	2.33	59	3837	28	13.1	29	0.33	0.12	0.03	10.97	99	0.12	1.00	30	57	216	193	468	2100	2
3	00	0.0	100	12.90	2.42	60	3872	26	13.1	28	0.33	0.09	0.03	10.97	99	0.09	1.00	30	58	223	158	440	00	3
3	300	0.0	100	12.90	2.50	62	3906	25	12.0	26	0.30	0.08	0.03	10.96	99	0.08	1.00	30	58	227	130	417	300	3
3	600	0.0	100	12.90	2.57	64	3937	23	13.0	24	0.32	0.08	0.03	10.96	99	0.08	1.00	30	59	227	104	392	600	3
3	900	0.0	100	12.90	2.65	66	3968	21	13.9	23	0.35	0.08	0.03	10.96	99	0.08	1.00	30	59	225	83	368	900	3
3	1200	0.0	100	12.90	2.75	69	4000	20	18.9	21	0.47	0.10	0.03	10.96	99	0.10	1.00	30	60	220	69	350	1200	3
3	1500	0.0	100	12.90	2.83	71	4044	18	16.8	19	0.42	0.08	0.03	10.96	99	0.08	1.00	30	60	213	63	337	1500	3
3	1800	0.0	100	12.90	2.93	73	4090	16	22.7	18	0.57	0.10	0.03	10.96	99	0.10	1.00	30	61	204	63	329	1800	3
3	2100	0.0	100	12.90	3.01	75	4145	15	19.6	16	0.49	0.08	0.03	10.96	99	0.08	1.00	30	61	194	66	321	2100	3
4	00	0.0	100	12.90	3.08	77	4187	13	19.5	15	0.49	0.07	0.03	10.96	99	0.07	1.00	30	62	184	69	317	00	4
4	300	0.0	100	12.90	3.15	79	4225	12	20.4	13	0.51	0.07	0.03	10.96	99	0.07	1.00	30	62	174	70	307	300	4
4	600	0.0	100	12.90	3.21	80	4262	11	19.4	12	0.48	0.06	0.03	10.96	99	0.06	1.00	30	63	163	67	295	600	4
4	900	0.0	100	12.90	3.25	81	4293	10	15.3	11	0.38	0.04	0.03	10.96	99	0.04	1.00	30	63	153	63	280	900	4
4	1200	0.0	100	12.90	3.30	83	4316	10	20.3	10	0.51	0.05	0.03	10.96	99	0.05	1.00	30	63	143	56	264	1200	4
4	1500	0.0	100	12.90	3.35	84	4358	9	18.2	9	0.46	0.04	0.03	10.96	99	0.04	1.00	30	64	133	50	248	1500	4
4	1800	0.0	100	12.90	3.37	84	4404	8	11.2	9	0.28	0.02	0.03	10.96	99	0.02	1.00	30	64	124	44	234	1800	4
4	2100	0.0	100	12.90	3.39	85	4430	8	10.1	8	0.25	0.02	0.03	10.96	99	0.02	1.00	30	65	115	38	219	2100	4
5	00	0.0	100	12.90	3.41	85	4452	8	10.1	8	0.25	0.02	0.03	10.96	99	0.02	1.00	30	65	107	31	204	00	5
5	300	0.0	100	12.90	3.43	86	4473	7	9.1	7	0.23	0.02	0.03	10.96	99	0.02	1.00	30	65	99	23	189	300	5
5	600	0.0	100	12.90	3.44	86	4491	7	7.1	7	0.18	0.01	0.03	10.96	99	0.01	1.00	30	66	91	18	176	600	5
5	900	0.0	100	12.90	3.45	86	4504	7	7.1	7	0.18	0.01	0.03	10.96	99	0.01	1.00	30	66	84	13	164	900	5
5	1200	0.0	100	12.90	3.47	87	4517	7	9.0	7	0.22	0.02	0.03	10.95	99	0.02	1.00	30	66	77	10	154	1200	5
5	1500	0.0	100	12.90	3.49	87	4533	6	12.0	6	0.30	0.02	0.03	10.95	99	0.02	1.00	30	67	70	8	146	1500	5
5	1800	0.0	100	12.90	3.50	88	4554	6	10.0	6	0.25	0.02	0.03	10.95	99	0.02	1.00	30	67	64	8	140	1800	5
5	2100	0.0	100	12.90	3.51	88	4570	6	8.0	6	0.20	0.01	0.03	10.95	99	0.01	1.00	30	67	58	8	134	2100	5
6	00	0.0	100	12.90	3.52	88	4583	6	7.0	6	0.17	0.01	0.03	10.95	99	0.01	1.00	30	67	53	7	129	00	6
6	300	0.0	100	12.90	3.53	88	4593	5	5.0	5	0.12	0.01	0.03	10.95	99	0.01	1.00	30	68	48	7	124	300	6
6	600	0.0	100	12.90	3.53	88	4600	5	3.0	5	0.07	0.00	0.03	10.94	99	0.00	0.97	30	68	44	6	119	600	6

SNOW MELT OPTIONS ARE MELT INDEX, DEPL. CURVE,LAPSE=Y

FIGURE 8.25 OUTPUT LISTING – RUNOFF FROM SNOWMELT AND RAINFALL ON SINGLE BASIN (70)

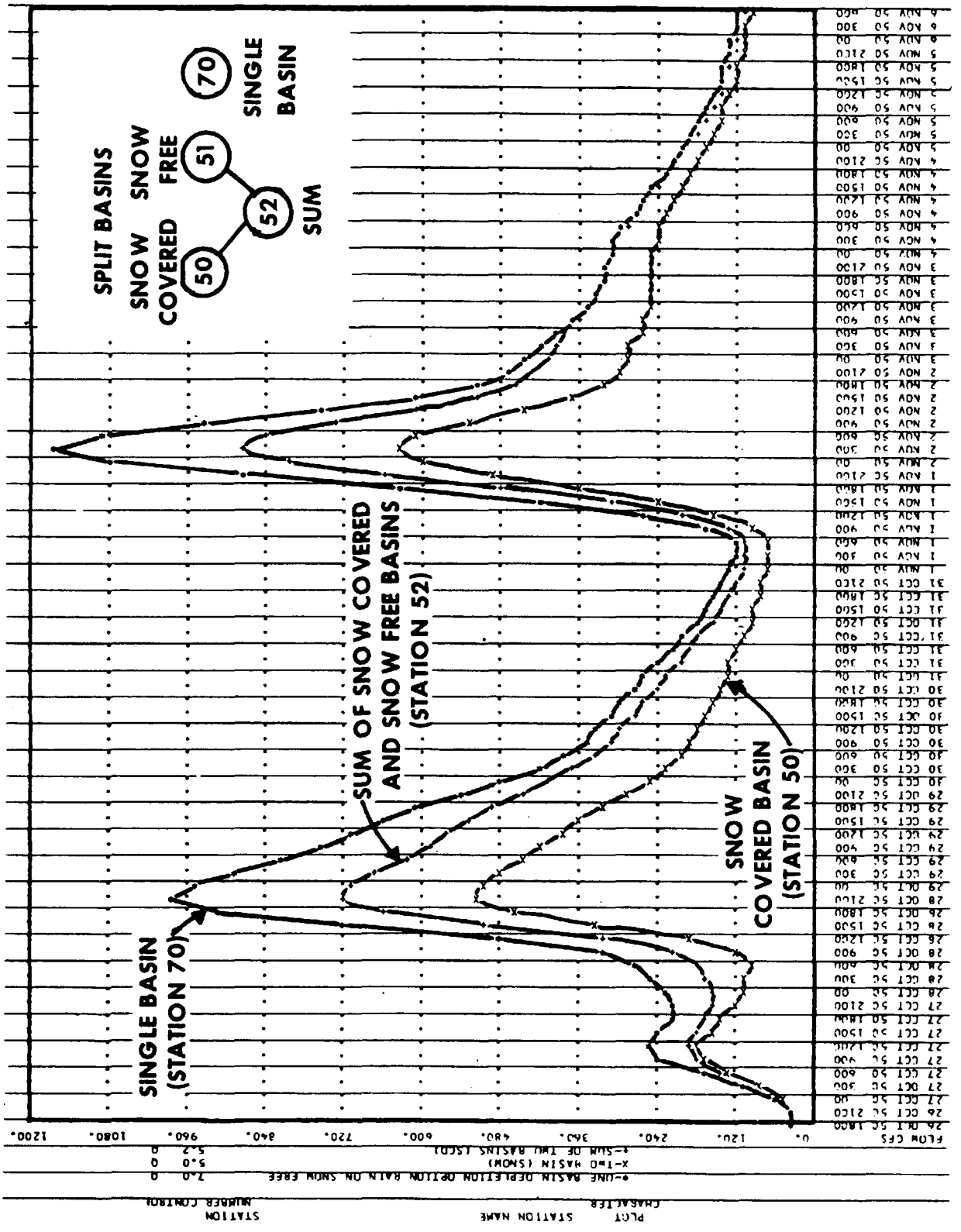


FIGURE 8.26 PLOTTED HYDROGRAPHS – RUNOFF FROM SNOWMELT AND RAINFALL ON SINGLE AND SPLIT BASINS

b. "Depletion-Curve" Watershed Snow Band Option.

The Tanana River Basin, Alaska, was selected for this example to illustrate the use of the snow band option. In addition, the application of the generalized snowmelt equation will be discussed. The mechanics and input requirements for these two options are emphasized in the following discussion.

The SSARR Model was applied to the Tanana River Basin to derive probable maximum and standard project floods for the Fairbanks area. The generalized snowmelt equation was used to determine snowmelt under maximized conditions which could reasonably be expected to occur. The entire Tanana Basin was assumed to be 100 percent snow covered, with snow-water equivalent increasing with elevation. Because of its size (over 25,000 square miles) and diversity, the basin was subdivided and the individual watersheds were modeled where adequate data existed.

For the sake of simplicity, the characteristics developed for one of the upper watersheds, the Chisana, will be described. The Chisana watershed (3,280 square miles) was suited for the use of the snow band option since during the spring runoff season, the lower elevations have little or no snow, whereas, higher elevations have considerable snow depth. Glacier capped peaks from the headwater areas of the Chisana River contribute runoff throughout the active melt and summer seasons. Therefore, the watershed was subdivided into five elevation bands with the uppermost 10 percent of the watershed designated as a glaciated area (see Figure 8.27). The succeeding lower elevation bands accounted

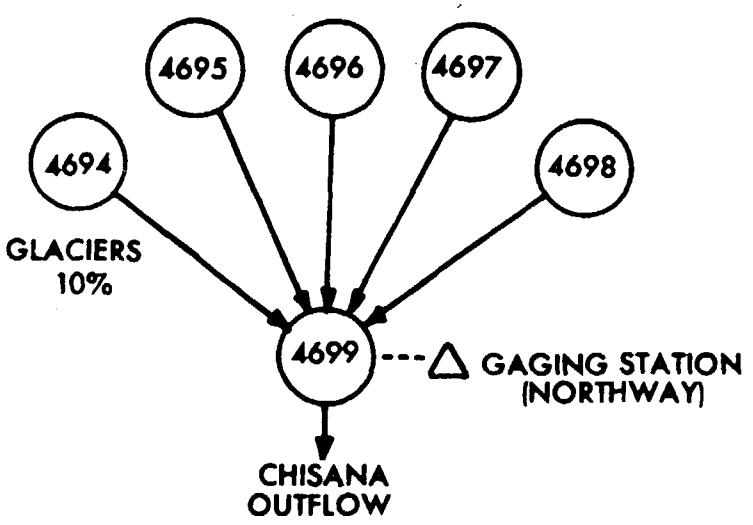


FIGURE 8.27 CONFIGURATION OF SNOW-ELEVATION BANDS FOR THE CHISANA WATERSHED

for 15, 25, 25, and 25 percent of the basin, respectively. The five bands were connected to a summing point (station 4699) which represented outflow from the entire watershed. Historical records from the stream gaging station at Northway were reconstituted to verify parameter relationships for the Chisana Basin.

Although data were sparse, adequate relationships were obtained. The input listing is shown in Figure 8.27. It should be noted that each band was treated as a separate basin with its own characteristics, area-elevation relationship, and initial condition specifications. Each band was 100 percent snow covered, with higher water equivalents designated for the higher elevation bands.

After parameters were established from reconstitutions, the storm criteria for Standard Project Floods (SPF) and Probable Maximum Floods (PMF) were input to the program. These criteria were taken from the report "Estimates of Probable Maximum Precipitation for the Tanana River, Alaska", June 1969, by the Hydrometeorological Branch of the National Weather Service. Basin precipitation, air and dewpoint temperatures and wind velocities were also obtained from this report and used to compute snowmelt with the generalized snowmelt equation (equation 4.2). If dewpoint temperatures had not been available, a table relating air temperature to dewpoint temperature would have been used (col. 48-51 in CBØ3). In addition, estimates of the following were input in data form:

(1) Solar Isolation in langleys (data code 7 in 4D cards). Values ranged from 650 langleys during rain-free periods to 250 langleys during storm periods.

(2) Albedo in percent (data code 6 in 4D cards), varied from 47 percent initially to 40 percent.

Snowmelt coefficients that are required for the generalized snowmelt equation were maximized for SPF and PMF derivations. The coefficients and their respective values for each snow band (indicated in CBØ3 cards) are listed below in Table 8.01.

TABLE 8.01

Snowmelt Coefficients Used for the Chisana Basin

Elevation Band	Percent of Total Area	Shortwave Melt Coefficient k'	Convection-Condensation Melt Factor k	Average Forest Canopy Cover F
4694 (Glacier)	10	0.9	0.6	0.01
4695	15	0.9	0.6	0.20
4696	25	0.9	0.6	0.30
4697	25	0.9	0.6	0.40
4698	25	1.0	0.6	0.40

```
1********10********20********30********40********50********60********70********80
JOB          240671 00020    0          TANANA AT NENANA  BROOKS
 *** SPRING STANDARD PROJECT FLOOD * TANANA BASIN *  COMPUTED  AUG.71  ***
CP        60      500
CP        70      500
CT01    8015          2       0       0     .05    .001     0.5     .05 S-SS
CT02    8015        1.0     0.2    9999    9999
CT 1    8110          2       4    0.03       5    0.09       6    0.11FTI
CT 2    8110          7    0.06       8    0.08       5    0.02       ETI
CT01    8211          2       0      20     1.5      23     3.0      35 HIGH
CT02    8211        4.0      48     6.5      80     8.5      95     9.0    SMI
CT03    8211        100     999     100
CT 1    8215          2       0      95    9999      95
CT 1    8315          2       0      80     0.1      50     0.2      33BTI
CT 2    8310        0.4      21     0.6      16     0.8      15     1.0    BTI
CT 3    8310         15     999      15                                FAIRBK
CT01    8315          2       0     100     1.0      95    9999      95 BIIGL
CT 1    8410          2       0     100     0.2      50     0.5      30KF
CT 2    8410        1.0      20     1.5      20    9999      20       FAIRBK
CT 1    8510          2       0     100     100     100    9999    9999    SCD
CBC1    4694    1 1 1          CHISANA RIVER BASIN GLACIAL 10%
CBC2    4694    3005 27 4  95 4 250    72 84108510    81108215
CBC3    4694    8315  10 8015 9   6   10                          34 35 300
CB 4    4694    3  701004  601005  601006  601007  601008  60140
C3 1    4694  7500    0  8300   40  8870   50  9150   60  9700   80 10000  999
C3 2    4694 9999999999
CBC1    4695    1 1 1          CHISANA RIVER BASIN FIRST 15%
CBC2    4695    5205 27 4  95 4 250    72 84108510    81108211
CBC3  C 4695    8310  10 8010 9   8   20                          34 35 300
CBC4    4695    3  701004  601005  601006  601007  601008  60140
C3 1    4695  5050    0  5300   20  6100   40  6750   60  7500  9999999999999
CB 1    4696    1 1 1          CHISANA RIVER BASIN SECOND 25%
CBC2    4696    8205 27 4  95 4 250    72 84108510    81108211
CBC3    4696    8310  10 8010 9   6   30                          34 35 300
CBC4    4696    3  701004  601005  601006  601007  601008  60120
C301    4696  3400    0  3600   20  3850   40  4150   60  4550   80  5050  999
C302    4696 9999999999
CBC1    4697    1 1 1          CHISANA RIVER BASIN THIRD 25%
CBC2    4697    8205 27 4  75 4 250    72 84108510    81108211
CBC3    4697    8310  10 8010 9   6   40                          34 35 300
CBC4    4697    3  701004  601005  601006  601007  601008  60110
C301    4697  2600    0  2780   20  2920   40  3050   60  3200   80  3400  999
C302    4697 9999999999
CBC1    4698    1 1 1          CHISANA RIVER BASIN LOWER 25%
CBC2    4698    8205 27 4  75 4 250    72 84108510    81108211
CBC3    4698    8310  10 801010   6   40                          34 35 300
CBC4    4698    3  701004  601005  601006  601007  601008  60100
C301    4698  1735    0  1990   20  2230   40  2430   60  2580   80  2690  999
C302    4698 9999999999
CC01    4699    1              CHISANA RIVER AT NORTHWAY CALCULATED
P       4694    4699
P       4695    4699
P       4696    4699
P       4697    4699
P       4698    4699
T   120160503120120190503060120300503120120300633
2B00    4694 120160503    0  50   03 9999100                  999  9999
2B02    4694 120160503     0     0     0     0
2B03    4694 120160503    50    50    50    50    50
2B04    4694 120160503    90    90    90    90
2B00    4695 120160503    0  50   03 9999                     135  1903
2B02    4695 120160503     0     0     0     0
2B03    4695 120160503    50    50    50    50    50
2B04    4695 120160503    90    90    90    90
2B00    4696 120160503    0  50   03 9999                     117  1903
2B02    4696 120160503     0     0     0     0
2B03    4696 120160503    50    50    50    50
2B04    4696 120160503    90    90    90    90
2B00    4697 120160503    0  50   03 9999                     108  1903
2B02    4697 120160503     0     0     0     0
2B03    4697 120160503    50    50    50    50    50
2B04    4697 120160503    90    90    90    90
2B00    4698 120160503    0  50   03 9999                      90  1903
2B02    4698 120160503     0     0     0     0
2B03    4698 120160503    50    50    50    50    50
2B04    4698 120160503    90    90    90    90
    SPP = 50% PMP        SPRING FLOOD PRECIP = 70 % SUMMER FLOOD PRECIP
    SPRING SPF -----STA 70 = ANTECEDENT STORM SPP ON 8500 SQ MI UPPER TANANA
    STA 75 = ANTECEDENT + PRIMARY STORM PRECIP ON LOWER TANANA BASIN
4D   6    70 2401905033  07  10  14  11
4D   6    70 2402005033  17  25  42  18
4D   6    70 2402105033  07  07  07  03
4D   6    75 2401905033  03  03  03  04
4D   6    75 2402005033  07  07  14  04
4D   6    75 2402105033  03  02  02  01
4D   6    75 2402205033  14  14  21  17
4D   6    75 2402305033  25  32  66  21
4D   6    75 2402405033  14  14  14  14
4D        60 1201705034 600
4D        60 1201805034 580 570 520 540 510 514 518 520 540 510 510 510 520 537
4D        60 1201006034 560 585 613 640 665 665 660 660 655 650 640 635 630 630
4D        60 1201506034 640 650 660 665 670 665 657 648 635 620 610 605 610 605
4D        60 1202906034 612 603
4D        60 1201705035 460
4D        60 1201805035 440 428 500 520 490 493 496 500 519 490 430 380 490 417
4D        60 1201006035 430 455 483 510 535 535 530 530 325 520 510 505 500 500
4D        60 1201506035 510 520 530 535 540 535 527 518 505 490 480 475 480 475
4D        60 1202906035 482 473
4D        60 1201705036 420
4D        60 1201805036 410 405 400 400 400 400 400 400 400 400 400 400 400 400
4D        60 1201006036 400 400 400 400 400 400 400 400 400 400 400 400 400 400
4D        60 1201506036 400 400 400 400 400 400 400 400 400 400 400 400 400 400
4D        60 1202906036 400 400
4D        60 1201705037 575
4D        60 1201805037 400 370 300 350 490 490 250 250 300 350 400 590 600 625
4D        60 1201006037 635 650 650 650 650 650 650 650 650 650 650 650 650 650
4D        60 1201506037 650 650 650 650 650 650 650 650 650 650 650 650 650 650
4D        60 1202906037 650 650
4D        60 1201705038 100
4D        60 1201805038 110 110 140 150 130 120 130 210 300 170 140 130 110 080
4D        60 1201006038 070 060 060 050 040 040 040 040 040 040 040 040 040 040
4D        60 1201506038 040 040 040 040 040 040 040 040 040 040 040 040 040 040
4D        60 1202906038 040 040
5      9999 1201405C3 4030 5 0 0 0 5203006
PQ     46990                          120160503120300603 120        0  75000
FINAL FILE OF TIME RECORDS FOR OUTPUT AND PLOT IS ON UNIT 21
PHC    604 100T                                                     0   1000
PHC    703 100P  753 100R                                          50      0
END

    END OF FILE ON INPUT DECK
```

Figure 8.28 Input Listing for Snow-Elevation Bands, Chisana Watershed

The same runoff relationships were used for all bands except the glaciated area. The SMI and BII relationships for the glaciated areas were designed to yield 95 percent runoff of which 95-100 percent was baseflow.

The initial conditions specified for each band (2BØØ cards) were the same except that the snow water equivalent varied from 9 inches in the lowest band to 13.5 inches in the second highest band and 99.99 inches in the glacial snow pack. The snow water equivalent for the glacial band was large enough to insure that the glacial pack was not depleted. The remaining lower elevations were designated to simulate a "snow wedge" effect.

A portion of the output for snow band 4695 is given in Figure 8.28. The snow band printout differs slightly from those previously described, primarily in that rain and snow are specified separately and the accumulated water equivalent is given. The resultant hydrograph for the entire Chisana watershed (station 52) is illustrated in Figure 8.29.

The Chisana was only one of several basins evaluated for the Tanana River SPF and PMF. Figure 8.30 illustrates how the Chisana fits into the overall Tanana Basin scheme. In this example, the snow band option was used for all watersheds. The other options, however, can be used with different watersheds when conditions warrant.

c. Summary of Snowmelt Options. Basically the SSARR Model offers the user either (1) the temperature index approach, or (2) the generalized snowmelt equation, to compute snowmelt from the basin snow pack. The basin snowpack in turn, can be defined by either (1) the elevation band or (2) the snow cover depletion (SCD) curve and its three options. Data availability, watershed characteristics, and user requirements should govern which options are used.

For snowmelt calculations, the temperature index approach is easiest to employ. Precipitation, air temperature, and melt rate specifications are essentially the only data input required. Input requirements for the temperature index and generalized snowmelt equations are outlined in Table 8.02.

The basic difference between the snow band and SCD options is that the band option maintains an inventory of snow water equivalent on each elevation band, whereas, the SCD only depletes the snow covered area as a function of percent seasonal accumulated runoff. Thus the band option is more quantitative. The differences in program specifications for the SCD and snow band options are outlined in Table 8.03. This table is designed to assist the user and to save computation time that is often wasted on incorrect program specifications.

BASIN RESULTS - STATION 469.5 CHISANA RIVER BASIN FIRST 15T

RUN DATE RUN NO. 240671 INITIAL DATE, HOUR 16 MAY 1903 1200 JOB DESCRIPTION 0 TANANA AT NENANA BROOKS N.P.D., CORPS OF ENGINEERS

FTI = 0.09 IN./DAY AREA = 520.0 SQ. MI.

DAY	HOUR	PCPN	%RA	RAIN	SNOW	AC-SN	D-DY	%MA	M-RATE	MELT	FTI	SMI	ROP	RGP	BTI	RFP	SURF	SURSF	BASEF	DISCH	HOUR	DAY
MAY 1903																						MAY 1903
16	1200	0.0	0	0.0	0.0	13.50	0.0	0	0.0	0.0	0.11	5.00	0	0.0	0.30	0	0	50	90	140	1200	16
17	00	0.0	100	0.0	0.0	12.78	0.0	100	0.0	0.72	0.09	5.00	61	0.43	0.39	27	1	50	90	142	00	17
17	1200	0.0	100	0.0	0.0	12.55	0.0	100	0.0	0.24	0.09	5.24	64	0.15	0.37	22	13	50	90	154	1200	17
18	00	0.0	100	0.0	0.0	12.21	0.0	100	0.0	0.34	0.09	5.28	64	0.22	0.38	23	49	52	90	192	00	18
18	1200	0.0	100	0.0	0.0	12.10	0.0	100	0.0	0.11	0.09	5.35	65	0.07	0.35	22	122	56	90	270	1200	18
19	00	0.0	100	0.0	0.0	11.98	0.0	100	0.0	0.12	0.09	5.35	65	0.08	0.32	24	235	63	90	389	00	19
19	1200	0.0	100	0.0	0.0	11.94	0.0	100	0.0	0.04	0.09	5.34	65	0.03	0.28	26	375	72	90	539	1200	19
19	1800	0.0	100	0.0	0.0	11.50	0.0	100	0.0	0.43	0.09	5.31	65	0.28	0.34	28	451	78	90	620	1800	19
20	00	0.07	100	0.07	0.0	11.47	0.0	100	0.0	0.03	0.09	5.44	66	0.07	0.34	24	576	84	90	702	00	20
20	600	0.10	100	0.10	0.0	11.47	0.0	100	0.0	0.0	0.09	5.47	67	0.07	0.33	25	600	92	90	784	600	20
20	1200	0.14	100	0.14	0.0	11.32	0.0	100	0.0	0.16	0.09	5.49	67	0.20	0.37	25	672	100	91	864	1200	20
20	1800	0.11	100	0.11	0.0	10.61	0.0	100	0.0	0.70	0.09	5.58	68	0.56	0.52	23	743	109	91	944	1800	20
21	00	0.17	100	0.17	0.00	10.56	0.0	100	0.0	0.05	0.09	5.83	71	0.16	0.53	18	813	119	91	1024	00	21
21	600	0.25	100	0.25	0.00	10.56	0.0	100	0.0	0.0	0.09	5.89	72	0.18	0.54	18	886	130	92	1109	600	21
21	1200	0.42	100	0.42	0.00	10.31	0.0	100	0.0	0.25	0.09	5.95	73	0.49	0.66	17	966	142	92	1201	1200	21
21	1800	0.18	100	0.18	0.00	9.74	0.0	100	0.0	0.57	0.09	6.13	75	0.56	0.78	16	1056	156	92	1306	1800	21
22	00	0.07	100	0.07	0.0	9.70	0.0	100	0.0	0.04	0.09	6.31	78	0.09	0.75	15	1162	171	93	1427	00	22
22	600	0.07	100	0.07	0.0	9.70	0.0	100	0.0	0.0	0.09	6.33	78	0.05	0.71	15	1286	189	93	1570	600	22
22	1200	0.07	100	0.07	0.0	9.50	0.0	100	0.0	0.20	0.09	6.33	78	0.21	0.72	15	1432	209	94	1736	1200	22
22	1800	0.03	100	0.03	0.00	8.90	0.0	100	0.0	0.60	0.09	6.38	78	0.49	0.82	15	1599	231	95	1926	1800	22
23	00	0.0	100	0.0	0.0	8.85	0.0	100	0.0	0.04	0.09	6.50	80	0.03	0.76	15	1785	255	95	2137	00	23
23	600	0.0	100	0.0	0.0	8.85	0.0	100	0.0	0.0	0.09	6.49	80	0.0	0.70	15	1987	282	96	2367	600	23
23	1200	0.0	100	0.0	0.0	8.64	0.0	100	0.0	0.21	0.09	6.46	80	0.17	0.70	15	2200	311	97	2610	1200	23
23	1800	0.0	100	0.0	0.0	8.30	0.0	100	0.0	0.34	0.09	6.49	80	0.27	0.73	15	2418	343	98	2861	1800	23
24	00	0.0	100	0.0	0.0	8.28	0.0	100	0.0	0.02	0.09	6.53	80	0.02	0.68	15	2632	377	99	3114	00	24
24	600	0.0	100	0.0	0.0	8.28	0.0	100	0.0	0.0	0.09	6.51	80	0.0	0.62	16	2846	414	101	3362	600	24
24	1200	0.0	100	0.0	0.0	8.16	0.0	100	0.0	0.12	0.09	6.49	80	0.10	0.61	16	3045	453	102	3601	1200	24
24	1800	0.0	100	0.0	0.0	7.75	0.0	100	0.0	0.40	0.09	6.49	80	0.32	0.66	16	3277	494	103	3826	1800	24
25	00	0.0	100	0.0	0.0	7.72	0.0	100	0.0	0.03	0.09	6.55	80	0.02	0.62	16	3387	537	105	4031	00	25
25	600	0.0	100	0.0	0.0	7.72	0.0	100	0.0	0.0	0.09	6.54	80	0.0	0.57	16	3525	582	107	4213	600	25
25	1200	0.0	100	0.0	0.0	7.58	0.0	100	0.0	0.14	0.09	6.51	80	0.12	0.56	17	3638	628	108	4376	1200	25
25	1800	0.0	100	0.0	0.0	6.69	0.0	100	0.0	0.89	0.09	6.57	80	0.72	0.74	17	3727	676	110	4514	1800	25
26	00	0.0	100	0.0	0.0	6.62	0.0	100	0.0	0.06	0.09	6.67	81	0.05	0.70	15	3792	725	112	4631	00	26
26	600	0.0	100	0.0	0.0	6.62	0.0	100	0.0	0.0	0.09	6.66	81	0.0	0.64	16	3838	775	114	4729	600	26
26	1200	0.0	100	0.0	0.0	6.30	0.0	100	0.0	0.32	0.09	6.64	81	0.26	0.67	16	3849	826	116	4813	1200	26
26	1800	0.0	100	0.0	0.0	5.91	0.0	100	0.0	0.39	0.09	6.68	81	0.32	0.72	16	3889	879	119	4888	1800	26
27	00	0.0	100	0.0	0.0	5.88	0.0	100	0.0	0.03	0.09	6.73	82	0.02	0.67	15	3902	932	121	4957	00	27
27	600	0.0	100	0.0	0.0	5.88	0.0	100	0.0	0.0	0.09	6.71	82	0.0	0.62	16	3917	986	124	5023	600	27
27	1200	0.0	100	0.0	0.0	5.74	0.0	100	0.0	0.14	0.09	6.69	81	0.11	0.61	16	3918	1040	126	5087	1200	27
27	1800	0.0	100	0.0	0.0	5.72	0.0	100	0.0	0.03	0.09	6.69	81	0.02	0.56	16	3923	1096	129	5149	1800	27
28	00	0.0	100	0.0	0.0	5.71	0.0	100	0.0	0.00	0.09	6.68	81	0.00	0.52	17	3923	1151	132	5208	00	28
28	600	0.0	100	0.0	0.0	5.71	0.0	100	0.0	0.0	0.09	6.65	81	0.0	0.48	18	3919	1207	135	5262	600	28
28	1200	0.0	100	0.0	0.0	5.70	0.0	100	0.0	0.01	0.09	6.63	81	0.01	0.44	19	3906	1263	138	5308	1200	28
28	1800	0.0	100	0.0	0.0	5.70	0.0	100	0.0	0.0	0.09	6.61	81	0.0	0.41	20	3882	1318	142	5343	1800	28

PCPN = Weighted Precipitation, in inches
% RA = Percent Rain Area
RAIN = PCPN that fell below the rain-freeze elevation, in inches
SNOW = PCPN above the rain -freeze elevation, in inches
AC-SN = Total Snow Water Equivalent on Band, in inches
D-DY = N/A (For temp. Index)
% MA = Percent of Band Contributing Melt
M-RATE = N/A
MELT = Total Melt for the Period, in inches

* The remaining column headings have been previously defined.

FIGURE 8.29 PORTION of the OUTPUT LISTING for the SNOW-BAND OPTION, BAND 4695, CHISANA WATERSHED

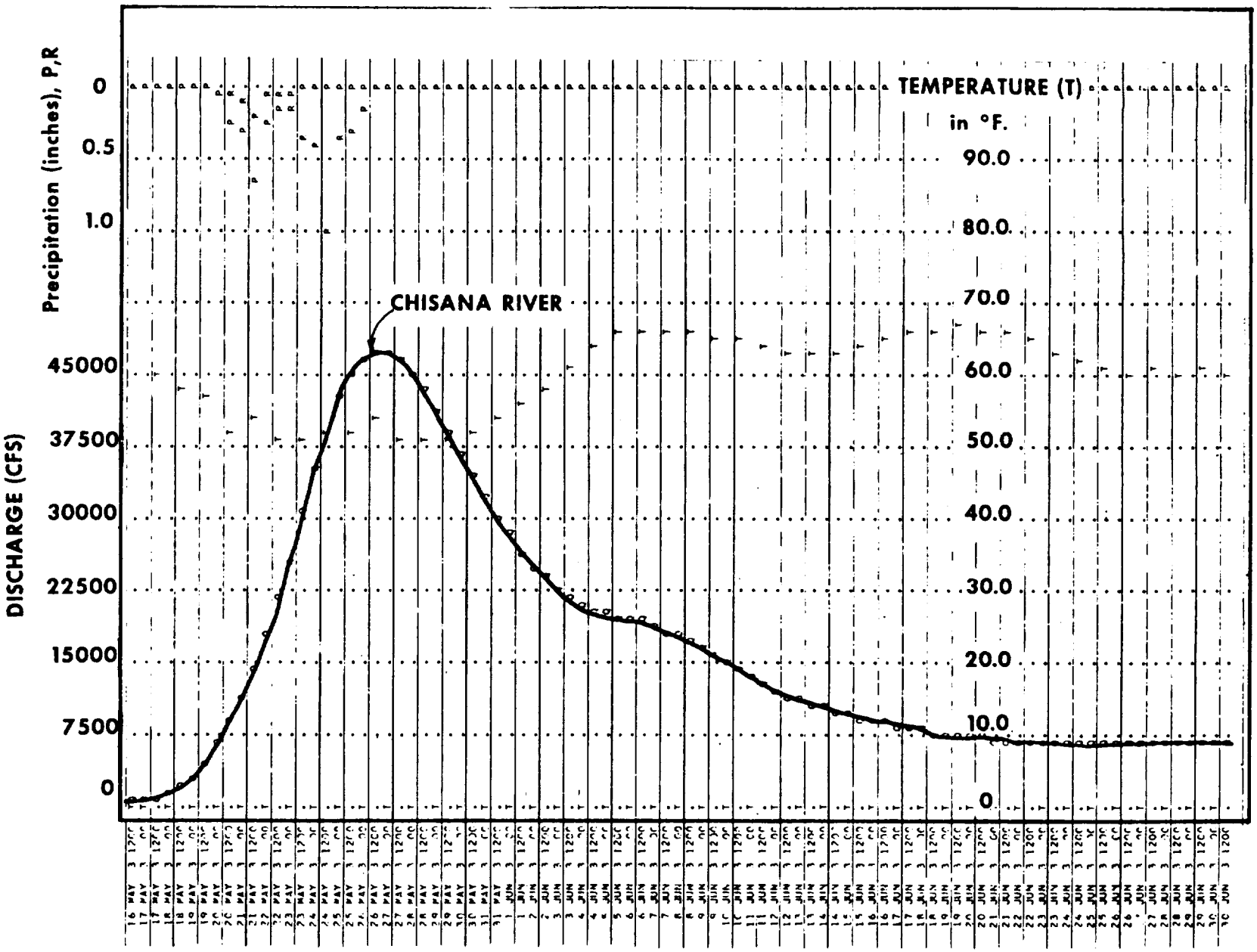


Figure 8.30 Resultant Streamflow from Snow-Elevation Bands, Chisana Watershed

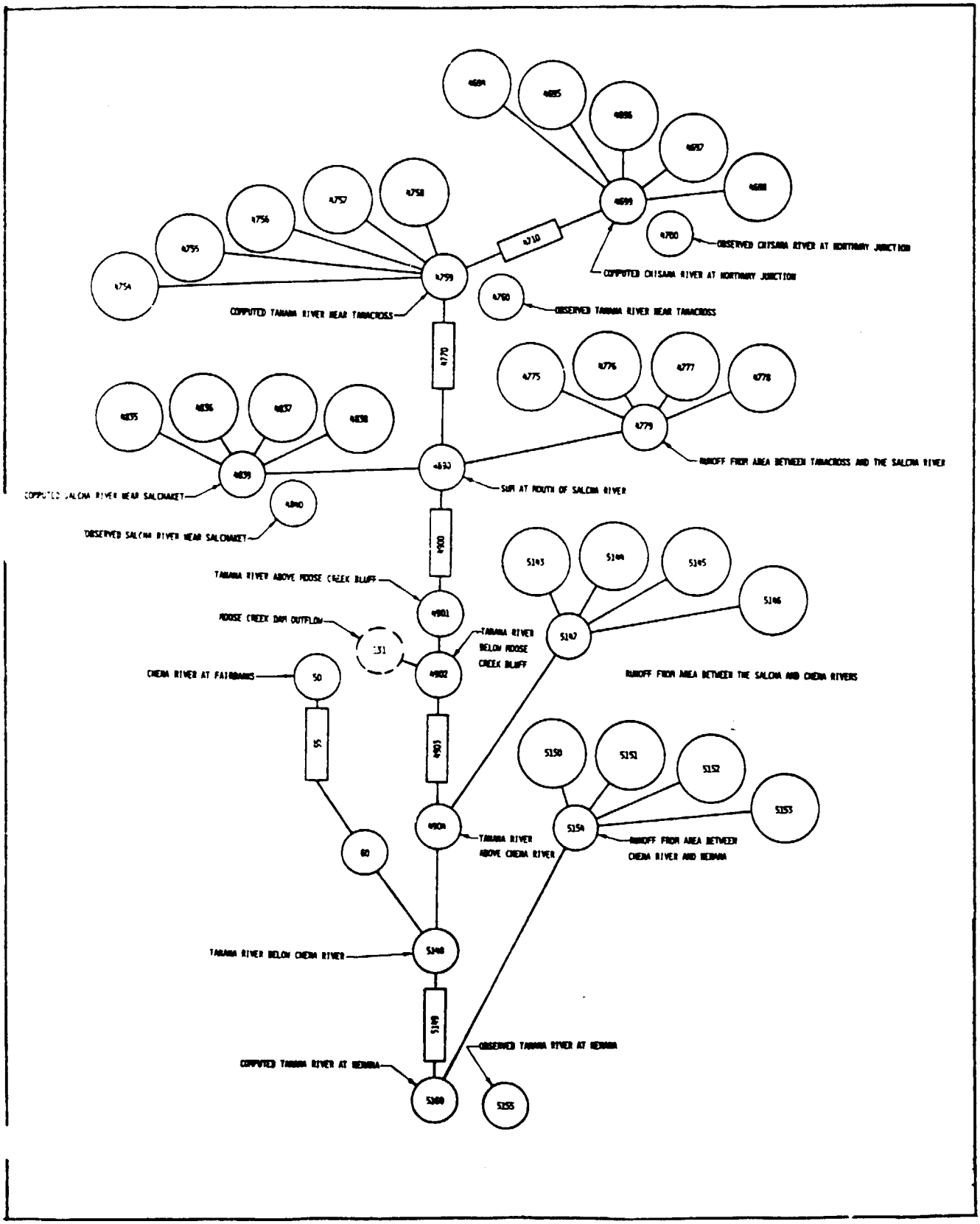


Figure 8.31 Configuration of the Tanana River Basin, Alaska

TABLE 8.02

Outline of Input Requirements for the Temperature Index and Generalized Snowmelt Equation Options for Calculating Snowmelt

Card	Columns	Requirements for Temperature Index	Requirements for General Snowmelt Equation
CBØ3	32-35	Blank	k'
	36-39	Blank	k
	40-43	Blank	F
	44-47	Blank	Constant Wind Speed if no data code 8, "4" Card
	48-51	Blank	Air Temp. vs Dew Pt. Temp Table I.D. if no data code 5,"4" Card.
	52-55	Melt Rate Table[1/] I.D.	Blank
	66-68	-- Rain Freeze Temperature (°F) --	
	69-71	-- Base Temperature (°F) --	
	72-74	-- Lapse Rate (°F/1000 ft) --	
2BØØ	38-41	Snowmelt Daily Distribution Table I.D. (optional)	
	46-49	Initial Melt Rate (inches/deg. day)	
CBØ4&4D		-- Precipitation (inches) --	
		-- Air Temperature (°F) --	
		N.A.	Dewpoint Temp (°F)
		N.A.	Albedo (%)
		N.A.	Insolation (ly)
		N.A.	Wind Speed (mph)
		Melt Rates (inches/deg. day) (optional)	N.A.

1/ This indicates to the computer that the temperature index approach is to be used. If melt rate data are input in "4" card formats, these data are used instead of the tabled values.

TABLE 8.03

Outline of Program Specifications for the Snow Cover Depletion and Elevation Band Options

Card	Columns	Requirements for Snow Cover Depletion (SCD) Option	Elevation Band Option
CBØ1	19	Blank	The digit 1
CBØ2	48-51	SCD Table I.D.	Table I.D. for SCD set = 100% for all values of runoff for the snow covered bands.
	52-55	Number required for two-basin option; must correspond to station number in CBØ4 for separate analysis of snow-free basin, otherwise, any digit other than I.D.	Blank
C3		There must be an area-elevation table for both options	
2BØØ	42-45	Snow covered area in percent*	Blank or 100%
	46-49	Initial Melt Rate	Initial Melt Rate
	59-63	Accumulated runoff to date (inches)	Snow water equivalent for band (inches)
	64-68	Estimated total seasonal runoff (inches)	Arbitrary number required.

* Snowline elevation can be specified in 4D cards (data code 1) in lieu of snow covered area in percent. This value overrides the snow covered area which corresponds to the Accumulated Generated Runoff (% of seasonal total) determined from col. 59-63 and col. 64-68.

Initial Conditions. The condition of the watershed model at start time must be specified for the simulation to begin properly. This condition at start time is called the "initial condition" (IC). The IC consists of a number of computed indexes (model state variables), plus the phase values of the three routed runoff components.

The IC for a basin are loaded into the basin IC record in the SSARR work file (record type 1), in preparation for a run of the watershed model. IC may be input via card code 2B and 3B formats; input and modified by the IC subcommand of IA (the interactive processor); or stored in the SSARR work file by a prior SSARR run with an end-time equalling the current start time.

There is a provision for automatic adjustment of IC to match the basin computed discharge to the observed discharge at run end time. This is a necessity because of the daily restart of the model required in operational forecasting.

Automated Adjustment of Watershed. The "T" card controls the time range of the watershed simulation, specifying start time, stop time, and hours-per-compute-period. The adjustment controls are as follows:

1. Observed discharge from 2B00 or 3B00 card.
2. Adjustment tolerance (%) and maximum cfs error from CB03 card.
3. Unadjusted result print code from 3B00 card.
4. Time shift code from rain distribution (card code 5 card — identified on 2B00 or 3B00 card). The adjustment procedure is as follows:

a. Simulate the watershed for the time range specified on the "T" card. If the "unadjusted result print code" (item 3.) is non-zero, print the results even if there is a non-zero "observed discharge" (item 1).

b. If the "observed discharge" is zero or unspecified, simulation of this watershed is complete.

   If the "observed discharge" is non-zero, test the final discharge of the watershed (at "stop time" specified on "T" card) to see if it is within the tolerance (item 2) of "observed discharge".

   If the computed discharge is within tolerance, proceed to step e (below).

c. Unadjussted simulation results in final discharge which is not within tolerance of "observed discharge".

   If the rain distribution has the "time shift code" on (item 4), resimulate the watershed with the rain distribution shifted either forward or back the number of hours equal to one half of a compute period.

d. If the time shift does not result in a final discharge within tolerance of "observed discharge", or no time shift is specified by the rain distribution, resimulate the watershed adjusting the volume of rain and snowmelt by a factor. The factor ranges from 0.5 to 2.0.

e. When the computed final discharge is within the tolerance of "observed discharge", any remaining error is distributed proportionately to the surface, subsurface, and baseflow phases to make them exactly match "observed discharge".

APPENDIX D

INTEGRATED-SNOWBAND WATERSHED MODEL

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APPENDIX D

INTEGRATED-SNOWBAND WATERSHED MODEL

This model is formulated to provide the ability to simulate on a continuous basis rainfall-runoff, snow accumulation and ablation, and snowmelt runoff in mountainous areas.

The watershed accounting is accomplished through the use of elevation bands, with independent accounting of precipitation, snow water equivalent, soil moisture and other characteristics for each band. The program permits flexible subdivision of the basin into as many as 20 bands with no restriction on the area of each band. Each band is considered to be either 100% snow covered or snow free. Runoff is calculated for each separate band and then combined before routing to form total watershed streamflow that can then be entered into the river and reservoir simulation.

GENERAL CONCEPT OF MODEL OPERATION

The snowband model computer program uses the SSARR work file as the data base for a simulation. The user must load all data, relations, and characteristics into the work file with the SSARR program. All of this information may be loaded by inputting the appropriate card formats into the SSARR program, as described in Appendix B.

Also, the "IA" command and interactive processor include a repertoire of subcommands for entering and managing this information.

The information required for a simulation is summarized as follows:

Characteristics. Fixed attributes of the drainage to be modeled. The characteristics are defined by attributes specific to the drainage; card formats ZC1, ZC2, ZC3, ZC4, ZC5, ZC6, ZCP, ZCH, and ZCA or ZCE. Attributes which may be more regional than specific to a given drainage are described by general purpose relations.

The general purpose relations are defined by CT and CF formats, or the alternative freeform formats ZCT and ZCF.

Model Configuration List, Called A "Model-List". This list is identified by a model name and may be loaded into the SSARR work file either with a combination of "N" and "P" (configuration) formats, or the "EM" subcommand of "IA".

The model-list lists the names of the basins and river stations to be processed. It determines the order of processing and describes the relative positions of the stations on the river tributaries.

A snowband watershed model of a catchment will be processed if the name of the watershed appears in the active model-list (which is set by the "N" card). A simulation of a single watershed can be done with the "BASIN" subcommand of "IA".

Time Range of the Simulation. Time control may be set by either the "T" card format, or the "T" subcommand of "IA". Time control information includes the beginning hour and date of the simulation, the ending hour and date, and the length of the compute periods in hours. Hours may be expressed in tenths of hours, the smallest time unit recognized by the SSARR program.

Hydrometeorological and Flow Data. Hydromet data includes air temperatures and precipation, as well as optional data including temperature lapse rates and potential evapotransipiration. Flow data representing observed basin discharge for a historic simulation may be provided to be printed on the snowband printout next to the computed flow. (The observed flow data must have a different station name that the watershed name.)

Hydromet data may be loaded into the SSARR work file via 4, Z1, Z4, and Z7 card formats, and the "L" and "CROHMS" subcommands of "IA". Flow data may be loaded via 6, Z1, Z6 and Z8 formats, and the "6", "SPECFLO", and "CROHMS" subcommands of "IA".

Initial Conditions. The initial condition of snowband watershed parameters at the start time of the simulation may be loaded via "Z2" card formats. When a simulation is completed through the ending time of the time range, the instantaneous values of model parameters are saved in the type 1 record in the SSARR work file. The model may then be restarted at this time point without loading a new set of "Z2" cards.

Snowband Watershed Result Summary. After the characteristics, time control, hydromet data and initial conditions have been loaded to the work file, the program takes three steps for the complete simulation of a snowband watershed. These steps and their results are summarized as follows:

Step 1. Process hydromet data to calculate basin weighted average values for each compute period. A type 104 record is written to the SSARR work file containing temperature, lapse rate, and precipitation and, optionally, potential evapotranspiration. This step is controlled by the "ZCH" cards.

Step 2. Simulate each snowband throughout the time range beginning with band 1 (the lowest band). The "L" parameter on the "ZR" card must be used to list the individual snowband results. The instantaneous conditions of each snowband at the end of the time range are saved in type 1 record in SSARR work file.

A snowband work file (FORTRAN unit 20) is used to save the snowband calculation results. A record containing model parameters for each compute period for each snowband is written. This can limit the length of the simulation. The capacity of the snowband work file is 19950 records, limiting the product of number of snowbands and number of compute periods (plus 1):

$$19950 > Z * (N+1)$$

where Z is number of snowbands in catchment, field 3 of ZC2 card.

N is number of compute periods in the time range; that is, the number of hours (total) between start and end of the simulation time range, divided by hours-per-compute period.

For example: If the basin is divided into 10 snowbands, the maximum number of compute periods is 1994. If the time range is one year (not a leap year), a daily compute period results in 365 periods; a 6-hour compute period results in 1460 periods.

This limitation is for each snowband basin. It does not limit the number of snowband basins that may be included in a model-list. See the next step for limitations on the number of basins (there can be a maximum of 50 basins in a model-list).

Step 3. Summarize the snowband results for each compute period to get basin averages of input to the runoff routing components, and route to develop basin flow. Produce snowband basin printout (which may be supressed with "S" option on the "ZR" card).

A basin summary work file (FORTRAN unit 19) is used to save calculation results. A record containing basin averages of model parameters for each compute period is written. These results may be displayed with the printer-plot by the "PZ" card format.

The capacity of the basin summary work file is 19950 records, limiting the product of the number of basins (snowband and depletion) in the "model" list, and the number of compute periods (plus 1). Also, the maximum number of basins in a model-list is 50.

A type 101 record of computed basin discharges is written to the SSARR work file. This record is used by the river model.

SNOWBAND MODEL PARAMETERS

The design of the snowband SSARR watershed model attempts to include as many as possible of the features suggested by SSARR users as the model has evolved. None of the new variables are "forced" on the user—he can "zero" them out by appropriate selections of coefficients or table values. None of the coefficients are predetermined, but default values are provided in most cases. Many of the methods, variables and default values come directly from "Snow Hydrology", herein referenced "SH". 2/

Division of Drainage Area Into Elevation Bands. The catchment may be treated as one elevation band, or divided into as many as 20. The division is described by either the "ZCA" or the "ZCE" card formats, in conjunction with the elevation vs. percent area relation described by "ZCP" cards.

Each snowband is represented by the elvation of the midpoint of the snowband and the percent of basin area within the snowband. The midpoint elevation is computed by, first, calculating the midpoint of the percent area and, second, evaluate the elevation vs. percent area relation for the corresponding elevation.

For example, consider the following description of a basin divided into three snowbands:

```
ZC1,...
ZC2, name, area, 3,...
ZC3,...
ZC4,...
ZC5,...
ZCA, name, 20, 50, 30
ZCP, name, 1000, 0, 1700, 70, 2300, 100
```

From these cards, we can see that the snowbands are as follows:

Band Number	Percent Area Below Lowest Limit of Band	Percent Area Below Highest Limit of Band	Percent Area of Mid-Point of Band
1	0	20	10
2	20	70	45
3	70	100	85

With the "ZCP" table, we find the following snowband elevations:

Band	% Area Below Mid-Point	Elevation of Mid-Point
1	10	1100
2	45	1450
3	85	2000

See Figure D-1

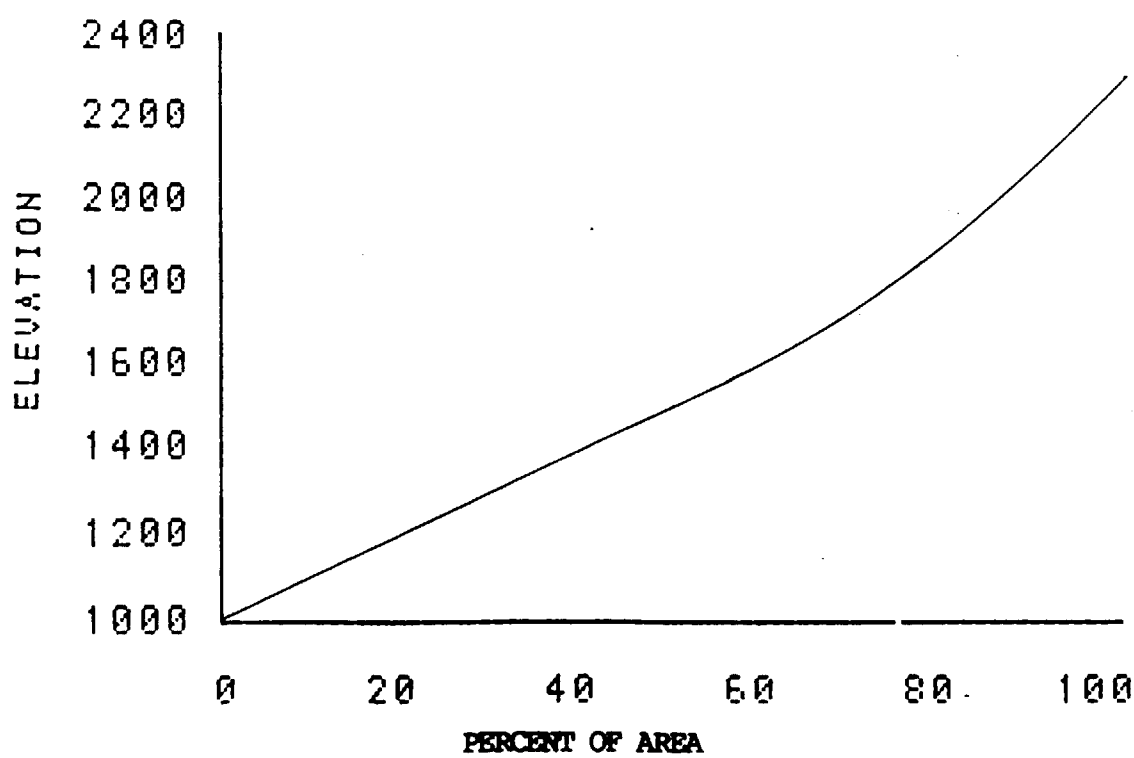


FIGURE D-1

The ZCE table could be used instead of the ZCA (one or the other is required). It would list the highest elevation of each snowband:

ZCE, name, 1200, 1700, 2300

Although the program will permit subdivision of a catchment into 20 snowbands, good results in long term simulations of annual runoff volume and water balance have been obtained dividing a catchment into snowbands representing about 2,000 feet of elevation range each. An algorithm is included in the snowmelt simulation to delay the melt of the last few inches of snow off a snowband, thereby reducing the impact on the computed hydrograph of a relatively large proportion of the snow covered area simultaneously losing its snow cover. See paragraph "Limitation on Snowmelt Rate." (Page D-17)

Temperature Lapse Rate. The lapse rate may be specified by the "ZC3" card. If left off the card, the lapse rate will default to 3.3^{o} F/1000 feet. Variable lapse rates may be specified with the "ZCH" card and type 26 records in the SSARR work file. If lapse rates are specified, the constant provided on "ZC3" becomes a maximum lapse rate. Lapse rate values are loaded into a type 26 record via "4D" cards with "6" in column 24, or any other alternative available for input of hydromet data such as "Z1", "Z4", "Z7" cards and the "L" subcommand of "IA". A type 26 record may also be produced with the "ZLAPSE" card.

The constant lapse rate field of "ZC3" card is useful to limit the unreasonably high lapse rates which can be derived with direct calculation of lapse rate between a high altitude temperature gage and a valley gage.

Variable lapse rate data records are coded as type "6" on the "ZCH" cards, and must be listed first before temperatures (type "4") and precipitation (type "3"). If more than one type "6" record is listed, a weighted average is calculated:

$$L_t = \frac{\sum_{n}^{i=1} L_{it} * W_i}{n}$$

$$0 \leq L_t \leq L_c$$

where

L_t	is weighted basin average lapse rate for time t.
L_{it}	is lapse rate from type "6" entry in the i position in the list of "6" records on the "ZCH" card, at time t.
W_i	is weight of type "6" entry in the i position in the list of "6" records on the "ZCH" card.
n	is the number of type "6" entries listed on the "ZCH" cards.

L_c is the maximum lapse rate from constant lapse rate field of the "ZC3" card.

If a type 26 record is not in the SSARR work file to provide values L_{it}, the number n is reduced by one in the weighting calculation.

Type 26 records are interpolated for values for time periods between specified values. For example, lapse rates may be specified at the beginning a storm, the mid-point, and end of the storm. The lapse rate for all compute periods throughout the storm will be interpolated as varying proportionally with time. Time t is the ending time of a compute period.

Basin Weighted Average Temperature. Temperature gages to be used to calculate basin temperature are listed on the "ZCH" cards with type "4" or "14". These temperatures are retrieved from type 24 records in the SSARR work file. Temperatures are loaded in type 24 records in the work file via "4D" cards with "4" in column 24, or any other alternative available for input of hydromet data such as "Z1", "Z4" and "Z7" cards, and the "L" and "CROHMS" subcommands of "IA".

The weighted average temperature for a compute period is calculated as follows:

$$TA_t = \frac{\sum_{n}^{i=1} (TA_{it} * W_i + E_i * L_t/1000)}{n}$$

where

TA_t is basin weighted average temperature at zero elevation for time t.

TA_{it} is temperature from type "4" or "14" entry in the i position in the list of "4" or "14" records on the "ZCH" card, at time t.

Temperature TA_{it} is the first temperature recorded during the compute period (but not including the time the period starts). If temperatures in the type 24 record are recorded at midnight and 6 A.M., and the compute period starts at midnight and ends at 6 A.M. (6 hour period; t is 6 A.M.), TA_{it} will be the 6 A.M. value.

Types "4" and "14" on ZCH Card. If a value TA_{it} is missing when entry i is type "4" (temperature), the value $TA_{i(t-1)}$ is substituted (that is, the previous period value) and an error message is sent to the user. If TA_{it} is missing when entry i is type "14", the divisor n is reduced by one for time t.

W_i is weight of type "4" or "14" entry in the i position.

E_i is elevation (as provided on "CP" or "ZH" card) of the temperature station names as type "4" or "14" entry in the i position.

L_t is lapse rate, basin weighted average for time t. If none available due to no type "6" entries on "ZCH", or no corresponding type 26 records in SSARR work file, the constant lapse rate from "ZC3" card is used.

n is the number of type "4" and "14" entries on the "ZCH" cards. As the divisor of the summation of the weighted temperatures, n is reduced by one for each type "14" entry for which a temperature at time t is missing. The divisor n is also reduced if a type 24 record is missing from the SSARR work file.

Snowband Temperature. Temperature for a compute period is calculated with either the constant or variable lapse rate, the snowband midpoint elevation, and the basin weighted average temperature.

$$TA_{zt} = TA_t + L_t * E_z/1000$$

where

TA_{zt} is temperature for snowband z at time t.

TA_t is basin weighted average temperature at time t.

L_t is lapse rate, basin weighted average for time t, or the constant lapse rate from "ZC3" card.

E_z is elevation of midpoint snowband z.

Basin Weighted Average Precipitation. Precipitation gages to be used are listed on the "ZCH" cards with type "3". Precipitation values for each compute period are retrieved from type 23 records in the SSARR work file. These type 23 records are prepared in the work file through the input of "4D" cards with "3" in column 24, or any other alternative available for input of hydromet data such as "Z1", "Z4", and "Z7" cards, and the "L" and "CROHMS" subcommands of "IA".

The basin weighted average precipitation for a compute period is calculated as follows:

$$PP_t = \frac{\sum_{n}^{i=1} (PP_{it} * W_i)}{n}$$

where

PP_t is basin weighted average precipitation during the compute period ending at time t.

PP_{it} is Precipitation from type "3" entry in the i position in the list of "3" records on the "ZCH" card, at time t. Period precipitation from a gage (PP_{it}) is retrieved from the type 23 record named in the i entry on "ZCH". It is the sum of all values recorded during the compute period, but not including a value at the start of the period (this value belongs to the previous period). For example, if the compute period is 12 hours, midnight to noon; precipitation at the gage is in 6-hour amounts recorded as:

Hour	Amount (Inches)
2400	.10
0600	.20
1200	.05

Then PP_{it} from the 12-hour period midnight to noon is .25 inches.

W_i is weight of type "3" entry in the i position.

Adjustment for Snow Catch Deficiency. Period precipitation from a gage (PP_{it}) may be adjusted for snow catch deficiency by the following algorithm (this option is eliminated if no "ZH" or "CP" card is provided for the precipitation gage):

a. The elevation of the precipitation gage, the temperaure at which precipitation falls as snow (PX temperature) and the gage catch adjustment percent for snow events (GCA) are provided on the "ZH" card for the precipitation gage.

b. With the basin average temperature for time t (TA_t) and the lapse rate (L_t), the temperature at the precipitation gage is computed:

$$TA_{it} = TA_t - E_i * L_t/1000$$

If the temperature at the precipitation gage (TA_{it}) is less than the discrimination (PX_i) temperature, precipitation at the gage (PP_{it}) is multiplied by the gage catch adjustment percent (GCA_i), divided by 100.

The PX temperature is dependent on the type of air temperature being used. If air temperature (TA_t) is average for the period, a typical PX temperature is 35° F. A typical gage catch adjustment percent is 115, dependent on the type of gage, exposure, etc. A GCA value of 115 means that during snow events, the gaged water equivalent will be increased by 15% to make up for losses.

Snowband Precipitation. Field 2 of the ZC3 card provides the name of the elevation vs. precipitation percent relation for this basin. Figure D-2 shows a typical set of values for this relation. From this relation, using snowband

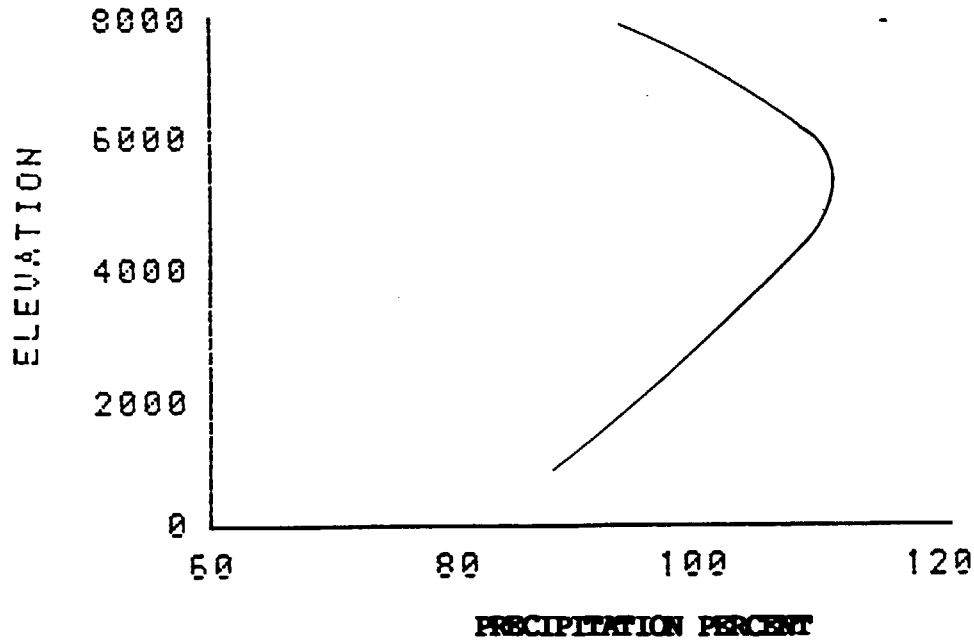


FIGURE D-2

mid-point elevation, a precipitation percent is obtained ($\%P_z$). This value multiplied times the basin average precipitation results in the snowband precipitation:

$$PP_{zt} = PP_t * \%P_z$$

where

PP_{zt} is the precipitation on the snowband for compute period ending at time t.

The elevation vs. precipitation relation may be used to express the user's knowledge or theory of this relationship.

SNOWBAND CALCULATION

A flow chart summarizing the computational process undertaken in each band in the watershed is shown on Figure D-3. Description of the separate elements in the calculation of moisture input are as follows:

Evapotranspiration. Potential Evapotranspiration (PET) is computed using Thornthwaite's formula 3/ converted to produce daily values. A temperature vs. PET relation may be used, or PET may be specified as hydromet input. Adjustments for season and latitude (as per Thornthwaite) and for elevation are also made. PET is adjusted by the factor called EKE which reduces PET on rainy days called EKE. EKE is specified in the relation of precipitation rate vs. EKE. If the snowband is snow-covered, PET is reduced by a constant adjustment, SNETF. An evapotranspiration index (ETI) is then evaluated through a relationship relating an adjustment factor, DKE, to Soil Moisture Index, SMI (DKE varies from 100% for moist conditions to low percentages for dry soil conditions. The calculation of ETI for a compute period ending at a time t for snowband z is as follows:

$$PET_{zt(1)} = ETP_t * \frac{EKE_{zt}}{100}$$ (or $PET_{zt(1)}$ may be specified as time-series data.)

then:

$$PET_{zt(2)} = PET_{zt(1)} * \frac{ETMO_t}{100} * \frac{ETEL_z}{100}$$

and, if there is snow on the snowband:

$$PET_{zt(3)} = PET_{zt(3)} * SNETF$$

finally:

$$ETI_{zt} = PET_{zt(3)} * \frac{DKE_{zt}}{100}$$

where

ETI_{zt} is evapotranspiration index for snowband z for compute period ending at time t.

PET_{zt} is potential evapotranspiration for snowband z at time t. The initial value of PET for a period may be specified as time-series data. One way to input PET is with card code "4D", with code 5 in col. 24. Whether the initial value is derived from ETP*EKE or specified, PET is then modified by the factors ETMO, ETEL, and SNETF, as shown in the relations above.

*SSARR

Moisture Input Calculation
One Snowband for One Compute Period:

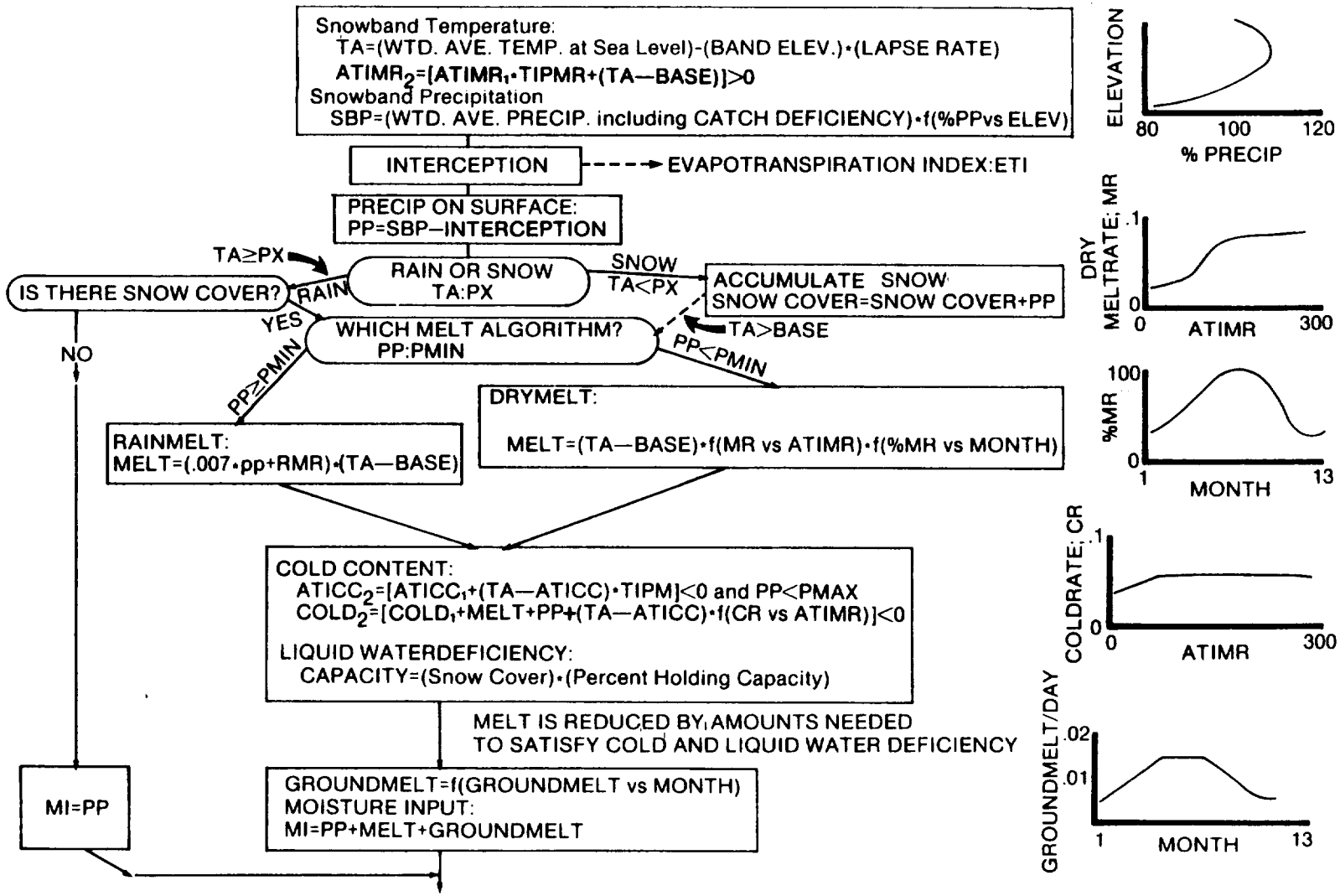


FIGURE D-3 Part 1

*SSARR

RUNOFF

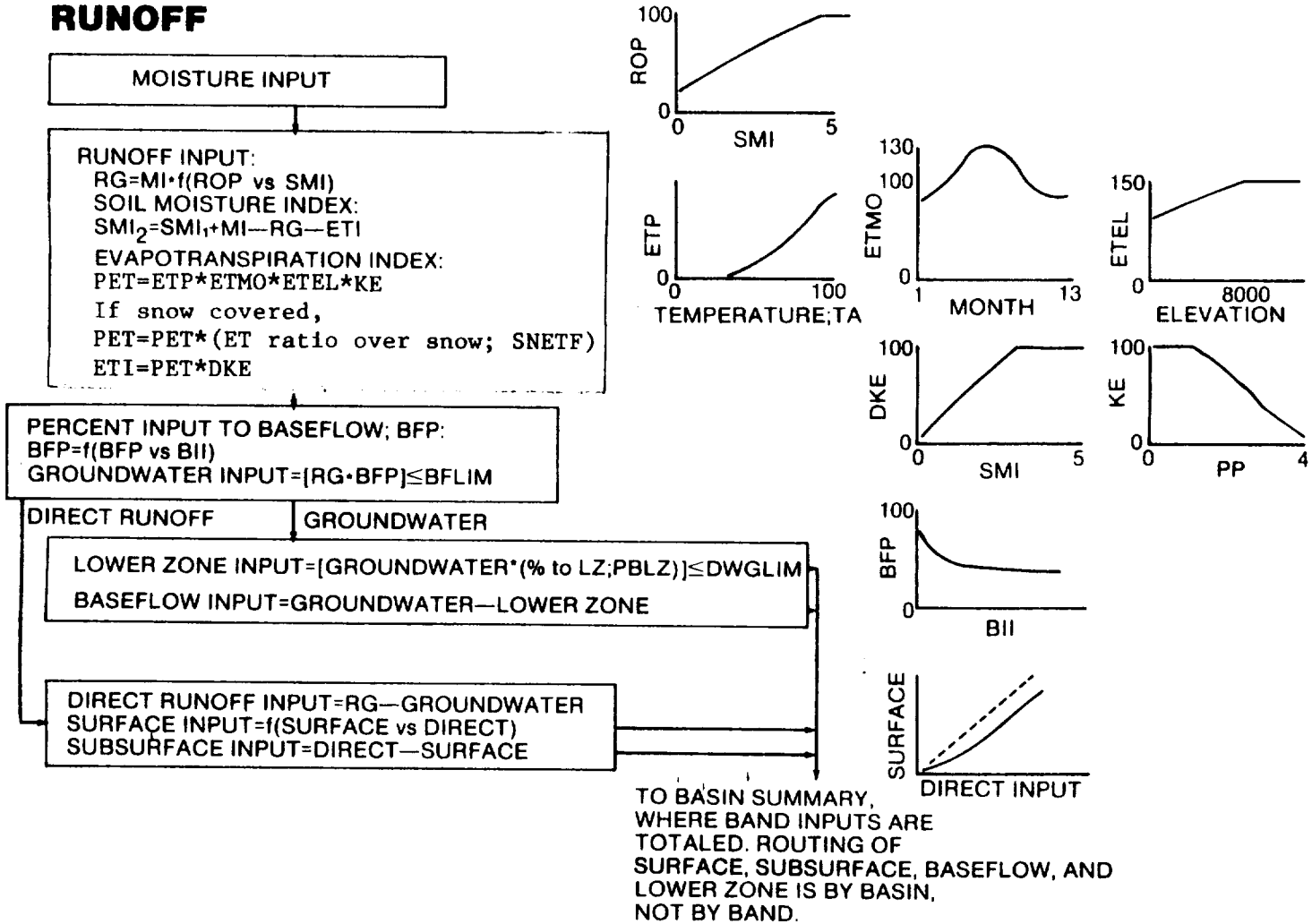


FIGURE D-3 Part 2

ETP_t is unadjusted potential ET at time t. Derived from a relation of basin temperature (TA_t) vs. ETP_t. See paragraph below titled, "Potential Evapotranspiration."

EKE_{zt} is the adjustment to PET for rainfall intensity. It is dependent on precipitation rate on the snowband, and a function of the relation named in field 5 on the ZC4 card.

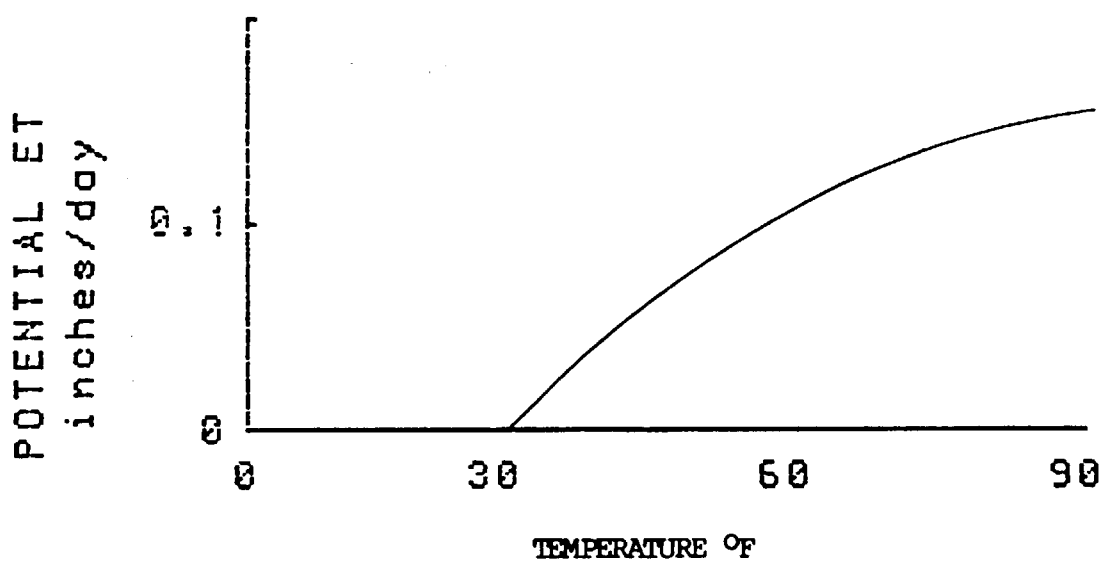
$ETMO_t$ is monthly adjustment factor from the relation named in field 8 of the ZC4 card.

$ETEL_z$ is elevation adjustment factor dependent on the snowband midpoint elevation and the relation named in field 8 of the ZC5 card.

SNETF is the raito of ETI effective if there is snow on the snowband. A typical value is 0.9 and it is entered in field 8 of the ZC3 card.

DKE_{zt} is soil moisture adjustment factor for reducing ETI when soil moisture becomes depleted. DKE_{zt} is a function of the relation named in field 7 of the ZC4 card.

Potential Evapotranspiration. In "Snow Hydrology," 2/ the Thornthwaite Method 3/ is adopted as being satisfactory and practicable with respect to data availability. For implementation of this method in the SSARR model, the equation is reduced to compute daily "unadjusted" values of potential ET as a function of temperature. This relationship is described with "CT" or "ZCT" cards and it's name appears in field 6 of the ZC4 card; see Figure D-4. The



TYPICAL RELATION OF TEMPERATURE TO POTENTIAL EVAPOTRANSPIRATION
FIGURE D-4

Thornthwaite monthly adjustment factors for possible sunshine and latitude are entered into a relation whose name appears as field 8 of the ZC4 card and is called ETMO.

Instead of the "unadjusted" values of potential ET being a function of temperature and precipitation rate, they may be provided as hydromet data by the user. The data type is "5"; values are in units of inches per day. The SSARR work file record is type 25. The type 25 record may be loaded and managed by any of the alternatives for hydromet data, which include 4D, 4E, 4P, Z4, and Z7 cards, and the "L" and "CROHMS" subcommands of "IA". The ZCH card for the snowband model will list the name of the type 25 record as data type "5".

Use of ETI Data from Depletion Model. The "Depletion Curve" watershed model defines mean monthly ET, adjusted by DKE (a function of soil moisture) and KE (a function of rainfall intensity). These same relations may be used in the "Snowband" model by setting up a relation to give ETP = 100% for all temperatures.

Use the month vs. ET relation from the depletion model to give ETMO; the DKE relation may be directly transferable; and the rainfall intensity vs. KE becomes rainfall intensity vs. EKE.

When soil moisture is adequate, DKE = 1.0, and the ETI approximates potential evapotranspiration. As the soil dries, DKE (percentage of ETI) diminishes, as illustrated in Figure D-5.

Interception. The quantitative loss of water by evaporation from vegetative surfaces is usually quite small. In heavily forested regions, however, this small quantity of water may be hydrologically significant in terms of the percentage of total annual precipitation. It is desirable, therefore, to have a simple function in the SSARR Model that simulates the interception process.

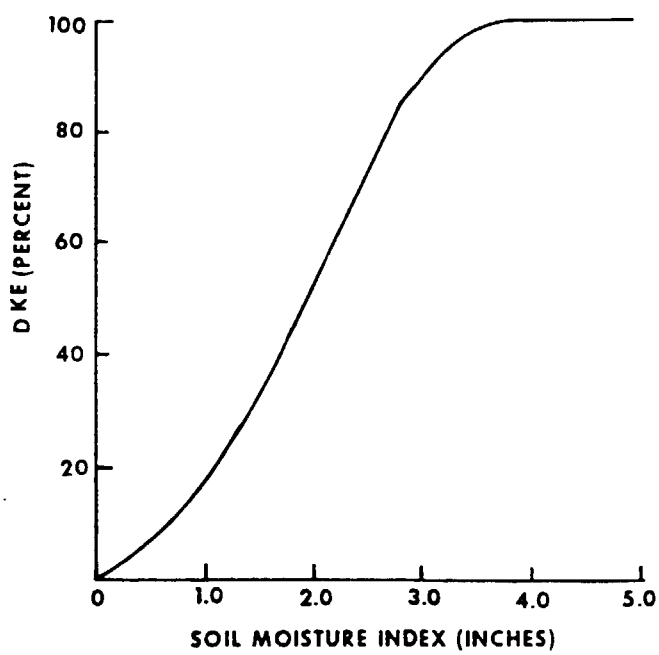


FIGURE D-5 EXAMPLE OF DKE (PERCENT EFFECTIVE ETI) vs. SMI

The user specifies a maximum interception quantity based on the type and density of vegetation present. An easy way to visualize the concept is to think of it as a "bucket" which must be filled before water can reach the snow or ground surface. The bucket is depleted by evapotranspiration.

The "bucket" capacity (TINTMX) may a be a constant, or vary as a function of month of the year. The constant or relation name is specified by field 2 of the ZC5 card. If a relation name is given, the name must include at least one alphabetic character.

A typical value is 0.2 inches. At the onset of a precipitation event, the interception storage quantity could range from 0. inches up to 0.2 inches as precipitation occurs. The difference between the interception accumulation (in the "bucket"), and the specified maximum interception capacity of 0.2 inches represents a deficit which must be satisfied before any precipitation reaches the snow or ground surface.

Snow Accumulation. The discrimination temperature (PXTEMP) is entered in field 4 of the ZC5 card. If the temperature on the snowband is less than PXTEMP, any precipitation not captured by interception adds to the snow water equivalent (SWE) on the snowband. Each snowband is treated as entirely snow-free, or evenly snow-covered.

In addition, the temperature and precipitation rate affect the snow pack cold content, discussed below under "Snow Conditioning".

Snowmelt. The snow pack on a snowband may be melted both at the snow-air interface, and the snow-ground interface. Groundmelt is accounted for by a month vs. groundmelt relation, and the resulting water enters the runoff simulation without being affected by the snow conditioning algorithm. Melt at the snow-air interface, on the other hand, must travel through the snowpack before entering the soil system and the snow pack "cold content" and "liquid water" deficits must be satisfied before any water is available to runoff.

A different calculation of snow melt at the snow-air interface is made depending upon the absence or presence of rain. The clear weather melt is calculated by the temperature index approach, where

$$M = MR\ (Ta-Tb) \qquad (1)$$

where

M = Snowmelt, inches
MR = Melt Rate Factor, a function of an antecedent temperature index
Ta = Temperature ^{o}F
Tb = Base Temperature, typically 32 ^{o}F

The seasonal variation of melt rate is indexed by an antecedent temperature function (ATI) of the following form:

$$ATIMR_2 = (Ta-Tb) + K\ (ATIMR_1) \qquad (2)$$

where

K is a "die-away" coefficient of approximately 0.98 for 24-hour calculations.

Melt during rain is distinguished from the preceding clear weather melt by a specified rainfall, on the order of 1 inch/24 hours. The followinng equation, taken from Snow Hydrology 2/, represents the general equation for snowmelt during rain for a heavily forested area:

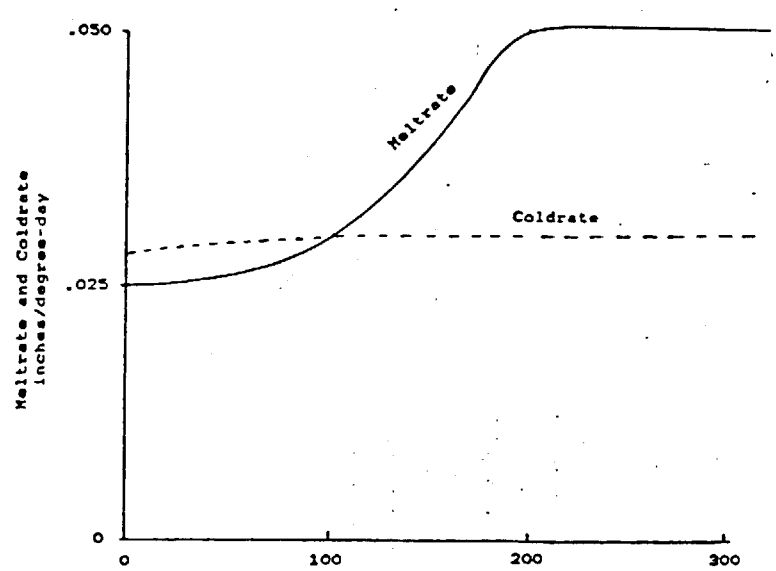
$$M = (RMR + .007\ P)(Ta-Tb) \qquad (3)$$

where

M = Snowmelt, inches
RMR = Rain melt rate, usually 0.074 inches/degree day
P = 24 hour precipitation, inches

Snowband Melt Calculation. The temperature index method requires a base temperature from which melting degree-days are calculated. The base temperature is entered in field 3 of the ZC5 card. The "melt during rain" calculation is used if the precipitation rate reaches the threshhold rate (PMIN) entered in field 5 of the ZC5 card.

If the precipitation rate does not reach PMIN, the "clear weather melt" algorithm is used. The melt rate is a function of the relation named in field 3 of the ZC3 card. The melt rate (and cold rate used by the cold content simulation) is a function of antecedent temperature index (ATI) shown by equation (2) above. The term "K", the die-away coefficient (TIPMR), is entered in field 4 of the ZC3 card. Figure D-6 shows a typical melt rate relation.



ANTECEDENT TEMPERATURE INDEX (ATIMR)

FIGURE D-6

This relation is entered on CT or ZCT cards with one independent and two dependent variables. For example, consider the following tabulation:

ATIMR	MELT RATE	COLD RATE
0	.025	.028
100	.030	.030
200	.050	.030
300	.040	.030
1000	.040	.030

The ZCT cards for this relation, if named "MRCR", are as follows:

```
ZCT, MRCR, 3, 0, .025, 0.28, 100, .03, .03
ZCT, MRCR, 200, .05, .03, 300, .04, .03, 1000, .04, .03
```

When the precipiation rate equals or exceeds PMIN, equation (3) is used to calculate melt. The rain melt (RMR) is entered in field 6 of the ZC3 card. The default value for RMR is 0.074 inches per degree-day.

Adjustment to Dry Melt Rate By Season. A relation may be named in field 2 of the ZC6 card which provides the dependent variable "percent effectiveness of dry melt rate" as a function of the month. The dry melt rate is derived as a function of antecendent temperature index (that is, an accumulation of melting degree days with a damping factor). When the average of maximum and minimum daily temperatures, or daily maximum temperature alone is used, the degree-day index values in the winter may not have the same melting affect as the same values in the spring because of differences in the length of the days and number of hours per day the air remains at the index temperature, even though the accumulation of preceding degree days is the same. Therefore, the capability is provided to adjust the melt rate by month regardless of antecedent conditions.

The option of varying melt rate as a function of season may not be needed in most modelling applications. The variation of melt rate as a function of accumulated melting degree-days (ATIMR vs. Melt Rate algorithm) often adequately simulates the variation of melt rate on a year-around basis without seasonal adjustment. The option was added for compatability with the NWS/RFS snowmelt calculation, which varied the melt rate only on a seasonal basis.

Limitation on Snow Melt Rate. The model assumes that an individual snowband is either entirely snow-free or snow-covered. As the melt season progresses, the basin snow covered area diminishes. The model simulation of the receding snowline jumps a snowband at a time as each band goes bare. During periods of high melt rates, the effect of a relatively large proportion of the snow covered area going bare with the resulting drop in input to runoff can cause a discontinuinity in the computed hydrograph.

The technique chosen to delay the melt of last remaining snow on a band is to limit the rate of melt. This is accomplished by the constants WEMIN, WEPCT, and WEMAX in fields 9, 10, and 11 of the ZC5 card.

a. When the snow water equivalent (SWE) of a snowband drops below WEMIN, then the snow melt rate is limited.

b. If limited, the amount of melt in a compute period is limited to WEPCT per day of the SWE on the snowband at the beginning of the period.

c. When the SWE gets as low as WEMAX, then the limitation is removed because no delay of this small amount is required.

For example, let WEMIN be 2 inches, WEPCT be 60% and WEMAX be 0.4 inches. With 24-hour compute periods, a constant melt rate of 0.1 inches per hour, and initial SWE is as follows:

Day	SWE	Computed Melt Limited to 60% SWE	End of Period SWE	If Melt Not Restricted Ending SWE
1	4.3	2.4 (no limit, SWE≥WEMIN)	1.9	1.9
2	1.9	1.1	.8	.0
3	.8	.5	.3	
4	.3	.3 (no limit, SWE≤WEMAX)	.0	

In this example, the melt of the last 2 inches of snow off the snowband was spread out over two additional days to simulate the natural delay to the last pockets of snow on a snowband representing a drainage area containing a variety of aspects, vegetation, and soil types as well as covering a range of elevations.

Snow Conditioning. The snowpack conditioning routine accounts for the "cold content" and liquid water deficiency of the snowpack which must be satisified before liquid water can enter the soil system. The formulation utilized essentially follows that used by Anderson 1/ for the NWS model. Cold content is calculated as a function of an antecendent index, ATICC:

$$ATICC_2 = ATICC_1 + TIPM(Ta_2 - ATICC_1) \qquad (4)$$

where

ATICC Index to the Snow Surface Temperature
TIPM Factor which considers the depth of cooling

If the precipitation rate reaches the ATICC input threshhold (PMAX), ATICC is set to the temperature of the precipitation, or base temperature (whichever is lower). PMAX is entered in field 6 of the ZC5 card.

Cold content is then calculated by:

$$CC = (Ta_2 - ATICC_1)\ Cr \qquad (D-5)$$

where

CC Cold Content, inches of water required to raise the snowpack to 0°C.

Cr Cold rate, a function of ATIMR.

Successive period quantities of cold contents are accumulated while air temperature is below the base temperature and depleted by the presence of liquid water from snowmelt or rainfall.

Liquid water deficiency is accounted for by specifying percent liquid water holding capacity, taken as a constant on the order of 2-5% of the water equivalent of the snowpack. This capacity must be exceeded before rain or snowmelt is available for input to the soil. The constant liquid water holding capacity percent is specified in field 7 of the ZC3 card.

Groundmelt. Snowmelt resulting from the conduction of heat from the ground is accounted for by specifying either a constant melt rate on the order of .001 to .05 inches/day, or the name of relation giving daily melt rate as a function of months; in field 7 of the ZC5 card. (The name of the relation must include at least one alphabetic letter).

Soil Moisture - Runoff Simulation

Water escaping from the snowpack or rain falling on a snow-free snowband must either (a) runoff, (b) be retained in the soil system, (c) return to the atmosphere by evapotranspiration, or (d) percolate into the ground water system and thereby be lost to the surface water system. If Item (d) is considered negligible, the moisture input may be divided into:

(1) Runoff
(2) Soil moisture increases
(3) Evapotranspiration losses

Runoff. The percent of total moisture input available for runoff is found from empirically derived relationships of soil moisture index (SMI) versus runoff percent (ROP). If desired, rainfall intensity (inches per hour) may be included as a third variable in the SMI-ROP relationship. The SMI relationship is entered into the program in the form of a relation named in field 2 of the ZC4 card. Figure D-7 illustrates typical SMI relationships with and without the precipitation intensity parameter.

The total generated runoff for a period (RGP) is computed as follows:

$$RGP = ROP * MI$$

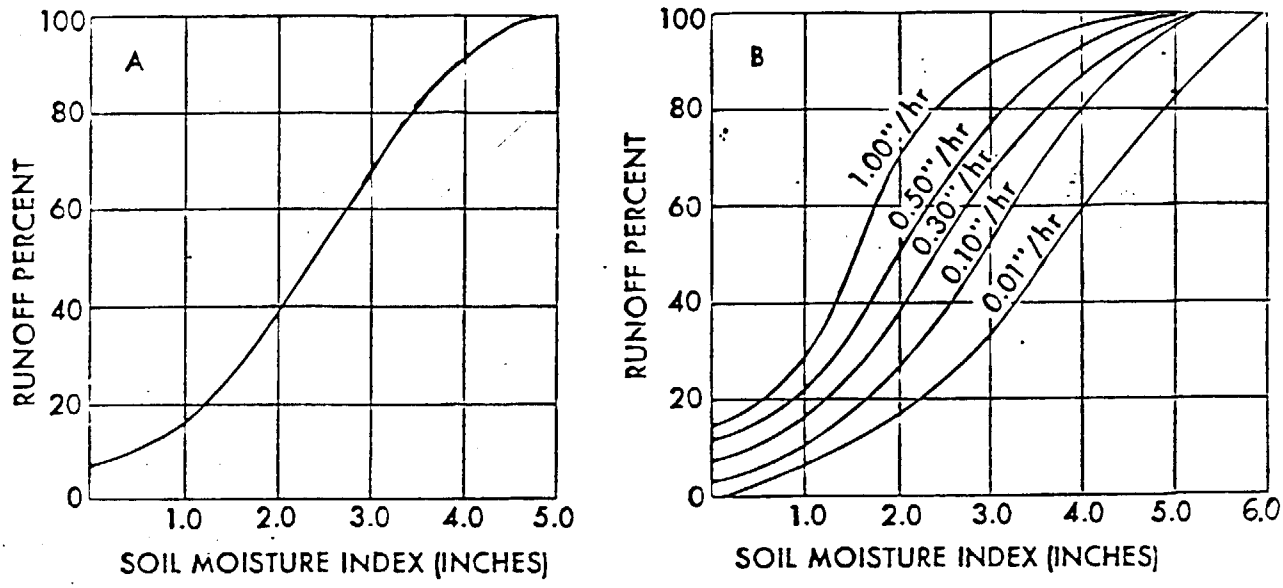
where

RGP = Generated runoff for the period, in inches

ROP = Runoff percent (from SMI table)

MI = Moisture input from snow pack or precipitation for the period, in inches.

The partitioning of RGP into the components of surface, subsurface, and base flow runoff is described in subsequent sections.



A. SMI vs. RUNOFF PERCENT

B. SMI vs. PRECIPITATION INTENSITY AND RUNOFF PERCENT

SOIL MOISTURE INDEX (SMI)

FIGURE D-7

Soil Moisture - Evapotranspiration Relationships. The soil moisture index (SMI) is an indicator of the relative soil wetness and is used to determine runoff. When the soil moisture is depleted to approximately the permanent wilting point, the SMI is a small number which yields little or no runoff. When precipitation recharges soil moisture, the value of the SMI increases until it reaches a maximum value considered to represent its field capacity or water holding capacity. At this value, the runoff percent would approach 100 percent. The SMI is depleted only by the evapotranspiration index (ETI).

SMI is calculated as follows:

$$SMI_2 = SMI_1 + (MI-RGP) - \frac{PH * ETI}{24}$$

where

SMI_1	Soil Moisture Index (in inches) at beginning of period
SMI_2	Soil Moisture Index (in inches) at end of period
PH	Compute Period Length in hours
ETI	Evapotranspiration Index, in inches per day

Base Flow. The portion of runoff that contributes to base flow is a function of the base flow infiltration index (BII). Base flow infiltration index may be thought of as an index of depression storage, which holds runoff available for deep percolation. The base flow components are computed as the product of Base Flow Percent (BFP) and Runoff Rate (RG). The BII versus base flow percent (BFP) table may have a third element, a base flow input limit, which is specified in inches per hour. With this option, each tabled value of BII must have a corresponding BFP value and a base flow input limit value. This table is named in field 3 of the ZC4 card.

The base flow infiltration index is computed for each period as follows:

$$BII_2 = BII_1 + (24^* RG - BII_1) \frac{PH}{BIITS + PH/2}$$

If BII_2 is greater than BIIMX, set BII_2 to BIIMX.

where

BII_1 Base Flow Infiltration Index (in inches per 24 hours) at beginning of period.

BII_2 Base Flow Infiltration Index (in inches per 24 hours) at end of period.

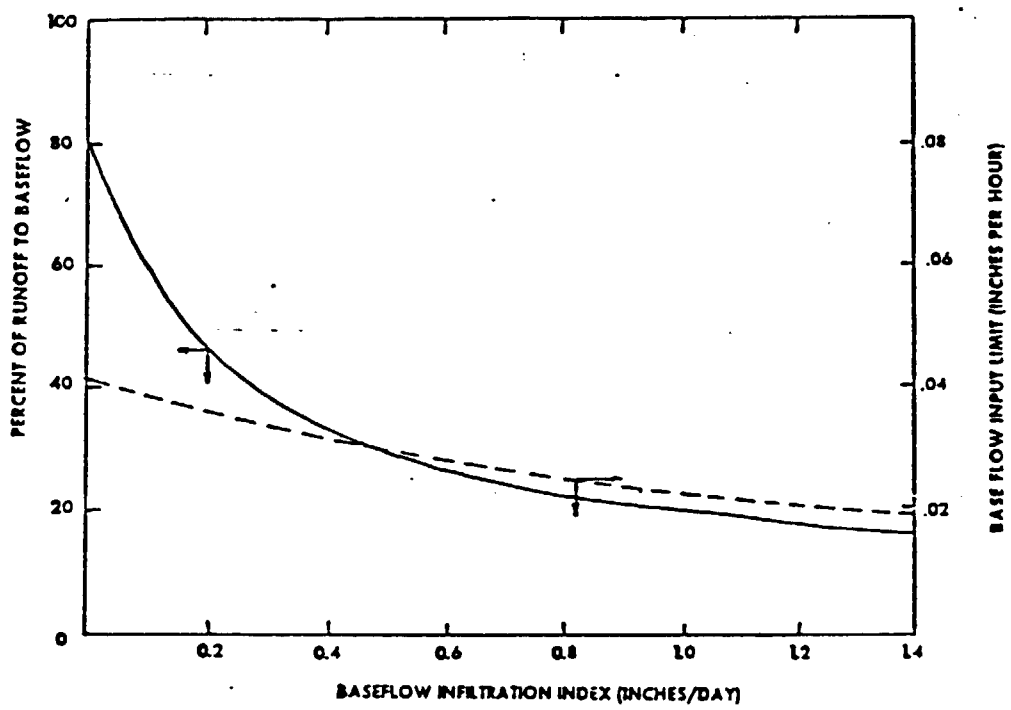


FIGURE D-8 TYPICAL BASE FLOW INFILTRATION INDEX FUNCTION WITH CORRESPONDING BASE FLOW INPUT LIMIT

RG RGP/PH = Runoff rate in inches per hour.

BIITS Time delay or time of storage, for calculation of change in BII. Typical values range from 30 to 60 hours. Constant in field 12 of ZC2 card.

BIIMX Maximum value for BII; specified as constant in field 13 of ZC2 card.

The total base flow input rate is a function of BII:

TBF = BFP * RG

If TBF is greather than BFLIM, set TBF to BFLIM.

where

TBF is the input rate, inches per hour, to the Baseflow and Lower zone routing components.

BFP is total baseflow percent; a function of BII via the relation named in field 3 of ZC4 card.

RG is Runoff rate.

BFLIM may be a constant from field 14 of ZC2 card. If the BII vs. BFP relations (field 3, ZC4) contains BFLIM as the second dependent variable, the constant in ZC2 field 14 is ignored and values from the relation are used.

The BFLIM rate can be somewhat dependent on the length of the compute period. Short compute periods such as 1 hour, 3 hours, or 6 hours, may generate some relatively high hourly rates of input from normal melt and precipitation events in the higher latitudes; while daily (24 hour) compute periods tend to keep the intensity levels lower due to averaging the storms over a longer peiod. A typical value for BFLIM for daily calculations is .05 inches per hours. This may be too low for a model running 6 hour compute periods.

Lower Zone Flow. The baseflow components of runoff are a longer term part called "lower zone" and a shorter term part called "baseflow." The separation of input to these two components is by percentage in field 15 (PBLZ) of the ZC2 card:

LZ = TBF * PBLZ

If LZ is greater than DGWLIM, then set LZ to DGWLIM.

where

LZ is input rate in inches per hour to lower zone routing components.

TBF is total baseflow plus lower zone input rate.

PBLZ is percentage of total baseflow to input to lower zone routing. A typical value is 50%.

DGWLIM is maximum input rate to lower zone routing, a constant from field 16 of ZC2. The effect of this variable has not been investigated; if DGWLIM equals BFLIM, it is effectively removed from consideration.

This component gives the watershed model the capability of reproducing the late summer, fall and winter groundwater recession. This represents a sizeable quantity in much of the Pacific Northwest. It averaged about three inches of runoff for the September-March period in the 5,000 square mile Kootenai sub-basin. Tests showed that two routing phases at 2,000 hours per phase was satisfactory.

Baseflow Flow. Input to the baseflow component of routing is the remainder of the total base flow input (TBF):

$$BF = TBF - LZ$$

where

BF is input to baseflow routing, in inches per hour.

Surface and Subsurface Runoff Components. The input to surface and subsurface runoff (RGS) is computed as follows:

$$RGS = RG = TBF$$

Surface - Subsurface Flow Separation. A table of surface runoff input (RS) versus total input to surface and subsurface runoff (RGS) is specified in field 4 of the ZC4 card. An example of surface - subsurface separation is illustrated in Figure D-9.

Any relationship may be specified in the table, but the separation commonly used is based on the following assumptions:

a. The minimum surface component (RS) is 10% of the total generated runoff (RGS).

b. The subsurface flow component reaches a maximum (KSS) and remains constant for input rates (RGS) above 200% of KSS.

c. Values commonly used are determined from the following equation:

$$RS = 0.1 + 0.2\ (RGS/KSS)\ RGS$$

and

If RS > KSS, then make RSS = KSS

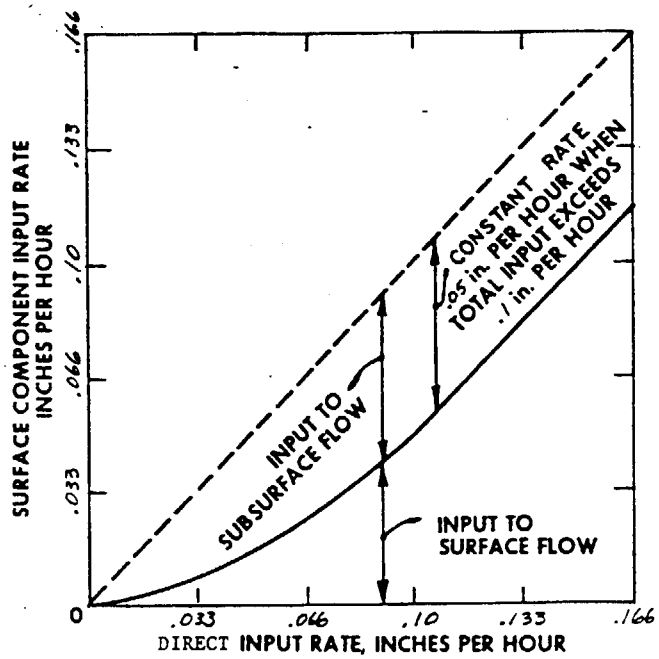


FIGURE D-9 SURFACE - SUBSURFACE SEPARATION CURVE

where

RS	Surface component input rate (inches per hour)
RSS	Subsurface components input rate (inches per hour)
RGS	Total input rate to surface and subsurface components, (inches per hour)
KSS	Maximum subsurface input rate (inches per hour)

Routing of Surface, Subsurface, Base Flow and Lower Zone. Each component of runoff excess is computed as an input rate, expressed in inches per hour. Each period value is converted to the equivalent inflow rate, in cubic feet per second, based on the drainage area of each snowband. Once the individual snowbands have all be processed through the entire range of compute periods, the results are summarized to arrive at basin values of input to surface, subsurface, baseflow, and lower zone routing components for each compute period.

Each component is routed through the specified number of increments of storage. These increments can be considered as a series of small lakes which delay runoff.

The modification of the inflow to represent the shape of the outflow hydrograph is determined by the specified number of increments, or routing phases, and time of storage per increment. Routing is accomplished by solution of the basic storage equation in finite time periods for each increment of storage routing. The moisutre input rate for a routing component is converted to average cfs for inflow to watershed routing.

The routing algorithm is different than that used in the "Depletion-Curve" model if time-of-storage is made a function of discharge. In the "Integrated-Snowband" model, the outflow of each phase at the beginning of the compute period is used to look up the time-of-storage for that phase for that compute period.

Generally, from two to five increments are used in typical drainage basins. The "time of storage" per increment can be from a few hours to a month or more. The routing specifications determine the time delay to the outflow of the watershed and the shape of the outflow hydrograph. Typical routing specifications for the four components of flow for a 208-square mile watershed in the Willamette River Basin, Oregon, are listed below:

Component Runoff	No. of Phases	Time of Storage per Phase (Hrs)
Surface	4	2.5
Subsurface	3	11.0
Baseflow	2	200.0
Lower Zone	2	2000.0

Virtually unlimited flexibility in time distribution of runoff can be achieved by the incremental storage routing technique. Examples of several unit hydrographs derived by this method are shown in Figure D-10.

Time of storage may be a function of flow instead of a constant. Words 5, 7, 9, and 11 of the ZC2 card may be names of relations instead of constants. The relation of flow vs. time-of-storage hours is read into SSARR via the CT or ZCT card formats. This capability can be useful when non-linear routing of a component of basin runoff is required.

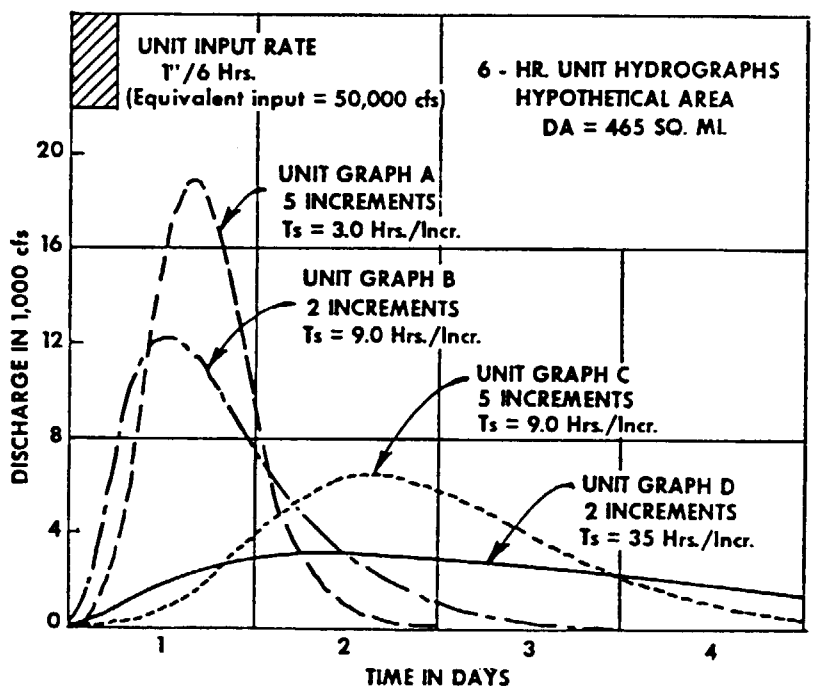


FIGURE D-10 HYPOTHETICAL UNIT HYDROGRAPH DERIVED BY INCREMENTAL STORAGE ROUTING

Individual Snowband Printout. These results may be printed, one line per compute period. The "ZR" card tells which bands to list. The values under the headings have the following meaning:

BASIN	Station name from ZC and P (Configure) cards.
ZONE	Band number within basin. Band 1 is the lowest elevation.
MM-YY	Month and year of first line of results.
AREA	Area of this band in square miles.
ELEV	Elevation of mid-point in band.
PP%	Percent of precipitation applied to this band.
TINTMX	Tree-interception maximum, inches.
MO	Month
DAY	Day
HR	Hour in tenths. (MO-DAY-HR are of the end of the compute period).
PCPN	Weighted precipitation on this band, inches.
INT	Precipitation lost to tree interception, inches.
WE	Water equivalent of snow accumulation, inches.
ATI	Cold Content ATI, degree-days (ATICC).
CC	Cold Content accumulation, inches
LIQD	Snow liquid water deficit, inches (SLIQWD).
TA	Average air temperature over band.
ATI	Melt rate ATI, degree-days (ATIMR).
MR	Melt rate, inches per degree-day (SMR).
MELT	Period melt from either rain-melt or dry-melt calculation, inches (TWATR).
MI	Moisture input, inches (WATER)
PET	Potential evapotranspiration rate, inches per day.
ET	Evapotranspiration rate, inches per day.
SMI	Soil moisture index, inches.
ROP	Runoff percent.
RO	Runoff generated, inches (RG).
BII	Baseflow infiltration index, inches per day.
BFP	Baseflow percent.
SFRO	Input to surface runoff, inches.
SSRO	Input to subsurface, inches.
BFRO	Input to baseflow, inches.
LZRO	Input to lower zone, inches.
ZONE	Snowband number.
F	Zone calculation flag. See "FLAGS BY ZONE" on page D-27.

TOTALS: Column totals are made at month-end and end-of-time. The column totals of PET and ET are inches.

NOTE: The names in parenthesis are the variable names which appear in the flow chart, figure D-3 on page D-10, D-11.

Integrated-Snowband Summary Printout. Composite snowband basin results are printed one line per compute period. This report is always made unless supressed by the "ZR S" card. The first line at the top of each page is the station number and description from the "ZC1" card. The values under the headings have the following meanings:

AREA	Total basin area in square miles.
BASE-TEMP	Base temperature, degrees Fahrenhiet.
ZONES	Number of snowbands basin is divided into.
DA HR	Day and hour (in tenths) of end of compute period.
PCPN	Period precipitation, basin average inches.
INT	Loss to tree interception, basin average inches.
SNOWLINE	Mid-point elevation of lowest band with non-zero WE.
WE	Water equivalent of snow accumulation, basin average inches.
LR	Temperature lapse rate, degrees/1000 ft.
TA	Average temperature at sea level, degrees.
MR	Average melt rate on bands with snow, inches per degree-day.
RG	Runoff generated, basin average inches.
ET	Evapotranspiration rate, inches per day.
ROP	Basin average runoff percent.
BFP	Basin average baseflow percent.
SURF	Discharge from surface component, cfs.
SUBSF	Discharge from subsurface component, cfs.
BASEF	Discharge from baseflow component, cfs.
LOWERZ	Discharge from lower-zone component, cfs.
TOTAL	Total basin discharge at end of compute period, cfs.
OBS	Observed basin discharge.
FLAGS BY ZONE	Certain conditions in each snowband calculation set flags as follows:

A: Snow accumulation
C: No runoff because of cold content calculation.
D: Dry melt calculations.
L: Dry melt calculation restricted by minimum band WE (WEMIN).
Q: No runoff because of snow liquid water deficiency.
R: Rain melt calculation.
S: Snow on band, no precipitation, TA less than rain freeze temperature.

TOTALS:	Column totals are made at month-end and end-of-time. The column totals are all basin average inches.
MELT	Total melt from rain melt and dry melt.
MI	Total moisture input.
PET	Total potential evapotranspiration.
LIQ-D	Total snow liquid water deficiency.
G-MLT	Total groundmelt.

Example of Snowband Model

This model is a portion of the Libby Reservoir (Montana) inflow simulation. It demonstrates several features of the SSARR program, including the snowband model.

- "ZC" cards are required for Snowband characteristics.
- Alpha and numeric names of stations and tables.
- "ZH" card is equivalent to "CP" for elevation of temperature station.
- "ZCT" card is equivalent to "CT" for relations.
- "Z2" is required for snowband initial conditions.
- "Z4" card is equivalent to "4D" card for hydromet time-series input.
- "ZR,L,7" causes snowband 7 calculation results to be printed.
- "PZ" plot control cards are demonstrated for plotting basin and snowband results.
- The synthetic reservoir (station "ACCUMERR") is included to accumulate the difference between computed basin discharge and observed basin discharge. A discussion of this technique may be found with Figure C-18 in Appendix C.

See Figure D-12 for the complete listing of input, and the four plates of Figure D-13 for the results. Figure D-11 shows the model configuration.

Figure D-13 Plate 1 is the printout of snowband 7 calculation results.

Figure D-13 Plate 2 is the summary printout of watershed results. The results from the 10 snowbands have been accumulated to get basin average values. The last tabulated column on the right labeled "OBS" is the observed discharge specified by card code "6" cards for station "00000101", as requested by the ZC6 card of the characteristics.

Figures D-13 Plates 3 and 4 demonstrate a number of new features in the printer-plot program:

- The two columns of tabulated values on the left are the first two plot codes from the commands for this chart.

- Snowband model summary results are plotted. Some "Depletion Curve" watershed model results may also be plotted, as noted in Appendix B, Page 71.

- Snowband individual band results are plotted.

Detailed Calculation of Example. Refer to plate 1 of Figure D-13. This is the listing of calculation results from snowband number 7. In the heading of the report are the following:

BASIN WARDNER	Basin name
ZONE 7	Number of the snowband for which results are listed in this tabulation.
MM-YY 8 70	Month (August) and year (1970) of the first line in the tabulation.

AREA
625.8 Drainage area in square miles of this snowband.

ELEV
6900. Elevation of the mid-point of this snowband.

PP%
95.5 Precipitation percent. This percent is multiplied with basin average precipitation to arrive at the average precipitation falling on snowband 7. The percent is a function of snowband 7 mid-point elevation, and the elevation-vs.-precipitation relation (word 2 of ZC3 card).

TINTMX
0.15 Maximum interception capacity (word 2 of ZC5 card).

In the body of the tabulation, the first line of results shows the initial conditions as of 2400, 31 August 1970. The second line is the results of the calculations for the first 24-hour compute periods, as follows:

MO DAY HR
9 1 240 Month (September), day, and hour (in tenths of hours) of the end of the compute period.

PCPN
0.12 Inches of precipitation which fell on this snowband during the first compute period.

INT
0.12 Inches intercepted (leaving no precipitation to reach the ground)

Since the remainder of this line of values are the result of no moisture input, skip down now to the period ending 23 September:

MO DAY HR
9 23 240 September 23, hour 24

PCPN
0.15 Precipitation on snowband 7 in the 24-hour period after (but not including) hour 24 of 22 September, and through hour 24 of 23 September.

INT
0.03 Interception. The previous compute period had precipitation greater than interception capacity so the only interception that can occur during the current perriod is to fill the space made by PET. The interception "bucket" is filled by precipitation, and emptied in the amount of Potential Evapotranspiration, PET. The previous period ending at midnight 22 September had PET value of .03 inches.

WE
0.19

Water Equivalent of snow accumulated on the snowband. The temperature (30.2) during this period is below the base temperature (35) so precipitation that was not intercepted (0.15 - 0.03 = 0.12 inches) will add to the accumulation of snow:

WE	
0.08	September 22.
+.12	Precipitation not intercepted.
-.011	Groundmelt September 23.
0.19	September 23.

ATI
30

Antecedent Temperature Index (ATI) of the Cold Content of the snow pack. It is a function of the ATICC at the beginning of the period (35), the temperature (30.2), and the factor which considers the depth of cooling (0.84, from word 5 of the ZC3 card):

$ATICC_2 = ATICC_1 + TIPM\ (Ta - ATICC_1)$
$30.97 = 35 + 0.84\ (30.2 - 35)$
(truncated to 30 by the printing program)

CC
-0.1

Accumulated Cold Content (CC) is a function of the difference between snowband temperature and ATICC (the ATI column to the left in this printout). It is also a function of the cold-rate. Cold-rate and melt-rate are functions of ATIMR (the ATI column to the right of CC in this printout). In the table "MRCR" in the data list (Figure 12, part 1), low values of ATIMR correspond to meltrate of 0.01 and coldrate of 0.015 inches per degree-day. The coldrate is a function of the ATIMR value at the end of the compute period. The calculation to update Cold Content is based on the value of ATICC at the beginning of the computer period:

$CC_2 = CC_1 + (TA - ATICC_1) * Cr$
$-.07 = 0 + (30.2-35) * 0.015$

LIQD
0.0

Liquid Water Deficit. The liquid water holding capacity of the snowpack is calculated as the product of "PLWHC" (word 7 of ZC3 card) and WE (snow water equivalent). The calculation is made before WE is reduced by groundmelt. Groundmelt is not effected by cold content or liquid water deficit, nor does groundmelt satisfy either of these snowpack conditioning factors because they represent conditions at the snow-air interface.

TA
30.2

Temperature over the snowband. Basin average temperature at zero elevation and the lapse rate are used to calculate the temperature at the snowband mid-point elevation (6900). See plate 2 of Figure D-13 for basin temperature (53 degrees):

$TA = T - Elevation * Lapse\ Rate$
$30.23 = 53 - 6900 * 3.3/1000$

ATI
0 Antecedent Temperature Index for Melt Rate (ATI). This degree-day accumulation of melting temperatures is a function of a "die-away" coefficient named "TIPMR" (word 4 of ZC3 card), and the base temperature (word 3 of ZC5 card):

$ATIMR_2 = (Ta - Base) + TIPMR^{DAYS} * ATIMR_1$
(the period ending September 28 is a non-zero example)
$11.3 = (41.4 - 35) + .98^{1.0} * 5$

Since the temperature is below Base temperature, there is no melt at the snow-air interface. There is, however, groundmelt. The 0.011 moisture input on September 23 is groundmelt from the bottom of the accumulated snow pack. It is determined from the relation named "GMLT" specified in word 7 of the ZC5 card. The table "GMLT" (Figure D-13) shows groundmelt values of .013 inches per day on the 1st of September and .010 on the 1st of October. Interpolation to September 23 gives the value .011.

Refer now to the period ending 27 September at hour 24. There is no precipitation during this period so the "drymelt" algorithm is used to compute snowmelt.

At the beginning of the period (September 26), snow water equivalent is 0.16 inches, ATICC is 34 degrees, cold content is -0.1 inches, and ATIMR is 0. Temperature for the day of September 27 is 39.7 degrees. The values for the 27th are computed as follows:

Calculate new ATIMR:

$ATIMR_2 = (TA - base) + ATIMR_1 * TIPMR^{DAYS}$

$5 = (39.7 - 35) + 0 * 0.98$

Look-up meltrate and coldrate with new ATIMR:

Table "MRCR" argument is ATIMR=5. Interpolating:

$MR = .01 + (.02 - .01) * 5/80$
$MR = .0106$ (meltrate)

Coldrate is .015

Calculate MELT:

$MELT = MR * (TA - base)$
$.050 = .0106 * (39.7 - 35)$

Calculate new ATICC:

$ATICC_2 = ATICC_1 + (TA - ATICC_1) * TIPM^{1/DAYS}$

35; maximum value is base temperature. Calculation results in:
$38 = 34 + (39.7 - 34) * 0.84$

Update Cold Content: (TA > base, so CC is updated with melt+rain)

$$CC_2 = CC_1 + MELT + (PCPN - INT)$$

$$= -0.1 + .050 + (0 - 0)$$

No MELT is left over to reach the soil after satisfying Cold Content. Therefore, a "C" is printed in the F(flag) column at the far right edge of the report.

If any MELT had been left, the next test would be to satisfy the liquid water deficit of the snowpack. The liquid water holding capacity (LIQMX) is calculated as a constant (PLWHC, with a value of 4%, coded as .04 in this example) times WE at the beginning of the compute period.

$$LIQMX = PLWHC * WE$$
$$.006 = .04 * 0.16$$

Liquid water in the snowpack (LIQW) is accumulated from precipitation and melt (not including ground-melt) left over after satisfying Cold Content (see above).

The results for the 28th of September will be used to describe the calculations for separation of moisture input (MI) into soil storage, evapotranspiration, and the four components of runoff:

MI
0.051 — Moisture Input is the rainfall and snowmelt reaching the soil surface during this compute period.

PET
0.05 — Potential Evapotranspiration is the combination of several factors:

ETP = .05, a function of band temperature (41.4) and table "ETP".

EKE = 100%, a function of PCPN (0) and table "EKE".

ETMO = 95%, a function of month (9.9) and table "ETMO".

ETEL = 141%, a function of band elevation (6900) and table "ETEL".

SNETF = .9, a constant from word 8 of ZC3 card.

PET = ETP * EKE * ETMO * ETEL * SNETF

ET
0.05

Evapotranspiration loss from the soil is the Potential ET adjusted for soil wetness:

DKE = 85.2%, a function of SMI at the beginning of the compute period (1.88) and the table "DKE".

ET = PET * DKE

SMI
1.86

Soil Moisture Index is the accumulation of soil recharge. It is depleted by evapotranspiration. Moisture Input (MI) is split into runoff (RO) and soil recharge by the SMI vs. ROP table. SMI at the beginning of the period (1.88) and table "SMI" result in a runoff percent (ROP) of 48%. Moisture Input multiplied by (1-ROP) yields soil recharge.

```
                MI     ROP    ET
SMI = 1.88 + .051*(1-.48) - .05
```

ROP
48.

Runoff Percent is a function of SMI at the beginning of the compute period (1.88) and the table "SMI".

RO
0.024

Runoff is the product of MI (.051) and ROP (48%).

Runoff is separated into the four components named surface, subsurface, baseflow, and lower zone.

BII
0.02

Baseflow infiltration Index is the argument for retrieving the Baseflow Percent (BFP) from the BII vs. BFP table. The BII is a function of a single phase of storage-type routing of Runoff (RO).

```
     BII      RO   BII    HR   BIITS HR
BII = .01 + (.024 - .01) * 24/( 36 + 24/2)
```

where BII to the right of the equal sign is BII at the beginning of the period, HR is hours per period (24), and BIITS is constant from field 12 of the ZC2 card.

BFP
88

Baseflow Percent is a function of BII at the beginning of the compute period (.01) and the table "BII". This percentage is used to split runoff (RO) between direct components and baseflow components.

SFRO
0.001

Surface Runoff is the input to surface routing. The surface portion of runoff (RO) is determined by multiplying RO by (100-BFP)/100. This portion is further split by retrieving the surface routing input rate from table "SSS".

Calling the surface portion "SST", then:

```
       RO          BFP    HR
SST = .024 * (1. - .88) / 24     (an hourly rate)
```

SST may be more than this if the combination of RO*BFP exceeds the baseflow input rate limit (BFLIM). See BFRO (below).

SFRO is retrieved from table "SSS" with SST as argument. The result is multiplied by 24 (HR) to make the printout units of measure be inches per compute period.

SSRO
0.002

Subsurface Runoff is the input to subsurface routing.

SSRO = SST*24 - SFRO

BFRO
0.011

Baseflow Runoff is the input to baseflow routing. The baseflow portion of runoff (RO) is determined by multiplying RO by BFP. This portion is split into input to baseflow routing (BFRO) and input to lower zone routing (LZRO) by the lower zone percent (PBLZ) from field 15 of the ZC2 card.

Calling the baseflow portion of runoff "TBF":

```
       RO   BFP   HR
TBF = .024 * .88 / 24 = .00088 inches/hour
```

The maximum value of TBF is BFLIM. BFLIM may be a constant from field 14 of the ZC2 card, or a dependent variable in the BII vs. BFP,BFLIM table. This example has BFLIM in the BII table. A BII value of 0.1 corresponds to a BFLIM rate of .047 inches/hour.

If TBF>BFLIM, TBF is set equal to BFLIM and the excess runoff is shifted to the surface portion (SST).

```
       RO          PBLZ
BFRO = .024 * (100 - 50)/100
```

BFRO may be more than this if LZRO (below) exceeds the lower zone input rate limit (DGWLIM). See LZRO (below).

LZRO
0.011

Lower Zone Runoff is the input to lower zone routing. It is determined by multiplying the baseflow portion (TBF) by the lower zone percent (PBLZ):

```
                          TBF     PBLZ
LZRO (as a rate) = .00088 * .50
```

The maximum value of LZRO is DGWLIM (0.0504) from field 16 of the ZC2 card. If LZRO>DGWLIM, LZRO is set equal to DGWLIM and the excess is added to BFRO.

LZRO is multiplied by the hours per compute period (24) for the printout.

ZONE
7

Snowband number for which this report was made.

F
D

Code "D" indicates that snow on the band was melting, and the "Drymelt" algorithm was in control. Melt was not impeded by cold content (flag "C"), liquid water deficiency ("Q"), or the minimum snowpack meltrate limit ("L"). If precipitation had exceeded the limit (PMIN, field 5 of the ZC5 card), the rain-melt algorithm would have been used, and the flag would be "R". Flag "A" indicates precipitation with temperature on the band less than base temperature causing accumulation. Flag "S" indicates no precipitation on an existing snowpack and temperature below base temperature. If the flag field is blank, there is no snow on the band.

Plate 2 of Figure D-13; Integrated-Snowband Summary Printout. After all snowbands have been processed, the individual band results are added up to get basin total values for each compute period. Routing of the four components of runoff is then accomplished, and the Summary printout is made, as shown in plate 2 of Figure 13.

In the heading of the report are the following:

SSARR SNOWBAND MODEL - WARDNER (FT. STEELE+BULL R.)

The portion following the dash (- WARDNER...) is from the card code J card.

WARDNER WARDNER COMPUTED

The first "WARDNER" is the snowband basin name. "WARDNER COMPUTED" is station description from the ZC1 card.

AUG-1970

Month and year of the first line of the body of the report.

AREA
5215 Total catchment drainage area.

BASE-TEMP
35.0 Base temperature; the temperature from which melting degree-days is computed.

ZONES
10 Number of snowbands into which the catchment is divided.

The first line of the body of the report is the initial conditions as given by the Z2 cards.

WE
0.0 Basin average snow water equivalent.

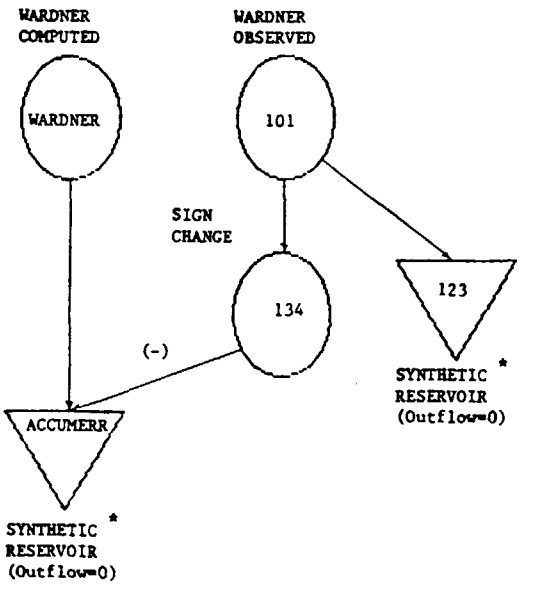
ROP
0. Basin average Runoff Percent. This value is zero because SMI values were given on the Z2 cards rather than ROP values.

BFP
0. Basin average Baseflow Percent. This value is zero because BFP values were not given on the Z2 cards.

The initial flows for each of the four components were given on the Z2 cards. TOTAL flow is the sum of the components.

OBS
3600 Observed flow is requested by field 3 of the ZC6 card. The flow values were input on card code 6D cards.

See paragraph "Integrated-Snowband Summary Printout", page ___, for a description of the meaning and units of measure of the numbers in the body of this report.



* 1 Foot of pool elevation equals 1 Inch of runoff.

FIGURE D-11 CONFIGURATION OF SNOWBAND MODEL EXAMPLE

```
PGM G072401N - SSARR MODEL (09OCT85)       INPUT DATA LIST    4DEC85 WEDNESDAY

1*******10********20********30********40********50********60********70**
J                   0 10          1       WARDNER (FT.STEELE+BULL R.)
CC01 00000101                  WARDNER OBSERVED (FT. STEELE + BULL R.)
CL01 ACCUMERR                  ERROR IN INCHES
CL02 ACCUMERR                          9     -9
C110 ACCUMERR    -100         1       -27813000  100         1        27813000
C111 ACCUMERR   9999999       1       999999999
CL01 00000123                  OBS VOL, INCHES
CL02 00000123                          100
C110 00000123                 1                  100         1        27813000
C111 00000123   99999999999999999999999999999
CC01 00000134                  SIGN CHANGE
CC02 00000134 1
CP      XCBX      3010
CP      XCBN      3010
CP      FRCX      544C
CP      FRCN      544C
ZR L 7
ZC1 WARDNER  WARDNER COMPUTED
ZC2 WARDNER 5215 10 5 C8 5 16 2 350 2 2000 36 1.5 .050 50 .0504
ZC3 WARDNER ELPP MRCR .98 .84 .074 .04 .9 7000
ZC4 WARDNER SMI  BII  SSS  EKE  ETP  DKE  ETMO
ZC5 WARDNER .15 35 35 .0334 .0333 GMLT ETEL 2. 50. .2
ZC6 WARDNER,,0000C101
ZCH WARDNER 3 KASB 70 3 FTIM 180 3 FLKB 90 3 KYUB 110
ZCH WARDNER 4 FRCX 100 4 FRCN 100 4 XCBX 100 4 XCBN 100
ZCA WARDNER 6 9 12 13 13 13 12 10 7 5
ZCP WARDNER 2400 0 300C 6 3500 12 4000 18 4500 25 5000 34 5500 44
ZCP WARDNER 6000 53 65C0 64 7000 74 7500 83 8000 89 8500 94
ZCP WARDNER 9000 98 95C0 100 99999 100
ZCT ELPP 2 2000 95 500C 105 9C00 85 99999 85
ZCT MRCR 3 0 .01 .015 80 .02 .015 170 .055 .017 300 .055 .025 9999 .055 .025
ZCT SMI  2 0 10 4.5 100 9999 100
ZCT BII  3 0 90 .C5 .2 60 .045 .4 40 .040 .6 30 .035
ZCT BII  1.0 20 .025 1.5 15 .012 9999 15 .012
ZCT SSS  2 0 0 .02 .004 .04 .011 .06 .020
ZCT SSS  .08 .034 .10 .05 .50 .38 100 80
ZCT EKE  2 0 100 1 10C 2.5 50 4 1 9999 1
ZCT ETP  2 30 0 40 .04 50 .075 60 .11 30 .18 100 .24 9999 .30
ZCT DKE  2 0 0 1 50 2 90 3 100 99999 1C0
ZCT ETMO 2 1 79 2 81 3 102 4 113 5 129 6 131 7 132
ZCT2 ETMO 8 122 9 104 10 94 11 79 12 74 13 76
ZCT GMLT 2 1 .004 2 .005 3 .010 4 .013 5 .015 6 .015
ZCT2 GMLT 7 .015 8 .015 9 .013 10 .010 11 .005 12 .004 13 .004
ZCT ETEL 2 0 100 1600 100 800C 150 99999 150
 ***  ***  CONFIGURATION  ***  ***
P    WARDNER   ACCUMERR
P    00000101  00000134  00000123
P    00000134  ACCUMERR
P    ACCUMERR
P    00000123
T   00 01097024 00 011C70
2L   ACCUMERR                 1                1
2L   00000123                 1                1
Z201   WARDNER    0010970,,, C.0  0.0     0.   35.   0.0   1.28 0.00 0.0
Z202   WARDNER    0010970,,, C.0  0.0     C.   35.   0.0   1.28 0.00 0.0
Z203   WARDNER    0010970,,, 0.0  0.0     0.   35.   0.0   1.28 0.00 0.0
Z204   WARDNER    0010970,,, 0.0  0.0     0.   35.   0.0   1.29 0.00 0.0
Z205   WARDNER    0010970,,, C.0  0.0     0.   35.   0.0   1.30 0.00 0.0
Z206   WARDNER    0010970,,, 0.0  0.0     0.   35.   0.0   1.31 0.00 0.0
Z207   WARDNER    0010970,,, 0.0  0.0     0.   35.   0.0   1.33 0.00 0.0
```

FIGURE D-12, PART 1 OF 2

```
Z208    WARDNER    0010970,,, 0.0  0.01    0.    35.    0.0    1.64 0.01 0.0
Z209    WARDNER    0010970,,, 0.0  0.0     0.    35.    0.0    1.71 0.02 0.0
Z210    WARDNER    0010970,,, 0.0  0.0     0.    35.    0.0    1.90 0.02 0.0
Z2S     WARDNER    0010970   376   360   346   335   323
Z2SS    WARDNER    0010970  1350   840   350   150   150
Z29     WARDNER    0010970   703   738
Z2LZ    WARDNER    0010970  1938  2328
  FLOE LAKE PRECIP DEVELOPED FROM SNOW COURSE
4D        FLKB 24 01097C3  10      76  07  08  19  22  30      13
4D        FLKB 24 15097C3          39  91  13      28  93
4D        FLKB224 2909703
  PRECIP DEVELOPED FROM KIMBERLEY UPPER SNOW COURSE
4D        KYUB 24 01097C3  10      76  07  08  19  22  30      13
4D        KYUB 24 1509703          39  91  13      28  93
4D        KYUB224 29097C3
  KASLO PRECIP
4D        KASB 24 0109703  28      09      07  18  05          07
4D        KASB 24 1509703          37  31  09  04  14  23
4D        KASB224 29097C3
  FORTINE PRECIP
4D        FTIM 24 0109703  07      16  26  04      20  22          11
4D        FTIM 24 15097C3                              15  35
4D        FTIM224 29097C3
  CRANBROOK MAXIMUM DAILY TEMPERATURES
4D        XCBX 24 01097C4 700 720 610 610 620 640 660 530 640 710 460 450 500 560
4D        XCBX 24 15097C4 620 560 560 620 550 590 570 560 520 530 550 630 660 680
4D        XCBX224 29097C4 690 750
  CRANBROOK MINIMUM DAILY TEMPERATURES
4D        XCBN 24 0109704 54  50  51  48  43  53  46  41  35  35  34  27  22  24
4D        XCBN 24 15097C4 32  31  40  45  39  32  36  44  36  21  29  30  33  35
4D        XCBN224 2909704 35  36
  FORDING RIVER (COMENCO) MAXIMUM DAILY TEMPERATURES
4D        FRCX 24 C109704 65  62  58  52  64  60  64  50  64  59  49  60  62  50
4D        FRCX 24 1509704 54  51  56  52  56  54  49  46  40  44  49  61  68  70
4D        FRCX224 2909704 69  66
  FORDING RIVER (COMENCO) MINIMUM DAILY TEMPERATURES
4D        FRCN 24 0109704 46  34  37  38  34  32  36  33  32  26  19  11  14  16
4D        FRCN 24 1509704 16  23  26  40  34  30  26  36  28  20  20  24  27  28
4D        FRCN224 2909704 29  31
  WARDNER OBSERVED DISCHARGE
6D   00000101124 31087C1   3600
6D   00000101 24 0109701   3600   3770   3870   4070   3750   3530   3550   3570
6D   00000101 24 0909701   3710   3590   3420   3350   3250   3000   2890   2910
6D   00000101 24 1709701   2730   2800   3420   4650   4550   4190   4130   4190
6D   00000101624 25097C1   4050   3690   3500   3480   3510   3510
PQ   00000101* WARDNER X                                                 0  10000
FINAL FILE OF TIME RECORDS IS ON UNIT 21
PEC  ACCUMERRD                                                          -5      5
PZCOWARDNER T2                                                        -100    100
PZCOWARDNER P1                                                          2.
PZ 1WARDNER T7                                                       -105.   95.
PZC2WARDNER P7                                                        .0833  0.
PZC5WARDNER C7                                                        -1.    1.
PZCCWARDNER M7                                                         0.    .1

 END OF INPUT
```

FIGURE D-12, PART 2 OF 2

BASIN	ZONE	MM-YY	AREA	ELEV	PP%	TINTMX
WARDNER	7	8 70	625.8	6900.	95.5	0.15

MO	DAY	HR	PCPN	INT	WE	ATI	CC	LIQD	TA	ATI	MR	WARDNER COMPUTED MELT	MI	PET	ET	SMI	ROP	RO	BII	BFP	SFRO	SSRO	BFRO	LZRO	ZONE	F
8	31	240			0.00	35	0.00			0						1.33			0.00							
9	1	240	0.12	0.12	0.00	35	0.0	0.0	49.9	0	0.000	0.000	0.000	0.11	0.07	1.26	37.	0.000	0.00	90	0.000	0.000	0.000	0.000	7	
9	2	240	0.00	0.00	0.00	35	0.0	0.0	45.7	0	0.000	0.000	0.000	0.09	0.05	1.21	35.	0.000	0.00	90	0.000	0.000	0.000	0.000	7	
9	3	240	0.45	0.15	0.00	35	0.0	0.0	42.9	0	0.000	0.000	0.297	0.07	0.04	1.36	34.	0.101	0.05	90	0.002	0.008	0.046	0.046	7	
9	4	240	0.15	0.07	0.00	35	0.0	0.0	40.9	0	0.000	0.000	0.072	0.06	0.04	1.37	37.	0.027	0.04	82	0.001	0.004	0.011	0.011	7	
9	5	240	0.07	0.06	0.00	35	0.0	0.0	41.9	0	0.000	0.000	0.004	0.07	0.04	1.32	37.	0.002	0.02	84	0.000	0.000	0.001	0.001	7	
9	6	240	0.12	0.07	0.00	35	0.0	0.0	43.4	0	0.000	0.000	0.053	0.08	0.05	1.31	36.	0.019	0.02	86	0.001	0.002	0.008	0.008	7	
9	7	240	0.20	0.08	0.00	35	0.0	0.0	44.2	0	0.000	0.000	0.124	0.08	0.05	1.34	36.	0.045	0.03	87	0.001	0.005	0.020	0.020	7	
9	8	240	0.24	0.08	0.00	35	0.0	0.0	35.4	0	0.000	0.000	0.159	0.03	0.02	1.42	37.	0.059	0.05	85	0.002	0.007	0.025	0.025	7	
9	9	240	0.00	0.00	0.00	35	0.0	0.0	39.9	0	0.000	0.000	0.000	0.06	0.04	1.38	38.	0.000	0.02	83	0.000	0.000	0.000	0.000	7	
9	10	240	0.07	0.07	0.00	35	0.0	0.0	38.9	0	0.000	0.000	0.000	0.05	0.03	1.35	38.	0.000	0.01	86	0.000	0.000	0.000	0.000	7	
9	11	240	0.05	0.05	0.00	35	0.0	0.0	28.2	0	0.000	0.000	0.000	0.00	0.00	1.35	37.	0.000	0.01	88	0.000	0.000	0.000	0.000	7	
9	12	240	0.00	0.00	0.00	35	0.0	0.0	26.9	0	0.000	0.000	0.000	0.00	0.00	1.35	37.	0.000	0.00	89	0.000	0.000	0.000	0.000	7	
9	13	240	0.00	0.00	0.00	35	0.0	0.0	28.2	0	0.000	0.000	0.000	0.00	0.00	1.35	37.	0.000	0.00	89	0.000	0.000	0.000	0.000	7	
9	14	240	0.00	0.00	0.00	35	0.0	0.0	27.7	0	0.000	0.000	0.000	0.00	0.00	1.35	37.	0.000	0.00	89	0.000	0.000	0.000	0.000	7	
9	15	240	0.00	0.00	0.00	35	0.0	0.0	32.2	0	0.000	0.000	0.000	0.01	0.01	1.34	37.	0.000	0.00	89	0.000	0.000	0.000	0.000	7	
9	16	240	0.00	0.00	0.00	35	0.0	0.0	31.4	0	0.000	0.000	0.000	0.01	0.01	1.34	37.	0.000	0.00	89	0.000	0.000	0.000	0.000	7	
9	17	240	0.25	0.04	0.00	35	0.0	0.0	35.7	0	0.000	0.000	0.210	0.03	0.02	1.45	37.	0.077	0.04	89	0.002	0.006	0.035	0.035	7	
9	18	240	0.49	0.03	0.00	35	0.0	0.0	40.9	0	0.000	0.000	0.455	0.06	0.04	1.69	39.	0.177	0.11	84	0.006	0.022	0.075	0.075	7	
9	19	240	0.08	0.06	0.00	35	0.0	0.0	37.2	0	0.000	0.000	0.017	0.04	0.03	1.67	44.	0.007	0.06	73	0.000	0.002	0.003	0.003	7	
9	20	240	0.01	0.01	0.00	35	0.0	0.0	34.9	0	0.000	0.000	0.000	0.03	0.02	1.65	43.	0.000	0.03	81	0.000	0.000	0.000	0.000	7	
9	21	240	0.16	0.06	0.09	33	0.0	0.0	33.2	0	0.000	0.000	0.011	0.02	0.01	1.64	43.	0.005	0.02	85	0.000	0.001	0.002	0.002	7	A
9	22	240	0.55	0.02	0.08	35	0.0	0.0	36.7	1	0.010	0.000	0.535	0.03	0.02	1.92	43.	0.229	0.12	87	0.006	0.023	0.100	0.100	7	D
9	23	240	0.15	0.03	0.19	30	-0.1	0.0	30.2	0	0.000	0.000	0.011	0.00	0.00	1.93	49.	0.005	0.06	71	0.000	0.001	0.002	0.002	7	A
9	24	240	0.00	0.00	0.18	26	-0.2	0.0	25.7	0	0.000	0.000	0.011	0.00	0.00	1.93	49.	0.005	0.03	80	0.000	0.001	0.002	0.002	7	S
9	25	240	0.00	0.00	0.17	28	-0.1	0.0	29.4	0	0.000	0.000	0.011	0.00	0.00	1.94	49.	0.005	0.02	84	0.000	0.001	0.002	0.002	7	S
9	26	240	0.00	0.00	0.16	34	-0.1	0.0	35.7	0	0.010	0.007	0.010	0.03	0.02	1.92	49.	0.005	0.01	87	0.000	0.001	0.002	0.002	7	C
9	27	240	0.00	0.00	0.15	35	-0.1	0.0	39.7	5	0.011	0.050	0.010	0.05	0.04	1.88	48.	0.005	0.01	88	0.000	0.000	0.002	0.002	7	C
9	28	240	0.00	0.00	0.10	35	0.0	0.0	41.4	11	0.011	0.041	0.051	0.05	0.05	1.86	48.	0.024	0.02	88	0.001	0.002	0.011	0.011	7	D
9	29	240	0.00	0.00	0.00	35	0.0	0.0	41.7	18	0.012	0.092	0.094	0.06	0.05	1.87	47.	0.044	0.03	87	0.001	0.004	0.019	0.019	7	D
9	30	240	0.00	0.00	0.00	35	0.0	0.0	43.2	25	0.013	0.002	0.002	0.07	0.06	1.81	47.	0.001	0.02	85	0.000	0.000	0.000	0.000	7	D
			3.14									0.181		1.17				0.844			0.022		0.366			
				1.00									2.137		0.81							0.090		0.366		

OVERALL TOTALS FOR ZONE 7

			3.14									0.181		1.17				0.844			0.022		0.366			
				1.00									2.137		0.81							0.090		0.366		

FIGURE D-13, PLATE 1 OF 4

SSARR SNOWBAND MODEL - WARDNER (FT.STEELE+BULL R.)

WARDNER WARDNER COMPUTED

AUG-1970	AREA 5215.	BASE-TEMP 35.0	ZONES 10

DA	HR	PCPN	INT	SNOWLINE	WE	LR	TA	MR	RG	ET	ROP	BFP	SURF	SUBSF	BASEF	LOWERZ	TOTAL	OBS	FLAGS BY ZONE 1***5***10***15***20
31	240				0.0						0.	0.	323	150	738	2328	3539	3600	
1	240	0.13	0.10		0.0	3.3	73.	0.000	0.01	0.08	38.	89.	306	301	736	2323	3666	3600	
2	240	0.00	0.00		0.0	3.3	68.	0.000	0.00	0.06	37.	89.	203	538	732	2318	3792	3770	
3	240	0.46	0.12		0.0	3.3	66.	0.000	0.12	0.05	35.	89.	128	591	742	2314	3775	3870	
4	240	0.15	0.07	8938.	0.0	3.3	64.	0.000	0.03	0.05	39.	81.	165	573	768	2310	3816	4070	A
5	240	0.07	0.05	8938.	0.0	3.3	65.	0.010	0.01	0.05	39.	83.	192	647	792	2305	3936	3750	D
6	240	0.12	0.08	8938.	0.0	3.3	66.	0.010	0.02	0.05	38.	86.	140	677	813	2301	3931	3530	D
7	240	0.20	0.07	8938.	0.0	3.3	67.	0.011	0.05	0.05	37.	86.	109	582	837	2297	3825	3550	D
8	240	0.24	0.07	7500.	0.0	3.3	58.	0.000	0.04	0.03	38.	84.	139	517	867	2293	3814	3570	AAA
9	240	0.00	0.00	7500.	0.0	3.3	63.	0.010	0.00	0.04	39.	84.	150	546	895	2289	3879	3710	DQS
10	240	0.08	0.06	7500.	0.0	3.3	62.	0.011	0.01	0.04	38.	87.	102	538	916	2284	3841	3590	DAA
11	240	0.05	0.04	7500.	0.1	3.3	51.	0.000	0.00	0.01	37.	88.	45	411	932	2280	3668	3420	AAA
12	240	0.00	0.00	7500.	0.1	3.3	50.	0.000	0.00	0.01	37.	89.	16	243	942	2275	3476	3350	SSS
13	240	0.00	0.00	7500.	0.0	3.3	51.	0.000	0.00	0.01	37.	89.	7	122	947	2270	3346	3250	SSS
14	240	0.00	0.00	7500.	0.0	3.3	50.	0.000	0.00	0.01	37.	90.	5	59	947	2265	3276	3000	SSS
15	240	0.00	0.00	7500.	0.0	3.3	55.	0.000	0.00	0.02	37.	90.	4	31	944	2260	3239	2890	SSS
16	240	0.00	0.00	7500.	0.0	3.3	54.	0.000	0.00	0.01	37.	90.	4	21	937	2254	3216	2910	SSS
17	240	0.25	0.09	7500.	0.1	3.3	58.	0.000	0.04	0.02	36.	90.	17	29	933	2249	3227	2730	AAA
18	240	0.50	0.04	7500.	0.1	3.3	64.	0.010	0.16	0.04	37.	87.	112	137	951	2244	3443	2800	DDA
19	240	0.08	0.06	7500.	0.1	3.3	60.	0.011	0.01	0.04	42.	77.	241	438	984	2240	3903	3420	DAA
20	240	0.01	0.01	7500.	0.1	3.3	58.	0.000	0.00	0.03	41.	83.	234	758	1010	2235	4237	4650	AAA
21	240	0.16	0.08	6900.	0.2	3.3	56.	0.000	0.01	0.02	41.	86.	120	782	1030	2230	4163	4550	AAAA
22	240	0.56	0.03	6900.	0.3	3.3	59.	0.010	0.16	0.03	41.	87.	121	608	1066	2226	4022	4190	DAAA
23	240	0.15	0.05	5639.	0.3	3.3	53.	0.000	0.02	0.02	45.	77.	240	629	1116	2223	4208	4130	AAAAAA
24	240	0.00	0.00	5639.	0.3	3.3	48.	0.000	0.00	0.01	46.	82.	255	837	1158	2219	4469	4190	SSSSSS
25	240	0.00	0.00	5639.	0.3	3.3	52.	0.000	0.00	0.01	46.	86.	140	856	1190	2215	4401	4050	SSSSSS
26	240	0.00	0.00	5639.	0.3	3.3	58.	0.010	0.00	0.03	45.	88.	45	600	1213	2211	4069	3690	DDCSSS
27	240	0.00	0.00	6900.	0.3	3.3	62.	0.011	0.01	0.05	45.	88.	19	317	1230	2207	3772	3500	DDCCCS
28	240	0.00	0.00	6900.	0.3	3.3	64.	0.011	0.00	0.05	44.	89.	19	159	1241	2202	3622	3480	DDCS
29	240	0.00	0.00	6900.	0.3	3.3	64.	0.012	0.01	0.05	43.	89.	21	102	1247	2198	3568	3510	DDCS
30	240	0.00	0.00	7500.	0.3	3.3	66.	0.012	0.01	0.05	42.	89.	22	89	1249	2193	3553	3510	DDCQ
													V O L U M E - I N C H E S					MELT	MI PET LIQD G-MLT
		3.22							0.73				0.02		0.21		0.81	0.07	1.93 1.57 0.00 0.02
			1.03							1.01				0.09		0.48		0.77	

FIGURE D-13, PLATE 2 OF 4

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                                        PLOT     DESCRIPTION                                   STATION
                                       CHARACTER                                              NAME    CONTRCL

                                          *-WARDNER OBSERVED (FT. STEELE + BULL R.)           00000101     Q
                                          X-WARDNER COMPUTED                                  WARDNER      Q
FLOW CFS                          0.     1000.     2000.     3000.     4000.     5000.     6000.     7000.     8000.     9000.    10000.
                                          D-ERROR IN INCHES                                   ACCUMERR     E
ELEV FT.                         -5.      -4.       -3.       -2.       -1.        0.        1.        2.        3.        4.        5.
                                          T-AIR TEMPERATURE (SEA LEVEL)                       WARDNER  SNOWBAND SUMMARY
                            -100.00   -80.00    -60.00    -40.00    -20.00      0.00     20.00     40.00     60.00     80.00    100.
                                          P-PRECIPITATION                                     WARDNER  SNOWBAND SUMMARY
            *          X       2.00      1.80      1.60      1.40      1.20      1.00      0.80      0.60      0.40      0.20      0.
31AUG70 2400   3600.0   3539.0 .          .         .         .       X*  .       T         .         .         .         .         P
 1SEP70 2400   3600.0   3666.0 .          .         .         .        *X .       D         .         .         .     T   .   P     .
 2SEP70 2400   3770.0   3791.6 .          .         .         .          * .      D         .         .         .   T     .         P
 3SEP70 2400   3870.0   3775.4 .          .         .         .         X*.       D         .         .     P   .  T      .         .
 4SEP70 2400   4070.0   3816.0 .          .         .         .         X .*      D         .         .         . T       . P       .
 5SEP70 2400   3750.0   3935.7 .          .         .         .         *X.       D         .         .         . T       .     P   .
 6SEP70 2400   3530.0   3931.2 .          .         .         .       *   X.      D         .         .         .  T      .   P     .
 7SEP70 2400   3550.0   3824.8 .          .         .         .       * X .       D         .         .         .  T      P         .
 8SEP70 2400   3570.0   3814.5 .          .         .         .       * X .       D         .         .        T.         P .       .
 9SEP70 2400   3710.0   3879.3 .          .         .         .        * X.       D         .         .         .T        .         P
10SEP70 2400   3590.0   3840.8 .          .         .         .       * X .       D         .         .         .T        .     P   .
11SEP70 2400   3420.0   3667.9 .          .         .         .     *   X .       D         .         .    T    .        .       P .
12SEP70 2400   3350.0   3476.4 .          .         .         .    *X   .         D         .         .    T    .        .         P
13SEP70 2400   3250.0   3346.5 .          .         .         .  *      .         D         .         .    T    .        .         P
14SEP70 2400   3000.0   3275.9 .          .         .         *  X      .         D         .         .    T    .        .         P
15SEP70 2400   2890.0   3238.9 .          .         .        *. X      .         D         .         .      T  .        .         P
16SEP70 2400   2910.0   3216.1 .          .         .        *. X      .         D         .         .      T  .        .         P
17SEP70 2400   2730.0   3227.2 .          .         .      *  . X      .         D         .         .     T.        P .       .
18SEP70 2400   2800.0   3443.4 .          .         .      * .   X    .         D         .         .    P    . T      .       .
19SEP70 2400   3420.0   3902.8 .          .         .         *     X.         D         .         .         T        .     P   .
20SEP70 2400   4650.0   4237.0 .          .         .                 . X    *  D         .         .        T.        .         P
21SEP70 2400   4550.0   4162.6 .          .         .                 . X   *   D         .         .      T .        . P       .
22SEP70 2400   4190.0   4021.5 .          .         .                 X *       D         .         .P       T        .         .
23SEP70 2400   4130.0   4208.1 .          .         .                 .*X       D         .         .    T   .        . P       .
24SEP70 2400   4190.0   4469.3 .          .         .                 . *  X    D         .         .  T    .        .         P
25SEP70 2400   4050.0   4401.4 .          .         .                 .*   X    D         .         .    T   .        .         P
26SEP70 2400   3690.0   4069.3 .          .         .               *  .X       D         .         .        T.        .         P
27SEP70 2400   3500.0   3772.1 .          .         .       *   X .             D         .         .         .T        .         P
28SEP70 2400   3480.0   3621.6 .          .         .       *X   .              D         .         .         . T       .         P
29SEP70 2400   3510.0   3567.9 .          .         .       *X   .              D         .         .         . T       .         P
30SEP70 2400   3510.0   3553.0 .          .         .       *X   .              D         .         .         .  T      .         P
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FIGURE D-13, PLATE 3 OF 4

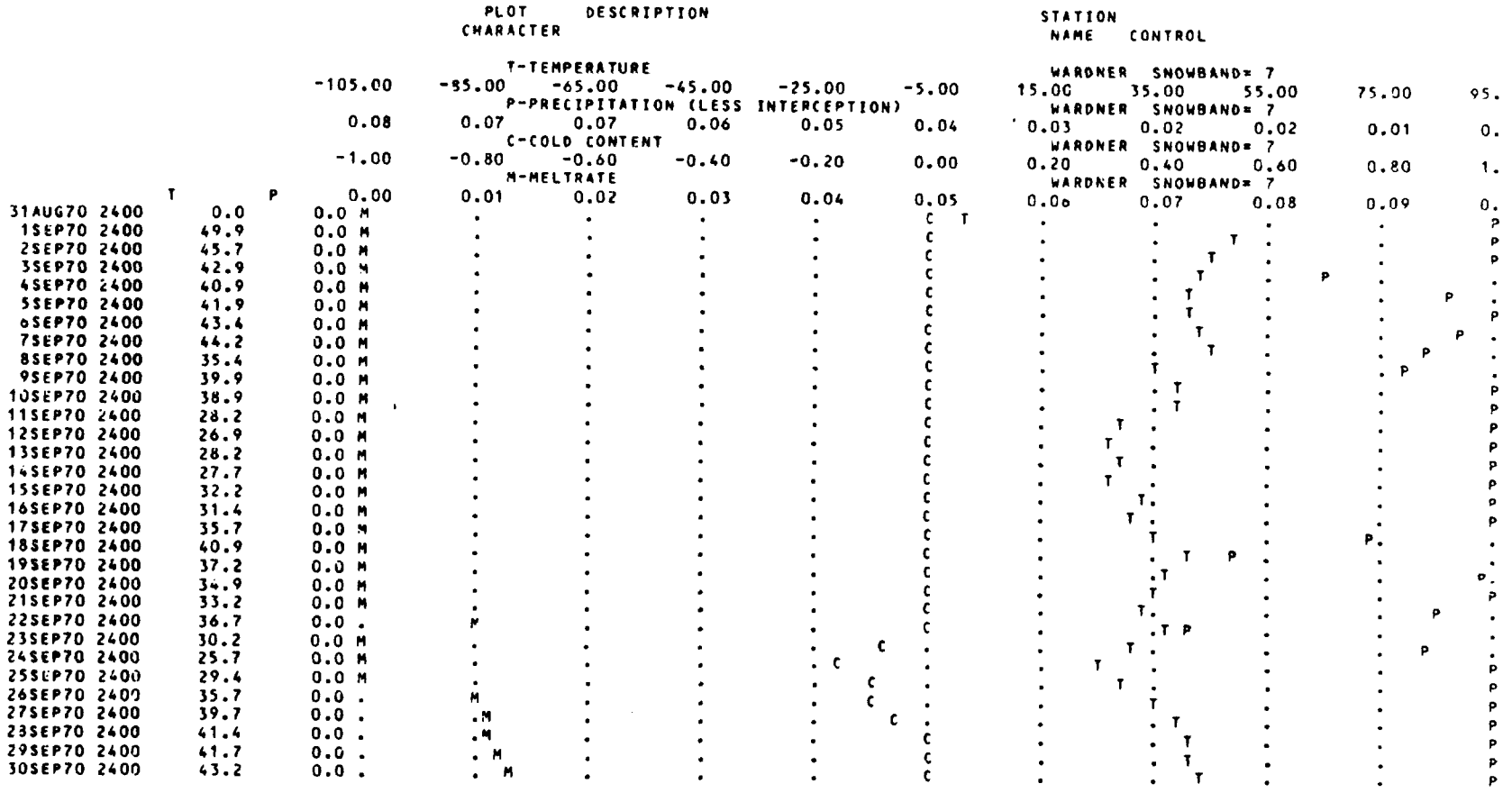

FIGURE D-13, PLATE 4 OF 4

D R A F T

AN APPROACH TO THE PREPARATION OF CHARACTERISTICS FOR A SSARR SNOWBAND MODEL

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AN APPROACH TO THE PREPARATION OF CHARACTERISTICS FOR A SNOWBAND MODEL

The goal of this section is to briefly review some of the considerations that go into the development of a set of snowband characteristics. The snowband model includes several facilities which are useful for simulation of both snowmelt and rain-only basins; a simple interception algorithm is included, and the operation to separate out a component of runoff with very long time-to-peak is available. These operations are helpful in the continuous simulation of a basin through many storms and seasons while accurately maintain the water budget.

The snowband characteristics are made up of card formats ZC1, ZC2, ZC3, ZC4, ZC5, ZC6, ZCH, ZCP, and either ZCA or ZCE. Twelve of the fields on these formats are the names of relationships. These relationships are prepared on ZCT or ZCF card formats.

Before the values of some characteristics can be determined, several major decisions must be made regarding the goals of the simulation and the availability of data. A careful data inventory should be the first order of business. Note length of record, completeness, changes in time of observation, evidence of location changes, etc. Much of this legwork has been done in the Columbia Basin (and probably in other areas) in the course of developing seasonal water supply volume forecasting procedures. Precipitation stations and snow courses whose records correlate well with seasonal runoff should be prime candidates for use in SSARR daily runoff forecasting. Snow courses must be high enough that winter melt is negligible.

Check data from morning observation stations to be sure that they are entered consistent with SSARR compute periods, e.g., that maximum temperatures are set back to the previous day when they normally occur. Check double-mass analyses for stations with evidence of location or exposure changes where adjustment of early records might be justified. A double-mass plot of compute vs. observed runoff from early simulations may disclose time trends not otherwise evident.

Precipitation station weights (p. D-7) should be chosen to yield a basin average annual or seasonal value consistent with the accepted water balance for the basin. While higher or lower values may apparently yield satisfactory computed runoff when compensated by too high or too low losses, undesirable bias will be evident in extreme years. To quote from Snow Hydrology 3/, "A knowledge of the water balance for a given area is essential in order to select appropriate forecasting parameters and interpret their reliability." The water balance values published in Snow Hydrology for the three snow laboratory basins are useful for guidance.

Compute Period Length. Determine the computational period to be simulated. The compute period of the model should be one of the following: 0.1 hour, 0.2, 0.5, 1, 2, 3, 4, 6, 8, 12, or 24 hours; it should be evenly divisible into 24 hours. The availability of data with which to drive the model (precipitation and temperature) and to compare with the computed discharges determine the shortest compute period which has meaning. The size of the drainage and its response time must also be taken into account.

Drainage Area and Elevation Bands. Establish the drainage area to be simulated by the watershed model. The drainage is usually defined by the availability of observed data.

Divide the drainage into elevation zones. Several factors influence this division: level of detail of the model, represented by length of the compute period, drainage area, and observed data being simulated; elevation range of the drainage, irregularities in the area vs. elevation curve, temperature lapse rate, and the relationship of basin precipitation and elevation. Although the program supports division into 20 snowbands, 10 seems to be a reasonable compromise. A greater number would reduce hydrograph discontinuities but increase compute time.

While both equal area zones and equal elevation-span zones have been used by various investigators, a smooth area distribution curve "tapered" at both top and bottom seems preferable. Ten equal area zones produce large discontinuities near the end of the melt season when the contributing area drops from 20 to 20%, and then suddenly to zero. (It should be acknowledged that this effect has been mitigated by a limitation on melt rate as described on page 17.) One objection to equal elevation-span zones shows up when a central zone may contain 25% of the basin area - again, a discontinuity in the hydrograph.

Basin Name. The first word on each of the characteristic cards is the basin name. The name must be 8 characters or less; 3 characters is the minimum practical name length. The name may be composed of alpha and numeric characters. The use of special characters like the pound sign (#) in names is not universally supported on all of the different host computers, so the name should be composed of only digits and letters.

Routing Coefficients. Estimate preliminary runoff routing characteristics. Runoff is simulated by dividing the water excess available for runoff from the drainage for each computational period. Excess is divided into four components which are named surface, subsurface, baseflow, and lower zone, respectively. The components are processed through the SSARR storage routing algorithm defined by two constants: number of routing phases, and time-of-storage per phase. Figure D-9a shows the relationship between lag time and unit peak for various combinations of multi-increment routing coefficients. If a unit hydrograph is available for the basin, Figure D-9a will permit a fairly close first approximation of the surface and subsurface constants. While the final adjustment of constants will be governed by the reconstitution of several year's flows, several steps can be taken which will improve the trial constants. If the unit hydrograph was very satisfactory it can be reconstituted with only surface and subsurface components. Otherwise, lag time can be determined from isolated, short duration rainfall. Snowmelt rises generally do not disclose timing adequately because of their longer duration. In any case, it is suggested that the trial coefficients be tested by generating hydrographs with, say 0.5, 1.0, and 2.0 inches runoff in unit time to see if hydrograph shapes appear reasonable. If, for instance, there is too much time difference between surface and subsurface, a double peak or secondary "hump" will appear. This shape is unlikely in most natural basins, yet the constants may appear satisfactory when reconstituting a snowmelt period.

The shape of the direct runoff (surface plus subsurface) hydrograph is also affected by the division of runoff between the two components. The "standard" relation of Figure D-9 has been satisfactory in many basins and is a good starting point. Look for patterns of over or under computation of peak discharge from short duration rainfall.

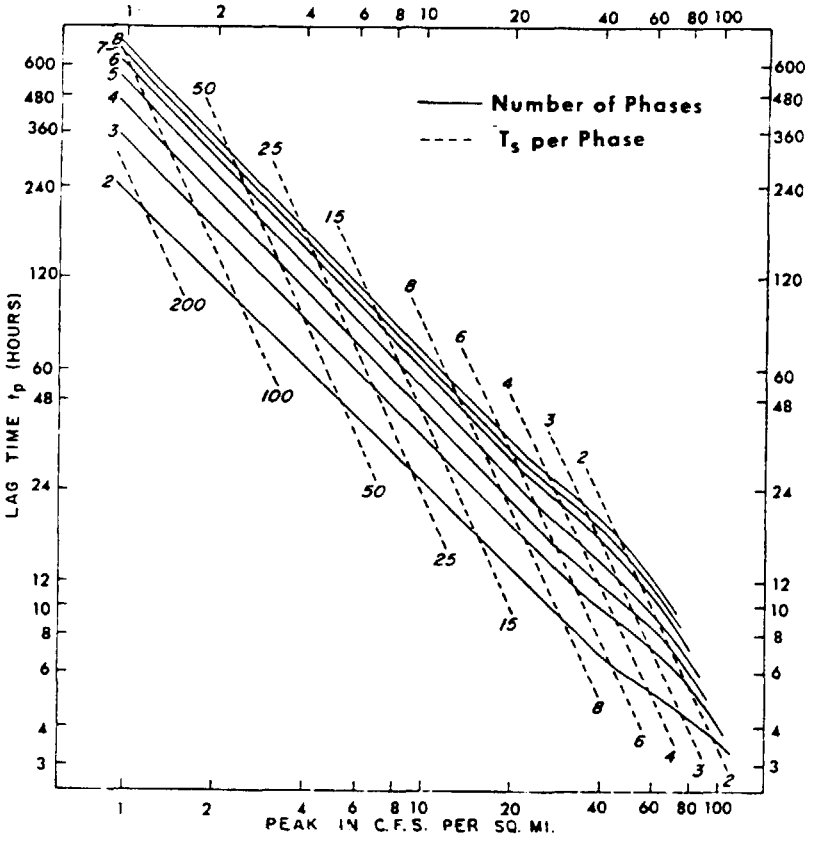

FIGURE D-9a **WATERSHED MULTIPLE PHASE STORAGE ROUTING**

A "typical" set of routing coefficients for a 2440 square mile drainage (from the Dworshak model) follows:

Surface	4	3.5
Subsurface	3	26
Baseflow	3	100
Lower Zone	2	2000

Baseflow. The remainder of the coefficients on the "ZC2" card plus the BFP relation on the ZC4 card determine the separation of water excess into baseflow and lower zone components. The BII index represents the delay to runoff from depression storage and deep groundwater percolation. A relation must be derived between the BII index and total baseflow percent (BFP). To set this relation, the maximum value of BII must be established (BIIMX). In addition, the maximum input rate to total baseflow (including the lower zone component) must be set, a constant affecting high-intensity precipitation and melt events. Further, total baseflow is divided between baseflow and lower zone components. In all, a rational objective analysis of what these model parameters should be is not only difficult, it is also affected by other parameters within the model. The best starting place may be the default values

with a BII vs. BFP relation copied from an example like the Libby model. During calibration, comparison of the observed and computed discharge duration curves can be an effective basis for adjustment. However, these adjustments are normally the final ones in the calibration process.

Precipitation as a Function of Elevation. The relation of elevation vs. percent precipitation is not required. If missing, each snowband receives 100% of basin weighted precipitation as directed by the ZCH cards (and ZH cards if "gage catch percent" is used).

The mid-point elevation of a snowband is used to extract the percent of basin weighted precipitation for that snowband. The actual total basin precipitation is the summation of the band precipitation. Therefore, the basin average precipitation may not be the same as "basin weighted precipitation".

The user can, therefore, adjust precipitation volume by adjusting the elevation vs. percent precipitation curve.

There is usually little direct observational data to define the variation of precipitation with elevation, but some deductions can be made. Since basin average precipitation is almost invariably greater than valley station averages, there must be an increase with elevation up to some point. Kuehl 4/ has shown a variety of excellent correlations of SSARR zone and snow course water equivalents in the Clearwater Basin. In such an area, analysis of snow course normals may yield some clues. A tendency to over compute or under compute late season (high elevation) snowmelt volume may indicate a need to reduce or increase high elevation precipitation.

Meltrate and Cold Rate. The relation of ATIMR vs. meltrate and coldrate is required. It may be best to start with a constant coldrate for all values of ATIMR such as .025 inches/degree day. This relation is easily adjusted after all other parameters are set. The coldrate does not effect volume.

The effective meltrate may be adjusted by the month vs. meltrate percent relation (ZC6). Since the model has snow conditioning factors (cold content and liquid water content), the meltrate is left to represent other factors which change as the snow ripens.

A value such as 0.02 inches/degree day seems a good place to start for ATIMR=0. As significant spring melt begins (which might be at ATIMR=100), the meltrate must be high enough to give modeled response; for example, a value of .03 inches per degree day. As spring melt proceeds and the snow pack ripens, the meltrate may increase to values as high as 0.06 inches/degree day, at an ATIMR of 300. There is some argument for reducing meltrate after the peak value in the late melt season. The ZCT cards for this trial ATIMR vs. MR, CR table (named, for example, "MRCR") are:

```
ZCT MRCR  3  0,.02,.025,100,.03,.025
ZCT MRCR     300,.06,.025,9999,.06,.025
```

Soil Moisture Simulation. The SMI vs. ROP relation affects the contribution of melt to runoff. Groundmelt (see month vs. groundmelt relation) can keep the SMI high under a snowpack, so that runoff responds to early spring melt. During calibration, the ROP as well as the meltrate must be analyzed. A proven technique is to calibrate the SMI/ROP relation for rain events, before adjusting the ATI/Melt rate curve for snowmelt simulation.

The SMI vs. ROP relation is very important in the SSARR model. The values of SMI range from 0 to a value representing the water holding capacity of the soil. Moisture input is computed from snowmelt and rainfall. Input to the routing of runoff is the product of ROP (runoff percent) and moisture input. The moisture that does not runoff represents recharge to the soil and is lost to runoff, because the soil moisture is only depleted by ETI, the evapotranspiration index. Therefore, the SMI/ROP/ETI algorithm can only be qualitatively verified with field measurements.

Evapotranspiration (ET). The snowband model includes the options from the original "depletion curve" SSARR model. In addition, the other calculations needed to compute each period potential ET as a function of temperature are available.

The Thornthwaite method 3/ is the basis for the selection of relations defining the ET simulation. The basic relation driving the calculation is snowband temperature vs. potential ET. This relation can be initially derived by the steps below. During calibration, this relation can then be adjusted to match up with whatever observed data may be available, such as measurements of pan evaporation. Since interception, ET, and the soil moisture algorithm are all interrelated, the modeler must select one "knob" to turn for calibration. The interception and ET relations are composed of variables that can be related to, and sometimes measured in nature; so it may be most productive to set them with the best estimates available, and then calibrate the basin water balance with the SMI vs. ROP relation.

Estimating the Relation of Temperature vs. Potential ET.

a. Select two temperature stations which will be used in the study and which have published monthly normals.

b. Compute the two-station average monthly normal temperatures and lapse them to the lowest elevation of the basin.

c. Tabulate the 12 monthly heat indexes from the 12 monthly mean temperatures with the following relation:

$$i_m = (t_m/5)^{1.514}$$

where

i_m is monthly heat index for month m.
t_m is monthly mean temperature in ^oC.

d. Add up the monthly heat indexes to get the annual heat index:

I = summation of 12 monthly values of i_m

e. Calculate "a" by the following formula. "Snow Hydrology" pages 100-103 and 140 discusses this technique and provides references.

$$a = (67.51 \times 10^{-8})\, I^3 - (77.11 \times 10^{-6}) I^2 + (179.21 \times 10^{-4}) I + 0.492$$

f. Now, derive the relation of temperature vs. potential ET with this formula:

$$e = 1.6(10t/I)^a$$

where

e is potential ET at temperature t, in cm./month.

t is in °C, a temperature in the relation "temperature vs. potential ET".

I and a are calculated above.

g. Convert to english units: the potential ET values are to be converted to inches per day so divide e (cm/month) by (2.54 cm/in)*(30 days/month).

For example, the mean monthly temperatures for a basin, and the resulting relation are as follows:

Month	°F	°C	i	Month	°F	°C	i
OCT	40	4.4	.837	APR	35	1.7	.190
NOV	30	-1.1	- .103	MAY	40	4.4	.837
DEC	25	-3.9	- .684	JUN	45	7.2	1.745
JAN	15	-9.4	-2.619	JUL	55	12.8	4.139
FEB	20	-6.7	-1.546	AUG	60	15.6	5.575
MAR	25	-3.9	- .684	SEP	45	7.2	1.745
						TOTAL	9.432

Total annual heat index I = 9.432

Therefore, a = .655 (see step e. above).

Representative temperatures and PET (see step f. above):

Temperature °C	°F	Monthly ET, cm.	PET, inches/day
0	32	0	.0
5	41	4.8	.063
10	50	7.5	.099
15	59	9.8	.13
25	77	13.7	.18
35	95	17.1	.22

If the temperature vs. PET relation is called "ETPLIB", the ZCT cards for this table are: ZCT, ETPLIB,2,-100,0,32,0,41,.063,50,.099,59,.13,77,.18,95,.22

In practice we find it necessary to alter the lower end of the relation in order to compute sublimation loss from intercepted snowfall during sub-freezing temperatures. A small, constant minimum daily PET of.03 inches/day has been used.

Rainfall Intensity Rate vs. EKE. This relation reduces the amount of evapotranspiration on rainy days. The independent variable, rainfall intensity rate, is precipitation rate reaching the surface (after interception) in units of inches per day. The dependent variable is percent of potential ET. Typically, during periods of no precipitation, 100% of PET is effective. During high precipitation rates such as over 1 inch/day, the percent is smaller.

One problem with this relation arises when the compute period length is changed. If all of the rain for a day occurs in a 6-hour period, the precipitation rate is very different when the compute period is changed from 6-hours per period to 24 hours per period.

A typical relation (named, for example, "EKE") is:

ZCT,EKE,2,0,100,1,100,2.5,50,4,1,99,1

Soil Moisture Index vs. DKE. This relation reduces the amount of ET when the soil is dry. As the soil gets wetter, more moisture is available for ET. A typical relation (named, for example, "DKE") is:

ZCT,DKE,2,0,0,1,50,2,90,3,100,9999,100 (This basin has maximum SMI of about 4.5 inches).

Month vs. ET Percent. This relation is meant to adjust PET according to the length of the days (hours of sunshine per day) and is needed if the Thornthwaite method 3/ is used to derive the temperature vs. PET relation.

It can also be used as a monthly pan coefficient modifier when daily pan evaporation is used.

Table D-14 gives the values as ratios as a function of latitude of the basin. For the SSARR program, this table is expressed as percent. For example, a basin with a median latitude of 49° would have a month vs. ET relation as:

ZCT,ETM,2,1,75,2,79,3,102,4,114,5,132,6,134
ZCT,ETM,7,135,8,124,9,105,10,93,11,76,12,71,13,75

Note that month 13 is included, matching month 1. The month number represents the first of the month and the program computes the fraction of the month for interpolation in this relation. If the user wished to assign these percents to the mid-point of each month, the ZCT cards would look like this:

ZCT,ETM,2,1,73,1.5,75,2.5,79,3.5,102,...

FACTOR BY WHICH UNADJUSTED POTENTIAL EVAPOTRANSPIRATION SHOULD BE MULTIPLIED TO ADJUST FOR LATITUDE AND SEASON
(C. W. THORNTHWAITE, 1948) 3/

N LATITUDE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	1.04	.94	1.04	1.01	1.04	1.01	1.04	1.04	1.01	1.04	1.01	1.04
5	1.02	.93	1.03	1.02	1.06	1.03	1.06	1.05	1.01	1.03	.99	1.02
10	1.00	.91	1.03	1.03	1.08	1.06	1.08	1.07	1.02	1.02	.98	.99
15	.97	.91	1.03	1.04	1.11	1.08	1.12	1.08	1.02	1.01	.95	.97
20	.95	.90	1.03	1.05	1.13	1.11	1.14	1.11	1.02	1.00	.93	.94
25	.93	.89	1.03	1.06	1.15	1.14	1.17	1.12	1.02	.99	.91	.91
26	.92	.88	1.03	1.06	1.15	1.15	1.17	1.12	1.02	.99	.91	.91
27	.92	.88	1.03	1.07	1.16	1.15	1.18	1.13	1.02	.99	.90	.90
28	.91	.88	1.03	1.07	1.16	1.16	1.18	1.13	1.02	.98	.90	.90
29	.91	.87	1.03	1.07	1.17	1.16	1.19	1.13	1.03	.98	.90	.89
30	.90	.87	1.03	1.08	1.18	1.17	1.20	1.14	1.03	.98	.89	.88
31	.90	.87	1.03	1.08	1.18	1.18	1.20	1.14	1.03	.98	.89	.88
32	.89	.86	1.03	1.08	1.19	1.19	1.21	1.15	1.03	.98	.88	.87
33	.88	.86	1.03	1.09	1.19	1.20	1.22	1.15	1.03	.97	.88	.86
34	.88	.85	1.03	1.09	1.20	1.20	1.22	1.16	1.03	.97	.87	.86
35	.87	.85	1.03	1.09	1.21	1.21	1.23	1.16	1.03	.97	.86	.85
36	.87	.85	1.03	1.10	1.21	1.22	1.24	1.16	1.03	.97	.86	.84
37	.86	.84	1.03	1.10	1.22	1.23	1.25	1.17	1.03	.97	.85	.83
38	.85	.84	1.03	1.10	1.23	1.24	1.25	1.17	1.04	.96	.84	.83
39	.85	.84	1.03	1.11	1.23	1.24	1.26	1.18	1.04	.96	.84	.82
40	.84	.83	1.03	1.11	1.24	1.25	1.27	1.18	1.04	.96	.83	.81
41	.83	.83	1.03	1.11	1.25	1.26	1.27	1.19	1.04	.96	.82	.80
42	.82	.83	1.03	1.12	1.26	1.27	1.28	1.19	1.04	.95	.82	.79
43	.81	.82	1.02	1.12	1.26	1.28	1.29	1.20	1.04	.95	.81	.77
44	.81	.82	1.02	1.13	1.27	1.29	1.30	1.20	1.04	.95	.80	.76
45	.80	.81	1.02	1.13	1.28	1.29	1.31	1.21	1.04	.94	.79	.75
46	.79	.81	1.02	1.13	1.29	1.31	1.32	1.22	1.04	.94	.79	.74
47	.77	.80	1.02	1.14	1.30	1.32	1.33	1.22	1.04	.93	.78	.73
48	.76	.80	1.02	1.14	1.31	1.33	1.34	1.23	1.05	.93	.77	.72
49	.75	.79	1.02	1.14	1.32	1.34	1.35	1.24	1.05	.93	.76	.71
50	.74	.78	1.02	1.15	1.33	1.36	1.37	1.25	1.06	.92	.76	.70

TABLE D-14

Elevation vs. ETI Percent. This relation, named in word 8 of the ZC5 card, allows the user to adjust the effect of ET as a function of elevation according to his knowledge or theory of this variation. Since only one SMI vs. ROP relation is used for all elevation bands, the elevation vs. ETI percent relation can compensate for the shallower soils at high elevations by boosting the effective ET. For example, a basin with an elevation range of 2400 feet to 9500 feet might have a relation (named, for example, "PEE") like this:

ZCT,PEE,2,2400,100,8000,150,9500,150

Interception. The capacity of the interception "bucket" may be either a constant or a function of month. If word 2 of the ZC5 card is a number less than 10, it is taken as a constant; if it is a name or a number greater than 10, it is taken as the name of the relation "Month vs. Interception Maximum". As in the "Month vs. ET Percent" relation, the month number represents the 1st of the month. A typical relation for a basin with a forest that loses foliage in the winter might look like this:

ZCT,INT,2,1,.1,4,.1,5,.3,9,.3,10,.1,13,.1

Base Temperature. This constant represents the lowest air temperature at which snow melt for runoff begins. This temperature may not be 32°, depending on the source, type, and weighting of the temperature data. If daily maximum temperature is used as the index of basin temperature, base-temperature may be 40°.

The relation "Temperature vs. Potential ET" and PXTEMP (word 4 of ZC5) are also dependent on the nature of the temperature data.

PXTEMP, the Snow Accumulation Temperature. This temperature is the highest at which precipitation accumulates as snow rather than running off. Typically, this temperature is equal to base-temperature, or a few degrees higher. The snowpack cold-content algorithm is active at temperatures below PXTEMP.

Month vs. Groundmelt. The rate of melt off the bottom of the snowpack, at the ground snow interface, may either be a constant expressed as inches per day, or the name of a relation giving inches per day as a function of month. If word 7 of the ZC5 card is a number less than 10., it is accepted as the constant.

"Snow Hydrology" pages 176-179 and plate 5-6 give some measurements of ground temperatures, gradients, and indication of melt quantities as follows:

ZCT,GMLL1B,2,1,.004,2,.005,3,.01,5,.015,8,.015
ZCT,GMLL1B,10,.01,11,.005,13,.004

Note that month number represents the first of the month, the same as for the "month vs. Potential ET" relation.

Month vs. Percent Melt Rate. This relation may be used to make melt rate a function of month. If the relation ATIMR vs. melt rate produces a constant melt rate, the "month vs. percent melt rate" relation can produce the same melt rate sequences used in the NWSRFS snowmelt model. 1/

Name of Observed Flows. Field 3 of ZC6 card contains the name of a type 100 record. The values from this record, if available, will be listed on the snowband summary printout beside the computed flows for comparison.

This name must not be the same as the snowband basin because the presence of a type 100 record in the SSARR work file will suppress the basin calculation.

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APPENDIX E

RIVER SYSTEM MODEL
APPLICATION AND EXAMPLES

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APPENDIX E

RIVER SYSTEM MODEL

Application. The modeling of a river system or a portion thereof, is dependent upon the ability to characterize the hydrologic response of individual watersheds, channel reaches, lakes, and reservoirs, and yet coordinate these responses to simulate the reaction of the system as a whole.. The objective of river basin simulation is to be able to predict river flow at various points in the system for any given sequence of climatic events, and any specified reservoir regulation scheme when applicable.

After the hydrological parameters of individual watersheds within the system have been characterized, channel routing characteristics must be developed so that river flow at downstream points of interest can be accurately determined. Often the routing characteristics of a channel reach can be more precisely defined than watershed characteristics because there are fewer "unknowns". Usually, several gaging stations exist from the upper to the lower reaches which allow good estimates of routing times for different streamflows. Also, known reservoir outflows within a system enhance the determination of river flow at downstream points.

Frequently the river system model is used without the watershed model for flood control planning and design work. In such applications, historic streamflow data are entered at upstream points and the model is used to route flow through the system.

This section illustrates various program capabilities to simulate river flow in a complex system including examples of channel routing, local inflow calculations, backwater effects, diversions, and return flows.

Channel Routing. Proper characterization of channel routing provides an integrated response of river system entities to hydrometeorological input. The program allows considerable flexibility to determine routing coefficients which simulate downstream peaks and timing response. Channel routing can be accomplished with either a routing equation for incremental routing, or a table which specifies time of storage-discharge relationships.

a. Channel Routing Equation. When the routing equation is used, the number of routing phases, n coefficient, and a KTS value are specified in the CRØ2 card for each channel reach. The derivation of these routing parameters should usually begin with values determined from channels with similar physical characteristics. Parameter values can then be determined by making adjustments to obtain the best reconstitution of observed flows.

The number of routing phases specified for a channel significantly affects the peak and timing response of the hydrograph (Figure 9.1). As the number of phases increases, with all other factors the same, the peak decreases and the total time of storage increases.

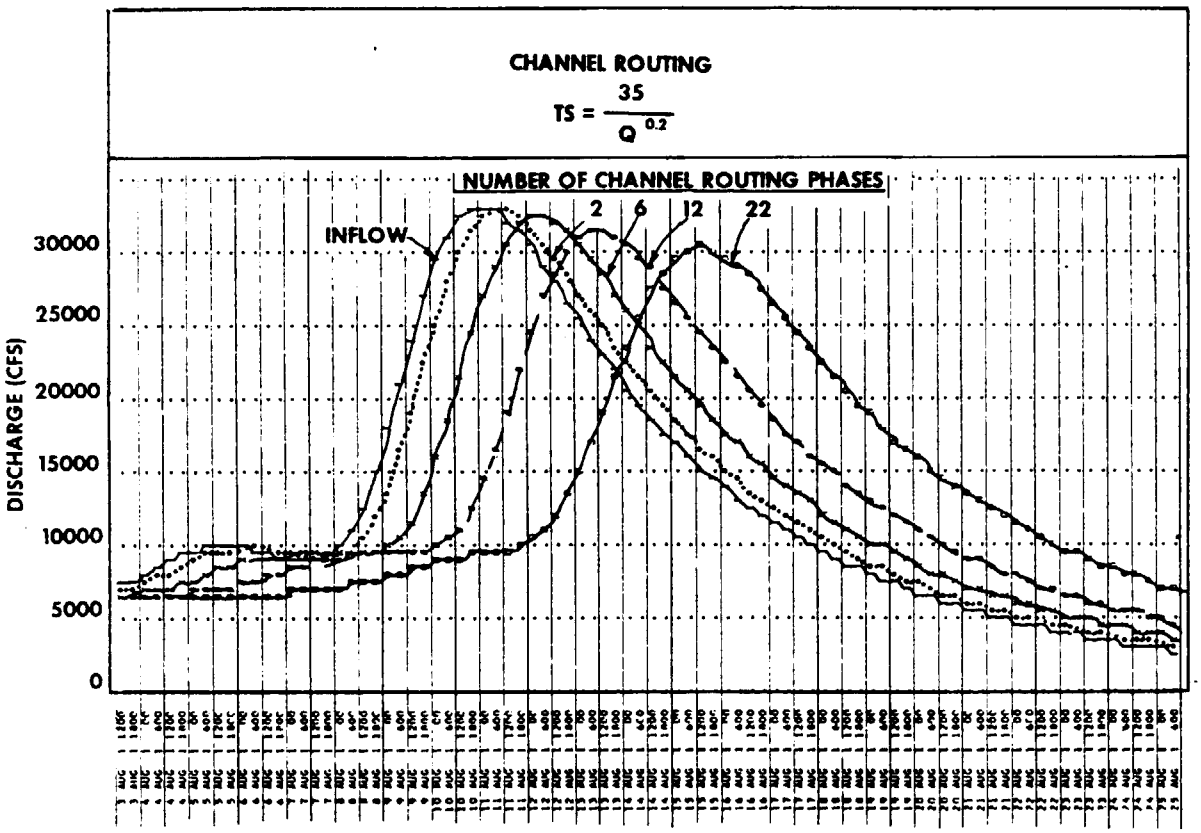


Figure 9.1 Effect of Varying the Number of Routing Phases with the Channel Routing Equation

The KTS and n parameters of the routing equation can be manipulated to obtain the desired time of storage per phase (T_s). KTS affects the time of storage linearly, as indicated by the routing equation:

$$T_s = \frac{KTS}{Q^n}$$

This equation is illustrated graphically in Figure 9.2 and 9.3, for a positive and negative n, respectively. Larger values of KTS result in longer time of storage for a given number of phases (Figure 9.4). The n coefficient, on the other hand, relates flow to time of storage exponentially, with smaller values of n yielding much greater time of storage for a given KTS (Figure 9.5). In this case, time of storage

CHANNEL ROUTING EQUATION

$$T_s = \frac{KTS}{Q^n} \quad \text{where } n = 0.20$$

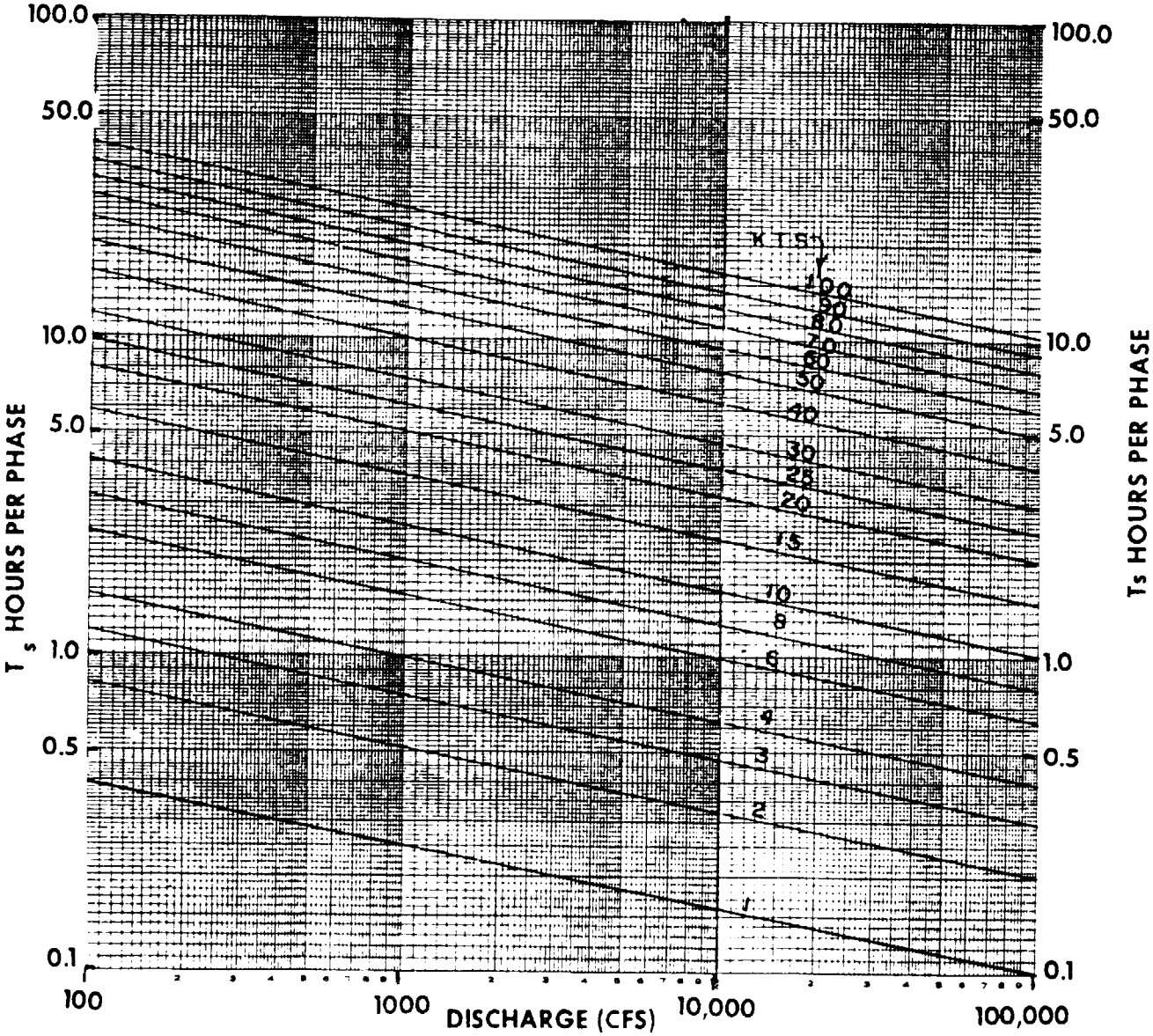


FIGURE 9.2 RELATIONSHIPS OF KTS, DISCHARGE (Q), AND TIME OF STORAGE PER PHASE FOR THE CHANNEL ROUTING EQUATION

$$T_s = \frac{KTS}{Q^{n}}$$

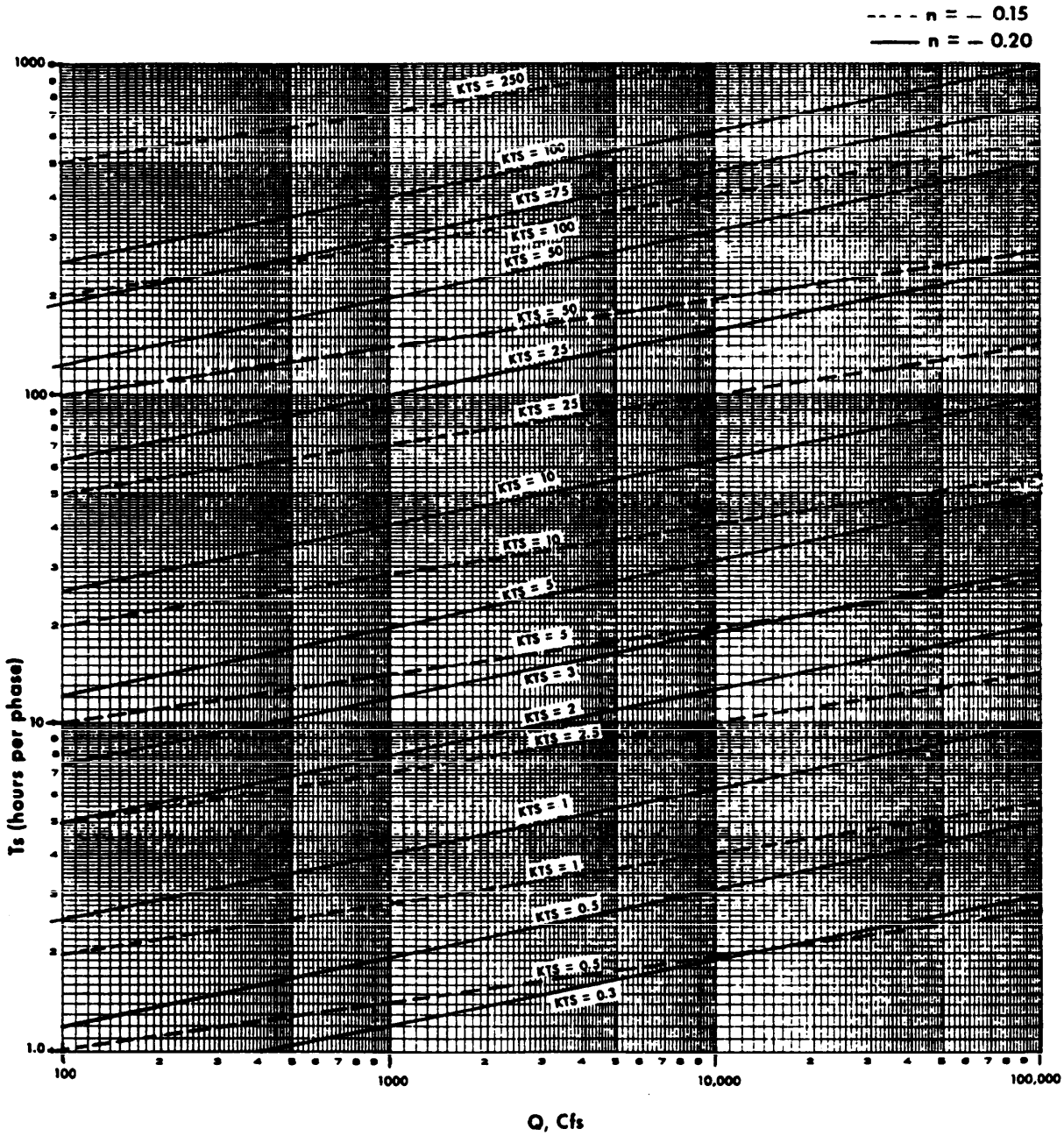


Figure 9.3 Relationships of a Negative n, KTS, Discharge (Q), and Time of Storage per Phase (T_s) for the Channel Routing Equation

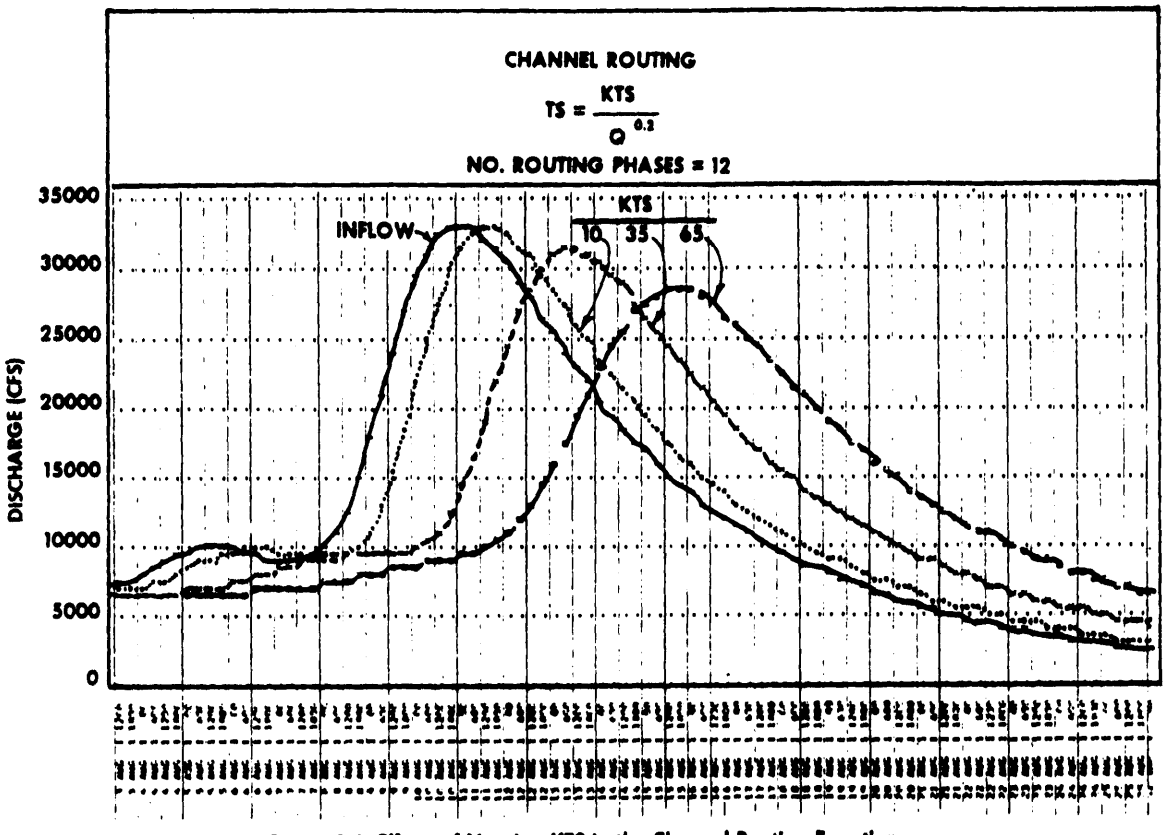


Figure 9.4 Effects of Varying KTS in the Channel Routing Equation

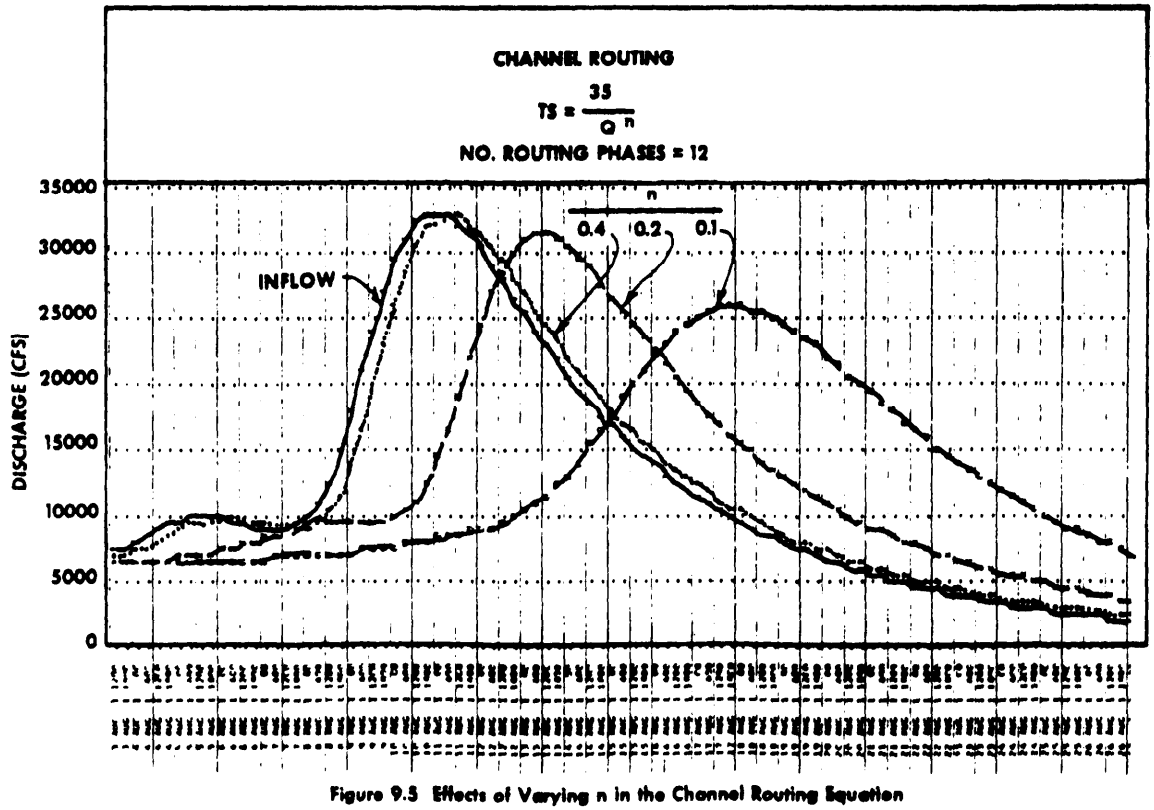


Figure 9.5 Effects of Varying n in the Channel Routing Equation

is related to discharge inversely. In some basins, however, time of storage varies proportionally to discharge (Figure 9.6). As illustrated with negative n values, the time of storage is extremely sensitive to slight changes in value of n.

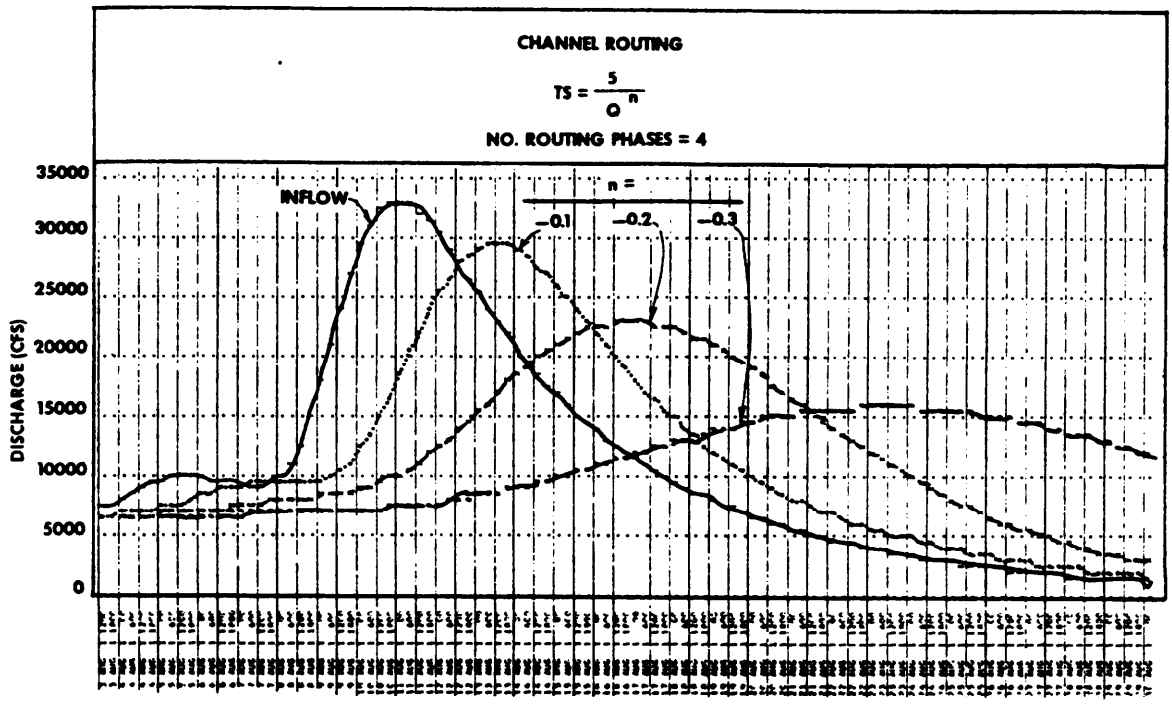


Figure 9.6 Effects of Varying Negative n in the Channel Routing Equation

The routing parameters for a given channel reach are usually determined as in the following example:

(1) Assume an n value, in this case assume n = 0.20.

(2) Determine the total time of storage for the reach. This equals approximately, the time of travel for the reach. For this example, total time of storage is approximately 48 hours.

(3) Determine the number of routing phases to be used. Larger number of phases results in less attenuation of the hydrograph peak, given a fixed total time of storage. The number of phases is ultimately determined by trial; however, for initial trials the number of phases can be estimated by assuming 5 to 10 miles of channel per phase. Once the number of phases is determined, divide the total time of storage by the number of phases to obtain time of storage per phase.

(4) From the routing equation as illustrated i Figure 9.2 find the value of KTS corresponding to T_s, n, and a disc .arge of 35,000 cfs. In this example, for n = 0.2, total time of storage = 48 hrs., and with four routing phases, KTS would equal 96. Once an initial trial is made, KTS, n, and the number of phases can be easily adjusted to improve reconstitutions. The variability of the routed hydrograph with number of phases, assuming total T_s is constant, is shown in Figure 9.7. A similar example, but with n = 0.4 is shown in Figure 9.8. By comparing the two figures, it is clear that n is relatively insensitive when a specific total time of storage is desired. The larger n value results in a slightly greater "non-linearity" which results in greater variability in the routed hydrographs.

b. Use of a Table for Channel Routing. The user has the alternative to define, in the C1-card format, a specific discharge-time of storage relationship for a channel reach. Such a table enables a precise definition of relationships and can be used to simulate rather unique or unusual channel routing changes with discharge. Figure 9.9 illustrates the use of three different routing-discharge relationships. For this example, 16 phases were specified on the CRØ2 card, and the T_s and n spaces on the card were left blank. The flow-T_s relationships were specified in a C1 table with the same station number as the CR cards. Hydrograph 4757 shows the effects of T_s decreasing as discharge increases. The inverse is true of station 4787.

A typical relationship for overbank flows is illustrated by station 4797. Here T_s decreases as flow increases up to the bank full point of about 20,000 cfs. After bank full is reached, T_s increases because of the overbank condition. As flow increases to 26,000 cfs the flood plain becomes inundated and T_s values become constant with additional flow. Complex routing-time of storage relationships can be defined for cases of flood flows when adequate information is available.

c. Optional Reach Routing Algorithm. In the SSARR program reach computations, the routing characteristics are determined mainly by the time of storage value T_S. This is computed for each routing period at each reach routing station. Whenever the computed value of T_S falls below the value of 1/2T (i.e., 1/2 the routing period), the program automatically breaks the current routing period into two or more sub-periods so that the sub-periods will never be longer than twice the T_S value.

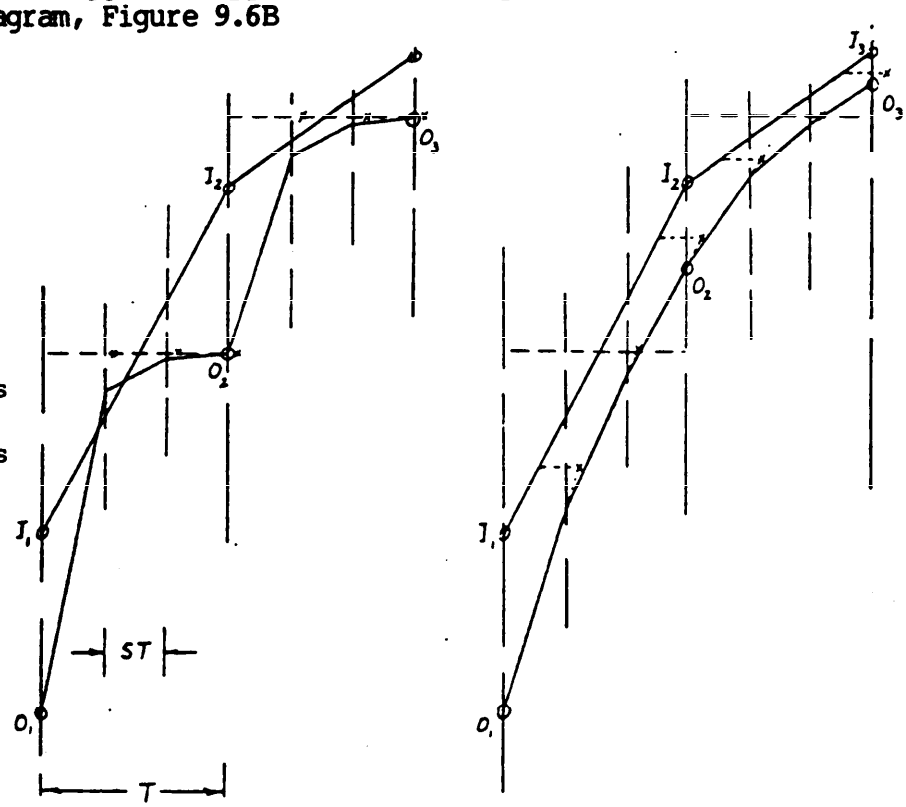
The program then handles each sub-division of the period as a separate routing period except that for each sub-period the average inflow is held equal to the average inflow for the whole period. This feature means that the computed outflow from a reach can never cross the average inflow for the whole routing period, no matter how short the T_S value may be. This limits the result that would be obtained from routing any one reach to that which would be obtained using a time of stroage value equal to 1/2 the routing period length.

The following diagram (Figure 1) for a routing period of 12 hours, a T_S value of about 2.5 hours and one phase of routing will give an idea of the result of this characteristic of the program.

Column 19 of the CR01 card may be coded with a "1" to select the option to recompute a new average inflow to the first phase for each of the subdivided periods. This average inflow would be based on interpolated flows for the start and end of the subdivided period (i.e., the mean would be the interpolated flow at the mid point of the subdivided period.

A comparison of the suggested approach with the present approach is shown on the following diagram, Figure 9.6B

where:
I = Inflow
O = Outflow
T = Compute Period Hours
ST= Subdivided Period Hours



Standard Routing

Optional Routing with Interpolated Inflow

FIGURE 9.6b

d. Reach Initial Conditions. The only information needed to specify reach initial conditions is the instantaneous inflow and the routing phase values. If the elevation-discharge relation is provided for the reach, the initial condition phase values may be specified in terms of elevation. If no initial condition phase values are input, the inflow to the reach will be computed at time zero and all phase values will be set equal to that inflow. If the user wishes to specify only the first and last phase values, he may leave the intermediate values equal to zero and the program will interpolate them on a straight line between the given values. The phase values may be adjusted to observed values through the use of the 3R card.

e. Reach Initial Condition Adjustment. When using the SSARR program for flow forecasting, initial conditions are output at the end of the forecast period when requested by the user on the "T" card. When observed values are available for that same time, these observed values may be input to SSARR to adjust the computed initial conditions so that the model can be operated from that time forward without the necessity of manual preparation of all initial conditions. If the stage-discharge relation is provided for a reach, the observed stage of the river may be expressed in terms of elevation.

Local Inflow. Local drainages along river channels and reservoirs often contribute significant runoff to a river system. Since local inflows are not measured directly, streamflow synthesis can become highly inaccurate when local inflows are large. The SSARR model has three "adjacent station" provisions to account for significant local inflows dependent on data availability and knowledge of the area.

a. The first method of determining local inflows involves a "hind-sight" approach which can be used when streamflow records above and below the local are available. A parallel reach technique is set up with observed flows in one reach and computed flows in the other. With proper instructions, the program simply subtracts the routed flow of the upstream station from the downstream station and applies the difference or local inflow to the "parallel", computed streamflow. The following example illustrates how this approach may be used.

HYDROGRAPH	NO. PHASES	KTS	n	TOTAL TIME OF STORAGE (hours)
4757	2	192	0.2	48
4767	4	96	0.2	48
4797	20	19	0.2	48

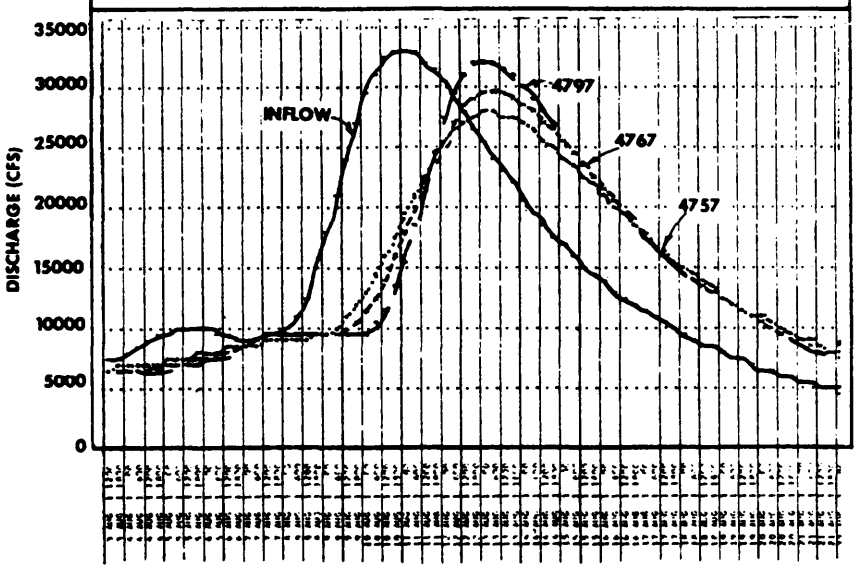


Figure 9.7 Example of Various Routing Characteristics for a Channel Reach with a Specific Time of Storage and n = 0.2

HYDROGRAPH	NO. PHASES	KTS	n	TOTAL TIME OF STORAGE (hours)
4757	2	1540	0.4	48
4767	4	770	0.4	48
4797	20	154	0.4	48

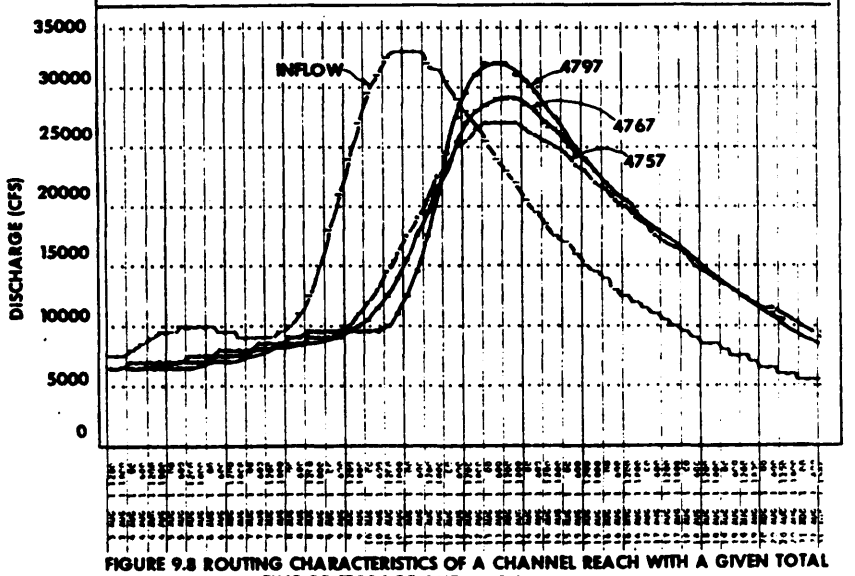


FIGURE 9.8 ROUTING CHARACTERISTICS OF A CHANNEL REACH WITH A GIVEN TOTAL TIME OF STORAGE AND n= 0.4

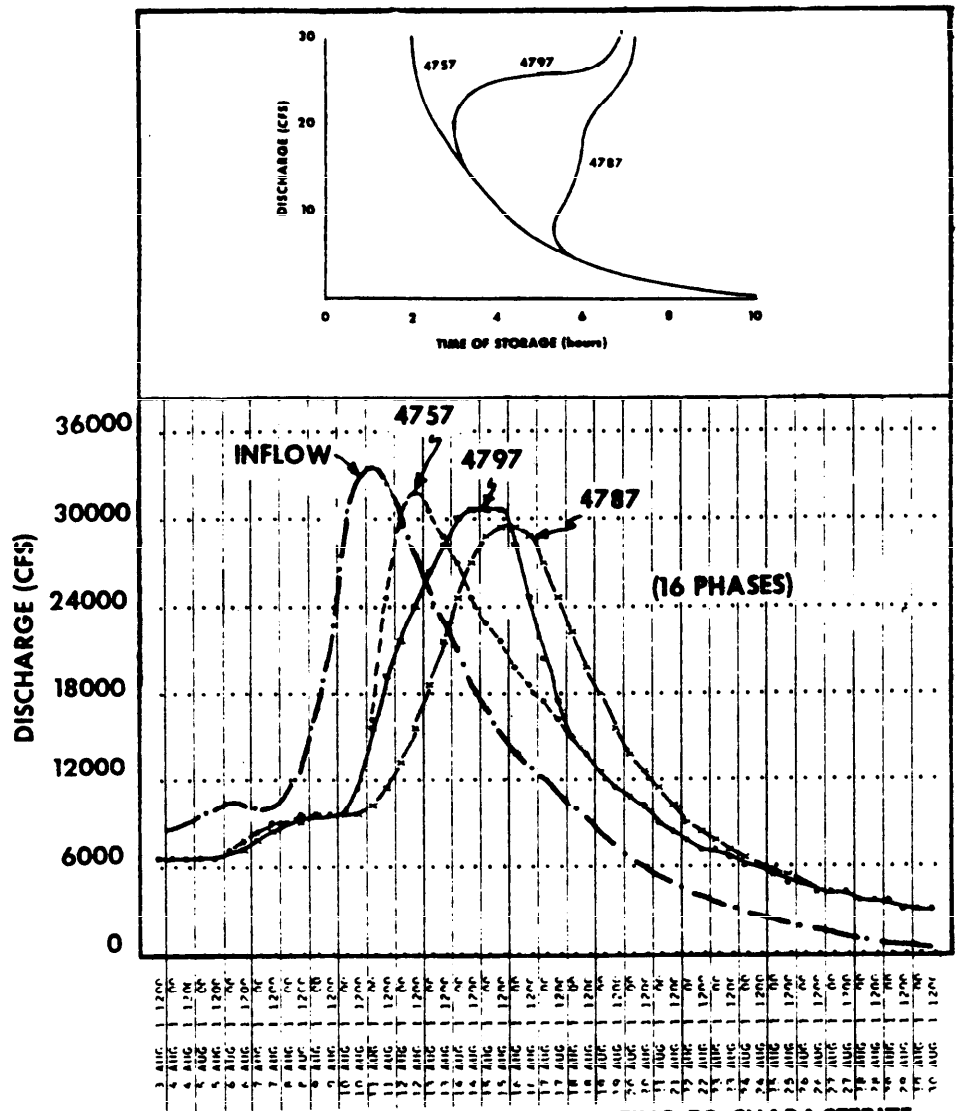


FIGURE 9.9 EXAMPLES OF THE USE OF ROUTING TO CHARACTERIZE CHANNEL ROUTING

REVISED JUNE 1975

Consider the hypothetical river reach in Figure 9.10 which consists of a specified inflow, a reservoir, and a downstream river reach with no other major drainage. Suppose a major flood occurred and we are to determine how a particular reservoir regulation scheme would have affected the downstream peak at station 5002. Streamflow was observed at station 4771 and at station 5001. From the observed records a significant local flow was detected and, therefore, would have to be added to the specified reservoir outflow to determine the regulated streamflow at station 5002. By specifying the observed flow at the downstream point (5001) on the CCØ2 card (columns 16-24) for the local inflow (4799), the flow at 4799 is determined as the difference between observed flow at 5001 and the flow routed from the next upstream observed station which is 4771. With P cards, the local (4799) is then added to station 5002

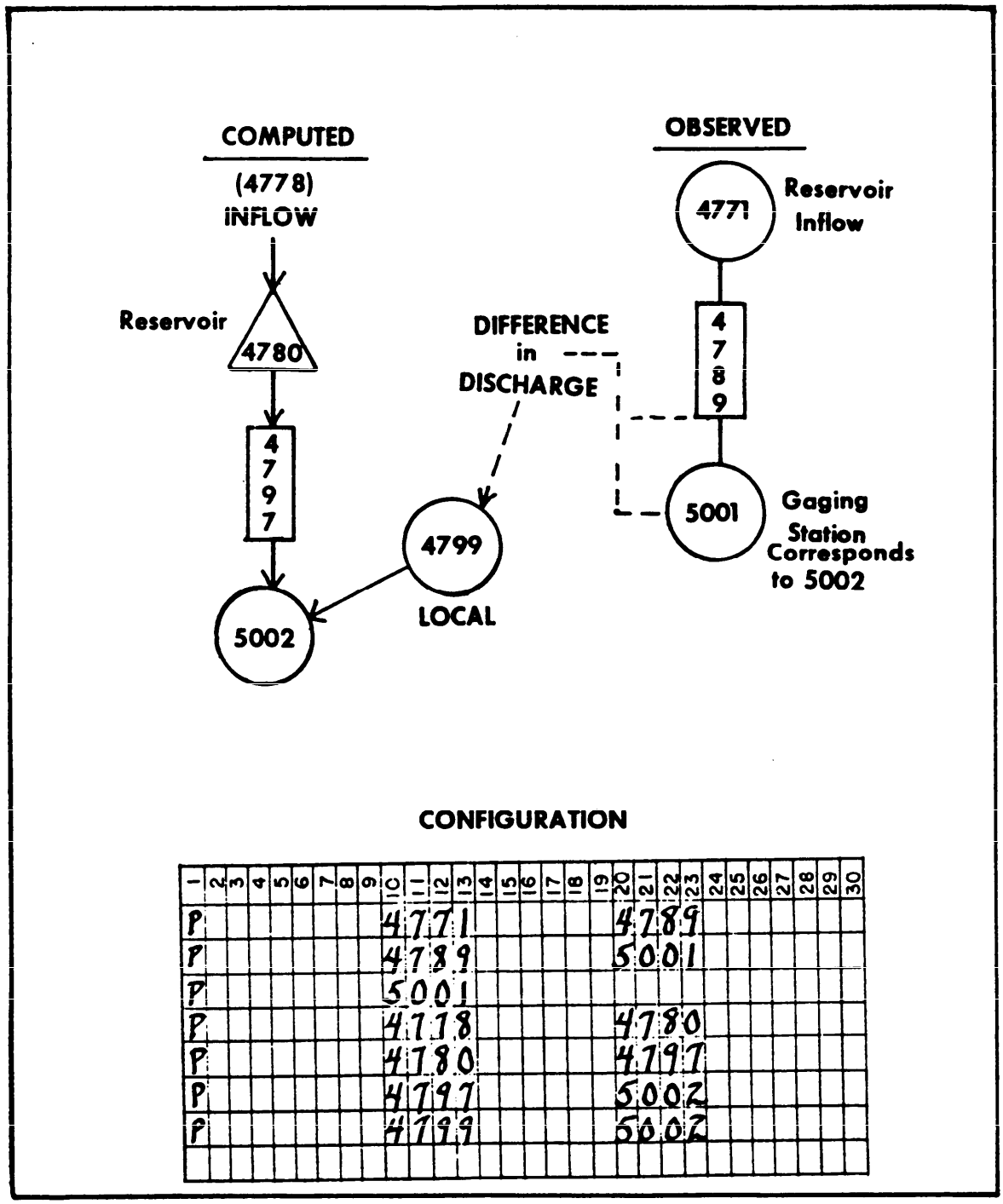


Figure 9.10 Hypothetical River Reach and Corresponding "P Card" Configuration to Compute Local Inflows

which also receives the routed reservoir outflow. The resultant hydrographs of such a computation are illustrated in Figure 9.11. The unregulated streamflow is represented by hydrograph 5001. With the specified reservoir outflows, and the same local inflow, the storm hydrograph would have been changed as indicated by hydrograph 5002.

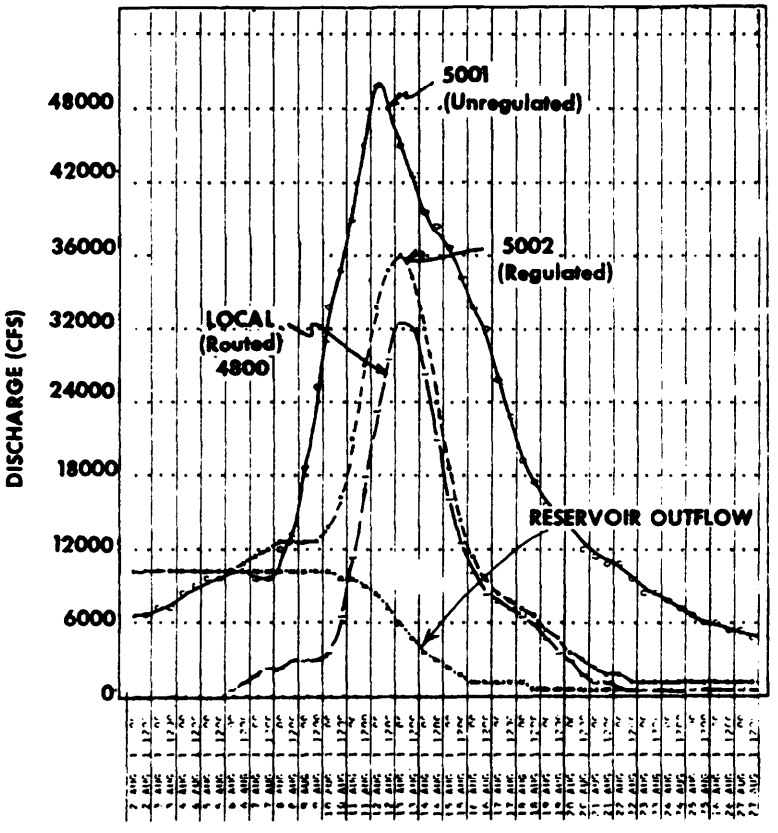


Figure 9.11 Resultant Hydrographs showing Effects of Local Inflow for Regulated and Unregulated Flow

b. Local inflow can often be computed as some function of river flow or elevation at some location or of the outflow from an adjacent watershed. This is the second provision for computing local inflows. For example, consider the local inflow (station 4799) to be 25 percent of the outflow from watershed 4778, (Figure 9.12). Station 4799 would be specified in the CCØ2 card as being 25 percent of 4778. Watershed 4778 was specified as the adjacent station (columns 26-34) and 25 percent was specified in columns 40-43.

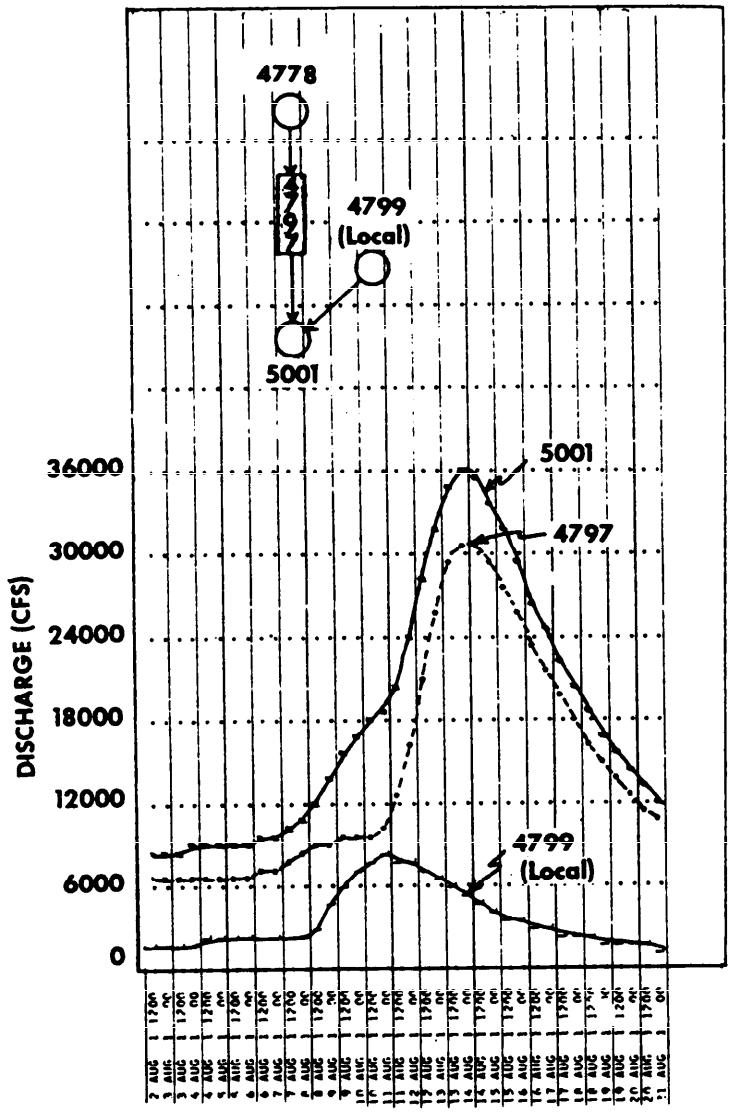


Figure 9.12 Example of Local Calculation where Local is 25 Percent of Watershed 4778

c. A third provision allows the local inflow to be dependent upon flow at some location in the basin in a unique relationship specified in a CT table. The independent variable is the flow from the adjacent station, and the local flow is specified as the dependent variable. In addition to the CT table, the adjacent station number (columns 26-34), adjacent station table I.D. (columns 36-39), and the adjacent station weighting percentage (100 percent in this case) must be specified in the CCØ2 card for the local station. In Figure 9.13, the local (hydrograph 4799) was specified to be a function of watershed outflow 4778 as indicated below:

Watershed Outflow (4778) cfs	Local Inflow (4799) cfs
0	0
5,000	2,500
10,000	5,000
25,000	15,000
60,000	25,000
100,000	30,000

The hydrograph at the summing point (5001) is the result of routed watershed outflow (4797) plus the routed local (4800).

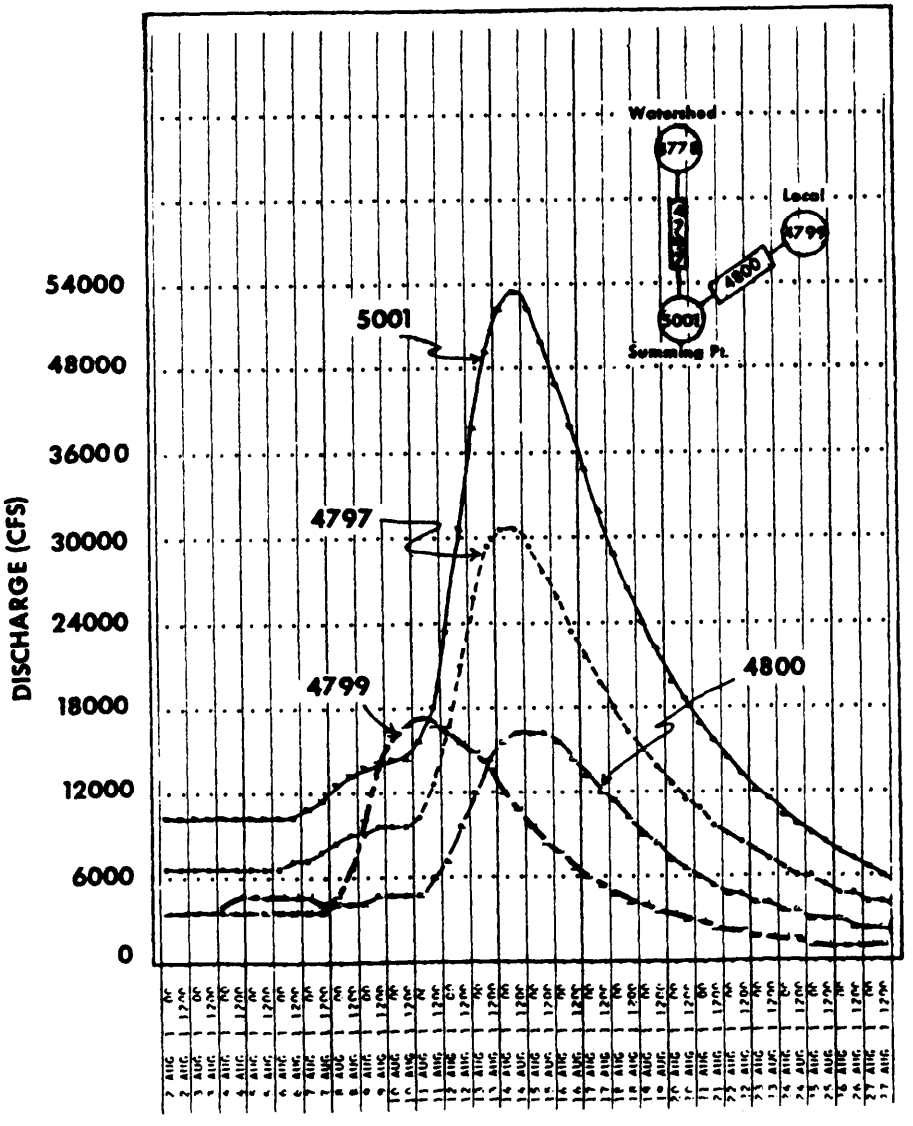


Figure 9.13 Example of Local Inflow Derived from a Table Relationship

Diversions and Return Flows. The adjacent station provision, previously discussed for local calculations, can also be used to compute irrigation diversions and return flows. The manner in which diversions and return flows are specified is primarily determined by the system configuration. One approach of specifying an irrigation diversion system is described in the following hypothetical example:

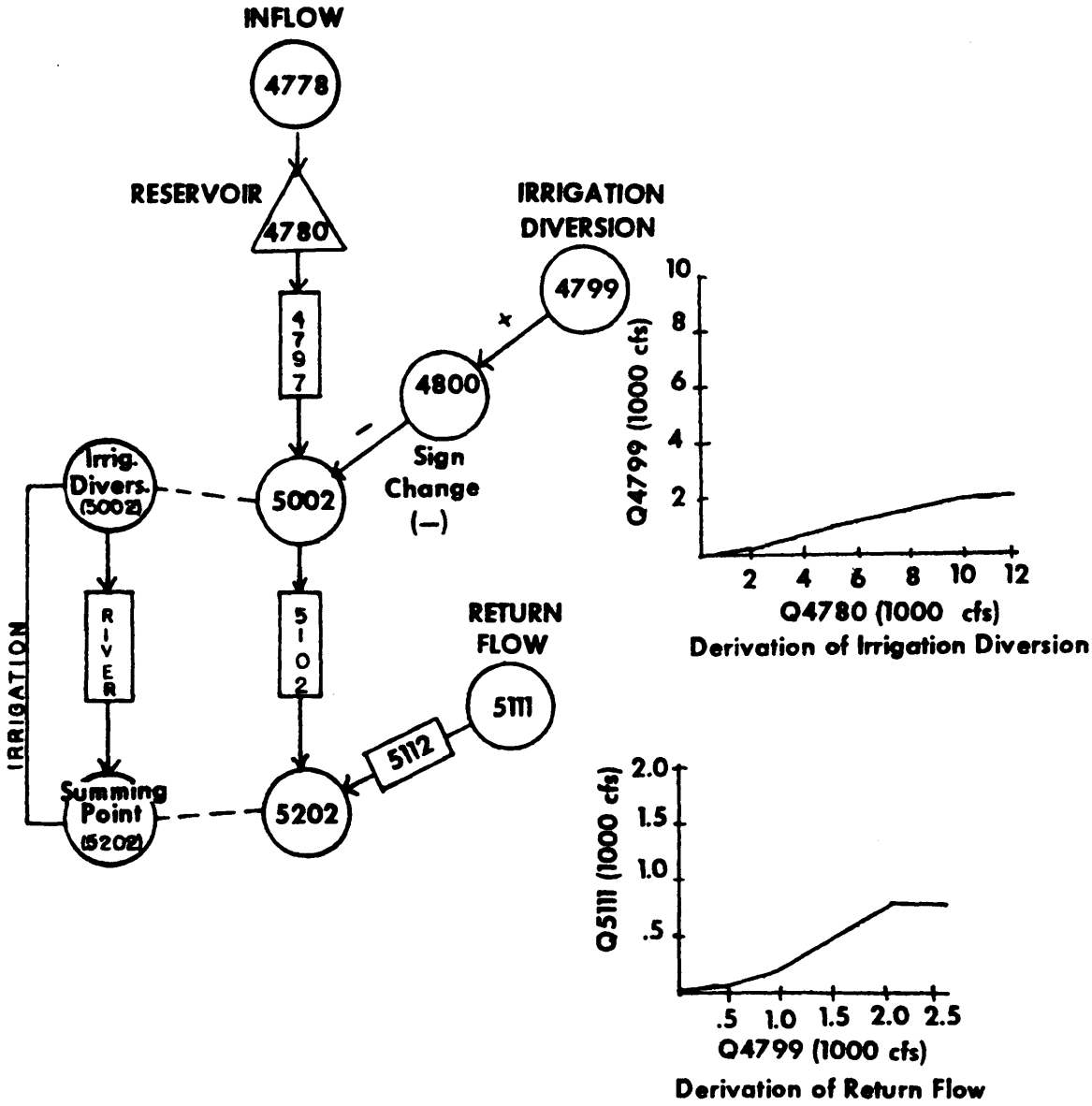
The amount of water diverted for irrigation is often dependent on the flow at another point in the system, for example, the outflow from a reservoir. This relationship can be specified as a percentage, or in a table relationship (Figure 9.14). In this example, when reservoir outflow equals 2,000 cfs, 100 cfs are diverted, and when outflow equals 10,000 cfs, 2,000 cfs are diverted. This relationship may vary throughout a season and different relationships can be specified as required. The configuration scheme in Figure 9.14 shows the diversion going through a sign change and then into station 5002. This is one method of specifying to the program that irrigation flow at station 4799 is to be subtracted, i.e., diverted, from station 5002. The return flow (station 5111) is specified as a function of the amount diverted (station 4799) and enters the river system at station 5202. The amount of irrigation water returned to the system would be highly dependent on the time of the year and the type of crops being irrigated. Therefore, the return flow relationship may also be altered from one season to the next.

The streamflow hydrographs at various points in the system for the preceding example are illustrated in Figure 9.15. The irrigation losses are represented by the difference between diverted (4799) and return (5111) flows. Realistically, the routing reach 5112 would be characterized by an extremely long time of storage.

Multi-Layered Routing. The adjacent station provision can also be used to separate streamflow for multi-layered routing. An example of application would be the case of routing overbank flows. This approach could be used in lieu of a specified table of flow versus time of storage for a channel reach, as previously discussed.

Consider a channel with a 25,000 cfs capacity (Figure 9.16). The routing for this reach (5102) is characterized by five routing phases, n = 0.2, and KTS = 30 hours. When flooding occurs, however, the overbank flow (5111) has a much longer time in storage, characterized by 5 phases, n = 0.2, and KTS = 36 hours.

Here the hypothetical station 4799 is related to inflow (4778) via the adjacent station provision. When inflow (4778) exceeds 25,000 cfs, station 4799 subtracts that flow above 25,000 cfs at station 5002. This relationship between 4799 and 4778 was specified in a CT table. Station 5000 is then specified in the adjacent station provision as 100 percent of 4799 and routed through the "longer" channel reach (5111) for overbank flow. The channel and over-bank flows are summed at station 5202; the corresponding hydrographs for a major storm event are shown in Figure 9.17. The flattened downstream hydrograph (station 5202) is primarily the result of the longer time of storage for flows exceeding 25,000 cfs. The pronounced lag is illustrated by the routed over-bank flow (station 5111).



CONFIGURATION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
P									4	7	7	8							4	7	8	0							
P									4	7	8	0							4	7	9	7							
P									4	7	9	7							5	0	0	2							
P									4	7	9	9							4	8	0	0							
P									4	8	0	0							5	0	0	2							
P									5	0	0	2							5	1	0	2							
P									5	1	0	2							5	2	0	2							
P									5	1	1	1							5	1	1	2							
P									5	1	1	2							5	2	0	2							

Figure 9.14 Configuration for Irrigation Diversion & Return Flow Example

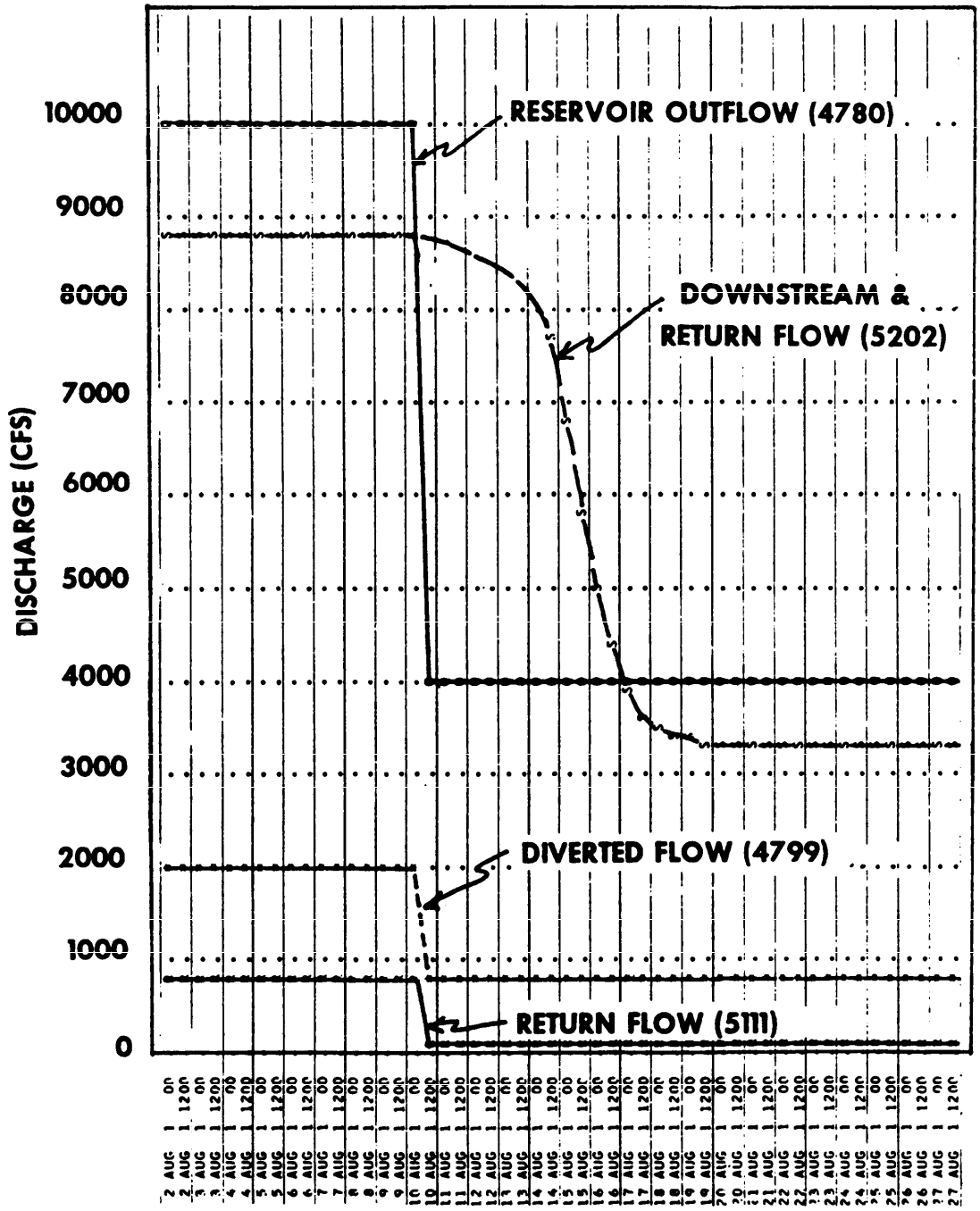


Figure 9.15 Hydrographs of Irrigation Diversion and Return Flow using the Adjacent Station Relationship

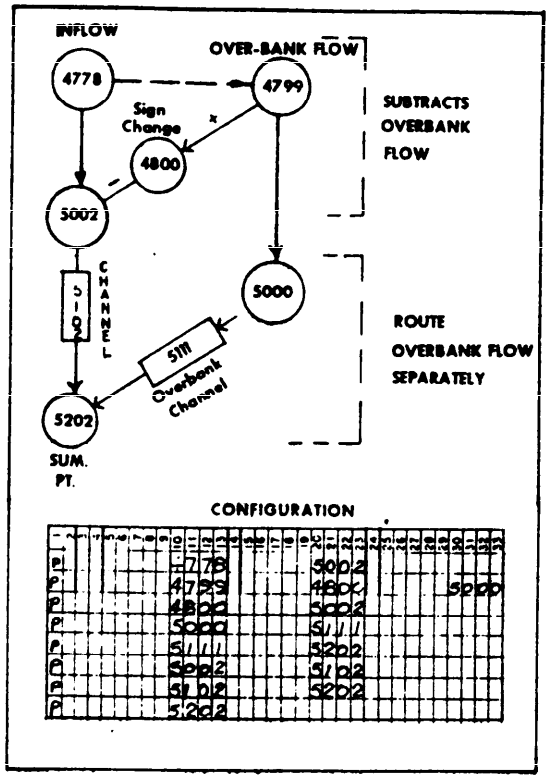


Figure 9.16 Example of Adjacent Station Provision used to Route Overbank Flow

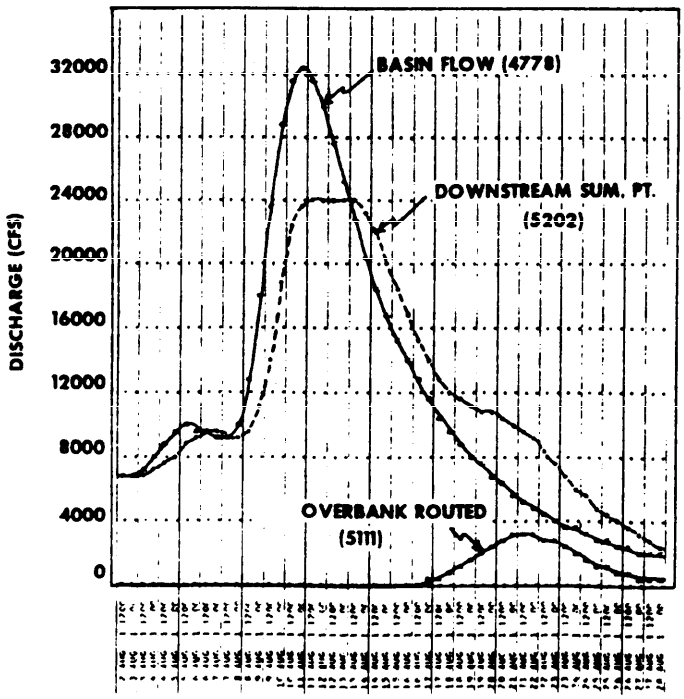


Figure 9.17 Resultant Hydrographs from Adjacent Station Provision used to Route Overbank Flow

Application of Backwater Mode. The backwater provision of the SSARR model is used in the Columbia River Basin where independent downstream controls affect the hydraulic characteristics at a given upstream location. The following examples illustrate some of the SSARR model capabilities in this regard.

a. Backwater Routing.

(1) Single Backwater Relationship. The backwater provision was applied in the upper Columbia River in Canada, where the elevation of Lower Arrow Lake affected the discharge-pool elevation relationships at Upper Arrow Lake (Figure 9.18). This three-variable relationship was specified to the computer in a C2 table for Upper Arrow. The backwater mode is indicated by a "2" in column 15 of the CLØ2 card of the upstream station (Upper Arrow Lake) as shown below:

	STA. NO. UPPER ARROW	INDICATES: ELEV. of LOWER ARROW IS CONTROL SPECIFIED IN C2 TABLE	STA. NO. LOWER ARROW	
CL01	22350025			UPPER ARROW LAKE OUTFLOW
CL02	22350025	2	22410025	1444400 1375980

The CLØ2 card indicates that the pool elevation of Lower Arrow (station 2241ØØ25) is the backwater control for Upper Arrow (station 2235ØØ25), as specified in the C2 table. In addition to CL and C2 cards, elevation-storage relationships must be specified in C1 tables, and initial conditions specified in 2L cards for both stations.

(2) Multiple-Backwater Relationships. A series of backwater relationships can be used for streamflow routing in situations where the hydraulic characteristics of a reach are affected by a downstream control. One such example of this procedure is in the river reach between The Dalles and John Day Dams in the lower Columbia River. Relationships were set up to determine the fluctuations in the water surface resulting from power peaking.

The forebay elevation at The Dalles affects upstream flow and elevation, as does the inflow from the Deschutes River. Several backwater stations were incorporated into the river model for this reach so that the reservoir characteristics could be adequately described

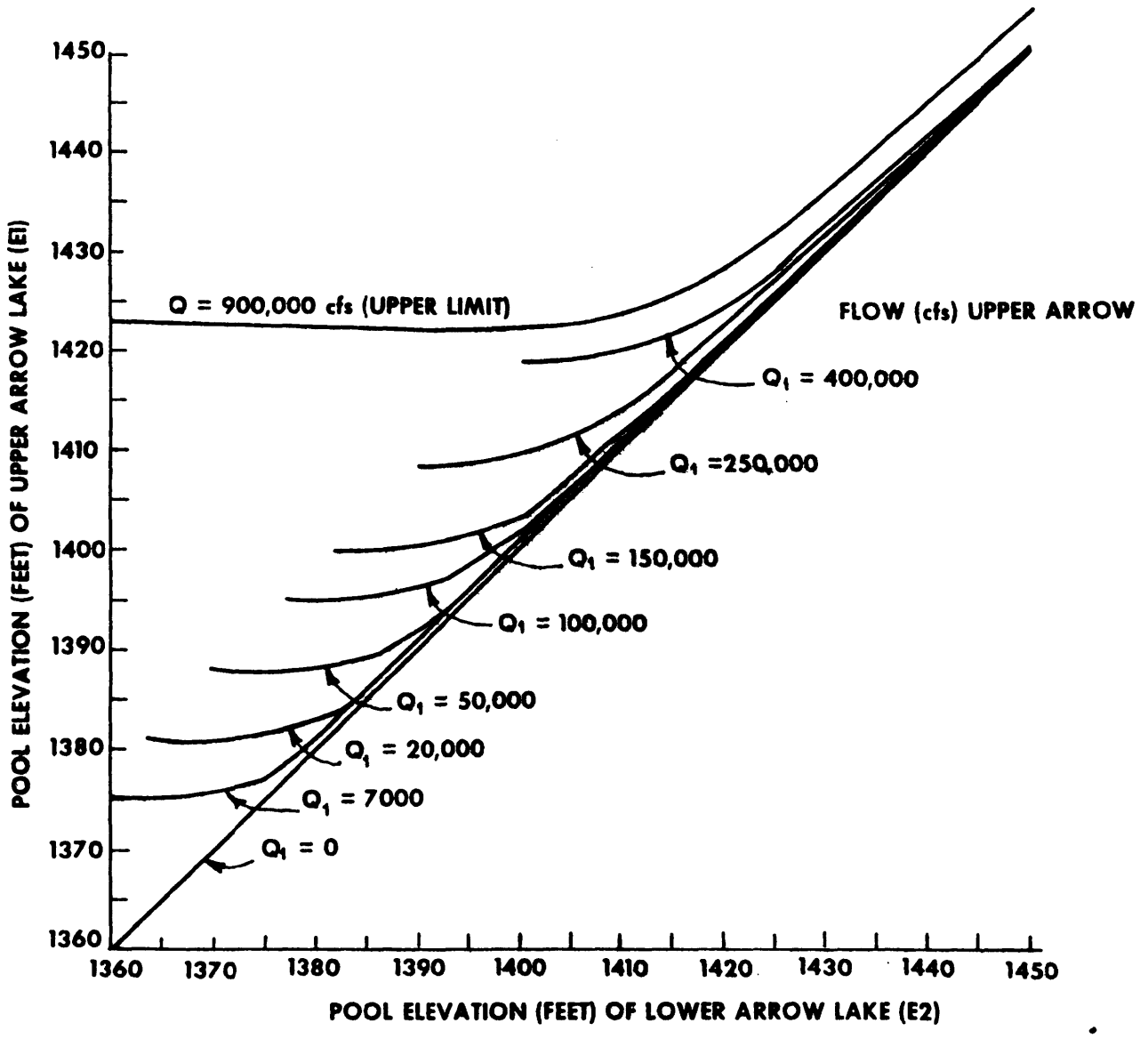


Figure 9.18 Pool Elevation - Discharge Relationships Between Upper and Lower Arrow Lakes in Canada

along The Dalles Reservoir (Figure 9.19). Four backwater relationships were specified along this reach as follows:

Upstream Station		Control Station	
Name	Number	Name	Number
R.M. 196.3	196300	The Dalles Forebay	200000
R.M. 202.7	202700	R.M. 196.3	196300
R.M. 208.2	208200	R.M. 202.7	202700
R.M. 214.0	214000	R.M. 208.2	208200

Elevation-flow relationships (C2 cards) were determined from observed and computed steady flow water-surface profiles. Storage data (C1 cards) were based on channel geometry. These data were adjusted somewhat, after reconstitutions of historical data were made. The C2 table, listing

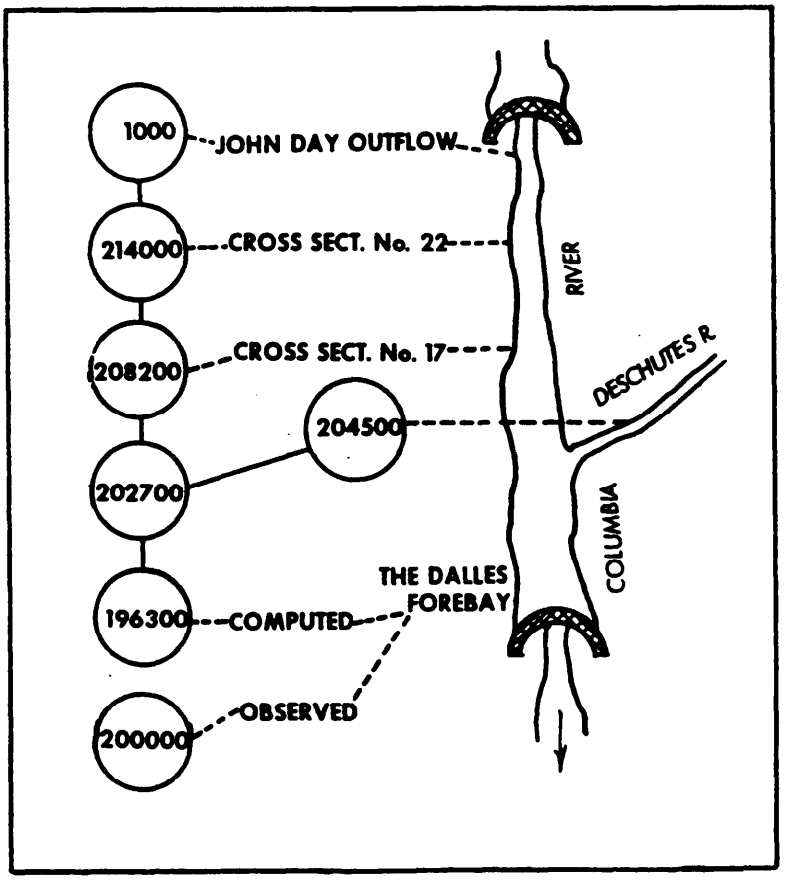


Figure 9.19 Configuration of a Section of the Lower Columbia River used with the SSARR Model Backwater Mode

backwater effects of The Dalles forebay (station 200000) on the upstream station 196300, is presented below:

CARD	STA. NO.	POINT 1 FLOW (cfs)	POINT 1 ELEV. (ft)	POINT 1 CONTROL ELEV. (ft)	POINT 2 FLOW (cfs)	POINT 2 ELEV. (ft)	POINT 2 CONTROL ELEV. (ft)	NOTES
C210	196300	0	15000	15000	0	17000	17000	
C211	196300	50000	15056	14990	50000	15509	15500	
C212	196300	50000	16006	16000	50000	16442	16430	
C213	196300	50000	16788	16770	100000	15098	15020	
C214	196300	100000	15522	15510	100000	16012	16000	
C215	196300	100000	16492	16430	100000	16810	16780	
C216	196300	250000	15152	15050	250000	15576	15540	
C217	196300	250000	16030	16000	250000	16430	16420	
C218	196300	250000	16716	16680	350000	14970	14760	
C219	196300	350000	15552	15480	350000	16014	15960	
C220	196300	350000	16448	16400	350000	16848	16300	
C221	196300	460000	15078	14770	460000	16090	15950	
C222	196300	460000	16960	16850	600000	15717	15500	
C223	196300	600000	15808	15600	600000	15901	15700	
C224	196300	600000	15993	15800	600000	16086	15900	
C225	196300	600000	16178	16000	999999			

The flows and respective elevations for station 196300 are listed in Columns 17-30 and 46-59. The controlling elevations at The Dalles forebay are listed in columns 39-45 and 68-74. Similar relationships were specified for the remaining three backwater stations.

b. Three-Variable Relationships. Stage-discharge relationships for a point in the river can be specified in a three-variable (CF) table when no backwater routing is required. A transfer point (CC card) can be input so that its discharge or elevation is dependent on flows or elevations of two control stations. The flow or elevation of the transfer point is the dependent variable. The flows or elevations of the two control stations are the independent variables. The CF table number is coded in Col. 36-39 of the CCØ2 card. The codes for flow or elevation are specified in the CCØ1 card in columns 24, 25, and 26 for the dependent, first control, and second control stations, respectively. Codes are placed only on the CCØ1 card for the dependent variable, never on the CCØ1 cards for the independent variable. In other words all three codes appear on the same card. If elevation is specified for any station, there must be a corresponding C1 table to relate elevation to flow.

The three-variable relationship can be applied where tidal action at the mouth of a river affects the elevation-discharge relationships upstream. The input listing for such an application is illustrated in figure 9.20. Discharge at station 1 and the downstream elevation at station 2 affect the elevation at station 3. Stations 1 and 3 are physically the same locations but must be numbered separately for the model. Hypothetical elevation-discharge relationships are specified for stations 2 and 3 with C1 cards.

```
JOB  79990004          120      1
CF          99          100        0    -330   50000    -140  100000      50
CF          99          100   150000     260  200000     470  250000     680
CF          99          100   300000     890  350000    1090  400000    1280
CF          99          100   500000    1660  600000    2020  700000    2330
CF          99          100   800000    2600  900000    2810
CF          99          400        0    -140   50000      20  100000     190
CF          99          400   150000     370  200000     550  250000     730
CF          99          400   300000     910  350000    1100
CF          99          700        0      70   50000     190  100000     340
CF          99          700   150000     480  200000     640  250000     790
CF          99          700   300000     940  350000    1100
CF          99         1100        0     330   50000     420  100000     530
CF          99         1100   150000     640  200000     750  250000     860
CF          99         1100   300000     970  350000    1130  400000    1310
CF          99         1100   500000    1680  600000    2000  700000    2020
CC 1         1        1
CC 1         2        1
C110         2     -100   -100                   100     100
C111         2                                 99999999999999999999999999999
CC 1         3        1  212
CC 2         3           1          2   99100
C110         3     -100   -100                   100     100
C111         3                                 99999999999999999999999999999
P            1
P            2
P            3
T    00 050366 1 21   70366
6 3          1  0  5 3661 165    166    168    174    178    180    180    187
6 3          1  0  6 3661 187    192    195    198    199    201    203    202
6 3          1  0  7 3661 200    195    181    173    176    182    178    171
6 1          2  0  5 3662    230    150    297    445    592    740    676    612
6 1          2  8  5 3662    549    485    421    357    294    230    397    565
6 1          2 16  5 3662    732    900    806    712    619    525    431    337
6 1          2  0  6 3662    244    150    282    414    546    678    810    727
6 1          2  8  6 3662    645    563    480    397    315    232    150    403
6 1          2 16  6 3662    657    910    826    741    657    572    488    403
6 1          2  0  7 3662    319    234    150    327    505    682    860    771
6 1          2  8  7 3662    682    594    505    416    327    239    150    337
6 1          2 16  7 3662    525    712    900    817    733    650    567    483
PE           2*        3X                   00 050366   070366  1        0     20
PUC          1+                                 050366   070366  1  110000 210000
END
/*
```

Figure 9.20 Input Listing showing the Application of the Three-Variable Table for Specifying Elevation-Discharge Relationships

Elevation data for station 2 and streamflow data for station 1 were given in "6-card" formats. The resultant changes in elevation at the upstream point (station 3) are shown in Figure 9.21. The tidal effects from downstream are revealed in the fluctuating elevations upstream. For illustrative purposes, the lag time from station 2 to station 3 was ignored.

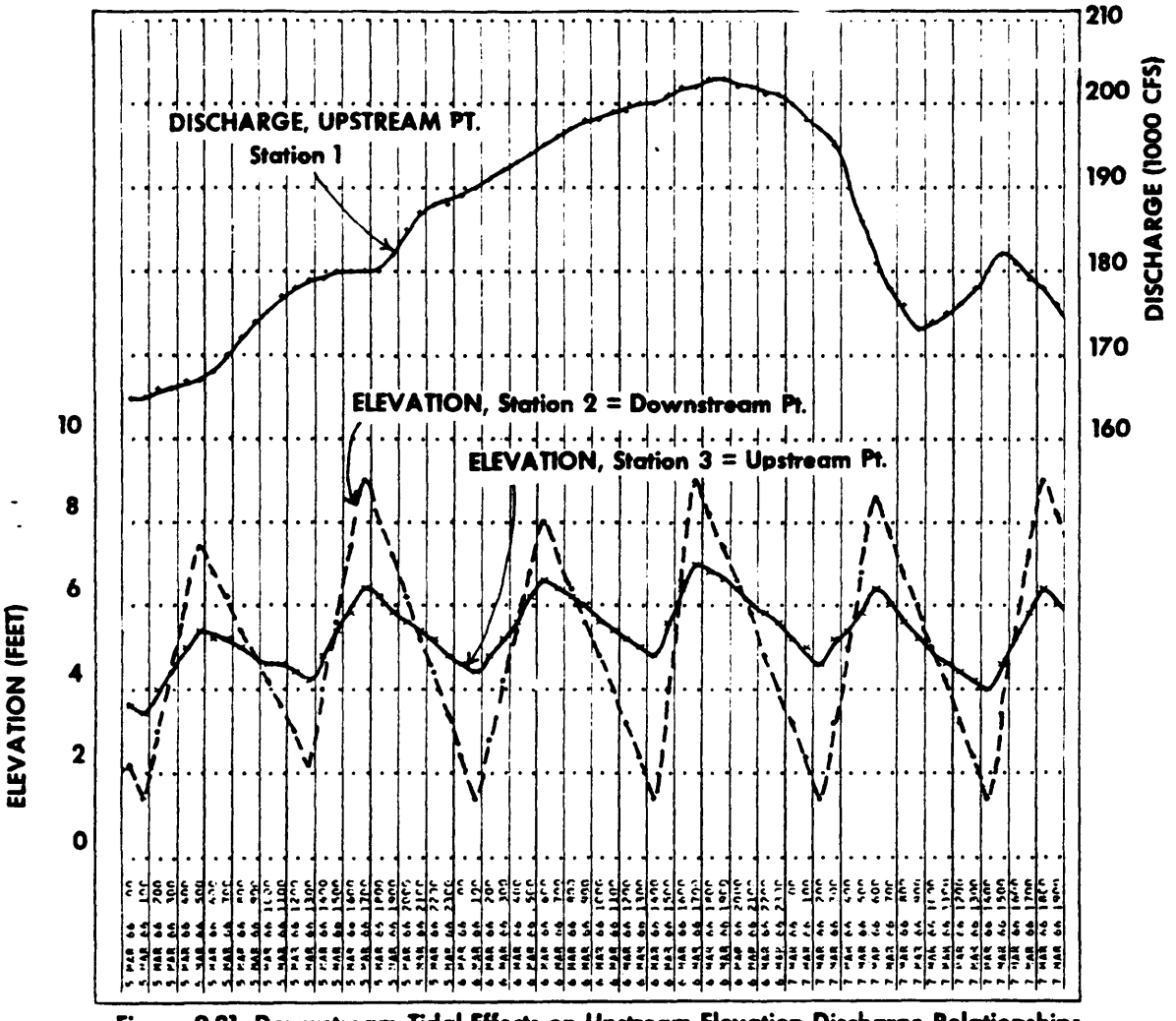


Figure 9.21 Downstream Tidal Effects on Upstream Elevation-Discharge Relationships

Reservoir Regulation. The reservoir regulation provision in the SSARR Model provides several methods of simulating reservoir regulation or specifying free flow. The type of regulation is dependent on the objectives of the user as well as system requirements. Often, the operation of a reservoir or reservoir system is determined by such multi-purpose aspects as flood control, power production, navigation, irrigation, fish and wildlife, and recreation.

The following discussion describes the capabilities of the SSARR Model to implement reservoir operational requirements and is not intended to illustrate all methods of reservoir operation. Program requirements are discussed initially, followed by hypothetical examples of a single reservoir operation which illustrates some of the capabilities of the model. In addition, a multiple-reservoir system, which has been regulated successfully with the SSARR Model, is described.

The physical characteristics of a reservoir, inflows to the reservoir, and downstream requirements, must be known to regulate a reservoir. Program requirements for a reservoir include the following input:

(1) Reservoir characteristics which consist of upper and lower pool elevation bounds specified in a CLØ2 card, and elevation-storage or elevation-storage-outflow capacity relationships specified in a C1 table.

(2) Initial conditions consisting of outflow and either elevation or storage (in 2L card).

(3) Reservoir regulation specifications in "6-card" formats which include freeflow, outflow, pool elevation or change in elevation (feet per day), and storage or change in storage (acre-feet per day or cfs-days). Any one or combination of the above specifications can be used over a specified time period. If a regulation is not specified or a "gap" is present within the 6-card specification, the program defaults to free flow; if no hydraulic capacity is present in a C1 table, the reservoir will pass inflow.

a. Regulation of a Single Reservoir. Several methods of operation of a single, hypothetical reservoir will be discussed in the following examples to illustrate program capabilities. The configuration of the reservoir system is presented in Figure 9.22. The program listing is presented in Figure 9.23.

(1) For the first example the reservoir was specified to pass inflow for the entire computational period.

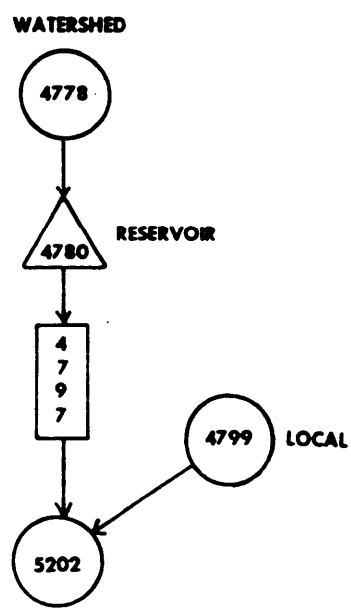


Figure 9.22 Configuration of Hypothetical River System with One Reservoir

```
1*******10*********20*********30*********40*********50*********60*********70*********80
JOB          240671 00120      0          RESERVOIR REGULATION EXAMPL. BROOKS
CP          60        500                                                    CLIMAT
CP          70        500                                                    INPUT
CP          75        500                                                       SPF
CT 1      1009          2       0       0     2300       0     2500     100
CT 2      1009       3000     600    4000     1600   10000     7600  999999
CT 3      1009     992500
CT 1      8010          2       0       0      0.1     .05      0.2     0.1
CT 2      8010        0.4     0.2     0.6      0.4     1.0      0.9    9999
CT 3      8010       9990
CT 1      8110          2       4    0.03        5    0.09        6    0.11ETI
CT 2      8110          7    0.08       8     0.06       9    0.02        ETI
CT 1      8210          2       0      30      2.0      46     4.0      80
CT 2      8210        6.0     100     999      100
CT01      8211          2       0      20      1.5      23     3.0      35 HIGH
CT 2      8211        4.0      48     6.5       80     8.5      95     9.0   SMI
CT 3      8211        100     999     100
CT 1      8310          2       0      80      0.1      50     0.2      33BII
CT 2      8310        0.4      21     0.6       16     0.8      15     1.0   BII
CT 3      8310         15     999      15                                  FAIRBK
CT 1      8410          2       0     100      0.2      50     0.5      30KE
CT 2      8410        1.0      20     1.5       20    9999      20        FAIRBK
CT 1      8510          2       0     100      100     100    9999    9999   SCD
CT 1      8610          2       0    .200      100    .200    9999   0.20 M R
CB 1      4778     1 1 1              ONE BASIN        0 TO 25
CB 2      4778   23063 25 3  50 3 100     84 84108510     81108210
CB 3      4778     8310  10 8010                     8610          33 32 30
CB04      4778     3  751004  60075
C3 1      4778  1000   00 1100  500 1400  9999999999999
CL 1      4780        1            RESERVOIR
CL 2      4780                          17478  151600
C110      4780    1276                        0 1280                        8
C111      4780    1300                      219 1320                      796
C112      4780    1340                     2855 1360                     5532
C113      4780    1380                     8065 1400                    12633
C114      4780    14195                   24070 1440                    29766
C115      4780    14605                   36948 147875                  45250
C116      4780    15005                   55660 151600                  64271
C117      4780    15325                   83904 154000                 109111
C118      4780    15605                  153047 158000                 198223
C119      4780    16005                  254748 162000                 322684
C120      4780    16405                  402060 165675                 509473
C121      4780    16605                  602984 168075                 705678
C122      4780    16905                  857759 171049                 955995
C123      4780    17255                 1525775 174055                2617320
C124      4780    17478                 305477099999999999999999999999999999
CR 1      4797        1            ROUTING REACH NO.4
CR 2      4797              16 2    35
CC 1      4799        1            LOCAL
CC 2      4799                   4778     005
CC 1      5202        1            DOWNSTREAM FLOW
P         4778      4780
P         4780      4797
P         4797      5202
P         4799      5202
1   000020801120240150901
2800      4778 240010801      5      1                          25  999
2802      4778 240010801     200    200    200    200
2803      4778 240010801    2500   2500   2500   2500
2804      4778 240010801    4000   4000   4000   4000
2L        4780 000020801          151600
4D   6      70 2400108013  10  15  20  15
4D   6      70 2400208013  25  35  60  25
4D   6      70 2400308013  10  10  10  10
4D   6      75 2400108013  04  05  05  05
4D   6      75 2400208013  10  10  20  05
4D   6      75 2400308013  04  03  02  02
4D   6      75 2400608013  20  20  30  25
4D   6      75 2400708013  35  45  95  30
4D   6      75 2400808013  20  20  20  15
4D          60 2400108014 550 555 630 690 685 640 585 500 525 535 560 660 670 520
4D          60 2401508014 550 560 555 630 660 670 685 640 585 500 525 535 520 560
4D          60 2402909014 540 530 520 510 510 510 520 530 510 520 510 500 500 501
4D          60 240010801910  08  10  09  09  08  08  08  08  08  08  08  08  08
4D          60 240150801908  08  08  08  08  08  08  08  08  08  08  08  08  08
6S        4780 0000208010
PQ        4778*     4780R     52020          000020801240150901 120       0  60000
FINAL FILE OF TIME RECORDS FOR OUTPUT AND PLOT IS ON UNIT 21
PEC       4780E                                                     1200   1700
END
```

RESERVOIR CHARACTERISTICS

INITIAL CONDITIONS

REGULATION

Figure 9.23 Input Listing for a Single Reservoir as shown in Figure 9.22

Since no outflow capacity was indicated in the C1 table, the freeflow specifications (data code "0" in 6S card) caused the reservoir to pass inflow (Figure 9.24). Another means of passing inflow would have been to specify changes in elevation (code 5) or changes in storage (codes 4 and 6) equal to zero.

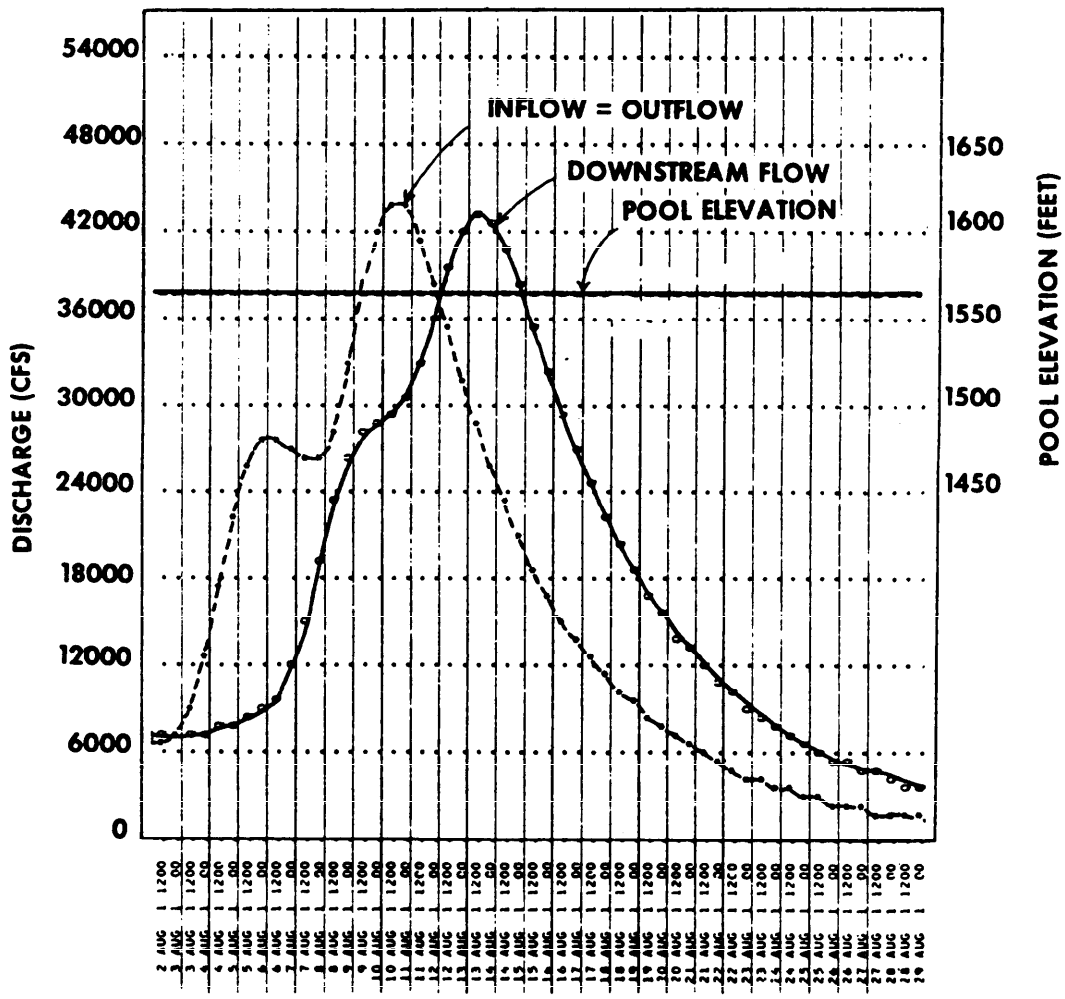


Figure 9.24 Hydrographs from a Reservoir Specified to Pass Inflow

(2) An example of freeflow routing is illustrated in Figure 9.25. Outflow capacity was specified in the C1 table in addition to freeflow specification with 6S cards. If the uppermost elevation of the reservoir is reached, the program automatically passes inflow if the reservoir's hydraulic capacity is not exceeded. If a hydraulic capacity curve is present, the model uses this curve to deplete surcharge.

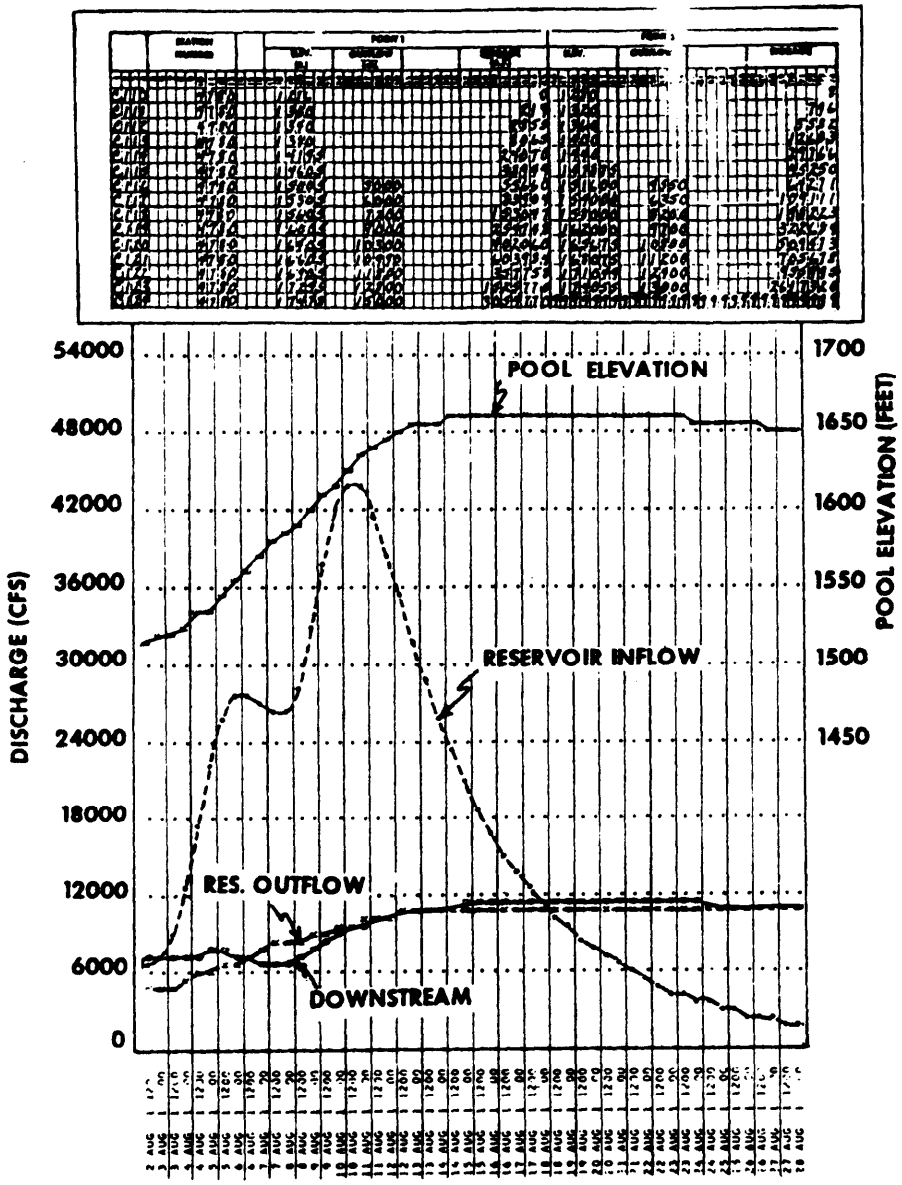


Figure 9.25 Storage-Elevation Characteristics with Outflow Capacity used for the Reservoir Specified for Free-Flow Routing

(3) Several types of regulation can be specified with time. Figure 9.26 illustrates a condition whereby the reservoir initially passed inflow by specification of freeflow with no hydraulic capacity curve in the C1 table. As inflow increased, the reservoir outflow was reduced to 6,000 cfs at 00 hours, 10 August and further reduced to 2,000 cfs at 1200 hours, 10 August for flood control. The outflow was gradually increased back up to 4,000 cfs on 15 September after flooding was presumably over. The reduction in downstream flow compared to the reservoir inflow was substantial. The downstream peak in this case was attributed to local inflows.

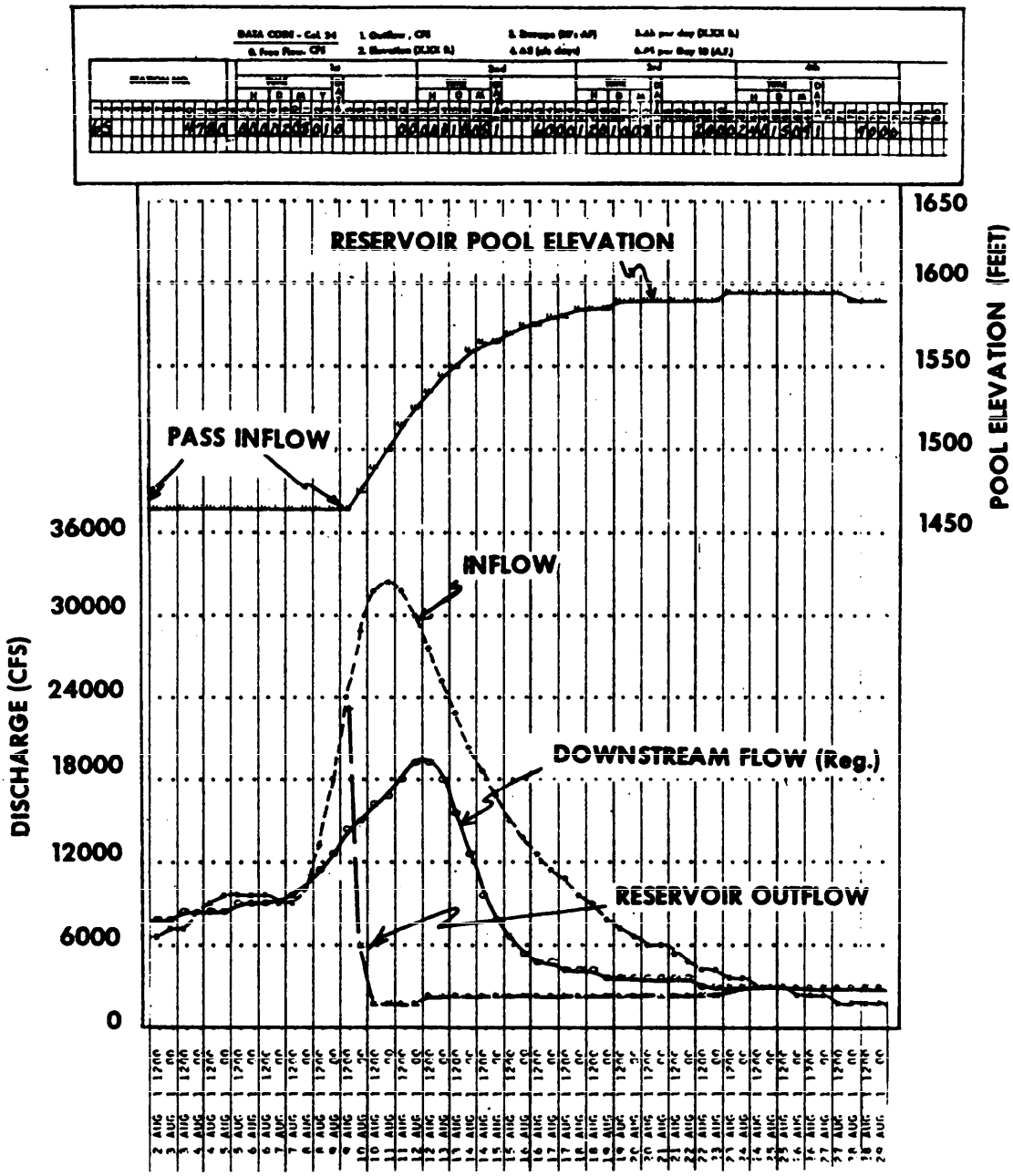


Figure 9.26 Reservoir Regulation Scheme of Freeflow and Outflow Specifications

(4) One method of passing inflow is to specify a constant pool elevation as illustrated in Figure 9.27 from 2 August to 8 August. In this case a "target" elevation of 1,585 feet was specified by 1200 hours on 22 August. When such a procedure is used, care must be made to insure that adequate inflows are available over the given time span to reach the specified elevation. The reservoir inflows were not adequate on 21-22 August which caused the model to compute "negative" outflows to meet the specified elevation. The elevation 1585 was maintained until the 3,000 cfs outflow specification at 1200 hours, 15 September.

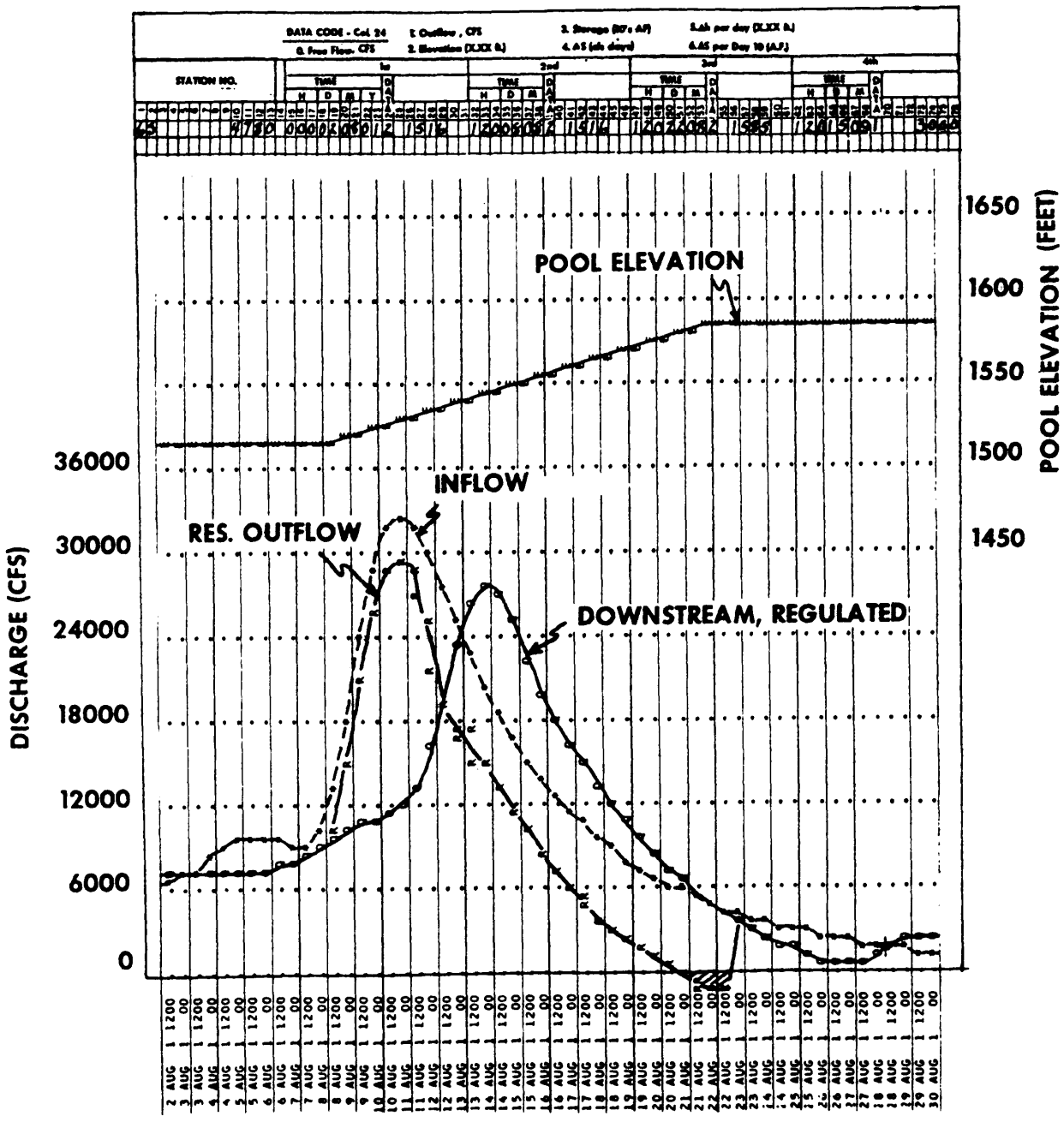


Figure 9.27 Reservoir Regulation by Pool Elevation Specification

(5) Reservoir storage volumes can be manipulated with time as indicated in Figure 9.28. A storage of 300,000 acre-feet was specified for 00 hours 21 August and maintained until 1200 hours, 15 September. Again, the program insured that these values were met, which caused "negative" outflows to be computed. Note that a negative outflow was computed at 00 hours, 21 August to reach the 300,000 acre-feet specification. Thus, the user must be familiar enough with the system under consideration to maintain realistic limits.

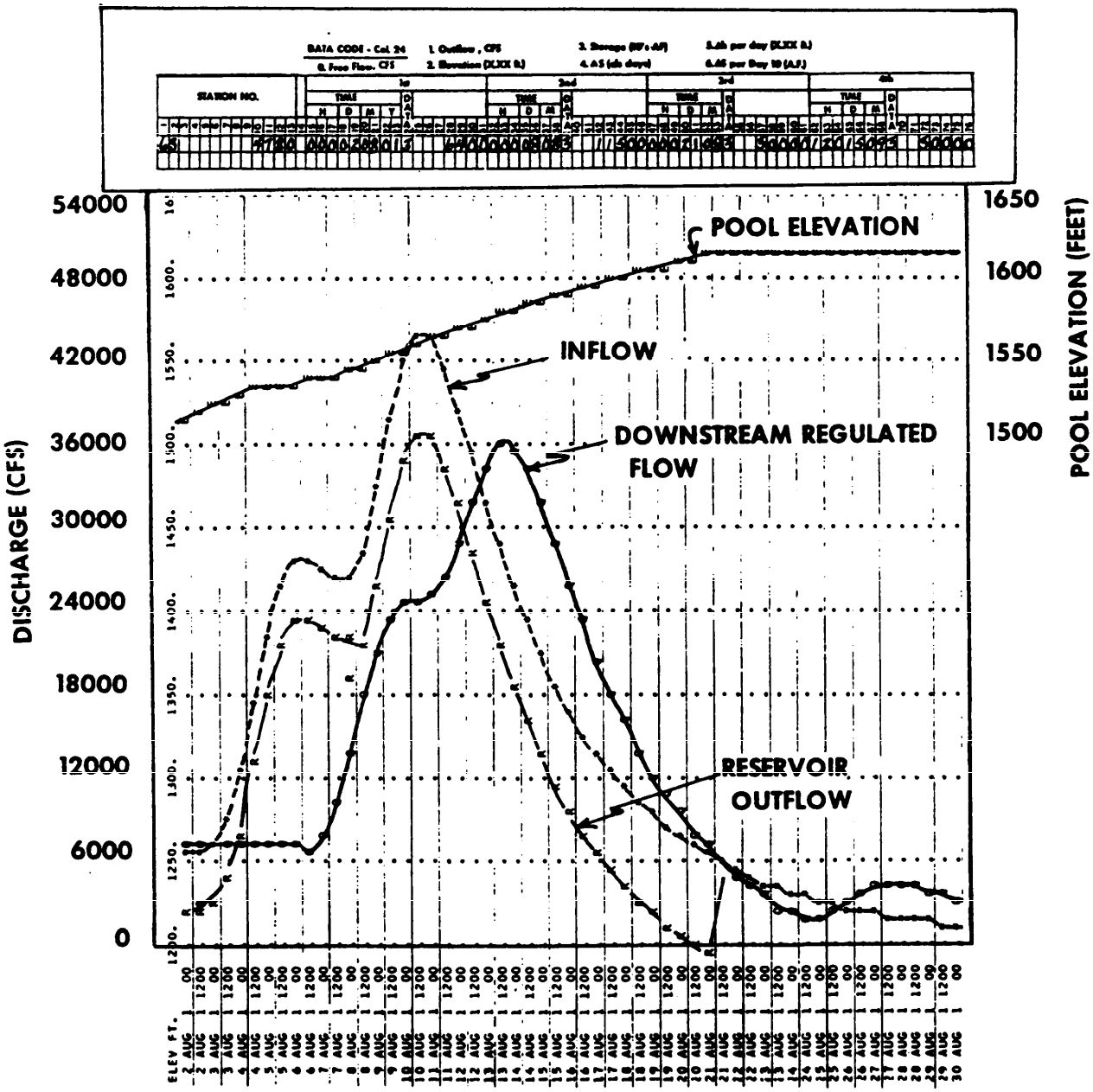


Figure 9.28 Reservoir Regulation by the Specification of Storage

(6) A filling schedule for a reservoir can be specified by the program as indicated in Figure 9.29. Initially a 3 ft./day increase in pool elevation was specified, however, due to the substantial reservoir inflow, the filling rate was increased to 10 ft./day to diminish the downstream peak. This enabled the pool elevation to reach 1600 feet sooner. Freeflow was specified at 1200 hours, 20 August. However, no regulation was specified from 16 to 20 August so the program automatically reverted to freeflow. This caused the reservoir to pass inflow because no reservoir outflow capacity was designated in the C1 table.

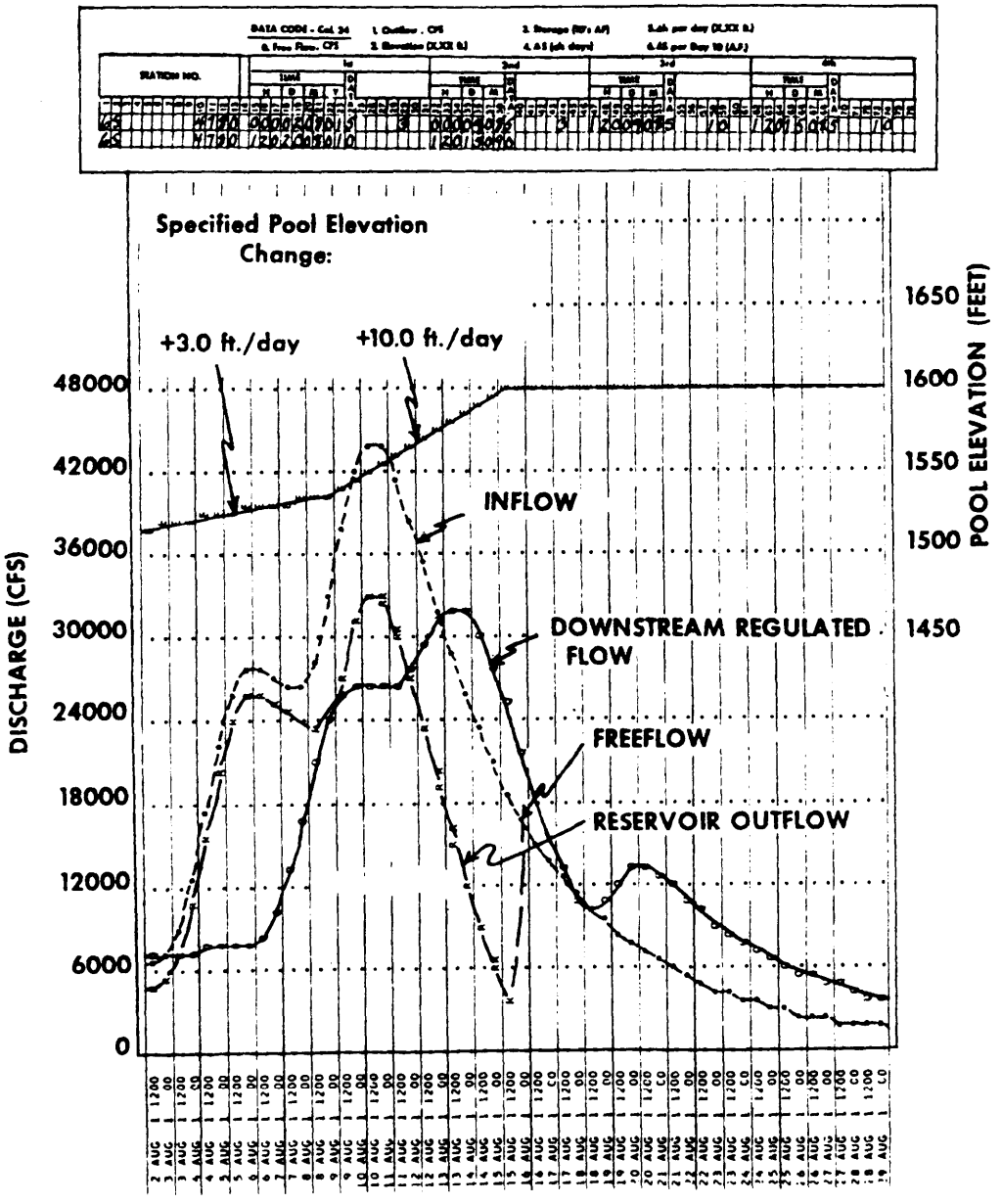


Figure 9.29 Reservoir Regulated by Specification of Change in Pool Elevation with Time

(7) The program has some "built-in" features that come into use when reservoir characteristics are exceeded. The problems of specifying unattainable pool elevations or storages have been discussed in previous examples. In cases where the maximum pool elevation and hydraulic capacity are exceeded, the reservoir automatically goes into a free-flow condition as illustrated in Figure 9.30. The same outflow hydraulic capacity for the reservoir as in Figure 9.25 was used. Initially an outflow of 15,000 cfs was specified, which exceeded the capacity in the table for elevation 1740 feet. Therefore, the program reverted to the

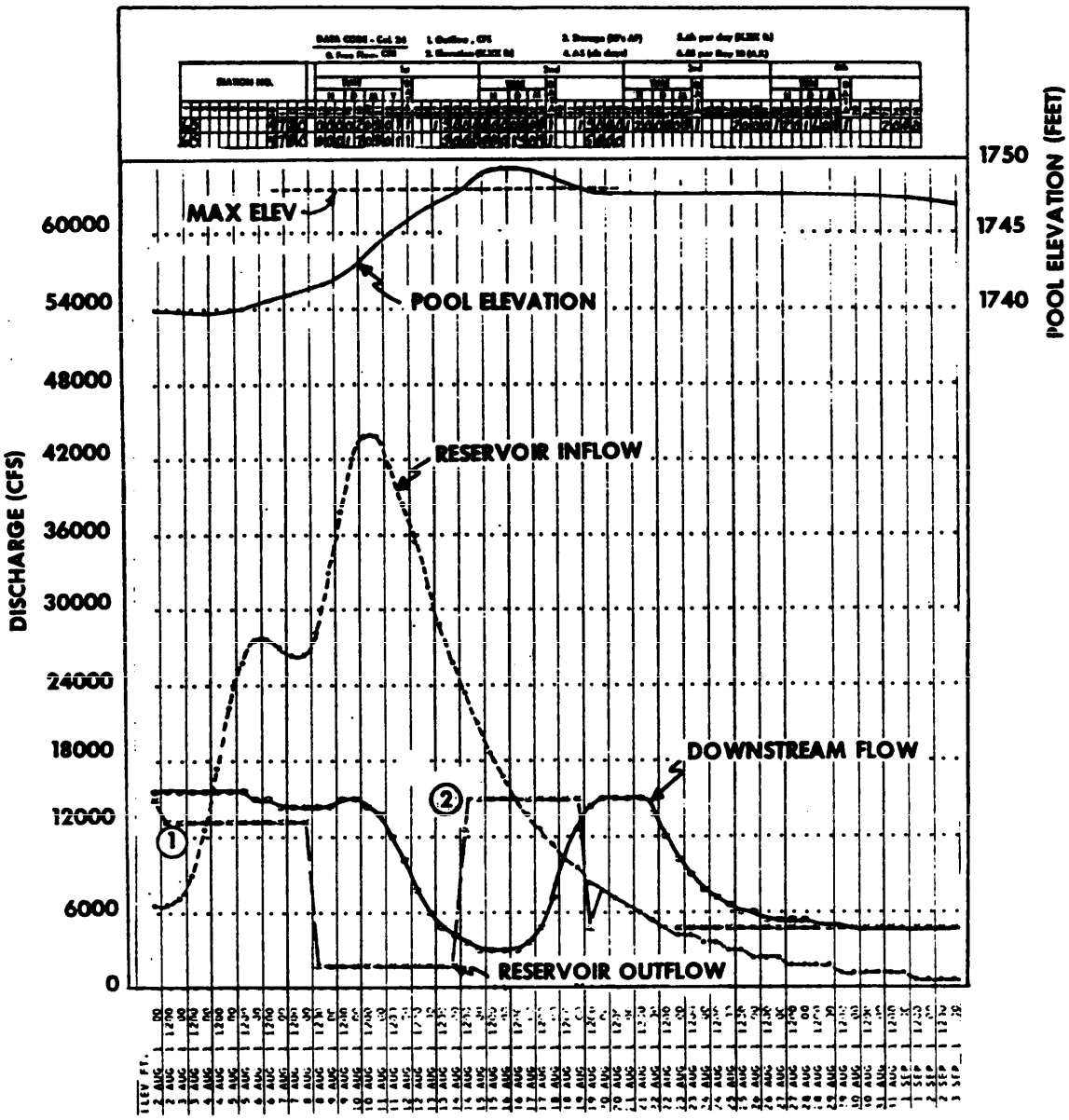


Figure 9.30 Example of Automatic Freeflow Routing when the Hydraulic Capacity of the Reservoir is Exceeded

table which specified 13,000 cfs for the 1739-1740 feet pool elevation (point 1 in Figure 9.30). The reservoir outflow was then reduced to 2,000 cfs at 1200 hours, 8 August, and specified to maintain that outflow until 1200 hours, 16 August. On 14 August between 00 and 1200 hours, however, the maximum pool elevation (1747.8 feet) was attained which in turn caused outflows to be determined from freeflow computations (point 2). The reservoir remained on freeflow until the pool elevation dropped below the maximum elevation, at which time the specified outflow of 5,000 cfs (from the 6S card) was used.

b. Instantaneous Flow Change. When reservoir operations are specified in terms of storage change (through 6-card code 2, 3, 4, 5, or 6), the reservoir outflow is calculated as being parallel to the inflow hydrograph, and separated by the stipulated volume amount. When the specified storage change differs from one period to the next, an instantaneous change in flow must necessarily be utilized. Such a condition is illustrated in Figure 9.31. The instantaneous flow change is printed out as an extra line of output, the outflow being designated by an "S". The flow values so designated are the starting flow for the next time interval; therefore, they must be utilized in computing hydrograph volumes. These values are stored in memory by the computer and are utilized in computing downstream reservoir inflow, if required.

An instantaneous flow change will also occur if the reservoir elevation computed from either storage change or specified outflow would exceed upper or lower bounds at the end of a time period. In this case the elevation is adjusted to equal upper or lower bounds at the end of the period and the outflow for that period is instantaneously changed from that originally computed or specified to compensate for the change in volume.

c. Multiple Reservoir System. The SSARR Model has been used operationally to study regulation procedures and to regulate several of the multi-purpose projects in the Columbia River system. Upstream from Bonneville Dam, the system consists of 67 watersheds, 47 channel reaches, and 28 reservoirs (Figure 9.31). Since the quantity of input for the entire system is substantial, the use of the model will be described only in general terms.

One use of the model in the Columbia River system has been to evaluate evacuation and filling procedures for the 14 flood control projects during the spring runoff period. Spring runoff of record were simulated in one study with reservoirs regulated by the program. Historical streamflow data were input for the entire system to study the compatibility of flood control requirements with other needs such as power, recreation, and fishery management.

The projects in the Columbia River system are regulated in accordance with prescribed procedures to achieve desired control at downstream points. Different magnitudes and timing of reservoir releases for the various projects have been studied in order to evaluate the system response. Often it is of interest to determine unregulated flows, i.e., flows that would have occurred had there been no projects. This can be accomplished by using parallel river reaches, one of which passes inflow throughout. For example, change in storage (data code 4 or 6) would be specified equal to "0" for the required time period for one reach.

The SSARR Model is used on a day-to-day basis for the projects in the Willamette River Basin, a tributary to the Lower Columbia River. The model is used to compute inflows, route river flows, and to operate the 11 reservoirs in the system. The reservoirs are operated with rule curves as guidelines to maintain storage space in the winter for flood control and to bring up the pool elevations in the spring and summer for recreational and other uses. Several projects have constraints because of power requirements. The basin configuration and respective characteristic cards have been established, therefore the operation of the reservoirs involves a minimal amount of card handling.

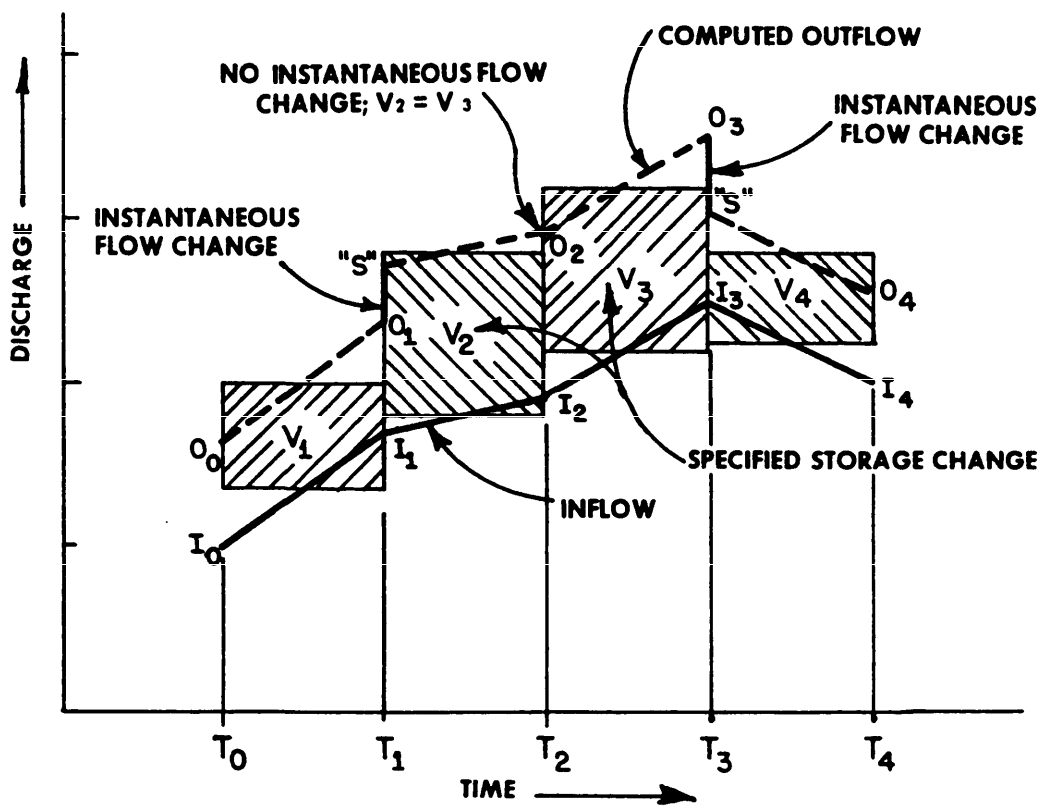


FIGURE 9.31 INSTANTANEOUS FLOW CHANGE

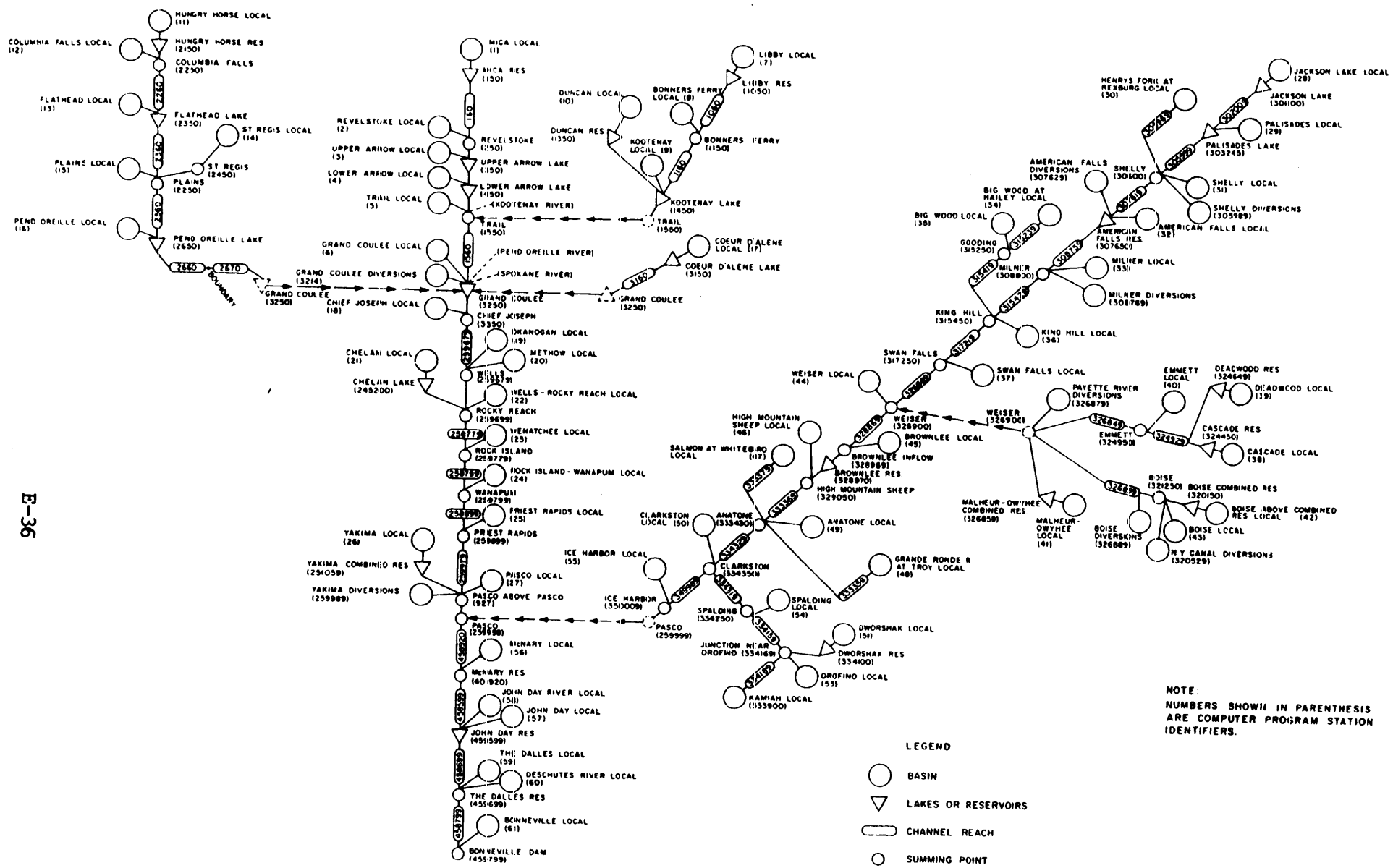


FIGURE 9.32 SYSTEM DIAGRAM OF THE COLUMBIA RIVER BASIN, CONFIGURATION USED WITH THE SSARR MODEL

Output from the River Model. When the river model has completed processing, the computed flow and elevation (when available) are available for each compute period for each station in the model-list. These values are in the river model temporary work file and must now be processed by one or more of the output processors to be viewed by the user and/or saved in the SSARR work file for later use.

The output processors may be summarized as follows:

The Output Phase. In the automatic program cycle (see page B-17 of Appendix B), the OUTPUT phase follows the river model. The OUTPUT phase is entirely controlled by the first card of station characteristics, the "CB01", "CC01", "CR01" and "CL01" card formats. Card column 21 of these formats direct the OUTPUT phase to print a tabular report and/or punch card code "6" cards containing the computed flows. The Snowband Model does not have OUTPUT phase controls in the characteristics.

Punched cards will be in "6D" (daily) format if column 33 of the "J" card is blank; "6hh" format is punched, representing all compute period values if "J" card column 33 contains "H"; if "J" card column 33 contains "P", a 1-per-card format is punched:

Columns

1	Blank
2-9	Station Name.
10-18	Time-date as hhhddmmyy where hhh is hour in tenths.
19-25	Flow, cfs
26-32	Elevation, feet in hundreths (xxxxx.xx)

These cards are punched in the order of: all stations in model-list requesting punched output, for each compute period. For example; if 5 stations in the model-list request punched output, the first 5 output cards will be for run-start-time; the next 5 will be for the end of the first compute period; and so on.

The printed report contains three stations per page. There is a column provided for discharge, elevation, and storage for each station. The columns are filled in depending on the type of station and availability of C1 table.

The time spacing of the report depends on columns 26-29 of the "J" card, and period hours on the "T" card. Lines will be printed for the end of the compute periods only.

The printed report is produced on FORTRAN unit 6 or unit 8 depending on column 30 of the "J" card.

If column 31 of "J" card does not contain a "1", the report skips to a new page at the beginning of each month.

The OUTPUT phase is not processed if the "T" card contains a "1", "2", or "4" in column 80.

PR, PT, and PU Cards. These card formats produce a tabular report, and punch mean-daily "6D". See Appendix B, page 73-75 for a description. The report may be restricted to 80-column printer width.

Printer Plot; PE, PH, PL, PM, PQ, PS, PZ Cards. A plot-format report is produced on the 132 character-width printer by these cards. See Appendix B, page 68-71 for a description.

XC, XH, XS Cards Teletype Report. This format is designed for display on printer or screen with 80 column width, particularly for the display of forecasts. See Appendix B, pages 77-79.

ZS Card, Statistical Summary. Produces a tabular report of monthly statistics, including comparisons designed for analysis of computed vs. observed. See Appendix B, page 39.

An option of the ZS card will cause "6D" cards of mean daily flows to be produced.

Saving River Model Results to the SSARR Work File: "A", "S", "ZA", "SZQ", "ZSE" Cards. The river model results may be copied from the temporary file into the SSARR work file into the type 100 and type 102 records. These records may then be used by other models as input. See Appendix B, pages 40, 48, and 75.

APPENDIX F

APPLICATION TO OPERATIONAL RIVER FORECASTING

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APPENDIX F

APPLICATION TO OPERATIONAL RIVER FORECASTING

Background. Simulation requirements for operational river forecasting are similar to those for research and planning purposes, however, there are four unique aspects of operational forecasting which require different model capabilities and operating procedures.

The utility of a river forecast is dependent on both the accuracy and the timeliness of the predictions. The value of a perfect forecast reduces with time until its value is near zero at the time of the event. Therefore, an important characteristic of a model for operational river forecasting is the ability to minimize the time of forecast preparation.

In operational river forecasting the computations are restarted daily or more frequently under rapidly changing conditions. This fact places great importance on the ability of the model to compensate for the effect of initial conditions and to adjust the antecedent computations to the observed initial conditions.

On a current basis the data available to evaluate hydrologic conditions in a watershed are at a minimum. Therefore, the model must minimize the effect of a deviation due to use of incomplete and inaccurate precipitation, runoff, and temperature data. As the runoff computation is extended into the future the hydrologic input is composed of forecast values which are subject to well known limitations. This places great responsibility on the forecaster and the model to be realistic about the compromise between theoretically desirable complexity and computational detail in light of the validity of the hydrologic data available as input.

River systems with reservoirs which exert significant control over the river flows add another level of complexity to the forecasting problem and the resulting model requirements. The interdependence of the forecast of runoff and the regulation of the reservoir makes manual specification of reservoir operations to the model impractical, if not impossible. Therefore, an ideal model should have the ability to "regulate" the reservoirs automatically on the basis of criteria for reservoir elevation and outflow as well as discharges and stages at points downstream from the reservoir. Justification of the decisions in design of the model for operational forecasting, in the choice of the options used, and in methods used in applying the model will generally be on the basis of one or more of the above four unique aspects of operational river forecasting.

Purpose and Scope. This discussion of the application of the SSARR Model to operational river forecasting will point out some of the options which are used in day-by-day forecasting in a real-time situation. In various cases special methods and approaches to the forecast operation are discussed. The user wishing to apply the SSARR Model to forecasting can experiment with these techniques to determine whether they are useful

in his particular area. Other discussions of the methods used will help to explain why some of the options and flexibilities were incorporated into the SSARR Model. In other cases this discussion emphasizes areas where additional refinement and programming is desirable.

With these purposes in mind, the following paragraphs discuss separate topics which make the application of the SSARR Model to forecasting different from historical simulation.

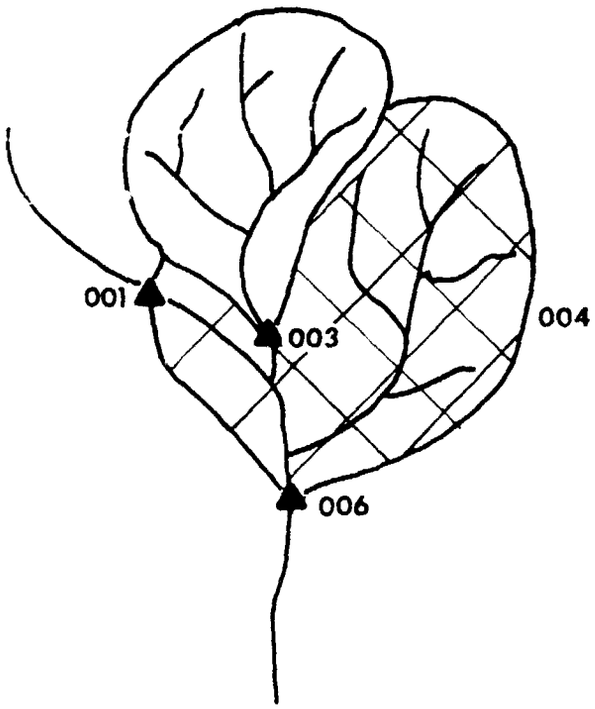
Local Area Runoff. The use of the adjacent station provision for local area runoff is described in pg. 49-50
In operational forecasting there are several important uses of the local area runoff concept. Because of the errors inherent in both the model routing and the reported hydrologic data there is a need for adding a "balancing flow".

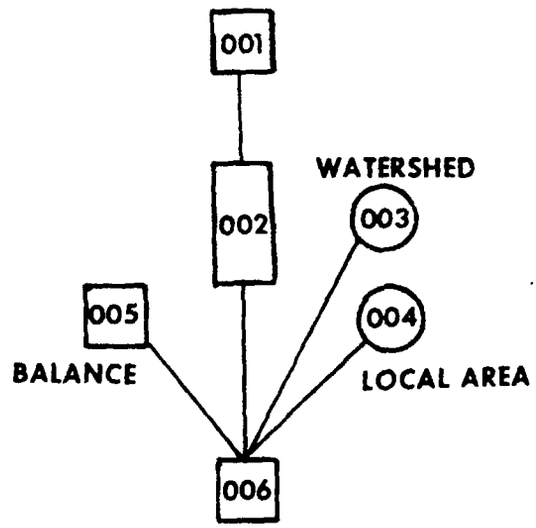
Figure 10.1 shows an ungaged local area watershed between two main stem stations. If there is a reasonable amount of runoff from this area which varies predominately in response to rainfall and snowmelt, the situation can be synthesized by the schematic shown. If the discharge from watershed 003 and the local area 004 are well correlated, it is an ideal application of the adjacent station provision. The local area's discharge can be specified as a fixed percentage of watershed 003 or as a function of the discharge of station 003. In Figure 10.1, the sum of the computed inflows to station 006 for a given point in time are shown in the flow accounting as 8,100 and the observed discharge at the station is 7,900. This discrepancy between the computed and the observed discharge at station 006 results partly because the relationship between watershed 003 and local area 004 is not perfect.

In operational forecasting where computer derived forecasts are disseminated automatically, it is necessary that the computed discharge for station 006 be equal to the observed at time, t=0. This problem is overcome by the use of a "balancing flow". The "balance" is designated as Station 005 and is specified in the input on a 6 card format. The nature of the balancing flow and the source of the discrepancy will determine what flows will be specified for the forecast period.

When there is relatively little inflow between two main stem points as indicated in Figure 10.2 (Stations 101 and 104), the consistency of the stage discharge relations causes a problem. Here the discharge from the local area 103 is too small to be treated as an adjacent local area. In fact it is so small that it is at times less than the combined discrepancies of the "observed" discharges at the main stem stations. Again, in an attempt to start the computation for Station 104 with the "observed" discharge, we employ the "balancing flow" Station 103. In this case the balance may be constant and the specification for the forecast period could possibly be a constant negative 800.

Irrigation diversions appear as negative local area runoff between two main stem gaging stations. These values are generally not adequately gaged or reported, therefore, their quantity must be inferred by





FLOW ACCOUNTING

(AS OF TIME = 0)

STATION		DISCHARGE
001	OBSERVED	5000
002	001 ROUTED	4500
003	OBSERVED	3000
004	LOCAL (20% OF 003)	600
	SUM	8100
005	BALANCE	−200
006	OBSERVED	7900

FIGURE 10.1 LOCAL AREA & BALANCING FLOWS

subtraction. Return flows from irrigation generally vary quite slowly and are seldom gaged. The problem is to account for the net of these two items. Presently the quantity of the irrigation diversion is not computed but is specified. For a long term forecast the best guide to reasonable diversions is the average of past seasons.

Figure 10.3 presents the schematic and flow accounting for irrigation diversions and balancing flows. The size of the balance is, of course, related to the irrigation demand which in turn is related to the current and forecast meteorological situation. Therefore, the specified balance is varied to reflect the expected departure of the irrigation diversions from the average; based on forecasts of meteorological conditions. Beyond the first several days when the meteorological forecast skill decreases the balancing flow (204) specification can be reduced to zero. Then the resulting net irrigation diversions will be equal to the flow of Station 203.

Temperature Input. There are several options for entering temperature data. The particular option used depends on the type of forecast and the watershed involved:

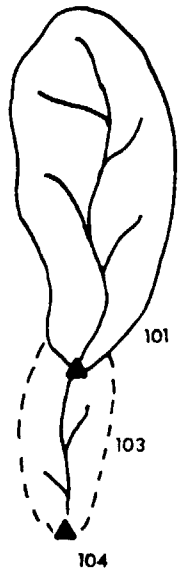
a. Temperatures can be surface observations or free air temperatures derived from upper air soundings or a combination.

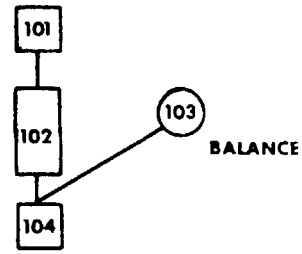
b. Temperatures can be entered as departures from normal temperatures. Temperature normals must then be entered as a separate input station.

Temperature station specifications on a CBØ4 card can call for several stations and any particular forecast run need not input all the stations. The program will use only the stations for which data are input. The divisor in the equ. on pg.35 is determined by the number of stations which have data for the first day of the run.

Temperatures can be entered for any time interval ranging from hourly up to daily. However, if several observations occur in one computational time period, the first observation will be used.

Use of upper air temperatures has advantages in some cases particularly in determining the rain-freeze level. The upper air temperature observation is closer to the mechanism which is being indexed, thereby reducing the error which might be introduced by the assumption of a constant lapse rate. However, in situations where the temperatures are used mainly for indexing snowmelt, surface observations are used because they are considered a better index to the radiational effects. The use of normals and departures from normal to input temperatures makes it practical to employ the same synthetic temperature variations on repeated runs and yet have the long term effect of the season incorporated in the temperature sequence.



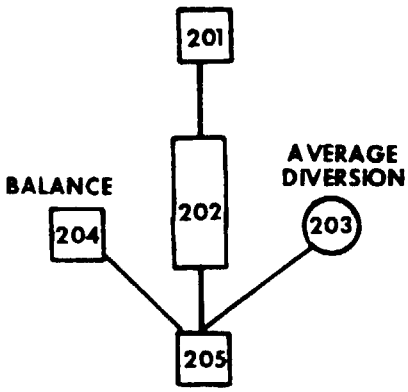


FLOW ACCOUNTING

(AS OF TIME = 0)

STATION		DISCHARGE
101	OBSERVED	5000
102	101 ROUTED	5000
103	BALANCE	−800
104	OBSERVED	4200

FIGURE 10.2 LOCAL AREA & BALANCING FLOWS



FLOW ACCOUNTING

(AS OF TIME = 0)

STATION		DISCHARGE
201	OBSERVED	5000
202	201 ROUTED	4500
203	AVERAGE DIVERSION	−2000
	SUM	2500
204	BALANCE	+300
205	OBSERVED	2800

FIGURE 10.3 IRRIGATION DIVERSIONS & BALANCING FLOWS

Figure 10.4A illustrates the temperature sequence used on a typical day in spring snowmelt forecasting, assuming one temperature station. Figure 10.4C is the five-day temperature forecast based on meteorological analysis, 10.4D is the synthetic sequence based on frequency analysis of climatological data, and 10.4B is the long-term normal. The model combines portions B, C, and D to arrive at the temperature sequence shown in A.

The CBØ4 card data for specifying this is as follows:

Card Columns	Data Code	Station Number	Weight	
19-26	4	0001	200	Normal (B)
27-34	4	0101	200	Forecast (C)
35-42	4	0201	200	Synthetic Sequence (D)

For use of two temperature stations the CBØ4 card data would be:

Card Columns	Data Code	Station Number	Weight	
19-26	4	0001	200	Normal Station 1
27-34	4	0002	200	Normal Station 1
35-42	4	0101	200	Forecast Station 1
43-50	4	0102	200	Forecast Station 2
51-58	4	0201	200	Synthetic Sequence 1
59-66	4	0202	200	Synthetic Sequence 2

This technique allows a temperature sequence for an extended period to be input and updated each day with current meteorologically derived temperature forecasts. The use of departure from normal for the five day forecasts has proven to be of advantage to the meteorologist in checking the consistency of the forecasts.

The five day forecast and the normals are dated in the usual manner but the synthetic temperature sequence is "relatively dated". The relative dating procedure is discussed on page F-10 This allows the use of several sequences representing maximum conditions, with minimum conditions easily run by just substituting a new relatively-dated deck.

In spring snowmelt forecasting it is desirable for reservoir management purposes as well as long term public warning to compute the streamflow for a period of 30 to 45 days. The skill of meteorologically derived temperature forecasts extends up to five days in some situations. Beyond this point synthetic temperature sequences must be used. The use of the climatological normal would not be a realistic value because the amount of melt generated each day would be a rather constant, low value and, the effects of intensity of melt would be improperly evaluated. So in order to test the remaining flood potential, the forecast has to have a realistic temperature sequence with reasonable warm and cold spells.

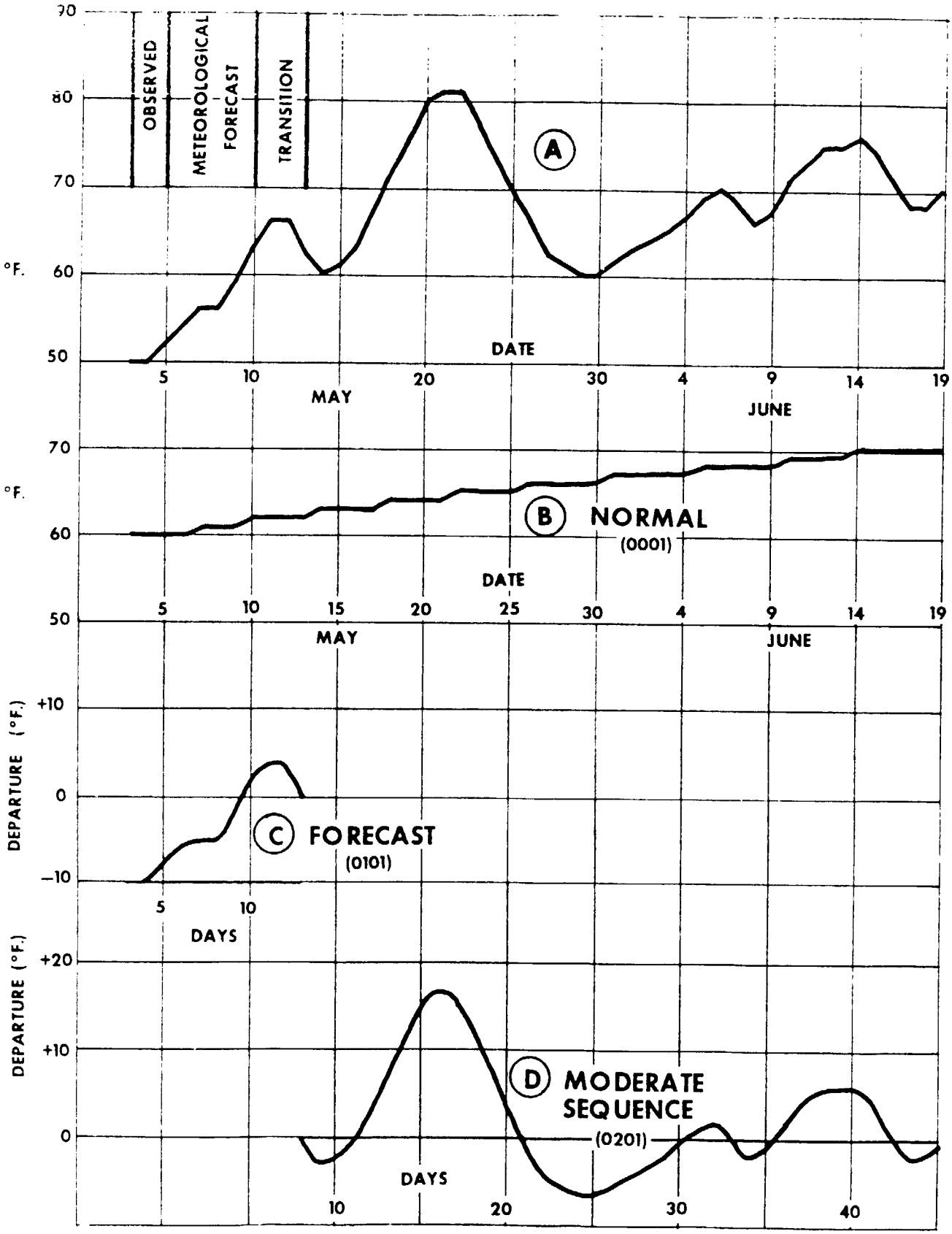


FIGURE 10.4 COMPONENTS OF TEMPERATURE SEQUENCE FOR SNOW MELT FORECASTS

To test whether the remaining potential runoff will fill a power or irrigation reservoir the temperature sequence is biased to the low side. Normally a series of temperature sequences is used: early season maximum, late season maximum, minimum, and moderate.

Precipitation Input. The primary criteria for selecting the best option of entering precipitation data is to minimize the quantity of input. The characteristics of the watershed must also be considered.

The most rigorous method would be to input period values (3 or 6 hours) for each observation station, both for the observed and forecast period. This would result in a maximum of data input. Because most observing and reporting data networks are inadequate to index topographic effects in the mountainous west, this method of precipitation input is impractical.

Precipitation reports and radar data are used to manually determine a value of watershed precipitation. This minimizes the precipitation input and helps account for topographic effects. Areal averaging of precipitation is accomplished manually by expressing precipitation in percent of normal annual precipitation (NAP). The manual data processing is minimized by using the option of inputting precipitation in daily basin amounts (4D cards) and providing within-day distribution of precipitation by means of a 5 card.

Adjacent watersheds are often grouped for the same precipitation input if the reporting network is not sufficient to differentiate between the watersheds. Provision is made in the watershed characteristics for the infrequent occasions when the precipitation is known to vary between adjacent watersheds.

Watersheds are often grouped on the basis of the daily distribution of precipitation. In the coastal area of the northwestern United States, the precipitation time distribution is much more conservative than the amount of precipitation over the watershed. However, the provision is available to specify a distinct distribution for each individual watershed on the days when variation is known to exist.

Because the manual processing of precipitation is done in terms of percent of NAP, the data are entered on the 4 card in these terms. This percent, in combination with the NAP (weight on CBØ4 card) produces the desired precipitation in terms of depth units.

Since the skill in forecasting precipitation is inversely related to the length of the forecast period, it is not justified to differentiate between daily distribution late in the forecast period. Therefore, precipitation amounts are included for the entire forecast period but the daily distribution is not varied in the later portion of the period. In order to facilitate this, the model will use one daily distribution specification. Note that the 5 card date (columns 15-23) is labeled "start time". This means that a daily distribution will be first used on that date. If the next daily distribution on the 5 card is several days later the first distribution will be used in the intervening period.

Forecasts for a specific station grid are often provided in terms of percent of NAP. Manual processing of these point forecasts is the same as for reported precipitation and are entered on the same input sheet. As in the case of entering temperature forecasts in terms of departures from normal, the preparation of precipitation forecasts in terms of percent of NAP assists meteorologists in providing consistent forecasts for the mountainous western United States.

The use of the normal annual precipitation is possible because of the consistency of the topographic effects during the rainfall runoff season. In areas where there is seasonal variation of the storm track, or other meteorological factors which affect the normal areal precipitation variation, it will be best to use normal seasonal precipitation in place of NAP.

In contrast to the temperature input (pg. F-5) the model will aceept zero values of precipitation. Therefore, the "n" in equation page 27 is determined from the data available for the first time period. Thus, all the precipitation records should be complete and continuous.

Relative Dating. One of the useful techniques to reduce the amount of data input to a minimum is relative dating. When any time-dependent data or plot card has a month of "zero-zero" or blanks (columns 20-21) the relative dating routine is activated. The values on the data card are read and stored with assigned date-time derived by the following rule. The date-time group from the preceding T card (columns 5-13) is advanced by the values found in the date-time group of the data card (columns 15-19).

Figure 10.5 shows the data input cards and a printout (see J card column 23) of the data as stored after the relative dating routine has operated. It is necessary to restrict the number of pieces of data to be read off the forecast card so that the forecast and synthetic sequence data sets to not overlap. In the printout, note that the data sets for 0101 and 0201 end 17 May and 18 May, respectively. The "9" in column 14 of the card for station 0101 restricts the data for this station to the first nine values on the card.

The preceding technique is used routinely to input the synthetic temperature variations used in the long range snowmelt forecasting as discussed on pg. F-5. Use of relative dating in this case makes it possible to prepare one set of cards of this temperature data which can be used for an extended period. If data input by cards is to be updated by a terminal then the relative dating will reduce the need for revising the date group.

D/ INPUT

```
T   06 08057212 06 100672  0

      TEMPERATURE STATION — NORMALS
4D01     0001 2400105724 60  60  60  60  60  60  61  61  61  62  62  62  62  63
4D02     0001 2401505724 63  63  63  61  61  61  61  62  62  62  62  62  66  66
4D03     0001 2401505724 63  63  63  64  64  64  64  62  62  62  62  66  66  66
4D04     0001 2402905724 66  66  67
4D05     0001 2400106724 67  67  67  67  68  68  68  68  68  69  69  69  69  70
4D06     0001 2401506724 70  70  77
4D07     0001 2401506724 70  70  70  70  71  71  71  71  72  72  72  73  73  73

      TEMPERATURE STATION — FORECAST
4D01     010192400805724-10  -8  -6  -5  -5  -2   2   4   4

      TEMPERATURE STATION — SYNTHETIC SEQUENCE
4D01     0201  001000004  01 -3  -2  01   4   8  12  16  17  16  12   8   4  01
4D02     0201  002400004 -4  -5  -6  -6  -5  -4  -3  -2  01   1   2  01  -2  -1
4D03     0201  003800004  2   4   6   6   6   4   1  -2  -2  01
END
```

DATA OUTPUT

```
   -1 TIME DEPENDENT DATA-HOUR,DAY,MONTH,YEAR,DATA      DATA CODE=  4  AIR TEMPERATURE (F)              LENGTH= 128
0- 2 572      60.00   0- 3 572      60.00   0- 4 572      60.00   0- 5 572      60.00   0- 6 572      60.00
0- 7 572      60.00   0- 8 572      61.00   0- 9 572      61.00   0-10 572      61.00   0-11 572      62.00
0-12 572      62.00   0-13 572      62.00   0-14 572      62.00   0-15 572      63.00   0-16 572      63.00
0-17 572      63.00   0-18 572      63.00   0-19 572      64.00   0-20 572      64.00   0-21 572      64.00
0-22 572      64.00   0-23 572      62.00   0-24 572      62.00   0-25 572      62.00   0-26 572      62.00
0-27 572      66.00   0-28 572      66.00   0-29 572      66.00   0-30 572      66.00   0-31 572      66.00
0- 1 672      67.00   0- 2 672      67.00   0- 3 672      67.00   0- 4 672      67.00   0- 5 672      67.00
0- 6 672      68.00   0- 7 672      68.00   0- 8 672      68.00   0- 9 672      68.00   0-10 672      68.00
0-11 672      69.00   0-12 672      69.00   0-13 672      69.00   0-14 672      69.00   0-15 672      70.00
0-16 672      70.00   0-17 672      70.00   0-18 672      70.00   0-19 672      70.00   0-20 672      71.00
0-21 672      71.00   0-22 672      71.00   0-23 672      71.00   0-24 672      72.00   0-25 672      72.00
0-26 672      72.00   0-27 672      73.00   0-28 672      73.00   0-29 672      73.00   0- 0 0 0       0.0

  -101 TIME DEPENDENT DATA-HOUR,DAY,MONTH,YEAR,DATA      DATA CODE=  4  AIR TEMPERATURE (F)              LENGTH=  28
0- 9 572     -10.00   0-10 572      -8.00   0-11 572      -6.00   0-12 572      -5.00   0-13 572      -5.00
0-14 572      -2.00   0-15 572       2.00   0-16 572       4.00   0-17 572       4.00   0- 0 0 0       0.0

  -201 TIME DEPENDENT DATA-HOUR,DAY,MONTH,YEAR,DATA      DATA CODE=  4  AIR TEMPERATURE (F)              LENGTH=  94
60-18 572       0.10  60-19 572      -3.00  60-20 572      -2.00  60-21 572       1.00  60-22 572       4.00
60-23 572       8.00  60-24 572      12.00  60-25 572      16.00  60-26 572      17.00  60-27 572      16.00
60-28 572      12.00  60-29 572       9.00  60-30 572       4.00  60-31 572       0.10  60- 1 672      -4.00
60- 2 672      -5.00  60- 3 672      -6.00  60- 4 672      -6.00  60- 5 672      -5.00  60- 6 672      -4.00
60- 7 672      -3.00  60- 8 672      -2.00  60- 9 672       0.10  60-10 672       1.00  60-11 672       2.00
60-12 672       0.10  60-13 672      -2.00  60-14 672      -1.00  60-15 672       2.00  60-16 672       4.00
60-17 672       6.00  60-18 672       6.00  60-19 672       6.00  60-20 672       4.00  60-21 672       1.00
60-22 672      -2.00  60-23 672      -2.00  60-24 672       0.10  60-25 672       0.0   60-26 672       0.0
60-27 672       0.0   60-28 672       0.0   0- 0 0 0       0.0   0- 0 0 0       0.0   0- 0 0 0       0.0
```

FIGURE 10.5 RELATIVE DATING

Snowmelt Options. Of the various snowmelt options described pg.C-32 - C-40 , the snow cover depletion option is most generally used in operational forecasting. The basic assumptions in this model and the nature of the snowpack and snowmelt in the Columbia Basin make this option the most practical.

In the spring the snowpack is deep and continuous over the upper portion of the watersheds. As a result, the ripening of the snowpack can be synthesized by the melt rate-percent seasonal runoff relation. Also there is little precipitation or new snow added during the snowmelt season. The area below the snowline drys out rapidly and the runoff from rainfall from this area during this season is infrequent.

In the coastal mountainous areas where the runoff is produced primarily from rainfall, associated snowmelt runoff is relatively unimportant. Also the snowline varies very little during the short range forecast period. A major portion of the flood runoff is produced by rainfall runoff from the lower portions of the watershed.

The same snowmelt option is used in both of these two quite different climatic and hydrologic areas. Despite the great advantage of snowpack accounting, the use of the snow-band option in operational river forecasting awaits additional programming to facilitate initial conditions specification.

Initial Conditions Adjustment. The method employed in the SSARR Model to establish and adjust computed values to the observed initial conditions is described in detail in Appendix C. . The provision for the automatic adjustment of initial conditions is a necessity because of the daily restarts required in operational river forecasting.

The adjustment of the computed conditions of a lake or reservoir to the observed conditions is rigorous and therefore the results are exact. However, in both channel and watershed routing the model is not an exact analogy and it is impossible to adequately specify all initial conditions. In Figure 10.6, Hydrographs I and IV are the inflow and outflow of a reach. Hydrographs II and III are the outflows of the two intervening increments of routing. If the initial conditions were punched or stored at time t=1 the 2R card would contain the values of 35, 16, 07, and 04. In order to restart the computation at t=1, the 2R card with these values would supply the computed initial conditions. No adjustment is necessary if the observed values of discharge for hydrographs I and IV for t=1 are equal to the computed values punched on 2R cards or stored.

Normally, however, there is some deviation of the computed from the observed. The adjustment can be accomplished in two ways. The 2R card values may be manually revised to approximate the current conditions, or the initial conditions can be adjusted automatically by use of a 3R card.

The automatic adjustment routine compares the currently computed inflow and the "observed" outflow as specified on the 3R card with the corresponding values from the 2R card. The example below will illustrate the adjustment of the initial conditions for a restart at time, t=1, Figure 10.6, when the "observed" outflow entered on the 3R card is 7, and the computed inflow corresponds to 35:

	Inflow	II	III	Outflow
Computed Values (2R)	35	16	7	4
"Observed" Values	35			7
Adjusted Values	35	17	9	7

The inflow is made to correspond with the inflow computed from the upstream observed data and the outflow is made equal to the value given on the 3R card. The intervening routed incremental values are adjusted linearly to account for the deviations in both the inflow and outflow.

The adjustment routine retains the "shape" of the hydrograph in the reach and makes only minor adjustments to the flow quantities. If the inflow to the reach is reasonably synthesized the adjusted incremental flow values will reflect the actual condition in the channel.

In the above discussion it must be remembered that the "observed" outflow of a reach usually is not the observed discharge that is reported at the gaging station. In the example in Figure 10.2 the "observed" outflow which is entered on the 3R card is 5,000 (Station 102) and not the 4,200 value which was reported from the gage at Station 104. The "observed" outflow from the reach is dependent on a good estimate of the routed flow; that is, a good pro-rating of the total flow into its routed and local inflow components. As noted in Figure 10.7 the reservoir at A causes rapid fluctuations into the reach and the routed flow value is difficult to determine manually. Ideally a preliminary SSARR Model routing is performed. Ultimately, an objective solution to the pro-rating problem will be programmed into the model.

The mechanism in watershed runoff computation from rainfall and snowmelt and watershed routing is much more complex than either lake or reach computation. Therefore, the amount of initial conditions to be carried forward and adjusted if necessary, is considerably greater. The data and indexes carried forward from the previous computation are shown on cards 2BØØ, 2BØ2, 2BØ3, and 2BØ4 .

As in the case of the channel reach the adjustments can be made manually by revising the values on these cards or automatically by means of a 3B card. As most of the values are not observed directly, the model must depend on the consistent set of derived values which, when used to operate on observed input, synthesize the current observed watershed outflow.

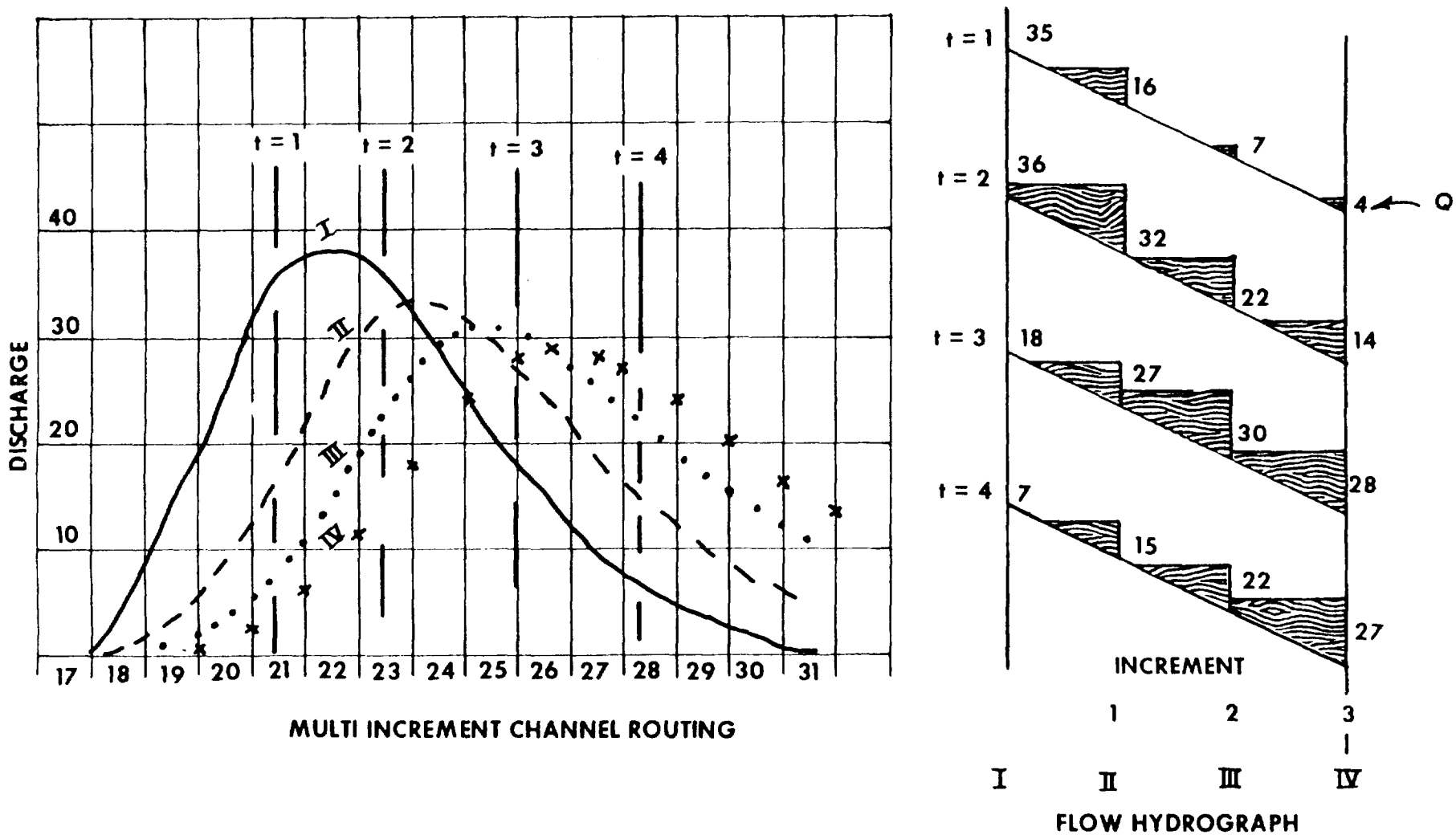


FIGURE 10.6 STORAGE ROUTING CHANNEL

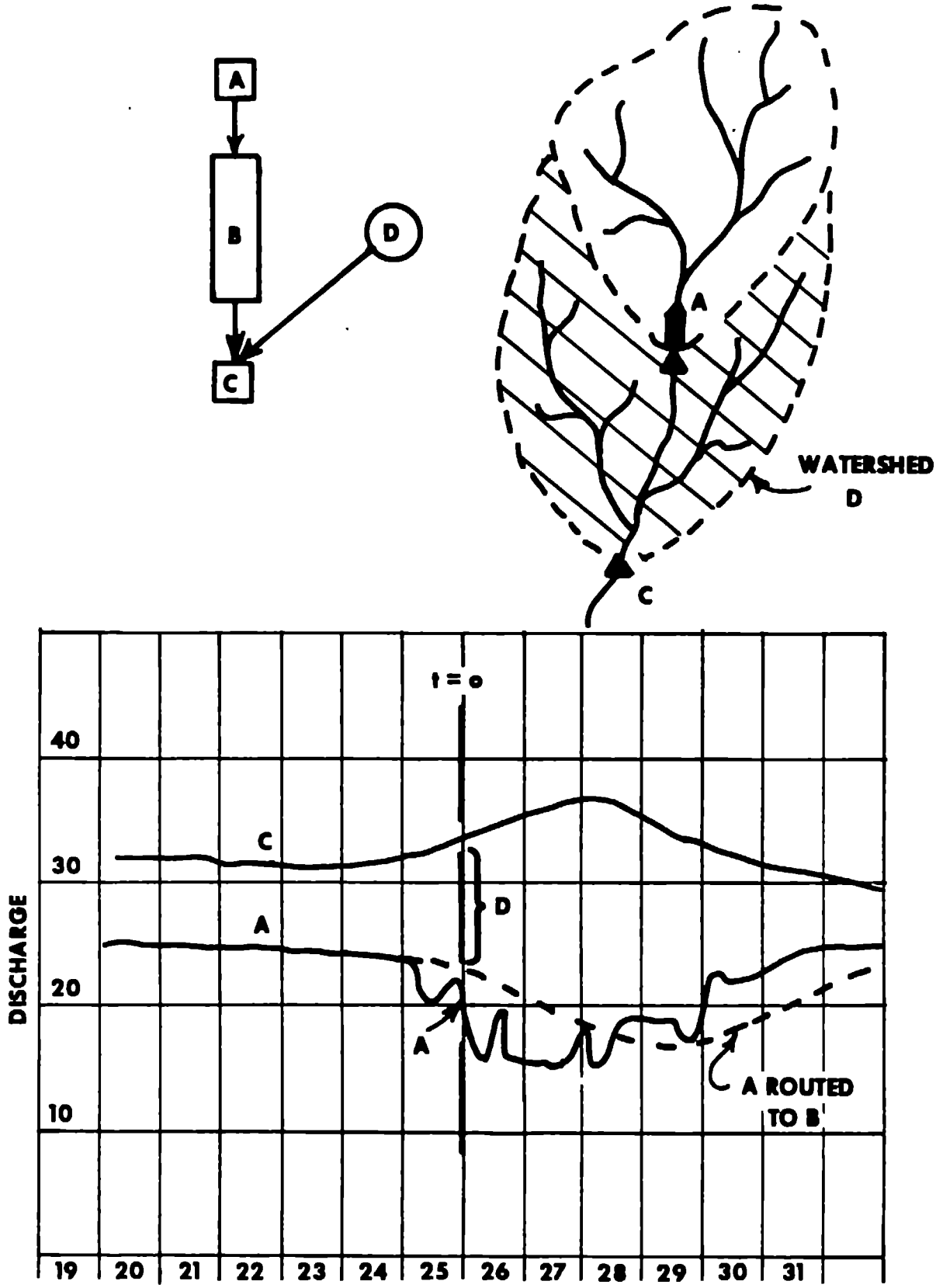


FIGURE 10.7 DETERMINATION OF LOCAL AREA OUTFLOW

In operational forecasting the computation is started some period prior to the current observation time. During this "backup" period, the model operates on currently available reports of rainfall and temperatures. The initial conditions at the beginning of the backup period were adjusted to "observed" conditions at the time of the previous run.

Case 1. If the hydrologic data are representative and the model is performing adequately the first computation of outflow at the end of the backup period (t=0) will be reasonably close to the observed discharge. If it is within a specified tolerance (CBØ3, columns 56-65) the model index will be accepted and the small remaining deviation between the computed and observed discharge will be distributed proportionately to the routing increments of surface, subsurface, and baseflow.

Case 2. In operational forecasting where hydrologic observations are seldom adequate adjustments are necessary to reproduce reported streamflow. If the first computation of the backup period does not result in the correspondence of the computed and observed discharge within the specified tolerance there is an option to recompute with the precipitation shifted forward or backward in an attempt to reduce the deviation between the computed and observed discharge. The time shift is limited to one half of the computed time period. If the tolerance is met the model proceeds as in Case 1, and again distributes the small remaining deviation.

Case 3. If after the first computation (with or without the time-shift option) the discharge is not within the tolerance the model recomputes the backup period with the rainfall and snowmelt adjusted upward or reduced to more closely approach the observed value of the watershed outflow (2B or 3B card columns 74-80). The adjustment factor which was in effect, 1.0, during the first iteration is varied automatically between 0.5 and 2.0[1/] by increasing or decreasing by one-half the remaining spread of the factor. The iteration continues until either (1) four iterations are made (at which point the adjustment factor is approximately 0.5 or 2.0; (2) no change is made in the previous result (the case when precipitation is zero); or (3) the tolerance is met. The model then proceeds as in case 1 to distribute the small remaining deviation.

Considering the potential error in precipitation and runoff data, adjustment factors between approximately 0.8 and 1.2 are considered normal and no action is taken. However, if the adjustment factor is beyond these limits it is necessary to attempt to isolate the source of the poor simulation, correct the value, and recompute.

1/ These limits and the maximum number of iterations may vary in some versions of the program. Ideally the maximum number of iterations will vary with the tolerances specified on card CBØ3. With four iterations a tolerance of just over 5 percent will be met.

River Model Backup. The option to compute only the watershed portions of the model during a given period of computation can be selected on the T card, column 80. In this mode the transfer point, channel reaches, lakes, and reservoirs are not computed. Also, if no routing increment values (2R) are input, the model will compute the inflow at t=0 and interpolate all the rest of the incremental values linearly from inflow to the outflow which was specified on a 3R card. If no 3R card is input the incremental values will all be set equal to the computed inflow.

By the use of these facilities the amount of computer time and input data for an operational forecast run can be reduced without adversely affecting the quality of the simulation. In an area where the reaches are short and the inflow to the reaches and the outflow from the lakes, reservoirs, and watersheds are natural and change gradually (relative to the length of the downstream reach) the incremental values in all reaches will vary closely approximate a linear condition. Therefore there is no need for 2R card input and punching out of 2R cards can be eliminated.

In an operational forecast run in this mode the first period data and computation would relate only to watersheds. In the second time period (after T02), the input includes 2L and depending on the nature of the reaches the 3R cards are optional.

Standardization of Operation. Because of its great flexibility the SSARR Model can be used under many varied simulation conditions. It is theoretically possible to select different options each day depending on the current hydrologic situation. Practically, however, it is wise to standardize the use of the model for a given area and given season so as to reduce possibility of input error causing delays in forecast preparation.

One method of reducing the time to prepare input for a forecast run for a large river system is to use input forms which are pre-printed with all repetitive data. In this way none of the required cards and needed data will be omitted and data checking will be facilitated. If the quantity of input is sufficient, the use of prepunched cards can further reduce the punching time and reduce the possibility of error. Revision of data for reruns of a forecast computation can also be accomplished by use of a remote terminal if the input for the first run is stored and made available for reuse.

Forecast Error. The total potential error in a forecast of watershed outflow derived from model simulation can be assigned to two major causes; inadequate evaluation of the antecendent events including the initial condition of the watershed, and the deviation of the meteorological forecasts from the subsequent events. A qualitative depiction of variation with time of these two sources of error are shown in Figure 10.8.

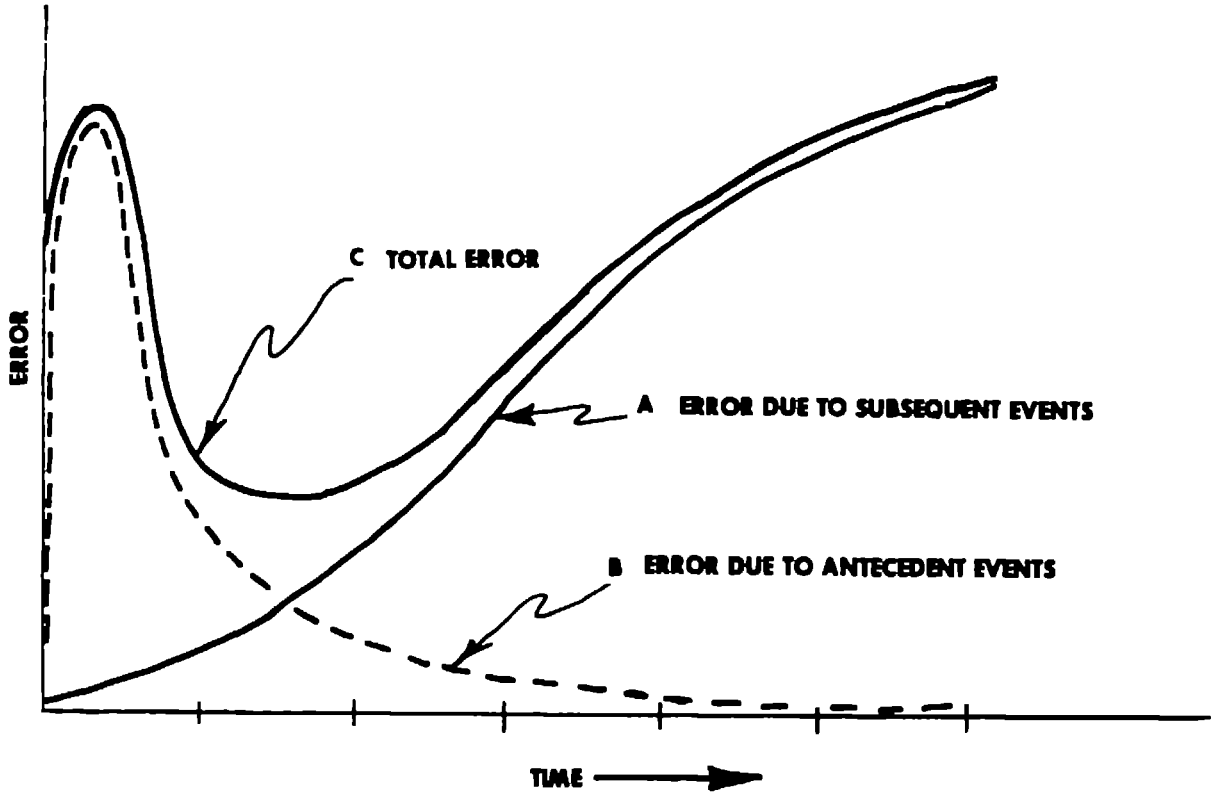


FIGURE 10.8 FORECAST ERRORS

If the hydrologic events of the immediately antecendent period are reasonably evaluated, then the error of the flow prediction is due mainly to the deviation of the meteorological forecast and the error should increase with time as indicated by Curve A. If, however, the precipitation and temperature over the watershed are poorly defined and the initial quantity and trend of the outflow of the watershed is not reasonably estimated, then the error from this cause follows a curve of the approximate shape of Curve B. This situation is often the case with a watershed which is the inflow to a reservoir where the evaluation must be derived from reservoir release plus change in pool storage. To a lesser extent Curve B applies to a local area watershed where the outflow is derived by a routing and subtraction process (page F-3).

In the case of poorly evaluated initial and antecendent conditions the total error Curve C increases after t=0 until the effects of the initial condition discrepancies have reached their maximum. At this point the total error decreases and reaches a minimum only to increase as the deviation of the meteorological forecasts become the dominant factor.

The vertical displacement of these curves and the relative time scale will depend on the nature of the watershed and the quality of the initial and antecendent conditions evaluation. The actual error in any single river flow forecast is of course dependent on the particular hydrologic conditions, but it is important for the user to recognize this variation of the potential error.

Forecast Dissemination. All of the various SSARR Model output options are used internally by the forecast staff. Three of these facilities are used to disseminate the forecast products: the PR Optional River Model Report , Line Printer Plot , and X Report

The optional river model report and the line printer plots are produced on the line printer and are available for local distribution. Different combinations of the results and a specified number of copies can be printed. The results of these output routines are stored for later release transmission to terminal printers. The temporary storage allows the staff to examine the output for quality control.

The "X" report generator is used to disseminate the majority of the forecasts produced by the SSARR Model. This facility is designated for either automatic transmission on hard wired teletype or re-perforation and transmission on either 5 or 8 channel teletype machines. The facility is available to examine and revise the reports produced by this generator prior to release.

Format of the report is a variable number of lines of heading followed by forecasts and ending with a variable number of lines of comment. The forecast line format includes specification of station name (distinct from SSARR name), data type, current observation, and up to seven days of forecasts per line. Any number of forecast values can be sent with seven values per line. Figure 10.9 shows a portion of an "X" report as sent via teletype.

AWBC

APW APS NPD 0617 1100PDT

COLUMBIA RIVER FORECASTING SERVICE
* * * * * * * * USCE/NWS/BPA * * * * * * * * *
LOWER COLUMBIA REGULATED STREAMFLOW AND RESERVOIR ELEVATIONS
ALL DATA AS OF 0600 HOURS

*

STARTING TIME = 0600, 17 JUN 72

*

STATION	TDY OBS.	* *	* * * * * * * FORECASTED DATE * * * * * * * * *						
		18	19	20	21	22	23	24
*								
GRAND COULEE DAM (COLUMBIA)								
OUTFLOW	350,000	350,000	350,000	350,000	350,000	350,000	350,000	350,000
*								
SIMILKAMEEN RIV NR HEDLEY								
STR FLOW	13,600	11,600	10,200	9,370	8,850	8,770	8,720	8,630
*								
OKANOGAN RIV NR TONASKET								
STR FLOW	22,100	21,600	20,700	19,300	17,900	16,800	16,000	15,500
*								
METHOW RIV NR PATEROS								
STR FLOW	8,300	7,950	7,910	8,000	8,250	8,340	8,430	8,530
*								
LAKE CHELAN								
[illegible] OW	10,000	8,950	8,430	8,330	7,970	8,030	8,140	8,210
[illegible] AN								
	[illegible].0	1,098.0	1,098.0	1,099.0	1,098.0	1,098.0	1,098.2	1,098.4
In[illegible]								
MCNARY [illegible]		[illegible]	8,430	8,330	7,970	8,030	5,040	5,110
OUTFLOW	60[illegible],							
*								
JOHN DAY DAM					1,040	1,010	1,010	1,010
FB ELEV	264.4	265.1	26[illegible]					
JOHN DAY DAM								
OUTFLOW	600,000	600,000	600,000	600,0[illegible]			12,000	13,000
*								
BONNEVILLE DAM								
OUTFLOW	571,000	580,000	581,000	581,000	581,000	582,000		
*								
VANCOUVER GAGE								
STAGE	21.1	21.1	21.2	21.2	21.1	21.1	21.0	21.0
*								

THESE FORECASTS ARE PREPARED BY THE COLUMBIA RIVER FORECASTING SERVICE FOR USE BY CORPS OF ENGINEERS NPD/RCC AND BONNEVILLE POWER ADMINISTRATION FOR CURRENT RESERVOIR REGULATION ACTIVITIES. THE NATIONAL WEATHER SERVICE PDX/RFC IS RESPONSIBLE FOR PUBLIC DISSEMINATION OF THESE STREAMFLOW FORECASTS. FORECASTS INCLUDE THE EFFECT OF ASSUMED RESERVOIR REGULATION AS WELL AS HYDROLOGIC EFFECTS AND ARE SUBJECT TO CHANGE ON A DAY-TO-DAY BASIS.

*

ROCKWOOD/POLOS
NPDRCC/RFC/JH

FIGURE 10.9 TELETYPE FORECAST OUTPUT

Seasonal Runoff Forecasting. The prediction of the volume of runoff for the coming season cannot at this time be based on any meaningful weather forecast. Instead, it is based on an analysis of historic record as a means of anticipating the potential future weather scenarios.

The well proven approach of deriving a linear equation giving total future runoff as a function of observed-to-date hydrometeorlogical elements gives good results for average years. However, this technique may not be responsive to record breaking precipitation and temperature extremes because the equation is derived from historical record, so it does not have these extremes available to shape the results.

Conceptual models have been considered as an alternative to the linear equation technique, but in the Columbia basin, the role of the conceptual model in long-range seasonal forecasting is still largely that of a check on the linear equation forecast. The subjective nature of calibration techniques and the subjective interpretation of input data (and missing data) such as basin averages of temperature and precipitation are counts against this technique when considering it as the basis for interagency agreements for reservoir system operations.

The conceptual model is a valuable tool for verifying the forecasts made by the linear equation method because the conceptual model can take unusual weather sequences into account. For example, a snowpack built quickly and followed by a dry period may produce a different runoff volume than a snowpack that is more gradually built up because of soil conditions under the pack, evapotranspiration losses, and the way "aged" snow melts, event though season total indexes such as the accumulation of precipitation and degree-days might be the same. In these two instances, the linear equation would be likely to forecast the same runoff volume despite the differences.

The "ESP" Procedure with SSARR. The National Weather Service "ESP" procedure uses a watershed model to simulate a statistically significant number of weather scenarios through the forecast period so that confidence statistics can be derived about the likely total runoff. The SSARR program has several facilities built in which make it convenient to run these scenarios.

Suppose that a forecast of total runoff is to be made from today through September 30. For this example, assume today is June 15, 1985. The procedure is to run the SSARR model with data from prior years as if those data were forecasts for this year. If enough years of data are available, useful probability statements can be made from the collection of forecasts. The Bulk File is used to manage the data from prior years. Loading and managing the Bulk File is discussed in Appendix B. The following steps would be involved to make a forecast:

a. With current observed data, run the SSARR model through today (June 15, 1985). The initial conditions (IC) will automatically be saved in the SSARR file.

b. With the ZLI card format, copy the IC set into the SSARR file as a "FILE" with the date fields zeroed out. If the basin name is WARNER, the card is:

ZLI WARNER EZ WARNIC

This card will cause the IC set to be saved in a "FILE" record (type 5 record) by the name of WARNIC.

c. Set time control to start on today's date in a prior year, and end time on September 30 in that year; for example, 1971:

T 00 15067124 00 300971

d. Load the weather data needed for the model for that period from the Bulk File with Z1 cards:

Z1 FTIM 23,,,FTIM 232
etc...

e. Use the "GET" card to load the IC; the zeroed out date is a "relative" date and will be set to the start time:

GET WARNIC

Considerations in the "ESP" Model Setup. The basin runoff model is usually designed to compute runoff at a gaging point in the drainage basin. It is convenient to put a synthetic accumulating reservoir in the model at this point, to measure total seasonal runoff. The "C1" table can be used to represent the runoff in basin inches by the following conversion:

If the maximum runoff amount to be represented in the table is 100 inches, the corresponding storage in acre-feet is:

A.F. = Area (sq. mi.) * 5333.33

The constant 5333.33 is in units of A.F. per 100-inch-sq. mi.

The C1 table to accumulate runoff from a 1,000 square mile basin would represent elevation units as inches of runoff with the following two points:

Elevation	Flow	TS	Storage	
0	1	0	0	
100	1	0	5333333	(1000 sq. mi. * 5333.33)

When this station is printed with the "PR" card with code 2 in column 14 for example (one way to print a column of elevation), the column heading will show "ELEVATION / FEET-MSL" even though the numbers in the column will be basin-inches.

The 1 cfs entry under "flow" in the C1 table is to force the synthetic reservoir release to be nearly zero. This is necessary in the SSARR program because an entry of zero flow in the C1 table signals "no hydraulic capacity available", causing the model to release inflow. If the range of flow values is small enough that 1 cfs is significant, the 7-column flow field may contain ".000001" as the smallest non-zero flow possible on this card format. (Normally, decimals are not to be punched on this card format.)

On the CL02 card, "Upper Elevation" and "Lower Elevation" are in the same units as the elevation field of the C1 table; that is, inches.

The "2L" card for this synthetic reservoir must also set the initial elevation or storage to the smallest non-zero number available with this card format. Usually, a 1 is punched in column 47, indicating initial storage of 1 acre-foot.

Post Processing. The ESP technique requires processing many years of data through the forecast season. For seasonal runoff forecasting, the meaningful output from these runs is the accumulated runoff at the end of the season in each of the years processed. One practical technique is to use PR cards to report the contents of the synthetic reservoir discussed above, and to have the output saved in a disk file rather than printing it. Then, with the use of the computer system editor, or some other analysis software, only the lines of the report for the last day of each season need be printed.

Column 4 of the PR card can be used to select an alternate output unit number for the report. The computer run control language ("JCL" on IBM systems) then directs the report to a disk file. Unit numbers 1-3 and 6-9 are available for the PR card format.

APPENDIX G

PROGRAM DESCRIPTION

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APPENDIX G

PROGRAM DESCRIPTION

STRUCTURE

The structure of the current program has evolved from the original structure devised in 1967 for a computer host environment composed of FORTRAN-4, direct access disk, and the IBM-MVT Operating System. The original practical region size was about 150K bytes. The program was divided into about a dozen overlays.

The current program has been converted to IBM-VS FORTRAN-77. The host computer runs under IBM-MVS control program and it is practical to use 2000K virtual memory allocation. The SSARR program is not overlayed, and several supplementary programs have been included as subroutines to make interactive operation quicker and easier.

There are versions available of the current program for VAX, Data General, Cromemco, and IBM-PC compatible computers. Each of these versions have slightly difference source statements and interfaces to the operating systems, but the SSARR models and input data are identical.

Major Subprograms. SSARR is composed of a number of major subprograms, each of which can nearly stand alone to accomplish their task. They are combined into one program structure as subroutines for ease of operation and reduction of overhead in transferring from task to task. Table G-1 lists the major subroutines in outline form, showing that the main program (AAAMAIN) calls INIT,CUPDAT,INPUT, etc. SBINPT calls SBINZ4, SBLAPS, and SBMISC.

There are currently 105 FORTRAN subroutines in the SSARR source statement library for the AMDAHL computer. The subroutines not appearing in Table G-1 are utility subroutines which may be called by several of the major subprograms.

TABLE G-1, HIERARCHY OF MAJOR SUBPROGRAMS

AAAMAIN	FORTRAN Main Program
INIT	Initialization and Shut Down
CUPDAT	Fixed Format Characteristic Input
INPUT	Fixed Format Time-Data Input
SBINPT	Z-Format Input
SBINZ4	Z4,Z6,Z7,Z8 Input
SBLAPS	ZLAPSE Command
SBMISC	ZLIST,Z1,ZBSTORE, ZR Commands
TSO	IA Command, Interactive Driver
TSOE	EM and EF Subcommands, Edit Models and FILES.
TSOIC	IC and 3 Subcommands, Edit IC
TSOIN	INPUT Subcommand

TSOTP	L (Hydromet) Subcommand, Edit Hydromet Data
TSO6S	6 Subcommand, Edit Regulations
HMAINT	HMAINT Subcommand, Edit SSARR File
HMLIST	HMLIST Subcommand, CROHMS Listing
P15B	CROHMS Subcommand, CROHMS Retrieval
SPECFL	SPECFLO Subcommand, Regulation Input
OUTPUT	River Model Default Print and Punch
PRINT	PR Card Processor, River Model Report
PLOTLK	PQ Card Processor, Printer Plot.
SAVERM	SR Card Processor, Save River Results
STATS	ZS Processor, Statistics from River Model
TTYPRT	X Card Processor, River Model Report
WASHED	Watershed Model Driver
BASINE	Depletion Watershed Model
BASIN2	Calculations for Depletion Model
SBMAIN	Snowband Driver
SBHYMT	Snowband Hydromet Averaging
SBASIN	Snowband Elevation Band Simulation
SBZONE	Elevation Band Calculations
SBROUT	Snowband Basin Routing
RTRSET	River Model Setup
CONFIG	River Model Configuration
ICADJ	Establish Initial Conditions
ROUTER	River Model Simulation Driver
LAKRT	Lake/Reservoir Calculations
RCHRT	Reach Calculations
TRPRT	Transfer Point Calculations

INPUT PROCESSING

The input stream is read on FORTRAN unit 5. The reads are all performed by subroutine IDREAD. The input unit may be changed by the "INU=" command.

The original SSARR fixed-format cards are mostly formatted by IDCARD, and processed by CUPDAT and INPUT. Exceptions are the print and printer-plot commands which are formatted directly by the main programs they control, PRINT, PLOTLK, TTYPRT, and SAVERM.

All card formats are assigned an internal card code (ICC) number by subroutine IDCARD. ICC is then used by AAAMAIN to determined which program is to be called next. Table G-2 shows assignment of ICC numbers.

The free-format "Z" cards are processed by SBINPT and its subroutines SBLAPS, SBMISC, FLDSTR, and SBINZ4. Exceptions are that STATS processes "ZS", SAVERM processes "ZSQ","ZAQ",etc., and IDCARD processes "ZFILE". IDREAD processes "ZGET".

TABLE G-2, INTERNAL CARD CODE (ICC) ASSIGNMENTS

IDCARD

ICC	Card Code	ICC	Card Code
1	Null - no card	62	4E
2	P - configure	63	4D
3	C1	64	6S
4	C2	65	5
5	C3	66	6P
6	CP	67	6D
7	CT	68	2B03
8	CB01,CC01,CL01, OR CR01	69	2B04
9	CB02	70	3(USGS)
10	CB04,5,or 6	71	2B00
11	CR02	72	H
12	CL02	73	3B00
13	CC02	98	J
16	CB03	99	END
18	CF	101	PR,PU,PT
19	N	102	PQ,PL,PE,PS,PM,PH
54	T	103	X
56	3F	104	L
57	2B02	105	SR,SQ,SE,AQ,etc.
58	2R	106	IA
59	2L/3L	107	Z Freeform
60	3R	108	ZS
61	4P	999	End of File

Free-format input, both "Z" formats and responses to interactive prompts, are interpreted by subroutines SCAN77, SCAN1, and FIELDS. The card image is formatted 80A1 into an array, and the SCAN subroutines find the next "word" on the input line and interpret it as a number or an alphabetic string.

Input Macros. With the FILE or ZFILE command, a stream of cards may be stored on the SSARR file. This stream may be edited or originated by the "EF" subcommand of IA (Subroutine TSOE). This stream may be included any place in the input with a GET or ZGET card. FILE and ZFILE, and storing of the stream is done by IDCARD. The GET/ZGET process is done by IDREAD. The number of "GET" cards which may be included within GET streams is limited by the array dimensions in COMMON/ZGET. There is no other restriction on the inclusion of GET and FILE cards within GET streams.

Display of the Input Stream. FORTRAN unit 3 is used to display messages for the user. During batch operation of SSARR, a copy of the input stream is printed on unit 3, along with input-related error messages. During interactive operation, prompting and information messages for the user are written to unit 3 with the expectation that unit 3 will be assigned to the users' terminal display. "Batch" or "interactive" operation is determined by the first command to SSARR; if it is a "J" card, "batch" operation is assumed; if it is "IA" card, then "interactive" operation is assumed. The mode may be changed with "J" subcommand of "IA". The initial determination is made by subroutine INIT, and subroutine TSO processes the "J" subcommand.

THE SSARR WORK FILE

This direct access file is the central warehouse for the results of the various subprograms of SSARR. Input data is formatted into "records" and stored in the SSARR file. The model subprograms retrieve the "records" they need for a given simulation and store their results in other "records" back to the SSARR file for subsequent use by the output subprograms.

Time-series records may be cumulative, allowing the composition of a hydrograph or gage record from successive reports or processes as the real-time season progresses.

When using the SSARR file for operational simulations and forecasting, it is permanent and may be shared and updated simultaneously by any number of concurrent users. In the study mode for long term simulations, the SSARR file is usually a temporary space initialized to empty condition before each run because all data for the run is contained in the study input stream, or in other files, such as the "Bulk" data file.

The subroutines for SSARR file storage management and retrieval have names beginning with "SR..." and "SS...". The higher level calls are SROPEN, SRGET, SRPUT, and SRLIST. These routines call the lower level SS... subroutines. Primitive file management operations may be done by the interactive "BMAINT" subcommand (subroutine BMAINT).

Records in the SSARR file are uniquely identified by an 8-character name and a record type. Table G-3 shows the record type meanings. Records may be no longer than 7812 words. (The records are stored on disk in 124 word segments. The maximum number of segments for a record is 63.)

TABLE G-3, SSARR WORK FILE RECORD TYPE CODES

TYPE	
0	Station Characteristic
1	Station Initial Conditions
2	Configuration List for Model
3	River Model Communication Record
4	Program Overlay Communication Record
5	FILE/ZFILE Stream
10	Hydromet Characteristic
11	Table
13	Distribution
21	Time-Series Snowline Elevation
22	Time-Series Snow Covered Area
23	Time-Series Precipitation
24	Time-Series Temperature
25	Time-Series Dew Point or ETI
26	Time-Series Albedo or Lapse Rate
27	Time-Series Insolation
28	Time-Series Wind Speed
29	Time-Series Melt Rate
61-69	Time-Series of Correction Data for 21-29 Type Records

100	Time-Series Regulation
101	Time-Series Watershed Outflow
102	Time-Series River Model Elevation
104	Snowband Hydromet Summary
108	Time-Series of Correction Data for 100 Type Record

SSARR File Structure. A separate initialization program is used to pre-format the SSARR file in an empty condition before the file is used by the SSARR program. At this time, the maximum size of the file is 12600 direct access physical-records. Each physical-record is 124 words long. (Logical SSARR records may be up to 7812 words long; as many physical-records as needed are used to hold a logical record, to a maximum of 63.)

The file does not have to be this large. Different versions of the initialization program produce smaller files more appropriate to particular applications.

The direct access extent is in three parts: (1) the header segment, (2) the directory, and (3) the file space.

(1) The Header Segment. Segment number one of the file contains the following:

Word 1:	Length of physical-segments, 124 words.
Word 2:	Number of physical-segments in the file. Maximum of 12600. Typical study usage is 5880.
Word 3:	Number of the next free physical-segment. All segments from the next free through the last (given by word 2) are unused at this time.
Word 4:	File name. On computer hosts which support enque/deque logic (such as IBM-MVS) this name is enqueued during directory changes so that many concurrent users may update the file without interfering.

After each update to the file, the Header Segment and Directory are updated on disk so that other concurrent users always have the correct file controls available.

(2) Directory. Physical-segments 2 through 100 contain the file directory. The directory is maintained in alphabetic sequence of names. The directory is stored in 121 word (or less) sections, beginning in physical-segment 2.

Each section occupies a physical-segment and is in the following format:

Word 1	Number of words used in the segment. (Cannot be more than 124, or less than 3)
Word 2	Number of the physical-segment containing the next higher section of the directory. If word 2 is zero, this is the last section of the directory.
Word 3	Number of the physical-segment containing the previous, or next lower section of the directory. If word 3 is zero, this is the first section, which resides in segment 2.

Word 4 thru end	Directory entries. Words 4 and 5 are always the first name in this section of the directory, unless word 1 contains a 3 indicating this section is empty. Directory entries are made of two parts, the Name and Director:

Name. Requires 2 words, in FORTRAN FORMAT 2A4. The name is left justified and the first character must be a letter (A-Z) or a digit (0-9). Trailing characters to the right of the name are blanks.

A name only appears once in the directory, and is followed by the Directors for records for this name.

Directors. A director occupies one word. It is composed of 3 numbers; the record type multiplied by 1048576 (Hexadecimal 00100000), plus the number of physical-segments allocated to this logical record multiplied by 16384 (Hexidecimal 00004000), plus the number of the physical-segment where the logical record begins.

There is a director for each logical record.

(3) File Space. The physical-segments from 101 through the end are used for storing records. New records are added at the beginning of the free-segment area pointed to by word 3 of the Header Segment. If an old record is replaced by a longer version, the old record space is used if possible, by a shorter record to retain as much free space as possible before the new copy of the record is stored into free space. Subroutine SSUPDT accomplishes this directory and space management. While SSUPDT is updating the directory, the file controls can be lost if, for example, the SSARR program was stopped before SSUPDT completes. This has not happened during our ten years of experience with this file structure.

Summary of Record Formats. A detailed description of the record formats is in comment statements in subroutine COMENT. The following discussion summarizes the key words in the record formats needed for identification and control.

In all record formats except type 1 (Initial Condition) the first word contains the number of words in the record. The length of the record is not necessarily a multiple of 124 words. (the direct access disk segment length.) The retrieval routine SRGET returns record length as a multiple of 124, according to the disk space allocated to the record. The actual logical record length must be gotten from the record itself; i.e., word 1 of most formats.

Mixed FORTRAN-Word Formats. Some of the SSARR record formats were devised during the first FORTRAN implementation in the years 1967-1976. For I/O and processing efficiency, some words in the records are in FORTRAN INTEGER format and some are in FORTRAN REAL format. Since the word lengths of these two formats were the same on the principle development computer as well as other large scale computers of the day, it did not matter what FORMAT the word was as long as EQUIVALENCE statements were used to keep the FORTRAN addressing correct.

A large body of FORTRAN statements was developed around these record formats, and there has not been sufficient motivation or resources to redesign and rewrite the program, even though most of today's FORTRAN programmers would consider this poor, if not illegal language technique.

In defense of this technique, this large program has run effectively on many different computers and with sufficient efficiency to meet our real-time forecasting requirements.

Input and output to the SSARR file transfers a complete record to/from an array in memory. Subroutines SRGET and SRPUT accomplish this transfer. The calling program defines the array with both an INTEGER and a REAL name with an EQUIVALENCE statement to allow proper reference.

Until FORTRAN-77, there was no universally supported syntax for dealing with alphabetic strings. SSARR deals with alphabetics either in A1 or A4 format, which take the same word length as INTEGER and REAL and, therefore, can be included in the I/O arrays and SSARR file record formats. Each implementation of the FORTRAN language has some slight differences in how this approach is handled requiring some conversion work to be done to transfer SSARR to different computers and compilers. FORTRAN-77 is more restrictive, particularly in not allowing I/O lists and their associated FORMAT statements to be unalike modes. The IBM, VAX, Data General, and Microsoft compilers allow renaming of variables with EQUIVALENCE statements. The microsoft compiler insists that an alphabetic format be associated with a CHARACTER variable, but the CHARACTER variables occupy the same word space as other variables and may be EQUIVALENCED. VAX CHARACTER variables cannot be EQUIVALENCED with other variables, but an alphabetic format can be used with an INTEGER name.

SSARR RECORD FORMATS

Type 0; Station Characteristic Record

These records are composed from input cards by CUPDAT and SBINPT. When a type=0 record is made, a type=1, I.C. record is assured to be in the file for that station if it is a depletion basin, a snowband basin, a lake-reservoir, or a reach. That is, if the station is not a transfer point ("CC" characteristic cards), an I.C. record must be in the SSARR file.

The exact format of type=0 records is described in subroutine COMENT. Some significant points are as follows:

Type 0; Depletion Watershed (Subroutine CUPDAT)

Word	
2	Code 1 identifies as Depletion Watershed
3-13	Alpha description from CB01 card
28	Word number in record of start of C1 table
31,33,35	Number of phases in surface, subsurface, and baseflow routing, respectively
39	Word number in record of start of C3 table
40	Word number in record of start of list of hydromet data and weights from CB04 cards
100	Beginning of dynamic part of record, the contents of which are described by words 28, 31, 33, 35, 39, and 40

Type 0; Snowband Watershed (Subroutine SBINPT)

Word	
2	Code 5 identifies as Snowband Watershed
3-13	Alpha description from ZC1 card
20	Number of snowbands
21	Word number in record of list of average snowband elevations and percent of area
22	Word number in record of list of hydromet data and weights from ZCH cards
25	Word number in record of elevation vs. area table from ZCP cards
100	Beginning of dynamic part of record, the contents of which are described by words of 20-25

Type 0; Reach Characteristic (Subroutine CUPDAT)

Word	
2	Code 2 identifies reach
3-13	Alpha description from CR01 card
28	Word number in record of C1 table
42	Number of routing phases, plus 1

Type 0; Lake-Reservoir Characteristic (Subroutine CUPDAT)

Word	
2	Code 3 identifies lake-reservoir
3-13	Alpha description from CL01 card
28	Word number in record of C1 table

Type 0; Transfer Point Characteristic (Subroutine CUPDAT)

Word	
2	Code 4 identifies Transfer Point
3-13	Alpha description from CC01 card
28	Word number in record of C1 table.

Characteristic records are listed by subroutine CPRINT, which is called by TSO, and BMAINT. The only means available to change characteristic records is to input the CB, CC, CL, CR, and/or ZC cards. If a change is to be made to the characteristics composed by CUPDAT, the entire set of cards for the station must be read. Snowband characteristics may be partially changed (subroutine SBINPT). For example, a new ZCH list may be loaded, or a new ZCP table, or a new ZCA table. If the number of snowbands is changed by reading a ZC2 card, a new empty IC record (type 1) is made.

Type 1; Initial Condition

This record is composed at the same time the station characteristic record is made by CUPDAT or SBINPT. The IC record has space for 20 sets of instantaneous conditions for a station, each IC at a different time. When an IC at a new time is stored into the IC record, one is dropped off to make room; if the new IC is newer than 10 already in the record, the oldest is dropped; if the new IC has a time earlier than 10 already in the record, the IC with the most advanced time is dropped off.

The contents of the IC record are managed by subroutines FINDIC and STORIC. The IC record is updated by INPUT, SBINPT, ICUPDT, SBASIN, SBROUT, and TSOIC. ICUPDT is called by ROUTER and BASINE, the river and depletion watershed models, respectively.

The IC at a given time may be listed with the "IC" subcommand of "IA" (subroutine TSOIC), the "ZLI" command (subroutine SBMISC), and through coding in Column 23 of the CB01, CL01, and CR01 card formats along with coding in Column 62-78 of the T card (subroutine ICUPDT).

The length of the IC record is dependent on the station type and number of routing phases, and number of snowbands for snowband watersheds. The length of each of the 20 sets of ICs is multiplied by 4096. This product is added to the total record length of the IC record and this sum is stored in word 2 of the record (Snowband IC records may be longer than 4096, so the record length is not added to word 2). Word 1 contains the station type from word 2 of the characteristic record: 1 for depletion watershed, 2 for reach, 3 for lake-reservoir, and 5 for snowband watershed.

Words 6-45 are pairs of (time, pointer) identifying and locating the sets of IC in the record. The newest time is always in word 6, and word 7 contains the number of the word in the IC record where the set of IC values for that time begin.

Times are in basetime. See subroutine COMENT for detailed description of each of the IC record formats.

Type 2; Configuration List for a Model

The card code "P" (configuration) cards describe the stations in a model, their order of processing (downstream order), and the pattern of flows from station to station in the model. The card code "N" card provides the name for a model. Subroutine CUPDAT processes the "N" card and "P" cards, assembles the "P" cards into the type 2 record, and stores the record to the SSARR file with the model name from the "N" card. If no "N" card is provided, the model name defaults to "AAARIVER".

A type 2 record may be edited and/or originated by the "EM" subcommand of "IA" (subroutines TSO and TSOE).

In addition to directing the processing of the watershed and river models (programs WASHED, RTRSET and ROUTER), these lists are used to direct interactive commands which process an entire model. Subroutines TSO, TSOIC, TSOTP, TSO6S, and TSOIN all use type 2 records to identify the names in a "model".

Format of Type 2 Record

Word	
1	Length of record, in words (L)
3	System basetime of last change to record
5-6	Name of model (and name of this record)
8-21	7 names from first P card
22-35	7 names from second P card
	etc.

The last P card ends at word (L-20) where L is the record length in word 1.

The last 20 words of the record are reserved for a model description, which may be partially loaded from Columns 14-80 of the "N" card format, but is not completely supported at this time.

Type 5; FILE/ZFILE Stream

The FILE or ZFILE card provides the name of this record, and an alphabetic description which is kept in the last 20 words.

The name of the type 5 record produced by a ZFILE card may be constructed from two numbers with the letter Z separating them. For example, a ZFILE command like this:

ZFILE 12 34

will produce a type 5 record with the name "12Z34".

Type 5 records are composed by subroutine IDCARD. They may be edited or originated by the "EF" subcommand of "IA" (subroutine TSO and TSOE).

Type 5 records are retrieved as macros by the GET and ZGET commands, in subroutine IDREAD.

Subroutine TSOIN operates the controls in COMMON/ZGET to internally compose a Type 5 record and include it in the input stream, simulating a GET command. This is outside the design control structure and could cause difficulty if changes are made to COMMON/ZGET or any of the GET control functions without compensating changes to TSOIN.

Type 5 Format

Word	
1	Length of record in words (L)
3	System basetime of last change to record
5-6	Name of record from FILE/ZFILE card
8 thru (L-20)	Filed card images, 20 words per card.
(L-19) thru L	Description of record from FILE/ZFILE card

NOTE: L is length of record, from word 1.

Type 10; Hydromet Characteristic

Produced by subroutine CUPDAT from a "CP" card, or subroutine SBINPT from a "ZH" card. This record is used by BASINE, SBHYMT, and SBLAPS. It may be listed by CPRINT as called by TSO. See subroutine COMENT for detailed format.

Type 11; Table

Produced by subroutine CUPDAT from "CT" or "CF" cards, and SBINPT from "ZCT" and "ZCF". The characteristic cards for a station provide table names to be used for various relations. The model programs (WASHED, BASINE, SBASIN, RTRSET, etc.) retrieve type 11 records from the SSARR file for these table names. For example, if the "CB02" for a depletion watershed names table "SMI5" in Column 60-63; when this basin is simulated, the type 11 record named "SMI5" will be retrieved from the SSARR file by WASHED (See statements following label 306 in WASHED) to provide the relationship between SMI and ROP.

Tables may be in several formats. Subroutine STLU2 evaluates the paired-value (2-dimensional) format loaded from "CT" or "ZCT" cards. Subroutine TLU3F evaluates the surface (3-dimensional) format loaded from "CF" or "ZCF" cards.

Subroutines STLU2C, STLU2G, and STLU2L are adapted from the CROHMS system of subroutines for evaluation of USGS log linear and storage table formats. These formats and subroutines are not in use or tested at the present time. No provision has been made to load tables in these formats.

TABLE FORMAT

Word in Record

1	Length of record (L)
2	Scan index; pointer from last reference to table while table resident in memory
3	System basetime of last change to record
5-6	Name of table
7	Format code, in REAL format:

Code=

0. Power Series
1. USGS log linear (not supported at this time)
2. or 3. Table of points describing 2-dimension relations.

Code .GT.4 Relation loaded from "CF" or "ZCF" cards, for evaluation by subroutine TLU3F.

See subroutine COMENT for detailed format description.

Type 13, Distribution

This format is presently only built by subroutine INPUT from card code "5" cards. It is used by BASINE and BASIN2 via calls to DEXTR. The record may be listed by CPRINT which is called by TSO, and BMAINT.

See subroutine COMENT for detailed format description.

Types 21-29; Hydromet Data Time-Series

The record type defines the data type and scaling:

Record Type	Data Type	Scaling
21	1 - Snowline Elevation	Feet
22	2 - Snowcovered Area %	Percent
23	3 - Precipitation	Inches
24	4 - Temperature	Degrees F.
25	5 - Dew Point Temperature or ETI	Degrees F. or in/day
26	6 - Albedo % or Lapse Rate	Degree F/1,000 feet
27	7 - Insolation	Langleys
28	8 - Wind Speed	MPH
29	9 - Melt Rate	Inch/Degree-Day

For example, a type 23 record for a station contains the precipitation time-series for that station.

These records are originated by subroutine INPUT with card code "4" cards, and SBINZ4 with "Z4" cards. They may be edited and originated by TSOTP in response to the "L" subcommand of "IA". They may also be added-on to or originated by subroutine P15B ("CROHMS" subcommand) and SBMISC ("Z1" command).

The type 21-29 records may be listed by subroutine HMLIST ("HMLIST" subcommand) and CPRINT called by TSO, or HMAINT. They may be plotted by PLOTLK ("PH" card).

Card codes "CB04" and "ZCH" provide the names and weighting of the hydromet time-series to be used for a watershed simulation. The time-series are retrieved by WASHED and SBHYMT, and evaluated by subroutine TEXTR.

Corrections may be made to hydromet time-series with subroutine SBINMG from correction time-series (type 61-69) built by SBINZ4 ("Z7" cards), SBMISC ("Z1" card), and TSOTP. Subroutine STORE is called to merge values into the record.

FORMAT OF HYDROMET TIME-SERIES

Word in Record

1	Length of record (words). May be less than 8, indicating an empty record.
2	Scan index used by subroutine TEXTR.
3	System basetime of last change to record.
5-6	Name of record.
7	Data code. If record type is 21, data code is 1; if type is (20+n), then data code is n.
8	Basetime of oldest value.
9	Oldest value.
10-11	Basetime of next value, and next value.
12-end	Pairs of basetime-value, in ascending order of basetime.

Types of 61-69; Correction to Hydromet Time-Series

These records are built by subroutine SBINZ4 from "Z7" cards. The types 61-69 correspond to types 21-29, respectively, for data code and scaling. When a type 61-69 record is loaded either by SBINZ4 or SBMISC ("Z1" card), the file is checked for a type 21-29 record of the same name. If one is found, the Correction record is applied to the Hydromet record with subroutine SBINMG.

For example, "Z7" cards for station "KASB" and data code 3 are read in to SSARR (subroutine SBINPT and SBINZ4). When all cards for this record have been input, and the type 63 record is complete:

(a) The type 63 record for KASB is stored to the SSARR file.

(b) If a KASB type 23 record exists on the SSARR file, it is retrieved and subroutine SBINMG is called to correct it with the contents of the type 63 record; and the corrected KASB type 23 record is stored back on the SSARR file.

The format of type 61-69 records is the same as the format of type 21-29 records.

Type 100; Regulation Time-Series

These records are originated by subroutine INPUT from code "6" cards, by subroutine SBINZ4 from "Z6" cards, by SBMISC ("Z1" card), and by subroutine P15B ("CROHMS" subcommand of "IA"). They may be edited by TSO6S and SPECFL, subroutines of TSO. In addition they may be added to or originated by subroutine SAVERM ("SR", "ZSQ", etc. cards). Subroutine STORE is called to merge values into the regulation record.

Corrections may be made to regulation time-series with subroutines SBINMG with Regulation-Correction time-series (type 108) built by SBINZ4 ("Z8" cards), or SBMISC ("Z1" card).

Regulation records are used to specify reservoir regulations, and to specify streamflow and gage height time-series. They are used by the watershed models to provide observed discharge for the watershed printouts. They are used by the river model as overriding specified values for the results from a station.

Type 100 records may be listed by CPRINT called by subroutine TSO or BMAINT. They may also be listed by BMLIST.

Subroutine FEXTR is used to retrieve a value from the 100-record at a point in time.

FORMAT OF REGULATION RECORD

Word in Record

1	Length of record (number of words). Length may be less than.
3	System basetime of last change to record.
5-6	Name of record.
7	Type code 100.
8-10	Three words for first value in record.

Word 8: Basetime of value.
Word 9: Value, in REAL format, scaled according to code in word 10.
Word 10: Code identifying value: Codes are those from Column 24 of "6D" card format.

11-end Three words per value; the second of the three is the value, in REAL format; the 1st and 3rd of each threesome are integers.

Times are in ascending sequence. Two values cannot occur at exactly the same time.

Type 101; Basin Outflow.

Both the depletion watershed model (subroutine BASINE) and the snowband watershed model (subroutine SBROUT) write type 101 records to the SSARR file. The type 101 record is originated by each execution of a watershed model. It contains the computed basin discharge in cfs at the start of time, and the discharge at the end of each compute period. The record is used only by the river model (subroutine RTRSET and ROUTER). In ROUTER, basin flow input to the river model is extracted from the type 101 record by subroutine TRPRT which calls FEXTR.

The type 101 record may be listed by subroutine CPRINT called by TSO, and BMAINT. It may also be listed by subroutine BMLIST.

FORMAT OF BASIN OUTFLOW RECORD

Word in Record

1	Length of record (words)
3	System basetime this record was written.
5-6	Basin name (which is the record name).
7	Type code 101.
8	Run start time in basetime.
9	Basin outflow at run start time, in FORTRAN REAL format.
10	Basetime at end of first compute period.
11	Basin outflow at end of 1st period, in REAL format.
12-end	Pairs of (basetime, flow) for each compute period.

Type 102; Elevation Time-Series from River Model

Only subroutine SAVERM processing an "SR" card writes the type 102 record. The record may be listed by subroutine BMLIST, TSO, and BMAINT via subroutine CPRINT.

The "SR" card adds the current results from the river model onto existing type 100 and 102 records. Therefore, the type 102 record is cumulative Subroutine STORE is used to update it.

The format of the type 102 is nearly the same as the type 101 except that the values are elevation instead of flow.

Type 104; Snowband Hydromet Summary

Subroutine SBHYMT gathers the hydromet data for a basin, calculates the weighted average for each compute period of precipitation, temperature, daily ETI, and lapse rate. These weighted average time-series are saved in the SSARR file in the type 104 record for use by subroutine SBASIN.

There is no capability to list or edit the type 104. The format of type 104 is described in subroutine COMENT.

Type 108; Correction to Regulation

Subroutine SBINZ4 makes this record from "Z8" format cards. The type 108 may also be loaded from the bulk file by subroutine SBMISC ("Z1" card). When the record is completed by either SBINZ4 or SBMISC, a type 100 record of the same name is looked for and if found, subroutine SBINMG is called to correct the 100 record with values contained in the 108 record.

The format of type 108 is the same as type 100 except word 7 contains the code 108.

The 108 record may be listed by TSO and HMAINT via CPRINT, and HMLIST.

INPUT/OUTPUT UNITS

The SSARR program is entirely written in FORTRAN so all input/output is via FORTRAN unit numbers. There is an exception: at NPD, subroutines P15B and HMLIST address the CROHMS data base.

The FORTRAN units used by SSARR are:

Unit 3: In batch mode, a listing of the input stream plus input-related error messages are printed on unit 3. In interactive mode, prompting and information messages are printed. Nearly all lines are 80 columns or less.

Unit 4: The SSARR work file; a direct access file which must be pre-formatted by the initialization program. The physical segment length is 124 words (496 bytes). The number of segments in the file is dependent on the intended use and the initialization program. OPEN statement is in subroutine SROPEN.

Unit 5: The standard input unit. The input stream may be read from another unit with the use of the "INU=" command, but the first read at the start of execution is to Unit 5.

Unit 6: The standard printout unit. All output from the watershed models, and the default output from the river model output programs subroutine PRINT, PLOTLK, OUTPUT, STATS, and TTYPRT. Most print lines are 133 characters or less with the first character being carriage control. There are some option controls in the program to restrict some reports to 80 columns.

Unit 7: Punched-card formats are written to this unit by subroutine ICUPDT, OUTPUT, PRINT, SBMISC, and STATS.

Unit 8. Optional river model report printouts. Column 30 of the "J" card can be coded to cause these reports to write to unit 8 rather than unit 6.

Unit 15. A sequential input file of card images read by subroutine TSOIN in response to the "INPUT" subcommand of "IA". By default, the cards on unit 15 are to be characteristic cards, either card code "C" fixed format or card code "Z" free format. The file is searched by station name, so all cards for a station should be together.

Unit 16. Like unit 15, a sequential input file of card images read by subroutine TSOIN in response to the "INPUT" subcommand of "IA". By default unit 16 is searched for finder cards (cards with a semi-colon in Column 1 and a name in Column 2-80). The group of cards following a finder card is the search target.

Unit 17. A direct access file read by subroutine BMLIST. The OPEN statement is in subroutine BMLIST. This file contains station descriptions for the BMLIST reports. This file is built by a separate program in the CROHMS system.

Unit 18. The "BULK FILE" direct access file which is read by subroutine BUGET and written by BUSTOR. The "Z1" and "ZBSTORE" commands are processed by subroutine SBMISC which calls the BU... routines. The Bulk file is intended for longer term time-series storage. It is initialized and maintained by a set of "Bulk File" programs separate from SSARR.

Unit 19. Direct access work file for holding watershed results. Opened and written by subroutine SBPUT via calls from BASINE and SBROUT. Read by subroutine SBGET via call from PLOTLK, processing the "PZ" card.

Unit 20. Direct access work file for holding snowband results. Opened and written by subroutine SBZNPT via call from SBASIN. Read by subroutine SBZNGT via calls from SBROUT; and PLOTLK processing the "PZ" snowband plot card.

Unit 21 and Unit 22. Sequential work files for holding river model results.

The upper end of the dynamic area in COMMON/C1 is used for river model result buffers, an output buffer and input buffer. At the beginning of the river model, unit 21 is the output file. As the output buffer fills, it is written to unit 21.

If the river model requires more passes through the time range, as determined by the memory requirements of the model described by the P-card list, unit 21 becomes the input unit and unit 22 becomes output. The units are flip-flopped for each additional pass.

When the river model is complete, the final output unit is noted by the message "FINAL FILE OF TIME RECORDS IS ON UNIT xx" where xx is either 21 or 22. The processing of river model output commands by subroutine PRINT, PLOTLK, OUTPUT, SAVERM, STATS, and TTYPRT use this unit for input. Subroutine RTRSET resets the unit 21 and 22 controls and calls ICADJ, which sets the format of the river model time records and the buffers in COMMON/C1. Subroutines TFGET and TFPUT are called by ROUTER and TFGET is called by the river model output routines (PRINT, PLOTLK, etc.) to manage the buffers in COMMON/C1.

See subroutine COMENT for detailed format of river model time records and buffers.

"BASETIME"; TIME-DATE REPRESENTATION

In the SSARR program and files, time-date is represented by a 31-bit positive integer whose value is the number of tenths of hours from the beginning of the century to this time-date. Leap year for years in the 20th century are accounted for: There is no representation of time-zones or daylight-saving time shifts.

To increment basetime one day, add 240. The subroutines used are:

BTINIT. Initializes COMMON/TIME by loading it with current time-date from the computer system clock. BTINIT is called by SROPEN, which requires system clock information for SSARR work file management.

BTIME. Converts clock time in hours and tenths, plus day, month, and 2-digit year to basetime.

CTIME and CDATE. Converts basetime to hour (in tenths), day, month, and year.

FORTRAN COMMON USAGE

There are 17 named COMMON statements. They are generally related to functional areas of the program. One goal in their definition was to contribute to an efficient overlay structure, when the program is run in a limited main-memory environment. This structure is also efficient in virtual memory environments by reducing the amount of real memory needed for individual program tasks.

COMMON/BASIN. Work area used for communication between subroutine WASHED, BASINE, and BASIN2.

COMMON/BUFILE. Work area for communication among the Bulk File subroutines BUOPEN, etc., which are called by SBMISC.

COMMON/CARD. Internal file which holds the input card currently being processed. Loaded by subroutine IDREAD.

COMMON/CDFLDS. Contains results from subroutine FIELDS which uses subroutine SCAN77 to interpret free form input into individual words. FIELDS is called by IDCARD, and TSO and its subroutines.

COMMON/CTSOIN. Work space for subroutine TSOIN.

COMMON/C1. This is the most widely used COMMON. It defines a large dynamic area, the ICS array EQUIVALENCE statements usually provide the names XCS, NPA, and XPA to this array. Each of the main parts of SSARR use this array in a different way, often to hold the records and data retrieved from input, the SSARR work file, and the other work files, and the results being produced.

Word ICLGT is set in subroutine INIT as the maximum length of useable space in the dynamic area.

Word NPALA is set in subroutine CONFIG as the next free word in the dynamic area above the river model controls. It is used in the river model output programs PRINT, PLOTLK, SAVERM, OUTPUT, STATS and TTYPRT.

The DIMENSION of ICS may be changed to a minimum of about 12000, with a corresponding change to ICLGT and COMMON/ZCOM. There are several programs which EQUIVALENCE other arrays to the first 12000 words of ICS, which will not have to be changed if the 12000 minimum is observed.

The main impact of reducing this dynamic space size is to reduce the amount and time range of data that can be processed by the watershed models.

COMMON/IO. Contains input/output unit numbers and control for communication between all subroutines that do I/O. Initially set by subroutine INIT.

COMMON/JOB. Run control information from the "J" card and "J" subcommand of "IA". The main program AAAMAIN and its subroutines communicate through word IERROR. The "J" parameters are set by INIT and TSO.

COMMON/SSSARR. Communication and control information for the SSARR file subroutines.

COMMON/STREAM. Control words for FORTRAN units 21 and 22 and subroutines TFGET and TFPUT used in the river model and output routines.

COMMON/TIME. Model time control information from "T" card processed by subroutine INPUT and "T" subcommand of "IA", subroutine TSO. The system clock time in words ICLOCK and array ICLCAL are loaded by subroutine BTINIT called by SROPEN called by INIT. The time control values are used throughout SSARR. The principle routines are BTIME, CTIME, CDATE, and PTIME.

COMMON/TIMEC. Alpha names of months and days, loaded by BTINIT. Used by most printout programs.

COMMON/ZBIO. Control words for FORTRAN unit 19 and subroutines SBPUT and SBGET. Word IBZOPN is set to zero by subroutine INIT.

COMMON/ZBOUT. Communication of variables between subroutine SBASIN, SBZONE, and SBROUT. Also, the IBNMA array is EQUIVALENCED to the first 43 words for output by subroutine SBZNPT and input by SBZNGT.

COMMON/ZGET. Control words for processing of "GET" and "ZGET" commands by subroutine IDREAD. IGMAX and IGPTR are initially set by INIT.

COMMON/ZONECM. Communication area between SBASIN and SBZONE.

COMMON/ZOUTCM. Input/output area for BASINE, SBROUT and PLOTLK using subroutine SBPUT and SBGET.

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Processors not documented in the SSARR User Manual:

2 ZPP Derive period-precipitation from accumulating gage readings.

4 ZPPD Distribute daily values to compute period with a table relating percent of daily value per compute period.

6 ZPPI Distribute daily precip to shorter periods with an index precip station.

8 ZPSC Derive daily precipitation from snow course readings using a precipitation gage as the index.

12 ZTD Derive compute-period temperatures from daily maximum and minimum temperatures and a diurnal temperature pattern.

14 Z1 Additional control fields available on the Z1 command.

16 Z1ADD Version of Z1 command that will add to a time-series rather than replace it.

16 ZBT Version of ZBSTORE command that will only store data to the Bulk file within the current SSARR time control range.

16 ZLIST/ZPUNCH addition: add code "T" so that output is only of data within current time control.

SSARR Additions not documented in the SSARR User Manual.

17 Additions to specification of time control

17 Addition to Initial Condition output time specification.

17 BULK-data file Maintenance program:

18 ADJUST Command; Watershed Model I.C. Adjustment
25 ADJUST Command format

30 Revision to Channel Routing Procedure

ZPP Command:

Calculate period-precipitation from data from an accumulating precip. gage.

This command uses a hydromet time-series data record in the SSARR work file as input. This record contains the readings from an accumulating precipitation gage. The gage readings are expected to be in inches (or centimeters in the metric system).

Output from this command is another hydromet time-series data record, record type 23, in the SSARR work file containing a precipitation value for each time period, as defined by the currently active SSARR time control. Each period- precipitation value is the total precipitation that fell in that time period, in inches (centimeters if metric).

If the output time-series of period precipitation already exists in the SSARR work file, the computed values for the currently active SSARR time control are added on, replacing any old values falling within this time range.

The following considerations control the interpretation of the accumulating precipitation gage readings:

> If the gage readings drop more than 5 inches, it is assumed that the gage was emptied and reset.
>
> If the gage readings drop less than 5 inches, it is assumed that the reading is a variation caused by wind or temperature change, and the highest value attained is kept as the basis for computing the next increment of precipitation. Therefore, the sum of the incremental values of precipitation output by this command will equal the total accumulation shown by the accumulating gage. There is no attempt to identify or account for losses in the accumulating gage, such as might be the result of evaporation.

Format of the ZPP Command:

> ZPP target-name,source-name[,source-record-type]

The "target-name" is the name of the type 23 record that will be written into with the computed period-precipitation values. This record may be used as input to the watershed models, by listing this "target-name" and data type 3 on the CB04 or ZCH cards.

The "source-name" is the name of the hydromet data record containing the accumulating gage readings.

The "source-record-type" is optional, and may be included on the

ZPP command if the source record type is not 23.

Other SSARR Commands Used With ZPP:

CROHMS subcommand of IA: The accumulating gage readings may be copied from the CROHMS Data Base into the SSARR work file with this command. The sequence of commands to retrieve data from January 1st through 31st into a hydromet time-series named SLZWACUM, record type 23, is as follows:

```
IA
CROHMS
T 00 010186 01 00 310186
4 SLZWACUM 3 0
SLZW PCIRAZ 60
```

The last non-blank line of this sequence names SLZW, parameter PCIRAZ in the CROHMS Data Base as the source. A blank line is entered following this to indicate there are no more CROHMS time-series to be used as source for this data.

ZLIST command: Displays a hydromet time-series in card code 4D format. The sequence of commands set SSARR time control for 31 days of January and to calculate period precipitation, and list both the accumulating gage readings and the resulting period precip. values is as follows:

```
IA
T 0 010186
31 1
ZPP SLZW SLZWACUM
ZLIST SLZWACUM 23
ZLIST SLZW 23
```

Note that the ZLIST command is not limited by current SSARR time control, so the entire time-series' will be displayed. Bothe the CROHMS subcommand of IA and the ZPP command add to whatever is already in these target time-series' in the SSARR work file.

ZPPD command card.

The ZPPD command will produce a timeseries for compute periods of less than 24 hours, from daily data and a distribution. For example, given daily ET and a table describing the distribution of the ET throughout the day, a timeseries of 6-hour ET may be output.

The start and end time and hour-spacing of the resulting timeseries is controlled by the currently active SSARR time control.

The ZPPD command is as follows:

ZPPD target, target-type, source, source-type, distribution

where:

target is the name of the resulting timeseries, to be written to the SSARR work file. The timeseries will replace any existing timeseries in the SSARR file of the same name and type. The start and end times and hour spacing are set by the currently active SSARR time control.

target-type is the record type of the resulting timeseries in the SSARR work file.

source is the name of the basis timeseries, usually a timeseries of daily values. The source timeseries must be in the SSARR work file before the ZPPD command is issued.

source-type is the record type of the basis timeseries in the SSARR work file.

distribution is a table relating hour-of-day to percent of daily total evapotranspiration (for example) that has occured up to this hour. Therefore, the table should always end at hour 24 with 100 percent.

For example, consider the following distribution:

Hours of period	Percent of ET occuring	Percent of ET up thru this period
0000-0600	10	10
0600-1200	30	40
1200-1800	40	80
1800-2400	20	100

The ZCT card for this distribution table is (table name "DIST"):

```
ZCT DIST 2  0 0. 6 10. 12 40. 18 80. 24 100.
```

NOTE: If daily potential ET is to be distributed for the Snowband Model, the units of measure of datacode 5 data is inches per day, regardless of the time spacing! The ZPPD command distributes the daily value into compute period values; if the last point in the distribution (hour 24) is 100 percent, then the period values will addup to match the daily source value. This is not correct if the data is daily rate of ET.

Therefore, some means is needed to adjust the distributed rate to inches/day. There are several ways to do this, and the first one is probably the best:

1. Multiply the weight on the ZCH card for the ET data (datacode 5) by the number of compute periods per day. If the compute period is 6 hours and the weight of potential ET is 70%, put 280 on the ZCH card (70*4).

2. or, Multiply the percents in the distribution table by the number of compute periods per day.

3. or, Multiply the source time series data values by the number of compute periods per day, so that when it is distributed, the result comes out in units of inches/day. This can be done with the Z1 command when bringing the source data from the bulk file.

ZPPI command card.

The ZPPI command will produce a target precipitation timeseries with a period length less than 24 hours, given daily precipitation (the source timeseries), and an index timeseries.

The start and end time and hour spacing of the target timeseries is controlled by the currently active SSARR time control. However, hour spacing is constant; set from the first hour spacing in the SSARR time control. If the SSARR time control contains more than one hour spacing, all but the first are ignored.

The ZPPI command is as follows:

ZPPI target,source,index

where:

target is the name of the resulting precipitation timeseries. If a timeseries of the same name and type 23 (precipitation) exists prior to the ZPPI command, it is erased. The length and hours/period of the target time series is dependent on the currently active SSARR time control.

source is the name of the daily precipitation timeseries to be distributed.

index is the name of the index precipitation timeseries, used to distribute the daily source timeseries into period values.

Method.

Step 1: the total precipitation for the first 24 hour period is extracted from both the source and index timeseries; all values within 24 hours are added together to get the 24 hour value (not including the start time of the 24 hour period), so the source timeseries is not required to be only daily values.

Step 2: the precipitation for the first compute period is extracted from the index timeseries; all values within the compute period are added together, not including any value at the start time of the compute period.

The target value for a compute period is:

CPP = PP*IPP/IDPP

where:

CPP is target compute period value.

PP is source daily value.
IPP is index compute period value.
IDPP is index daily value.

Step 2 is repeated for each compute period in the day. All target values are rounded to the nearest .01 inch, and the last target period non-zero value for a day is adjusted so that the sum of the period values equals the source daily value.

Step 1 is repeated for each day (with step 2 for each period in the day).

Example:

If the input data are:

```
Z406 LWSI 100010489 3 .1 .2 0 0  0 0 0 0
Z424 HQSI 040020489 3        .5       .4
```

and time control is:

```
T   04 01048906 04 030489
```

and the ZPPI command is:

```
ZPPI HQS6 HQSI LWSI
```

the result timeseries may be output with the command:

```
ZPUNCH HQS6 23
```

which gives the card image:

```
4D  060  HQS681000104893  17  33   0   0  10  10  10  10
```

ZPSC command:

Produce period precipitation data from snow course readings. This is an adaptation of a program written by Rich Sears (G0723820).

Winter precipitation on some northern basins may best be represented by snow course readings. Snow course data is sometimes available only once or twice a month. The SSARR model is usually run with daily or shorter compute periods, and period precipitation is usually needed as input.

If it is assumed that melt is negligible during the snow accumulation period of the winter, the period distribution of precip at a snow course can be estimated by referring to a precipitation gage record that is observed at proper intervals. When precip occurs at the observed gage, it can be assumed that precip also occurred at the snow course. The amount at the snow course can be computed by proportion of total change at the snow course versus total precipitation at the observed gage during the time interval between snow course readings.

Input for the ZPSC command are two time-series in the SSARR work file. These time-series may be read in from card input (4D or Z4 cards), or loaded by Z1 command from the Bulk file, or any of the other means of entering time-series data into the SSARR work file.

Output from the ZPSC command is a new precipitation time-series, plus messages on the monitor or printout describing the parameters of the distribution of precip.

Format of the ZPSC command:

ZPSC target-precipitation-record-name, target record type,
snow-course name, snow-course record type,
template name, template record type,
snow course ratio, precip. weight

where:

"Target-name and record type" identify the new precipitation time-series to be produced by this command. Record type is usually 23. An old record already in the SSARR work file will be replaced by this new record.

"Snow-course name and record type" identify the time-series containing snow course values. Snow course readings are usually in inches, and the record type may be 23. If the record type is 27 and was produced by reading in 4D cards with 7 in column 24, the data values may be 100 times too large. Use "snow course ratio", field 7 of the ZPSC

command, to scale to inches (field 7 would contain .01).

"Template name and record type" identify the precipitation time-series record which will serve as the basis for calculating the period precip at the snow course. The target time-series will contain values at the same times as the template time-series.

"Snow course ratio" is multiplied with the values in the snow course time-series before period precip values are computed.

"Precip. weight" is the percentage difference between the snow-course normal season precip (NAP) and the template NAP. For example, if an average of 15 inches of precip is observed at the template station during the snow accumulation season, and the average annual highest snow-course reading is 30 inches, the "precip. weight" percent is 200. This weight is multiplied with the template time-series values (and divided by 100) for time intervals when the snow course is not increasing.

Example:

Station KAS, type 23 is the template time-series. Station FLKB, type 27 is the snow-course time-series. The resulting target time-series is identified as FLK, type 23. Snow course FLKB normally gets twice as much precip during the winter as station KAS. The snow course record was entered on 4D cards with data type 7, so the snow course readings are scaled wrong and must be multiplied by .01 to convert them to inches.

```
ia
*
lt
RUN START TIME IS HOUR 24.0, 30 SEP 70, WEDNESDAY   ,  24.0 HOURS/COMPUTE PERIOD
      END TIME IS      24.0  31 MAR 71  WEDNESDAY
*
zlist flkb 27
4D  240  FLKB124028 47072541
4D  240  FLKB1240 110707   1
4D  240  FLKB1240 3 27173073
4D  240  FLKB124022 27173373
4D  240  FLKB1240 1 47174322
ENTER INPUT-CARD FORMAT:
zlist kas 23
4D  240  KAS 118030 9703   0
4D  240  KAS 1180 110703   0
4D  240  KAS 3180 410703  14   7   6
4D  240  KAS 2180 610703  11   1
4D  240  KAS 11801110703   6
4D  240  KAS 11801410703   0
4D  240  KAS 11801810703  13
4D  240  KAS 51802010703  24  13  17  32  15
4D  240  KAS 11802810703   0
4D  240  KAS 11803110703   0
4D  240  KAS 1180 511703   9
4D  240  KAS 2180 811703  21  33
4D  240  KAS 21801111703  11   2
4D  240  KAS 41801411703   2  24  21   5
4D  240  KAS 31802211703  25  52  14
4D  240  KAS 41802711703  20   0  10  32
4D  240  KAS 7180 112703  70  15  30  10  90  73  25
4D  240  KAS 11801012703  15
4D  240  KAS 31801412703  20  52  24
4D  240  KAS 21801912703   2   2
4D  240  KAS 11802212703  10
4D  240  KAS 11802412703   5
4D  240  KAS 61802612703  10  80  10  40  40   2
4D  240  KAS  180 6 1713  12  12  25  30  35  30  70  70 100  22  34   7  50  22
4D  240  KAS  18022 1713  10  10   8  40  50  11  12 198  75   4
4D  240  KAS 2180 2 2713   2  40
4D  240  KAS 7160 9 2713  10  15  11  32  16  46   3
4D  240  KAS 218023 2713  12  32
4D  240  KAS 116026 2713   2
4D  240  KAS 118028 2713   0
4D  240  KAS 2180 2 3713  20   5
4D  240  KAS 1180 7 3713  17
4D  240  KAS 318010 3713  61   5   4
4D  240  KAS 118014 3713   0
4D  240  KAS 418023 3713  23   7  20  55
4D  240  KAS 418028 3713  38  29  12   0
4D  240  KAS 1180 6 4713   7
ENTER INPUT-CARD FORMAT:
```

```
ia
zpsc flk 23 flkb 27 kas 23 .01 200
FLKB     , SUM OF RAIN, DIFF IN SC=   20.4   30.7 DATES=  4 10 70  3  2 71
FLKB     , SUM OF RAIN, DIFF IN SC=    1.3    3.0 DATES=  9  2 71 15  2 71
FLKB     , SUM OF RAIN, DIFF IN SC=    3.4    9.5 DATES= 23  2 71 31  3 71
ENTER INPUT-CARD FORMAT:
zlist flk 23
4D  240  FLK 118030 9703   0
4D  240  FLK 1180 110703   0
4D  240  FLK 3180 410703  21  11   9
4D  240  FLK 2180 810703  17   2
4D  240  FLK 11801110703   9
4D  240  FLK 11801410703   0
4D  240  FLK 11801810703  20
4D  240  FLK 51802010703  36  20  26  48  23
4D  240  FLK 11802810703   0
4D  240  FLK 11803110703   0
4D  240  FLK 1180 511703  14
4D  240  FLK 2180 811703  32  50
4D  240  FLK 21801111703  17   3
4D  240  FLK 41801411703   3  36  32   8
4D  240  FLK 31802211703  38  78  21
4D  240  FLK 41802711703  30   0  15  48
4D  240  FLK 7180 112703 105  23  45  15 135 110  38
4D  240  FLK 11801012703  23
4D  240  FLK 31801412703  30  78  36
4D  240  FLK 21801912703   3   3
4D  240  FLK 11802212703  15
4D  240  FLK 11802412703   8
4D  240  FLK 61802512703  15 120  15  60  60   3
4D  240  FLK  180 6 1713  18  18  38  45  53  45 105 105 150  33  51  11  75  33
4D  240  FLK  18022 1713  15  15  12  60  75  17  18 298 113   6
4D  240  FLK 2180 2 2713   3  60
4D  240  FLK 7180 9 2713  23  34  25  72  36 104   7
4D  240  FLK 218023 2713  33  89
4D  240  FLK 118026 2713   6
4D  240  FLK 118028 2713   0
4D  240  FLK 2180 2 3713  55  14
4D  240  FLK 1180 7 3713  47
4D  240  FLK 318010 3713 169  14  11
4D  240  FLK 118014 3713   0
4D  240  FLK 418023 3713  64  19  55 153
4D  240  FLK 418028 3713 105  80  33   0
ENTER INPUT-CARD FORMAT:
```

ZTD command: Distribute daily temperatures to compute periods.

Given daily maximum and minimum temperatures and a diurnal temperature pattern, this command processor will produce a temperature value for each compute period.

The ZTD command has no parameters. Instead, it prompts the user with the message:

```
ENTER COMMAND: T, D, P, BLANK LINE, Q, OR ?
```

If a ? is entered, the following explanation results:

```
DISTRIBUTE PERIOD TEMPERATURES IN SSARR FILE FROM DIALY MAX/MIN,
AND A TEMPERATURE PATTERN.
ENTER COMMAND:
  ENTER START DATE, HR/PERIOD, AND END DATE AS:
 D DDMMYY,HR,DDMMYY          TO RESET DATE
   OR ENTER TIME-SERIES NAMES AS:
 T TARGET, MAX-TEMPS, MIN-TEMPS
   OR ENTER 24 HOUR TEMPERATURE AS:
 P T1, T2, T3,...        (1 PER PERIOD MUST BE ENTERED)
   OR ENTER A BLANK LINE TO INITIATE PROCESSING

   OR ENTER
 Q                         TO RETURN TO SSARR
```

If the D subcommand is not issued, time control defaults to the currently active SSARR time control.

The T subcommand is required. The station names provided for the TARGET, MAX-TEMPS, and MIN-TEMPS fields refer to record-type 24 (temperature) records in the SSARR work file. The TARGET time-series will replace any old type 24 time-series of the same name.

The P subcommand is required. It must contain one temperature for each compute period of the day. These temperature represent the typical daily fluctuation of period temperatures. The first temperature is for the first compute period of the day; that is, the compute period that begins at hour 0000. Note: if no D subcommand is given and time control is taken from SSARR time control, the hour of start and end time is ignored; only the beginning and ending dates are used, along with the compute period hours.

After the P and T subcommands (and D subcommand, if necessary) are entered, enter a blank line to initiate processing to produce the target time-series of temperatures.

The Q subcommand is required to exit the ZTD processor. If a

blank line has not been entered before the Q subcommand, no processing will have taken place, and the target time-series will not have been produced.

Enter a ? to repeat the main processor prompt.

For example:

Minimum daily temperatures are put in the SSARR work file in the type 24 record named XCBN

Maximum daily temperatures are put in the type 24 record named XCBX

To produce a time series of 6-hour temperatures named XCB6, issue the following input lines to SSARR:

```
 ENTER INPUT-CARD FORMAT:
Z4 XCBX 000010387 4 50 60 70
 ENTER INPUT-CARD FORMAT:
Z4 XCBN 000010387 4 20 30 55
 ENTER INPUT-CARD FORMAT:
ZTD
 ENTER COMMAND: T, D, P, BLANK LINE, Q, OR ?
 ENTER INPUT-CARD FORMAT:
D 010387 6 020387
 START DAY MONTH YEAR= 28  2 87, PERIOD HOURS=  6.0 ENDING DAY MONTH YEAR=  2  3
 87
 ENTER COMMAND: T, D, P, BLANK LINE, Q, OR ?
 ENTER INPUT-CARD FORMAT:
P 32 40 55 40
 ENTER COMMAND: T, D, P, BLANK LINE, Q, OR ?
 ENTER INPUT-CARD FORMAT:
T XCB6 XCBX XCBN
 ENTER COMMAND: T, D, P, BLANK LINE, Q, OR ?
 ENTER INPUT-CARD FORMAT:

 XCB6     DATE RANGE- 1 387 TO  2 387, NO. VALUES=   8 STORED.
 ENTER COMMAND: T, D, P, BLANK LINE, Q, OR ?
 ENTER INPUT-CARD FORMAT:
Q
 ENTER INPUT-CARD FORMAT:
ZLIST XCBX 24
4D  240  XCBX124028 2874 500
4D  240  XCBX2240 1 3874 600 700
 ENTER INPUT-CARD FORMAT:
ZLIST XCBN 24
4D  240  XCBN124028 2874 200
4D  240  XCBN2240 1 3874 300 550
 ENTER INPUT-CARD FORMAT:
ZLIST XCB6 24
4D   60  XCB660 60 1 3874 300 404 600 404 550 602 700 602
 ENTER INPUT-CARD FORMAT:
```

Z1 Command additional fields not documented in User Manual:

Additional fields have been added to the Z1 command so that data retrieved from the Bulk data file may be shifted in time and scaled, before entry into the SSARR work file. If these fields are not provided by the user, the function of the Z1 card will be as it was before this change.

Z1 card fields:

(original fields of the Z1 command)

1 SSARR work file record name
2 SSARR work file record type code
3 Start time of data retrieval
4 End time of data retrieval
5 Bulk file record name
6 Bulk file record code number
7 Regulation record type
(fields added to the Z1 command)

8 Shift hours. The retrieval time is gotten from SSARR time control. The "shift hours" are added to the retrieval time before retrieval from the Bulk file.

For example, if the "shift hours" is -24, data dated the first of the month in the Bulk file will be stored in SSARR dated the second of the month. This can be used to compensate for NWS precip data that is dated one day late in the Bulk file.

9 Scale factor. The Bulk file value (plus the Addon value from field 11) is multiplied by the scale factor to get the SSARR value.

10 Addon value. The "addon" value is added to the Bulk file value, and the sum is multiplied by the scale factor (field 10) to get the SSARR value.

Example:

The first example is retrieval of precip data from station KASB, bulkcode 235; and a ZLIST of the resulting data.

The second example is the same retrieval with a time shift of -24 hours, resulting in the precip being shifted one day later in the SSARR file record (station KAS, record code 23).

The third example is retrieval of temperature data from station FRCX, bulkcode 245.

The fourth example is that same retrieval with conversion to Celcius.

```
RUN START TIME IS HOUR 24.0, 30 SEP 70, WEDNESDAY    ,  24.0 HOURS/COMPUTE PERIOD
      END TIME IS      24.0  30 OCT 70  FRIDAY
*
zl kas 23,,,kasb 235
ENTER INPUT-CARD FORMAT:
zlist kas 23
4D  240  KAS 118030 9703   0
4D  240  KAS 1180 110703   0
4D  240  KAS 3180 410703  14   7   6
4D  240  KAS 2180 810703  11   1
4D  240  KAS 11801110703   6
4D  240  KAS 11801410703   0
4D  240  KAS 11801810703  13
4D  240  KAS 51802010703  24  13  17  32  15
4D  240  KAS 11802810703   0
4D  240  KAS 11803110703   0
ENTER INPUT-CARD FORMAT:
zl kas 23,,,kasb 235,,-24
ENTER INPUT-CARD FORMAT:
zlist kas 23
4D  240  KAS 118029 9703   0
4D  240  KAS 2180 110703   0   0
4D  240  KAS 3180 510703  14   7   6
4D  240  KAS 2180 910703  11   1
4D  240  KAS 11801210703   6
4D  240  KAS 11801510703   0
4D  240  KAS 11801910703  13
4D  240  KAS 51802110703  24  13  17  32  15
4D  240  KAS 11802910703   0
4D  240  KAS 1180 111703   0
ENTER INPUT-CARD FORMAT:
zl frc 24,,,frcx 245
ENTER INPUT-CARD FORMAT:
zlist frc 24
4D  240  FRC 118030 9704 660
4D  240  FRC  180 110704 669 601 691 660 460 360 331 379 379 370 410 370 390 430
4D  240  FRC  1801510704 480 531 550 540 520 430 410 390 360 379 379 309 340 410
4D  240  FRC 31802910704 450 511 540
ENTER INPUT-CARD FORMAT:
zl frc 24,,,frcx 245,,,.55556,-32
ENTER INPUT-CARD FORMAT:
zlist frc 24
4D  240  FRC 118030 9704 189
4D  240  FRC  180 110704 194 156 206 189  78  22   6  33  33  28  50  28  39  61
4D  240  FRC  1801510704  89 117 128 122 111  61  50  39  22  33  33  -6  11  50
4D  240  FRC 31802910704  72 106 122
ENTER INPUT-CARD FORMAT:
```

Z1ADD command: Version of Z1 command that will add to a time-series, rather than replace it.

The fields are the same as the Z1 command. The Z1 command will replace any old time-series in the SSARR work file with the same name and record code. For example, if there is a type 23 record (precip.) in the SSARR work file for station KASB and a "Z1 KASB 23..." command is given, the old record is replaced. If no data is available in the Bulk file for this Z1 retrieval, then the Type 23 record for KASB is erased. The Z1ADD command will add to the old record, or replace data within the old record for the time range of the Z1ADD retrieval.

ZBT command: Version of ZBSTORE command that will only store data to the Bulk file within the current SSARR time control range.

The ZBSTORE command disregards the current SSARR time control; it stores the entire SSARR work file time-series to the Bulk file. The ZBT will only store data values falling within the current SSARR time control.

Addition to ZLIST/ZPUNCH command:

The ZLIST and ZPUNCH commands have an additional parameter, the code 'T'; if this code is present, only data within the current time control is output. For example, if a precipitation time series named DWRF contains 6 months of data, and the following commands are given:

```
    ZLIST DWRF 23
```

all 6 months of data is listed regardless of current time control.

However, if current time control was set by the following:

```
    T   00 010188 6 00 010288  (1 Jan 88 to 1 Feb 88)
```

and the time-series contains data from September 87 to March 88, and one of the following commands is given:

```
    ZLIST DWRF 23 T
or  ZPUNCH DWRF 23 8 T    (output to unit 8)
```

only the data from hour 00, 1 Jan 88 through hour 00, 1 Feb 88 is output.

Additions to specification of time control

The fields of the time commands all take advantage of the relative dating policy of the SSARR program, described briefly on page B-25 of the SSARR User Manual.

A new subcommand, "TF" causes start time to be set at the end time of the prior time specification. When the "TF" subcommand is given, the program prompts for number-of-days and hours-per-period, as if a "T hh ddmmyy" subcommand had been given.

When the T subcommand of IA prompts for end time, the user may give the exact ending time and date, instead of replying "number-of-days and hours-per-period".

Addition to Initial Condition output time specification. The ICOUT subcommand may give time and date istead of number of hours for initial condition output; and several times may be given on the subcommand line.

BULK-data file Maintenance program: BULKMAIN.EXE is a standalone maintenance program for the BULK-data file. The BULK-data file is used by the "Z1" and "ZBSTORE" subcommands of the "Z" command. If you run BULKMAIN, you will get a menu on your screen. The "INITIALIZE" command is used to initially setup a BULK file, and must be the first command given.

The "C" (compress) command causes a new file name "NEWBULK" to be produced. The BULK file is named "BULK".

The goal of this adjustment scheme is to make the computed instantaneous conditions of the model match observed conditions at the end of the adjustment period. This is done by small changes to lapse rate, temperature, and precipitation to make the computed hydrograph match the observed hydrograph. The rationale is that if the hydrographs match, the model state variables will best represent observed conditions.

The adjustment scheme is currently limited to changing temperature lapse rate, basin average temperature, and basin average precipitation. The user specifies which of these parameters are candidates for adjustment, the adjustment increment for each, and the maximum number of increments of change allowed in any compute period. The goal is to make the minimum number of incremental adjustments so that the computed hydrograph will match the observed hydrograph within user-specified tolerance. All parameters are adjusted simultaneously.

The adjustment cycle follows these steps:

1. Process the basin through time to produce the unadjusted computed hydrograph.

2. Compile a tabulation of the estimate of difference for each time period. The estimate of difference is an estimate of the difference between the observed and computed hydrographs which potentially can be corrected by a change in moisture input.

3. Derive a set of trial adjustments to the parameters for each compute period. If the estimate of difference is already within error tolerance for a compute period, no adjustment is made.

4. If the maximum number of cycles (specified by the user) has not been exceeded, and if changes have been made to the adjustment time-series, go back to step 1; if the maximum cycles have been made, or no additional adjustments were made in the last cycle, the adjustment procedure is complete.

The Objective Function:

The objective function is the standard error between the observed and computed hydrographs. After the adjustment procedure is complete, the trial resulting in the smallest standard error is accepted as best.

Estimate of difference between observed and computed hydrographs:

A table of attribution percents (in the form of a mass curve) is provided by the user. These percents represent the portion of the cfs error in each future period (starting with the current

period) which can be corrected by a change to RG (generated runoff) in the current period. If for example the table of attribution percents contains 5 points, the estimate of difference for period i is:

$$E_i = P_i * (C_i - O_i) + P_{i+1} * (C_{i+1} - O_{i+1}) + \ldots + P_{i+5} * (C_{i+5} - O_{i+5})$$

$$F_i = E_i * CF / (1 - BFP_i / 100)$$

where:

i is compute period

P from Attribution table; it is the ratio of volume of runoff in a compute period to total volume of the hydrograph. Please see derivation below.

C computed discharge

O observed discharge

BFP Baseflow Percent; (1-BFP/100) is the contribution to direct runoff.

E cfs error attributed to input to runoff from this period.

CF conversion factor: (cfs hours)*CF=basin-inches, CF=1/645.3333*area

F the estimate of difference in basin inches of RG (generated runoff)

The Attribution Percent Table:

This table is a percentage description of a unit hydrograph. It is a relationship of time versus the percent of volume of the unit hydrograph that has passed up to that time.

If, for example, 50% of the volume of the unit hydrograph is in the first 6 hours, 30% in the period from hour 6 to hour 12, and 20% in the period from hour 12 through hour 18, the accumulated percents are as follows:

Hour	Accumulated-percent
6	50%
12	80%
18	100%

and the ZCT table (named "ATTR") is as follows:

```
ZCT ATTR 2  6 50 12 80 18 100
```

Since the shape of the hydrograph resulting from a unit of precipitation varies with the intensity of input, a family of curves relating intensity to attribution percents can be used. A 3-variable attribution table may be input with the ZCF or CF card format. The "Z" value is the input to direct runoff (input to direct runoff is RG*(100-bfp)/100). "X" is hours and "Y" is accumulated percent, in percent of runoff through that hour.

The attribution table can be derived by running the model with a unit of precipitation in the first compute period as demonstrated in Appendix A. The BASIC program in Appendix A will make the computation of the accumulated-percent representation of the unit hydrograph. It is necessary to enter the flows in the DATA statements (BASIC statement number 31).

The Adjustment Scheme:

The "ADJUST" command card in the SSARR input stream contains controls for the adjustment procedure. These controls include designation of which parameters (lapse rate, temperature, and/or precipitation) are candidates for adjustment. Also specified are the amount of change (i.e., the "increment") allowed for each parameter during a trial cycle, and the maximum number of increments of change allowed in any one compute period. There is also tolerance information to control closeness of fit.

In addition, the "ADJUST" command specifies the total number of trial cycles allowed, and the "WET" constant to identify periods which have too much precipitation to allow the lapse rate to exceed 3.3 F./1000 ft..

The adjustment procedes as follows for each compute period (the "compute period" is the computational interval, typically 6 hours for Columbia basin forecasting):

A. The First Step.

The first step is to derive the tolerance, against which the estimate of difference is measured. If the absolute value of the estimate of difference is less than the tolerance, no adjustment for this compute period is necessary.

The user specifies a maximum allowable error in terms of percent of "attributed observed" flow (typically 5 percent). The "attributed observed" flow is calculated in the same way as the estimate of difference; the series of attribution percents are multiplied by the current and future observed flows to arrive at the "attributed observed" flow for this period. The allowable-error-percent times this flow gives "maximum error". If the estimate of difference is smaller than the "maximum error", no adjustment for this period is necessary.

The "maximum error" can be no larger than a user supplied maximum value. In addition, the "maximum error" can be no smaller that the product of the maximum error cfs, and the allowable-error-percent. For example, if the user supplied 5% as the allowable error and 1000 cfs as the maximum value of the "maximum error", than the "maximum error" can be no smaller that 50 cfs. This keeps the procedure from adjusting to small errors during low flow periods.

B. UNDERCOMPUTE:

When the estimate of difference for a period is negative, more RG is needed and the lapse rate should probably be lowered, the temperature raised, and/or precipitation increased. Several rules are now in place to determine whether these changes should be made:

LAPSE RATE:

Lapse rate is the first parameter checked by the adjustment scheme. If the user does not elect it as a candidate for adjustment, the scheme goes on to the next parameter (temperature).

1. If there is no snow on the basin, then it will do no good to raise temperature; so no adjustment is made to the lapse rate.

2. Calculate Temperature at average gage elevation.
   Freezing level.
   Percent rain area.
   Percent melt area.
   Estimate moisture input (MI) at current LR, TA, PP.
   Estimate MI at minimum adjusted Lapse Rate.

3. To lower the Lapse rate (to raise basin average temperature):

3.1 Insure that the user-specified maximum increments of change is not exceeded.

3.2 Estimate the change to MI due to reducing lapse rate one increment. If the change does not exceed the error expressed by the estimate of difference, adjust lapse rate one increment.

TEMPERATURE:

After adjusting lapse rate and estimating the effect of the adjustment, the effect is added to the estimate of difference (which is negative; undercomputed) to see if more correction is needed.

4. If there is no snow, there is no use increasing temperature.

5. If temperature has already been increased by the maximum number of increments, it cannot be adjusted higher.

6. Calculate freezing level at the highest possible temperature if all increments were to be applied. If that maximum freezing level is below the snowline, there is no use increasing temperature.

7. Estimate the effect on MI of increasing temperature one increment (as a function of average melt rate and melting area from the last cycle). If the change does not exceed the error expressed by the estimate of difference, increase temperature one increment.

PRECIPITATION:

After adjusting temperature and estimating the effect of the adjustment, the effect is subtracted from the estimate of difference to see if more correction is needed.

The maximum amount of change to precipitation during a single trial cycle is 10% of observed precip for a period, taken in whole increments (precip increments specified by the user in word 8 of the ADJUST command). For example, if observed precip is 0.5 in. in 6 hours and the precip increment is 0.1 in. per day (.025 in 6 hours), the adjustment scheme can change precip two increments each trial cycle; 10% of .5 is .05 inches, which is two increments of .025 inches.

8. If precipitation has already been increased by the maximum number of increments, it cannot be adjusted higher.

9. Estimate the effect on MI of increasing precipitation by the maximum amount of change for the period (as a function of area below the freezing level from the last cycle, not from the estimates made for this adjustment cycle). If the change does not exceed the error, increase precipitation.

9.1 If the maximum change does exceed the error, and the maximum change is more than one increment, reduce the maximum change by one increment and try the estimate again (go back to paragraph 9).

C. OVERCOMPUTE:

If the estimate of difference is positive, less RG is needed and the lapse rate should probably be raised, the temperature lowered, and/or precipitation reduced.

LAPSE RATE:

Lapse rate is the first parameter checked by the adjustment scheme. If the user does not elect it as a candidate for adjustment, the scheme goes on to the next parameter (temperature).

1. If there is no snow on the basin and no precipitation in this period, then it will do no good to lower the temperature so no adjustment is made to the lapse rate.

2. Calculate Temperature at average gage elevation.
   Freezing level.
   Percent rain area.
   Percent melt area.

Estimate moisture input (MI) at current LR, TA, PP.
Estimate MI at maximum adjusted Lapse Rate.

3. To raise the Lapse rate:

3.1 Insure that the user-specified maximum increments of change is not exceeded.

3.2 If precipitation for the period exceeds the user-provided limit ("WET", field 12), donot adjust the lapse rate above 3.3 F/1000 ft. (6.0 C/1000 m.).

3.3 If these tests are met, estimate the change to MI of raising lapse rate one increment. If the change does not exceed the error expressed by the estimate of difference, adjust lapse rate one increment.

TEMPERATURE:

After adjusting lapse rate and estimating the effect of the adjustment, the effect is subtracted from the estimate of difference to see if more correction is needed.

5. If there is no moisture input, there is no use reducing temperature.

6. If temperature has already been decreased by the maximum number of increments this period, it cannot be adjusted lower.

7. Calculate freezing level. If there is no precip and if the freezing level is already below the snowline, there is no use decreasing temperature.

8. If there is precip, and if the freezing level is below the basin, there is no use decreasing temperature.

9. Estimate the effect on MI of decreasing temperature one increment (as a function of average melt rate and melting area from the last cycle). If the change does not exceed the error expressed by the estimate of difference, decrease temperature one increment.

PRECIPITATION:

After adjusting temperature and estimating the effect of the adjustment, the effect is subtracted from the estimate of difference to see if more correction is needed.

The maximum amount of change to precipitation during a single trial cycle is 10% of observed precip for a period, taken in whole increments (precip increments specified by the user in word 8 of the ADJUST command). For example, if

observed precip is 0.5 in. in 6 hours and the precip increment ins 0.1 in. per day (.25 in 6 hours), the adjustment scheme can change precip two increments each trial cycle.

10. If precipitation has already been decreased by the maximum number of increments, it cannot be adjusted lower.

11. Estimate the effect on MI of decreasing precipitation by the maximum amount of change for the period (as a function of area below the freezing level from the last cycle, not from the estimates made for this adjustment cycle). If the change does not exceed the error, decrease precipitation.

11.1 If the maximum change does exceed the error, and the maximum change is more than one increment, reduce the maximum change by one increment and try the estimate again (go back to paragraph 11).

D. After correcting for a single compute Period:

If changes are made to the adjustment time-series for this period, the estimated effect on MI is subtracted from the estimate of difference in the subsequent periods (by distributing the effect with the attribution table percents).

<u>ADJUST Command format:</u>

The adjustment scheme is built into the SSARR Interactive Processor. In response to the * prompt, the command "ADJUST..." may be entered. The ADJUST command causes a single basin to be processed, much the same as the BASIN command. However, a separate ADJUST command must be given for each basin in the model; the "ADJUST model-name..." option (like the "BASIN modelname" is not available.

The ADJUST command causes a type 101 record to be written to the SSARR file, and basin summary results (and zone results, for Snowband basins) are written to the temporary files for plotting by PZ cards. The Initial Condition records are updated the same as for a BASIN command.

A time-series is written to the SSARR file for each of the parameters adjusted. Lapse rate, temperature, and precipitation are the parameters which may be selected for adjustment, resulting in the writing of type 26, 24, and 23 records (respectively) containing the adjustment amounts. The type 26 lapse rate record will contain the degrees/1000ft. (or degrees/1000 meters) that the lapse rate was changed, including zeroes for all periods which were not changed.

The type 24 temperature record will contain the number of degrees

each period was changed, and the type 23 precipitation record will contain the amount each period was changed. If a record existed with the same name and type as one of these outputs, the old record is replaced.

The basin printed output is subject to control of the J card and ZR card. The J card (and J subcommand of IA) contain several printout options. The formats for the Depletion-Curve english unit "BATCH" (132 character width) format has been modified to show the number of increments of adjustment of temperature and precipitation. The snowband summary printout has also been changed.

The ADJUST command must be contained on one line of input. It is a subcommand of IA. It is composed of the following fields:

field following the word "ADJUST":
---

1 Basin name

2 Attribution Percent table name. See discussion of estimate of difference and Attribution Percent Table above.

3 Name for temperature (type 24) adjustment output record. If this field is missing (denoted by ",,"), temperature is not adjusted and no type 24 record is written.

4 Name for precipitation (type 23) adjustment output record. If this field is missing, precipitation is not adjusted and no type 23 record is written.

5 Name for lapse rate (type 26) adjustment output record. If this field is missing, lapse rate is not adjusted and no type 26 record is written.

6 Maximum number of trial cycles; defaults to 10. The adjustment scheme will rerun the basin for each trial cycle.

This scheme will sometimes oscillate. So, donot set the number of trials much larger than 10, and keep the increment sizes small. The standard- error test will select the best trial as the final result, even when it oscillates.

7 Temperature increment, degrees per compute period; defaults to 1 degree F., .56 degree C. (note: early experience has shown these increment sizes to be too large).

The maximum adjustment of temperature for a period is the product of the increment and the maximum number of increments (word 14 of the ADJUST command). Since only one increment of change is allowed per trial, the effective maximum change may be limited by the maximum number of

trials (word 6).

The Depletion-Curve model with daily melt distribution computes snowmelt only once per day, from one-per-day temperatures. However, if the model is running 6 hour compute periods, the temperature adjustment will attempt to change temperature each period and the output temperature time-series will have a value for each 6-hour period. Only the first period of the day is used in the computation of the basin, as will be seen on the basin printout.

8 Precipitation increment, in inches (or centimeters) per day. When the compute period is 6 hours, this value is divided by 4 to get the compute period increment. Defaults to .15 inches or .38 cm.

The maximum adjustment of precipitation for a period is the product of the maximum number of increments (word 14) and the daily increment divided by number of periods per day. Precip may be adjusted more than one increment per trial cycle.

9 Lapse rate incremet, in degrees per 1000 feet (or 1000 meters); defaults to .9 F/1000ft or 1.8 C/1000m. (note; this is probably too large an increment).

10 Allowable error as percent of observed flow; default to 10% (5% seems to be a good choice.)

11 Maximum allowable error in CFS (or CUMECS); default to 0.

12 Precipitation rate per day signalling "WET" lapse rate; default .2 inches/day or .5 cm. per day.

13 "PU" or "1" in this word causes basin to print during first unadjusted trial cycle. Suppress this printout by entering ",," for this word.

14 Maximum number of increments of adjustment allowed on a compute period; defaults to 4. (current experience and increment size seem to indicate this word should be 10)

15 "T" in this word will cause a trace printout of values for each period for each adjustment trial cycle. the units of the error values are inches/hr of RG. The data output are:

error tolerance
error (estimate of difference)
lapse rate increments-of-change and residual error
temperature increments-of-change and residual error
precipitation increments-of-change and residual error

EXAMPLE:

The adjust command for Whitebird is:

ADJUST WHBIS LSAT WHBT WHBA WHBL 10 .5 .1 .2 5 1800 .2 PU 10

where:

WHBIS basin name
LSAT attribution table name
WHBT temperature record name; causes temperature to be adjus ted.
WHBA precipitation record name; causes precipitation to be adjusted.
WHBL lapse rate record name: causes lapse rate to be adjusted.
10 maximum of trials
5 5% error allowed, unless limited by the next word.
1800 cfs upper limit on the 5% error. If observed flow is 40000 cfs, 5% would yield an allowed error of 2000 cfs, but the actual allowed error is 1800 cfs because of the upper limit in word 11.
PU Code indicating that the unadjusted basin results should be printed.
10 Maximum number of increments of change of any of the adjustment parameters that may be applied to a compute period.

Another EXAMPLE:

ADJUST WHBIS LSAT WHBT,,,,.5,,,5 1800

causes adjustment of WHBIS temperature only.

Results:

This procedure seems to work well for snow events. If model parameters such as soil moisture, and snow pack condition and depth are representative of current conditions, small adjustments to temperature and precipitation correct the computed hydrograph accurately and quickly, even during extreme conditions. In fact, the procedure works best under extreme conditions because the rising or falling hydrograph gives a clear view of the corrections needed to the hydromet data. When there is no prevalent rise or fall during the duration fo the unit hydrograph, the correction to errors cannot be as easily identified.

Since this procedure makes the estimate of difference based on a unit hydrograph, it tends to spread the correction to precipitation over the major part of the unit hydrograph, rather than making large changes to individual precip measurements. Therefore, it does not shift the timing of precip very well. A step is now being added to the procedure to change the timing of precipitation when it is found that incremental adjustment is not closing on the error.

This procedure is currently in use in daily forecasting of a few of the catchments in the Columbia river basin. It is not satisfactory for unattended fully automatic use. The forecaster typically runs the adjustment procedure to simulate the backup period for a basin, reviews the goodness of fit and amount of automatic changes made to the observed data, and either accepts the corrected ending state variables or makes manual adjustments to the observed data and reruns the adjustment procedure. The forecaster avoids, if possible, manually changing state variables; the state variables are manipulated as much as practical by changing the hydromet input.

REVISION TO CHANNEL ROUTING PROCEDURE: Problems noted with existing channel routing routines:

The volume of the routed hydrograph can be significantly different than the volume of reach inflow if relatively long compute periods are used to simulate a rapid increase or decrease in flow, such as with a dam breach hydrograph.

The equation used in SSARR channel routing is:

$$O2 = O1 + (Im-O1)*t/(Ts+t/2)$$

In the old procedures Ts was estimated from the average of all beginning of period phase outflows. When flows are changing rapidly this can result in a large estimate error of Ts for some routing phases.

Alternate channel routing technique:

In the alternate procedure, time of storage is estimated for each individual phase as a function of both beginning and end of period outflows. This requires a trial and error solution. The average of Ts over a period is computed as follows:

For an equation:

```
Ts avg. = KTS*(O2**(1-N)-(O1**(1-N))/(1-N)/(O2-O1)  ; N <> 1
        = KTS*(1/(O2**N) + 1/(O1**N))/2             ; N = 1
```

For a table:

```
Ts avg.= [(Ts1+Tsi)*(Qi-O1)/2+(Tsi+Ts2)*(O2-Qi)/2]/(O2-O1)
where: O1 is lesser of begin or end period outflows
       O2 is greater of begin or end period outflows
       Ts1 and Ts2 are table look-ups for O1 & O2 resp.
       Tsi,Qi  are table points where O1<Qi<O2
```

The trial and error process works as follows. First an estimate of O2 is made with the routing equation with Ts = f(O1). Then for each successive trial Ts average for the period is computed as a function of O1 and O2. A new O2 is computed with the routing equation and compared with the previous estimate of O2. When there is agreement within an error tolerance of 0.1% the solution is assumed to have converged. On every third trial an estimate is made from previous trials for faster convergence.

Usage of alternate routing procedure:

On SSARR input card image CR01, if column 19 is the digit 2 the new routing procedure is selected.

November 1990

Subject: Update to the SSARR program.

From: Ed Davis, CENPD-PE-WM-HEB

A major update has been made to the SSARR program. These changes have been in development during the last 9 months:

1. An improved reach routing algorithm was developed by Dan Barcellos last year and installed as option 2 (col. 19 of the CR01 card). That algorithm is now the default, as well as being option 2. The original reach routing algorithm is now option 3.

2. The "instantaneous flow change" line has been removed from PR-card printouts. If the user wishes to see this line, a character must be put in the column preceding the station name on the PR card. For example, if the user wants to see the "instantaneous flow change" values for the second station (col. 16-24) of the PR card, a non-blank character such as "S" must be put in col. 15.

3. A specified flow may contain values within a compute period, and the correct volume now will be accumulated downstream. Also, the correct volume will be passed downstream for "instantaneous flow change" at a lake/reservoir, and outflow from a reach that must subdivide a compute period because of short time-of-storage.

4. The J command in the IA mode has two new options: TUPD and TREP. TUPD causes input data provided on 4 and 6 (and Z4 and Z6) cards to update the time-series in the SSARR work file, rather than replace it. The default is to replace, and the TREP option causes replacement. Once the TUPD option is given, it stays in effect for all 4 and 6 card input until turned off by the TREP option.

5. The ADJUST command processor has been worked over to operate better for precipitation adjustments. No change is required in the ADJUST command. The program change is to shift precipitation either half a period or a whole period, before adjusting the quantity of precipitation. The assumption is that the error is more likely in timing than in amount.

Some old examples of the ADJUST command show a "number of increments" of 80. The limit in the program is 49 increments, so any specification greater than 49 is automatically changed.

The best results seem to happen with the precipitation increment set at 0.1 inches, or less. However, an increment of 0.1 inches will allow the program to change precipitation no more that 4.9 inches per day (because of the 49 increment limit).

The SSARR graphics Plot program, PLOTIODC.EXE: November 1990

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Example 8

This program draws a single grid on the screen with time as the horizontal axis (abscissa). The user may add as many plots as desired on the grid, in 7 colors on host computers with an EGA or VGA graphics adapter. For a CGA adapter, only black and white plots seem to be available. The plots are of data from the SSARR program work files, including watershed and river model results, as well as time-series stored in the SSARR work file IODC.

All labelling of the plots except for abscissa and ordinate values must be provided by the user. The text may be written in any of the available colors, but the only font that can be used is the characters generated by the hardware.

This program requires a graphics adapter. It uses Microsoft FORTRAN 5 graphics statements.

The graphics initialization statements configure the video display for the maximum resolution available with the installed graphics adapter. If the host system has CGA graphics, the program sets up for black and white. See the "V" command under "Keyboard Commands" for other options.

OPERATING the PLOTIODC program:

When PLOTIODC is executed, a temporary work space file is opened in the default directory named "SPAC.". The user has no control over this file name. After completion of the PLOT session, this file may be deleted by the user.

When PLOTIODC is executed, the program reads the plot directive file (unit 1). This file is an ASCII file and can be prepared with an editor such as EDLIN. These directives describe the contents of the display screens (called "charts"). During actual plot operations from the keyboard, the user refers to these charts by number or name.

The command to execute is "PLOT". This refers to the procedure file PLOT.BAT which contains these DOS commands:

```
PLOTIODC  PLOT.DES
MODE CO80       (the MODE command resets the screen and cursor,
                regardless of how the PLOTIODC program ends.)
```

As mentioned in the introduction, the program automatically selects the highest resolution available on the host computer video board. Some other options are available with the "V" command described under "Keyboard Commands".

For example, on an IBM PS/2 model 50 with VGA, the command "V 6" sets it to black and white mode. In this mode, the graphics display can be printed with the "print screen" key on an IBM graphics printer if the DOS command GRAPHICS was run before the PLOTIODC program was started.

Plot directive file PLOT.DES:

This file is in two parts. Part one is the chart descriptions. Part two is the time code definitions.

Part one: the Chart descriptions:

A "chart" is a screen, with one abscissa (horizontal axis). The abscissa is always time. The first line of the ordinate (vertical axis) description contains a code which defines the time length of the abscissa.

The order of the chart descriptions in file PLOT.DES is significant because the user may proceed from chart to successive chart by pressing the ENTER key.

The first line of a chart must begin with a number, which must start in column 1, and identifies the chart. The fields on the first line of a chart are as follows:

WORD

1 Chart number - must begin in column 1.

2 Chart name, which may be a maximum of 12 characters, and may contain the

character "-". The chart name may not contain any blanks. The first four characters of the chart name may be used to identify the chart, instead of the chart number.

3 minimum ordinate on the left side of the grid.

4 maximum ordinate on the left side of the grid.

5 time code, which sets the abscissa scale.

6-8, 9-11, etc. are three-word groups composed of:
name
type
color code
where:

name is a SSARR station name.

type identifies the data.

type <u>numeric</u> codes are:
23 Precipitation
25 Pan Evaporation
100 Flow or elevation data read from Z6 cards, or saved with ZSQ and ZSE commands.
101 Watershed output record (flows).

type <u>alphanumeric</u> codes:
Q or E Flow or Elevation directly from River Model work file. The current river model may be displayed with the LR command.
Cc The first character "C" identifies this as basin summary data. The next character is the plot code from the "PZ 0" command described on pages B-71 and B-72 of the SSARR User Manual. For example, the type "CB" would cause the variable RG (generated runoff in basin inches per compute period) to be plotted.

Other alphabetic types for plotting from the basin summary:

PCPN	period precip (same as type "C1" in the Cc form of the type code)
TA	Sea level temperature (same as type "C2")
S	Flow from the surface component of basin discharge ("C3")
SS	Flow from the subsurface component ("C4")
B	Flow from the baseflow component ("C5")
BF	Also flow from the baseflow component ("C5")
LZ	Flow from the lower zone component ("C6")
TQ	Basin discharge. Same as type "C7", or type 101.
QOBS	Basin observed discharge ("C8")
INT	Interception ("C9"); only available for Integrated basins.
RG	Generated runoff ("CB")
ET	Loss rate to evapotranspiration, per day ("CG")
WE	Snow water equivalent ("CH")

SWE also Snow water equivalent ("CH")
ROP Runoff percent ("CJ")
SMI Soil moisture index ("CK")
BFP Baseflow percent ("CS")
Znnc The first character "Z" identifies this as snowband Band data. The "nn" is band number and must be entered as two digits. The "c" is the plot code from the "PZ" command described on page B-73. For example, the type code "Z013" will plot WE (snow water equivalent) from band 1. Note that band data from only the last snowband basin processed is available for plotting.

color codes are:

Dim colors	Bright colors
0 none (black)	8 none
1 blue	9 blue
2 green	10 green
3 cyan	11 cyan
4 red	12 red
5 magenta	13 magenta
6 red (not yellow)	14 yellow
7 white	15 white

<u>Additional lines</u> in a chart description must either begin with a blank in column 1, or a quote character in column one.

<u>Blank in column one</u>:
WORD
1 Minimum ordinate. (must begin after column one)
2 Maximum ordinate
3 time code.
4-6,7-9,etc. are three-word groups composed of
name
type
color code

If the Minimum or maximum ordinate is different than the previous ones, a new ordinate scale will be drawn.

<u>Quote in column 1 (text strings)</u>:
WORD
1 String of characters and blanks, but not including quote character. The string is terminated by a quote.

2 Character position where string is to begin on the chart. The screen is 80 characters wide. The grid is between column 7 and column 72.

3 Line on the chart where the string is to appear. The top line on the screen is line 1. The grid is from line 6 to line 22.

4 Color code

PLOT.DES part two: Time code section:

WORD
1 Column 1 must contain "D", and column two contains the time code, any alphabetic or numeric character.
2 Start date
3 End date

Dates are in the form:
ddmmyy where dd is day of month
mm is month number
yy is two digit year.
For example, 15 January 1982 is coded "150182".

An alternate form:
dd or -ddd
where dd is a positive number less than 100. The date is gotten by adding dd days to the current computer system date. If -ddd form, then ddd days are subtracted from the current computer system date.

Keyboard commands:

When the program begins, it copies the PLOT.DES file to the work file SPAC. When finished, it writes a white "-" in the upper left corner of the screen. The program is now waiting for the user to enter a command on the keyboard:

Enter a blank line:
This command causes the next chart in the PLOT.DES file to be drawn.

Enter a number, or a series of numbers:
Entering numbers causes the program to search PLOT.DES for those numbered charts, and draw them. Normally, only one number is entered. Multiple numbers are useful in the G4 mode described below.

Enter a blank and a four-character string:
Causes the program to search PLOT.DES for a chart with the chart-name beginning with this string, and draw it.

L
Entering an L results in a list of the chart numbers and names.

LT
List the time codes.

LA nnn
List the chart commands from PLOT.DES for chart number nnn.

LB or LB nnn

List the current watershed model time control and station list that is available for plotting. nnn is the page number. The first page is the time control, and the station list begins on the second page.

LR or LR nnn
List the current river model time control and station list that is available for plotting. nnn is the page number. The first page is the time control, and the station list begins on the second page.

LS or LS nnn
List all of the time-series in file IODC. The listing contains start and end date of the data, and the minimum and maximum. nnn is the page number. Please also see the P command.

P
List the next page of the LB, LR, and LS listings.

Dc start end
The time code "c" in the "Dc" command may be redefined with a new start and end time, or a new code can be added to the list. This command is the same format as the "Dc" command in PLOT.DES.

BY or QU
Return to DOS.

I
Read plot description from the keyboard. The screen is cleared and the following prompt is displayed:
"Enter min,max,time code, sta,rec.code,color"

If a blank line is entered while in the I mode, control is returned to Keyboard Commands.

Enter BY or QU to exit the program from the I mode.

Enter a plot description command or quote string as described above under Additional lines, and the requested plot will be immediately drawn. In this mode, it is not necessary to leave column one blank; the command line should begin in column one with the minimum ordinate value.

For example, if IODC contains the METTEST or RUNMET example, the following commands will demonstrate this feature. The PLOTIODC program is running and has given the "-" prompt:

```
DT 010966 010967          Set timecode "T" for the time range of
                          the example data.
I                         Enter the direct-command mode.
0 400 T W5 101 10         Draw basin W5 flows in bright green for
           time range T, with max. ordinate of 400.
'W5 COMPUTED FLOWS' 1 3 10
```

Write this text beginning in
col. 1, on line 3, in bright green.
Press ENTER key to return to "-" prompt.

G4

Switch to a four-grids per screen format. Enter "G" to switch back to one grid per screen. Multiple grids for a screen under "G4" control are defined by having several chart-names with the same number.

X

Initialize the video format to the highest resolution available on the host computer (default).

V nn

Initialize the video format to the following specific setups:

nn:

-3 Highest resolution (default, same as "X" command. CGA sets up as code 6, EGA as code 16, and VGA as code 18)
-2 Graphics mode with most colors (CGA will set up as code 4)
-1 restore screen to original mode
4 320X200 4 color
5 320X200 4 grey
6 620X200 BW (may be only option for CGA adapter)
8 720X348 BW for Hercules Graphic Card (requires that MSHERC.COM be run before PLOTIODC.EXE)
13 320X200 16 color
14 640X200 16 color
15 640X350 BW
16 640X350 4 or 16 color (EGA)
17 640X480 BW
18 640X480 16 color (VGA)
19 320X200 256 color
64 640X400 1 of 16 colors (Olivetti)

Program source and compilation:

The PLOTIODC program was compiled with Microsoft FORTRAN-5. Several subroutines are used from the SSARR Model program library. Procedures FT.BAT and LT.BAT compile and link the program. The link directives are in PLOT.LNK.

EXAMPLE:

The SSARR distribution disks contain the program, the PLOT.BAT procedure, and the work files left after running the two SSARR examples RUNMET.BAT and RUN.BAT (on the SSARR distribution disks). The PLOT.DES file contains a set

of chart descriptions tailored to these two examples. Also included in PLOT.DES is chart 35 showing the color codes, and chart 36 demonstrating screen positioning for quoted strings.

To run the example plots, put the SSARR PLOT disk in drive A:, and enter the following commands:

```
PLOT
35              (shows color codes)
10              (plots chart 10)
LR              (lists river model time control)
P               (lists first page of river model station list)     I
 (enters direct-plot mode)
0 2000 A REACH Q 10 RREACH Q 11     (plots from river model)
BY              (exits to DOS)
```

(draft)

S. S. A. R. R. Model

for IBM-PC Microcomputer

November 1990

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CONDITIONS OF USE

The following conditions regulate the use of computer programs developed by the North Pacific Division, Corps of Engineers, Department of the Army. By accepting and/or applying any such program, the recipient agrees to be bound by these conditions:

1. The computer programs are furnished by the Government and are accepted and used by the recipient individual or group entity with the express understanding that the United States Government makes no warranties, express or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the information or data contained in the programs, or furnished in connection therewith, an that the United States shall be under no liability whatsoever to any individual or group entity by reason of any use made thereof.

2. The programs belong to the United States Government. Therefore, the recipient agrees not to assert any proprietary rights thereto nor to represent the programs to anyone as other than Government programs.

3. The recipient may impose fees on clients only for ordinary charges for applying and modifying these programs, and may not sell any program, whether modified or not, for profit.

4. Should the recipient make any modifications to the program(s), the North Pacific Division (NPD) must be informed as to the nature and extent of those modifications. Recipients who modify NPD computer programs assume all responsibility for problems arising from, or related to, those modifications. User support from NPD to third party recipients will only be provided after the second party demonstrates that program difficulties were not caused by their modifications.

5. This "Conditions of Use" statement shall be furnished to all third parties that receive copies of NPD programs from the recipient. Third party recipients must be notified that they will not receive routine program updates, correction notices, and other program services from NPD unless they obtain the program(s) directly from NPD.

6. All documents and reports conveying information obtained as a result of the use of the program(s) by the recipient, or others, will acknowledge North Pacific Division, Corps of Engineers, Department of the Army, as the source of the program(s).

1. Introduction.

The SSARR model features, input and output descriptions, and computer program characteristics are described in the SSARR User Manual. The modeler preparing to use the SSARR program should be familiar with the parts of that manual pertinent to his application before working with the Micro Computer Version of SSARR.

2. Differences between Mainframe version and Micro-computer version:

Explanation of Interactive Mode versus I/O Mode:

The "I/O mode" will process the fixed-format input card formats, and all of the free-format data and commands that begin with a "Z". These formats are listed on page B-1 and B-2. Some other commands are listed in the paper "SSARR User Manual Supplement December 1989". Also, there is the "ZBL" command, listed below under "Some additional commands...".

The "I/O mode" is entered with the RETURN subcommand of IA (in response to the * prompt). Also, the "I/O mode" is entered with the entry of an input line beginning with a "Z".

In the "I/O mode", prompting messages are controlled by the "J" subcommand of IA, described on page B-108.

The "interactive" mode is active when the program starts. When the program is in the "I/O mode", the command "IA" switches to "interactive" mode.

The "interactive" mode issues the "*" prompt. The major commands available at this prompt are listed on page B-3.

The micro-computer version does not have these features:

"Automatic processing cycle" (see below).
Access to the CROHMS data base; the CROHMS and HMLIST commands of IA.
INPUT subcommand of IA.
SPECFLO subcommand of IA.

The micro-computer version of SSARR does not have the "automatic processing cycle" capability that is built into the AMDAHL mainframe version. The sequence of processing of the AMDAHL mainframe may be controlled entirely by the order of input card types; the standard sequence is J card, C cards, P cards, T card, card codes 2 and 4 and 6 cards, and PR and PQ cards. The mainframe program processes the input until it encounters the PR and PQ cards, at which time it automatically runs the watershed and river models before producing the PR and PQ output. This facility is described on pages B-18 through B-21 of the User Manual.

Some additional features included in this version of SSARR:

The micro version has the "INFILE" command as an alternative to the "INU-" command for directing the program to take input from a file rather than the keyboard. The "INFILE" command is unique to the micro-computer version of the program. It has only one field:

INFILE filename

where: filename is the file name of the input stream.

When the end of the input-stream file is reached, the program looks for the next input line from the keyboard. (the INFILE command may be included within an INFILE stream, in which case processing resumes with the next command in the higher level INFILE stream)

NOTE: At this time, the program does not issue a prompt when it reaches the end of an INFILE input stream file and returns to read from the keyboard.

Additional features in "interactive" mode:

The command "REGULATE" has been added. It provides for interactive input and editing of flow data in the same manner as the Hydromet processor ("L" command subcommand of IA).

The "J" subcommand of IA has two new options included: "TUPD" causes a timeseries currently existing in the IODC file to be updated rather than replaced by the I/O-mode input of cards 4D, 6, Z4, and Z6. The program can be switched back to the replace mode with the option "TREP".

MODEL lists, loaded with the N and P cards in I/O mode, may be displayed with the IA subcommand "L name 2", where "name" is the MODEL list name from the N card.

FILE lists, loaded with the "ZFILE" or "FILE" commands, may be displayed with the IA subcommand "L name 5".

The HMAINT subcommand of IA does not require a password (mentioned on page B-107) to allow use of the change commands.

Additional feature in I/O mode:

The command "ZBL" causes the listing portion of program BULKMAIN.EXE to be called, to allow the SSARR user to list the directory of the BULK file without leaving the SSARR program.

2. Program Installation.

CONFIG.SYS requirements:

The SSARR program requires that a CONFIG.SYS file exist on the root directory of the booted disk. This file must contain (at least) the following line:

FILES=15

For a hard disk system, another typical entry in CONFIG.SYS is:
BUFFERS=15

Loading SSARR onto the hard disk:

The program distribution package includes two 3.5" high density (HD) disks formatted to 1.44 meg.

Copying the distribution disks to hard disk, and running the examples uses about 2.5 megabytes.

The SSARR installation is completed by copying the disks of the SSARR Distribution package to hard disk, and running the program FINITEXE. This originates and formats the SSARR work file named "IODC". On the screen will be the message:

"FINIT program: Initialize file IODC"

and a list of possible commands.

Your response may be "S=500" to make a file large enough for the two examples. This initialization program takes less than 1 minute (on an AT).

The examples may be run by these commands:

RUNMET — a .BAT file that runs a metric unit example with a year of daily data. Output goes to files M9.OUT, M8.OUT, and M6.OUT.

RUN — a .BAT file that runs a metric unit model of a 20 day period with several examples of adjustment of the watershed models to observed conditions. Output goes to files 9.OUT, 8.OUT, and 6.OUT.

All of the .OUT files include 133 character line lengths.

Work files and disk space:

The size of file IODC is fixed by the initialization program FINITEXE. The sample runs RUN.BAT and RUNMET.BAT together require less than 400 segments in file IODC (about 200k bytes). The maximum size of this file is 4000 segments

(about 2 MB). It is difficult to anticipate how big this file should be, since it depends on the number of stations in the user's models, and the amount of data. Each time the user exits the SSARR program (by typing the BY command), a message is output telling the current number of segments in use.

There are four work files (FILE19, FILE20, FILE21, and FILE22) that are originated by the SSARR program. Their sizes are dependent on the size of the models and number of time periods being processed.

File FILE19 contains one 172-byte record for each basin for each compute period processed by the BASIN command. It is not cumulative; each BASIN command starts the file over. Both the Depletion and Snowband basins use this file.

File FILE20 contains a 172-byte record for each snowband for each time period. It is used only for Snowband basins, and contains the results from only the last basin processed regardless of the number of basins in a model.

Files FILE21 and FILE22 are written by the River model, and used as input by the river model display commands, PR and PQ. The length of these files depends on the number of stations in the river model, and the number of compute periods.

The BULK file is initiated by the program BULKMAIN. BULKMAIN.EXE is a standalone maintenance program for the BULK-data file. The BULK-data file is used by the "Z1" and "ZBSTORE" subcommands of the "Z" command. If you run BULKMAIN, you will get a menu on your screen. The "INITIALIZE" command is used to initially setup a BULK file. The "INITIALIZE" command can only be given immediately after starting the BULKMAIN program.

The "C" (compress) command causes a new file named "NEWBULK" to be produced. The BULK file is named "BULK".

Usage of data stored in the BULK file is described in the SSARR User Manual on pages B-28 and B-29.

4. SSARR runs using a Job-stream file:

Long-term simulations require long time-series of hydromet data and many minutes of processing which, hopefully, may be unattended by the user. Initial conditions (IC, the model initial state variables) are set up at the beginning of the run and then automatically carried forward by the program.

Typically, the user puts the input data into a "job-stream file" so that the data need only be entered into the computer once no matter how many times it is to be read into the SSARR program.

A "Job-stream file" is a disk file containing SSARR input cards, as described in Appendix B of the SSARR User Manual. This disk file may be prepared with a line editor such as EDLIN in the DOS system, or any word-processing software that can produce an ASCII file. Two examples included in the SSARR package

are EXAMPLE.DAT and METXMPL.DAT.

SSARR input commands and/or data may be read from the computer keyboard until the program is told to read input from some other source, such as the "Job-stream" disk file. The micro-computer program can be directed to get input from a disk file with the "INFILE filename" command, described above.

5. SSARR program description:

This version of the program for IBM-PC compatible micro-computers is overlaid into one executable module, so that the operation of this program is very much like the mainframe version described in the SSARR User Manual.

Since this program is overlaid, it must be either on the current DOS PATH or reside in the default directory.

This program requires about 390K of RAM. It does not require a Math Coprocessor, but will run 50% to 100% faster if one is installed.

Fortran source:

The source files are named with the .FOR suffix. Several of the files (SRTNS.FOR for example) contain several subroutines.

The .CM files are INCLUDEd by the source statements.

The link-edit directive files (.LNK) compose the following programs:

SSARR.EXE	SSARR Model program
BULKMAIN.EXE	BULK file management program (page B-28)
FINITEXE.EXE	File IODC origination program
PLOTIODC.EXE	Graphics display program (PLOT.LNK), described in a separate paper.

Procedure FT.BAT compiles .FOR files, and LT.BAT links the .LNK files with Microsoft FORTRAN version 5.

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November 1990
revised April 1994

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CONDITIONS OF USE

The following conditions regulate the use of computer programs developed by the North Pacific Division, Corps of Engineers, Department of the Army. By accepting and/or applying any such program, the recipient agrees to be bound by these conditions:

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2. The programs belong to the United States Government. Therefore, the recipient agrees not to assert any proprietary rights thereto nor to represent the programs to anyone as other than Government programs.

3. The recipient may impose fees on clients only for ordinary charges for applying and modifying these programs, and may not sell any program, whether modified or not, for profit.

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6. All documents and reports conveying information obtained as a result of the use of the program(s) by the recipient, or others, will acknowledge North Pacific Division, Corps of Engineers, Department of the Army, as the source of the program(s).

I. INTRODUCTION

The SSARR model features, input and output descriptions, and computer program characteristics are described in the SSARR User Manual. The modeler preparing to use the SSARR program should be familiar with the parts of that manual pertinent to his application before working with the Microcomputer Version of SSARR.

II. DIFFERENCES BETWEEN THE MAINFRAME VERSION AND MICROCOMPUTER VERSION:

A. Interactive mode versus I/O mode

1. Interactive mode - overview and new features

a. The interactive mode is active when the program starts. When the program is in the I/O mode, the command IA switches to interactive mode.

b. The interactive mode issues the * prompt. The major commands available at this prompt are listed on page B-3 of the manual.

c. The command REGULATE has been added. It provides for interactive input and editing of flow data in the same manner as the Hydromet processor (L subcommand of IA).

d. The J command of IA has two new options: TUPD causes a timeseries currently existing in the IODC file to be updated rather than replaced by the I/O mode input of cards 4D, 6, %4, and %6. TREP switches the program back to the replace mode.

e. MODEL lists, which are loaded with the N and P cards in I/O mode, may be displayed with the IA subcommand L name 2, where name is the MODEL list name from the N card.

f. FILE lists, which are loaded with the %FILE or FILE commands, may be displayed with the IA subcommand L name 5.

g. The HMAINT subcommand of IA does not require a password (page B-107 of the manual) to allow use of the change commands.

2. I/O mode - overview and new features

a. The I/O mode will process the fixed-format input cards and all of the free-format data and commands that begin with %. These formats are listed on page B-1 and B-2 of the manual. Some other commands are listed in the

paper "SSARR User Manual Supplement - December 1989".

b. The I/O mode is entered with the **RETURN** or **IO** subcommands of **IA**, in response to the * prompt. I/O mode is also entered with an input line beginning with **%**.

c. In the I/O mode, prompting messages are controlled by the **J** subcommand of **IA** (page B-108).

d. **%BL** causes the listing portion of program **BULKMAIN.EXE** to be called, allowing the SSARR user to list the directory of the BULK file without leaving the SSARR program.

B. Features removed from the PC version.

1. Automatic processing cycle: The microcomputer version of SSARR does not have the "automatic processing cycle" capability that is built into the mainframe version. The processing sequence on the mainframe may be entirely controlled by the order of input card types, as described on pages B-18 through B-21 of the User Manual. In the microcomputer version, the watershed and river models are processed by the **BASIN** and **RIVER** subcommands of **IA**.

2. Access to the CROHMS database.

3. The **CROHMS** command of **IA**.

4. The **HMLIST** command of **IA**.

5. The **INPUT** command of **IA**.

6. The **SPECFLO** command of **IA**.

C. Features added to the PC version.

1. **INFILE** command as an alternative to the **INU=** command for directing the program to take input from a file rather than the keyboard. The **INFILE** command is unique to the microcomputer version of the program. It has only one field: **INFILE filename** where filename is the input file. When the end of the input file is reached, the program looks for the next input line from the keyboard. The **INFILE** command may be included within an **INFILE** stream, in which case processing resumes with the next command in the higher level **INFILE** stream. The program does not issue a prompt when it reaches the end of an **INFILE** input file and returns to read from the keyboard.

III. PROGRAM INSTALLATION AND OPERATION

A. System requirements

Installing the program and running the examples requires about 2.5 MB of disk space. Make sure you have that amount available before beginning installation.
The program is distributed on two 3.5" high density (HD) disks formatted to 1.44MB. You should be able to use these disks or have a method available for making a usable copy.
A **CONFIG.SYS** file must exist on the root directory of the booted disk. This file must contain the line: **FILES=15**
The number of files may be larger than 15.
Hard drive systems should also have: **BUFFERS=15**
The number of buffers may be larger than 15.

B. Installing the program

Create a subdirectory for the program by typing **md C:\SSARR**
Put disk 1 in drive b: and type **copy b:*.* c:\ssarr**
Put disk 2 in drive b: and type **copy b:*.* c:\ssarr**
(You may substitute a: for b: if you are using your a: drive).
You must initialize the SSARR workfile before running the program. Run the initialize program by typing **FINITEXE**. The message "FINIT program: Initialize file IODC" will appear, followed by a list of possible commands. Respond by typing **s=500**. This will create and format the SSARR workfile IODC. The file will be large enough for the two examples. This initialize program should run in less than 1 minute.

C. Work Files and Disk Space

The size of file IODC is fixed by the initialization program **FINITEXE**. The sample runs **RUN.BAT** and **RUNMET.BAT** together require less than 400 segments in file IODC (about 200kb). The maximum size of this file is 4000 segments (about 2MB). It is difficult to anticipate how big this file should be, as it it dependent on the number of stations in the user's models and the amount of data. Each time the user exits the SSARR program (by typing **BY**),a message is output telling the current number of segments in use.

There are four work files (FILE19, FILE20, FILE21, and FILE22) that are created by the SSARR program. Their sizes are dependent on the size of the models and number of time periods being processed.
FILE19 contains one 172-byte record for each basin for each compute period processed by the **BASIN** command. It is not cumulative; each **BASIN** command starts the file over. Both the Depletion and Snowband basins use this file.

FILE20 contains a 172-byte record for each snowband for each time period. It is used only for Snowband basins, and contains the results from only the last basin processed, regardless of the number of basins in a model.
FILE 21 and FILE22 are written by the River model and used as input by the river model display commands **PR** and **PQ**. The length of these files depends on the number of stations in the river model and the number of compute periods.

The BULK file is initiated by the program **BULKMAIN**. **BULKMAIN.EXE** is a stand-alone maintenance program for the BULK data file. The BULK data file is used by the **Z1** and **ZBSTORE** commands. If you run **BULKMAIN**, you will get a menu on your screen. The **INITIALIZE** command is used to set up a BULK file. The **INITIALIZE** command can only be given immediately after starting the **BULKMAIN** program.
The C (compress) command causes a new file named NEWBULK to be produced. The BULK file is named BULK. Usage of the data stored in the BULK file is described on pages B-28 and B-29 of the manual, and page 17 of the Supplement.

D. SSARR runs using an input file

Long term simulations require long time series of hydromet data and many minutes of processing which may be unattended by the user. Initial conditions (IC, the model initial state variables) are set up at the beginning of the run and then automatically carried forward by the program.
Typically the user puts the input data into an input file so that the data need only be entered into the computer once no matter how many times it is to be read into the SSARR program. An input file is a disk file containing SSARR input cards, as described in Appendix B of the manual. This disk file may be prepared with any editor or word processing software that can produce an ASCII file. Two examples are included in the SSARR package. SSARR input commands and/or data may be read from the keyboard until the program is told to read input from some other source, such as an input file. The microcomputer can be directed to get input from a disk file with the **INFILE filename** command (described above).

E. Examples

1. **RUNMET.BAT** is a metric unit example with a year of daily data. Output goes to files M9.OUT, M8.OUT and M6.OUT. To execute this example, type **RUNMET**. All output files have 133 character lines.

2. **RUN.BAT** is a metric unit model of a 20 day period with several examples of adjustment of the watershed model to observed conditions. Output goes to 9.OUT, 8.OUT and

6.OUT. This example can be run by typing RUN. All output files have 133 character lines.

F. SSARR program description

This version of the program for the IBM-PC compatible microcomputer is overlaid into one executable module so that operation is much like the mainframe version described in the SSARR User Manual. Since this program is overlaid, it's directory location must be in the current DOS PATH or the program must be located in the default directory.
The program requires about 390K of RAM. It does not require a math coprocessor, but will run 50-100% faster if one is installed.
The FORTRAN source files are named with the .FOR suffix. Some of the files contain several subroutines. The .CM files are INCLUDEd by the source files.
The link files (.LNK) create the following programs:

SSARR.EXE	SSARR Model program
BULKMAIN.EXE	BULK file management program
FINITEXE.EXE	File IODC initialization program
PLOTIODC.EXE	Graphics display program (PLOT.LNK) is described in a separate paper.

Procedure FT.BAT compiles the .FOR files.
Procedure LT.BAT links the .LNK files.
These commands are compatible with Microsoft FORTRAN v.5 .