

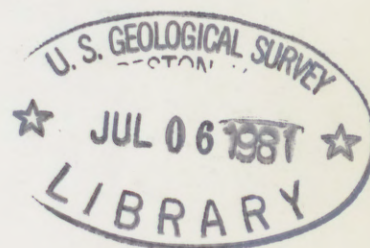
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Computer Program Documentation USER'S MANUAL

General Purpose Dam-Break Flood Simulation Model (K-634)



U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 80-116

WATER RESOURCES DIVISION

Gulf Coast Hydroscience Center



NSTL Station, Mississippi

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USER'S GUIDE FOR A GENERAL PURPOSE DAM-BREAK FLOOD SIMULATION
MODEL (K-634)

By Larry F. Land

U.S. GEOLOGICAL SURVEY

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UNITED STATES DEPARTMENT OF THE INTERIOR

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FACTORS FOR CONVERTING U.S. INCH-POUND UNITS TO SI UNITS

<u>Multiply U.S. inch-pound units</u>	<u>By</u>	<u>To obtain SI units</u>
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)

USER'S GUIDE FOR A GENERAL PURPOSE DAM-BREAK FLOOD
SIMULATION MODEL (K-634)

By Larry F. Land

ABSTRACT

An existing computer program for simulating dam-break floods for forecast purposes has been modified with an emphasis on general purpose applications. The modified version is documented in this report. The original program was formulated, developed, and documented by the National Weather Service. The model is based on the complete flow equations, that is, continuity and momentum, and uses a nonlinear implicit finite-difference method for solving the equations. The reservoir routing is separate and may be a hydrologic technique or the hydraulic technique used for streamflow routing. The dam fails gradually after the reservoir's water level rises to a specific elevation. A complete discharge hydrograph is computed at the dam before it is routed through the stream which may be nonprismatic and have segments with subcritical or supercritical flow. The results are discharge and stage hydrographs at the dam as well as all of the computational nodes in the channel. From these hydrographs, peak discharge and stage profiles are tabulated. The data requirements include (1) in the reservoir; surface area-elevation tables or channel geometry and roughness, (2) at the dam; breach shape, duration of breach development, structure stage-outflow ratings, and water-surface elevation when failure begins to occur, and (3) in the stream; channel geometry, roughness and state of flow (subcritical or supercritical).

INTRODUCTION

The U.S. Geological Survey has a responsibility to collect data and conduct investigations concerning floods. This includes developing and maintaining the expertise, as well as, the capability to make field investigations as needed. Most of the Survey's flood work in the past was related to natural causes; however, disasters in the last few years have brought attention to those floods resulting from dam failures. In contrast to the natural floods where the analysis is mostly statistical, the analysis for dam-break floods is made with deterministic digital models. To meet the new need in an effective manner, the Survey has conducted an investigation to select a general purpose dam-break flood model. The investigative procedure included (1) selecting four existing models for evaluation, (2) selecting three field data sets for model testing, (3) simulating the three reservoir-stream systems with the four models, (4) comparing

the computed results with the observed results, (5) comparing individual model features with desirable dam-break model features, and (6) selecting a model that would best meet the needs of the Survey. Reports describing the investigation were written by Land (1980a, 1980b).

The selected dam-break flood model was formulated, developed, and documented by Fread (1977) of the National Weather Service as a dam-break flood-forecast model. Minor modifications were made to the forecast model to meet the objectives of a general purpose model. This included eliminating the multiple dam-failure option, altering the computation of the time step, reorganizing data-entry and printout formats, preventing the model from switching from one state of flow to the other (supercritical to subcritical or the reverse) in a given subreach, and allowing for tributary inflow. The model formulation is based on the two open-channel (complete) flow equations, that is, continuity and momentum for shallow and unsteady conditions. The numerical analysis technique is known as a nonlinear implicit finite-difference method. The model first computes a discharge hydrograph at the dam and then routes it through the stream system. The breach is assumed to develop at a constant rate for a finite time span, generally greater than 5 minutes, and to take the shape of a triangle, rectangle, or trapezoid. The stream is subdivided into segments, as needed, to separate reaches of subcritical and supercritical flow. The model computes complete stage and discharge hydrographs at all nodes, tabulates the flood crests, and plots the specified discharge hydrographs.

The purpose of this report is to document, in a user's guide format, this general purpose dam-break model (K-634). The discussion is limited on the mathematical representation of the reservoir-stream system, the equations defining the hydrodynamics, and the numerical analysis techniques. The discussion is much more detailed on the mechanics of applying the model to a field case.

MODEL DESIGN

General Discussion

The model is designed to simulate a dam-break flood in one computer run; however, the simulation is done in two distinct parts. One part is computing the reservoir's outflow hydrograph, and the other part is routing this hydrograph through the stream system below the dam.

The model begins its first major task by routing an incoming flood through the reservoir. The routing is mathematically done with a hydrologic (storage-continuity) method or with the hydraulic (hydrodynamics) method that is used for the streamflow routing.

The initial characterization of the hydrologic event and the reservoir system has the water level below the elevation where the breach is to begin forming. During this time the water level is rising due to the incoming flood and the limited outflow of the dam's structures. When the water level at the dam reaches the preselected elevation, a breach in the dam begins to develop. The breach's base begins at the water level and has a zero width. For a specified time the breach develops by widening and deepening at a constant time rate. Its side slopes remain equal and constant. After the breach fully develops, it remains constant for the remainder of the simulation. The total flow past the dam is now the sum of the flow through the dam's structures and the breach. The discharge through the breach is computed by triangular- and rectangular-shaped weir equations which represent a trapezoid. The computation of the outflow hydrograph continues in small time steps until the simulation period is complete.

The second and last major task is routing the outflow hydrograph through the stream. The routing is mathematically accomplished with the Saint Venant flow equations and a nonlinear implicit finite-difference algorithm. If the stream has segments where the state of flow is different, then the flood wave is completely routed through one segment before being routed through the next.

For purposes of this report, cross sections refer to the ones that were obtained by field surveys, computational cross sections are the ones that were used as primary input into the model and may or may not have been field surveyed, and computational nodes, or simply nodes, refer to the locations where discharge and water-surface elevations are computed inside the model. The term reach refers to the stream, beginning at the dam and ending at the end of the study area, while segment refers to a length of stream used as one computational reach, that is, a length of stream where the state of flow (subcritical or supercritical) is constant. Subreach refers to the stream located between two computational sections.

Routing Techniques

Hydraulic Routing

Hydraulic routing is based on the complete one-dimensional equations of unsteady, shallow open-channel flow, the Saint Venant equations. The complete equations are the conservation of mass (continuity) and the conservation of momentum (motion). Fread uses the form of the equations, in which the dependent variables are discharge (Q) and water-surface elevation (h). The continuity equation is

$$\frac{\partial Q}{\partial x} + \frac{\partial (A + A_Q)}{\partial t} + q = 0 \quad (1)$$

where A and A_0 are the active (conveyance) and inactive (storage) cross-sectional areas, respectively; t is time; x is distance along the channel; and q is lateral inflow per unit length along the channel. The motion equation is

$$\frac{\partial Q}{\partial t} + \frac{\partial(Q^2/A)}{\partial x} + qA \left(\frac{\partial h}{\partial x} + S_f + S_{ce} \right) = 0 \quad (2)$$

where S_f is the friction slope and S_{ce} is the expansion-contraction slope.

The selected numerical analysis technique for solving equations 1 and 2 is a "weighted four-point" implicit scheme (Amein and Fang, 1970; and Ponce and others, 1978). It has distinct advantages for uneven time and space intervals and exhibits good stability-convergence properties. In this scheme, the continuous x - t region is represented by a rectangular net of discrete points at which Q and h values are sought.

Applying a finite-difference form of equations 1 and 2 to N nodes along the new time line defining a segment, $2N-2$ equations and $2N$ unknowns can be formulated. Using boundary conditions at the upstream and downstream ends for subcritical flow or two upstream boundary conditions for supercritical flow, two additional equations are available, thereby making the system of equations determinate. A coefficient matrix of the two dependent variables is written for the resulting system of $2N$ equations. The matrix has a banded structure which allows the system of equations to be solved by a quaddiagonal Gaussian elimination algorithm and the Newton-Raphson (iteration) method. Fread (1971, 1974, and 1977) gives a detailed explanation of this hydraulic routing and numerical analysis scheme.

Hydrologic Routing

The hydrologic routing technique is based on the law of conservation of mass. The equation is

$$I - O = dS/dt \quad (3)$$

where I is the inflow during the differential time (dt); O is the outflow for the same dt ; and dS is the change in reservoir storage. The inflow is known while the outflow is a function of the reservoir's water level. To solve for the outflow and the water level at the new time step the Newton-Raphson method is again used. The time intervals are rather small to minimize the mathematical errors.

FLOOD-WAVE ROUTING

Reservoir

A reservoir outflow hydrograph may be obtained by either the hydrologic or hydraulic routing technique. For the hydrologic technique a stage-surface area table defines the necessary reservoir geometry, while the hydraulic method requires computational cross sections. The upstream boundary must be a known inflow hydrograph. The downstream boundary is a stage-discharge relation consisting of several components. They include flow through the breach, over the dam, over an uncontrolled spillway, through gates, and through turbines. The rating is automatically computed from data provided for each component.

The instantaneous flow through the breach is approximated by broad-crested-weir equations for triangular and rectangular shapes. Together they can represent a trapezoidal shape. The equation for instantaneous flow through a breach (Q_b) is

$$Q_b = C_1 (H - h_b)^{1.5} + C_2 (H - h_b)^{2.5} \quad (4)$$

where C_1 and C_2 are the coefficients for the rectangular and triangular portions of the weir equations, respectively; H is the elevation of the water surface inside the reservoir; and h_b is the elevation of the breach's base. The coefficients C_1 and C_2 are defined by

$$C_1 = 3.08 C_v C_s b \quad (5)$$

and

$$C_2 = 2.44 C_v C_s z \quad (6)$$

where b is the width of the breach's base; z is the side slope (horizontal/vertical); C_v is a velocity of approach correction coefficient (Brater, 1959); and C_s is a submergence correction coefficient (Vennard, 1954). Usually C_v and C_s are 1.0, particularly during the time of maximum outflow. The breach develops gradually during a time period (τ) and progressively takes the shape as shown in figure 1. The outflow from the breach is zero until the reservoir's water level reaches a specified elevation.

The instantaneous outflow from the reservoir by means other than the breach is computed by

$$Q_s = C_s (H - h_s)^{1.5} + C_d (H - h_o)^{1.5} + C_g (H - h_g)^{0.5} + Q_t \quad (7)$$

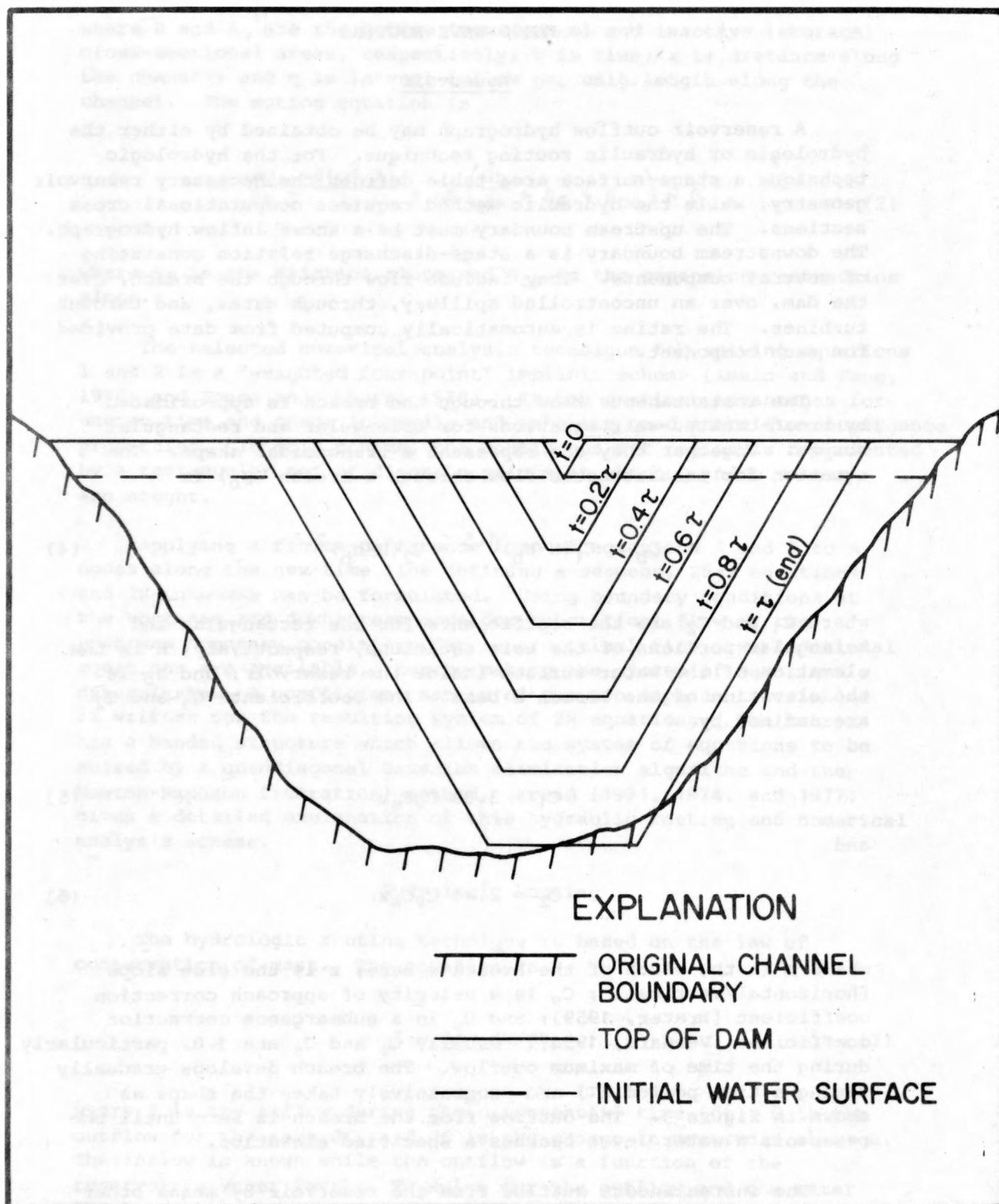


Figure 1.--Breach's shape as it gradually develops.

where Q_s is the total discharge through the dam's structures; and C_s , C_d , and C_g are the complete discharge coefficients for the spillway, dam, and gates, respectively; h_s , h_o , and h_g are the elevation of the spillway crest, dam crest, and center of the gates, respectively; and Q_t is the discharge through the turbines. The total reservoir outflow at an instant in time is the sum of Q_b and Q_s . The flow through the dam structures continues as long as the water surface is higher than the structure's elevation, except for the turbine discharge. The latter remains constant until the breach is completely formed, then it stops.

Using either the hydrologic or hydraulic routing methods discussed earlier, the inflow hydrograph is routed through the reservoir. At the beginning of a simulation run, the dam is assumed to be intact; therefore, no water is flowing through a breach. As the simulation continues, the water surface rises and finally reaches an elevation where the breach begins to occur. The simulation continues with the breach gradually developing for τ hours and terminates when the specified simulation period is completed.

Streamflow

Routing the reservoir's outflow hydrograph through the river is accomplished with the hydraulic routing method. If the flow in the river remains subcritical or supercritical, the entire reach is simulated in one pass. However, if the reach has different states of flow, then the reach must be subdivided into segments having a constant state of flow. Simulations are completed for one segment before stepping to the next downstream segment. Each segment is treated as a reach, that is, it has a complete set of boundary conditions just as a total reach would.

Boundary Conditions

Upstream.--The upstream boundary during the streamflow simulation is always the outflow hydrograph that is automatically computed for the reservoir or for the adjacent upstream segment. A straight line interpolation scheme is used to compute the discharge at any instant of time.

Tributaries.--The model allows inflow into a stream segment from two tributaries. The entry point is specified by a subreach number. The hydrograph ordinates for the tributary inflow are in hourly intervals, beginning at $t=0$. An exception occurs when the model is used for utility streamflow simulation. This option is discussed later.

Downstream.--The downstream boundary condition is a dynamic stage-discharge relation that is computed from the nonuniform, unsteady flow equation. It is expressed in terms of the Manning

equation in which the friction slope is evaluated by a backward difference approximation of the motion equation (eq. 2). The approach reproduces the hysteresis effect, loop rating, found in unsteady stage-discharge relations.

Channel characteristics.--The geometry of a channel is defined by a series of cross sections along the channel while the geometry of a cross section is described by corresponding pairs of elevations and top widths. To accurately represent the conveyance and storage areas of a cross section, the top width consists of an active and inactive flow portion. The channel friction (Manning n) may vary with depth and from subreach to subreach. Also included in defining channel characteristics is the S_{ce} parameter in equation 2. It defines the loss of momentum due to expansions and contractions. The expression defining this parameter is

$$S_{ce} = \frac{k}{2g} \frac{\Delta V^2}{\Delta x} \quad (8)$$

where k is the expansion-contraction coefficient which varies from -0.5 to -1.0 for expansions and 0.1 to 0.3 for contractions, and ΔV^2 is the difference between the square of the velocities at adjacent nodes which are separated by a node spacing of Δx . A k coefficient is assigned to each subreach and remains constant during the simulation.

Occasionally, the model will have convergence problems that are related to irregular channel geometry. To help the model with these problems, a routine for "smoothing" the geometry is available. Two types of smoothing are available, that is, vertical or horizontal. For vertical smoothing, a value is smoothed with a corresponding value above and below it in the given cross section. For horizontal smoothing, a value is smoothed with corresponding values in adjacent cross sections. A smoothed value reflects 25 percent of each of the adjacent array values and 50 percent of its original value. A depth and distance weight is not used. As specified by the user the array describing the top width of the active and inactive flow element can be smoothed vertically and horizontally while the array containing the elevation data can only be smoothed horizontally. Care should be taken not to have major discontinuities in the elevation and top width arrays of the computational cross sections when this option is used. The upstream and downstream elevations are not changed. The smoothing operation is performed before additional computational nodes are inserted.

Lateral inflow.--The q term in equation 1 allows a lateral flow to enter or leave the stream. This may occur when flood water infiltrates dry overbanks or an alluvial aquifer or is held in detention storage. The equation describing the lateral inflow is

$$q = \left[\frac{\frac{Q_i^j + Q_{i+1}^j}{2} - \frac{Q_i^1 + Q_{i+1}^1}{2}}{\max \frac{Q_i}{2} + \max \frac{Q_{i+1}}{2}} - \frac{1}{Q_i^1 + Q_{i+1}^1} \right] q_{\max} \quad (9)$$

where q is the lateral inflow in $(\text{ft}^3/\text{s})/\text{ft}$ for stream between nodes i and $i+1$ and at time j ; $q_{\max}$ is the maximum lateral flow (-) leaving and (+) entering the stream for the segment; Q_i^j is the discharge at node i and time j ; and $Q_i^{\max}$ is an estimate at node i and is based on an expected exponential attenuation of the peak discharge through the reach. Equation 9 proportions the lateral inflow with time and space according to the current discharge in relation to the initial discharge and the expected maximum discharge. In other words, no lateral outflow occurs at base flow while the maximum outflow coincides with the peak discharge.

Initial.--Establishing Q and h values at each of the computational nodes at $t=0$ is required to begin the simulation. Using initial discharges at the upstream and downstream ends of a stream segment with the initial tributary discharges, the computational node discharge is computed by a linear interpolation on the basis of the number of nodes, not distance. The h values may be computed by either normal depths or by running a step-backwater computation using the gradually varied equation of steady flow which is equation 2 without the $\partial Q/\partial t$ term. The latter option is required when the reservoir is simulated with the hydraulic method. The former option will not function where the streambed has a subreach with a negative, zero, or very mild slope.

SITE CHARACTERIZATION

Model Layout

Representing a reservoir-stream system with a hydraulic model requires a grid schematization. The system is differentiated into discrete units. There are large discrete units for the reservoir and stream segments and small discrete units for subreaches. Engineering judgment is needed to determine a sufficient amount of subreaches for detail yet not so small as to make the computations and data requirements unrealistic.

An example of how a site is laid out for use with computer program K-634 is given in figure 2. The example site shows a reservoir-stream system consisting of a reservoir, dam, two segments, and two tributaries. The basic data available are inflow into the reservoir, tributary inflow into the stream, reservoir area-capacity curves, structure ratings, topographic maps, and four cross sections. It has been determined that the stream between river mile 0.0 and 3.0

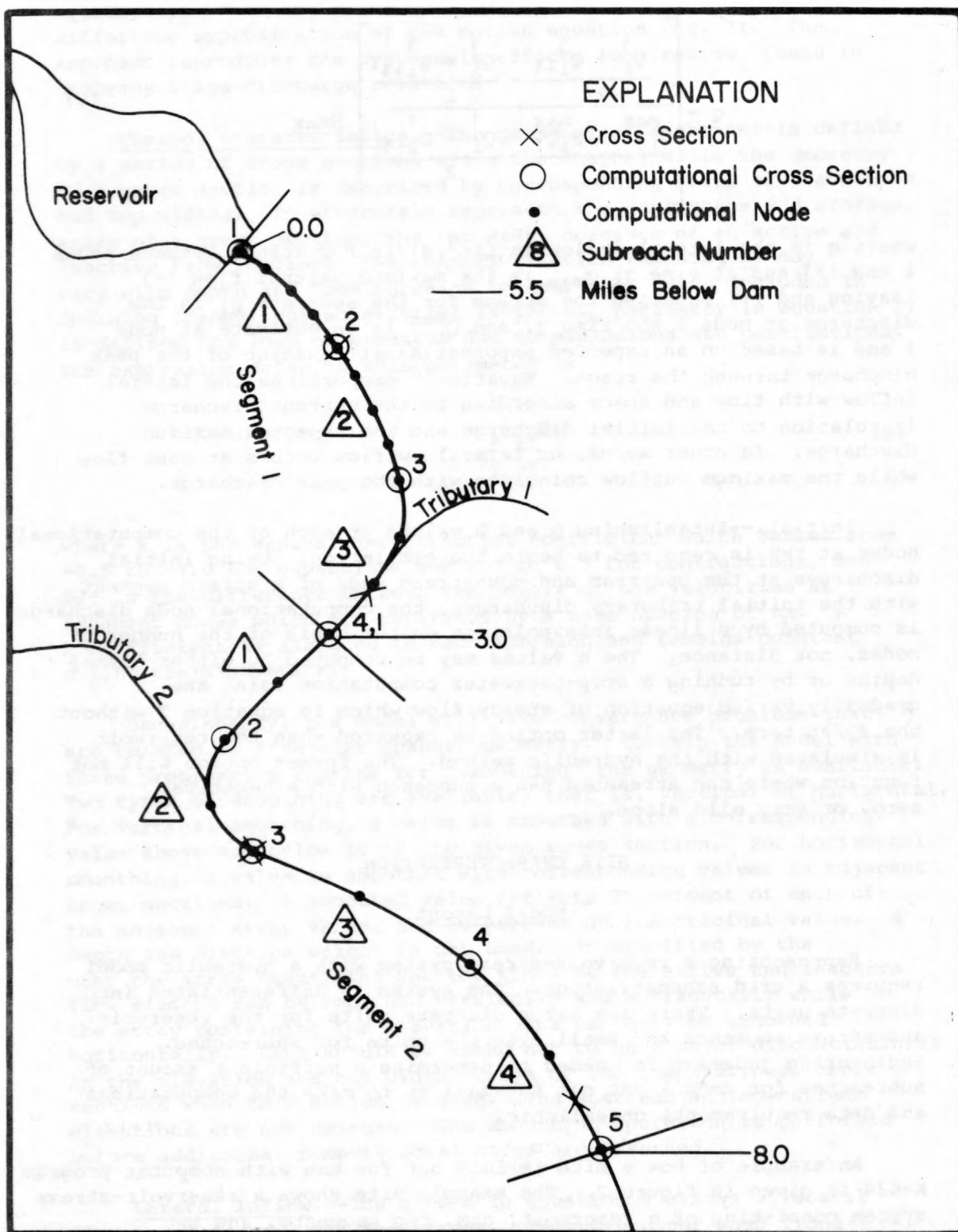


Figure 2.--Model layout for an example reservoir-stream system.

is hydraulically steep (supercritical flow) and the stream between 3.0 and 8.0 is hydraulically mild (subcritical flow). Therefore, two segments are required. Computational cross sections at the beginning and end of a segment are required. Therefore, a minimum of four computational cross sections would be needed for this example. The second and third ones would share the same data. However, additional computational cross sections are needed, for illustration purposes, to accurately describe the stream. These computational cross sections are prepared from the surveyed cross sections and topographic maps. This layout shows that four computational cross sections are used for the upper segment and five for the lower segment. It should be noted that the simulated reach should be extended past the study reach in order to eliminate any irregularities of the self-setting downstream boundary. The final step in the layout is to estimate the concentration of computational nodes. The model uses the computational cross sections as nodes but allows nodes to be inserted, equally spaced, between the computational cross sections. The geometry of the nodes is interpolated from the adjacent computational cross sections. Note that the density of computational nodes increases toward the dam, where the flood peak is more pronounced.

Selection of Δx and Δt

As a general guide the computational node spacing (Δx) usually ranges from a few hundred feet to over a mile. Usually, shorter spacings improve accuracy and are needed when the duration of the failure is short.

The time step (Δt) is computed automatically; therefore, it is not directly controlled. For hydrologic routing in the reservoir, Δt is selected on the following basis: (1) before the breach begins to occur, Δt is 0.1 hour; (2) during the duration of the breach development, τ hours, and for three additional τ time periods, Δt is 0.02τ hours; (3) thereafter, Δt is increased by 10 percent each time step but not exceeding 0.25 hours. For hydraulic routing, Δt is generally defined by: (1) initial Δt is 0.25 hour which is the maximum; (2) normal Δt during breach development and shortly thereafter is 0.05τ ; (3) Δt is increased by 1 percent between 3τ and 10τ hours after breach began, and by 2 percent thereafter, but not exceeding 0.25 hours, or Δt is increased by the position of the flood wave in the segment, that is, increase Δt by 1 percent when the flood peak is in the lower half of the segment and by 2 percent when it has passed through the segment. If the iteration closure is not obtained in any time step, that step's computation is repeated with Δt cut in half. It is obvious that τ is very important in the automatic selection of Δt .

Experience with mathematical models has proven that if numerical instability is a problem, adjustments to either Δx or Δt will often permit stability to be obtained. In the use of this model the Δx values are the ones that are adjusted, or possibly the τ value if it is not critical to the simulation.

SENSITIVITY TO SELECTED PARAMETERS

As an aid to the user when selecting or changing certain parameter values and model operations, a limited number of sensitivity tests were performed. The parameters selected for analysis include (1) concentration of computational nodes, (2) computational cross-section smoothing operations, (3) expansion-contraction coefficients, (4) variation of Manning n to maintain a state of flow, (5) designation of active and inactive flow areas, and (6) the duration of dam failure. For illustration and test purposes, the data set is hypothetical but includes many characteristics that a field case may have. The channel geometry and characteristics for this example are illustrated in figure 3. The upper sketch is a profile of the reach. It shows two segments: the first one is hydraulically steep and the second one is mild. The first and second segments have four and five computational cross sections, respectively. The middle sketch shows the cross-sectional geometry for the upper segment. The lower sketch shows the channel geometry for the stream reach between river mile 4.0 and 8.0. The subreach between computational cross sections 1 and 2 of segment 2 has a gradual transition between the two shapes. The layout in this data set closely corresponds to the example given in figure 2, except for the location of the computational nodes. The data deck used to make the base model run is given in Attachment D. The results of the sensitivity tests are presented in table 1. These results can be used only to show the relative influence of selected parameter and option changes. The percent of change would vary from case to case.

STREAMFLOW SIMULATION WITHOUT A DAM BREAK

The program, K-634, is designed so that it can also be used as a utility streamflow simulation model. Selecting this option bypasses the dam-break computations and goes directly into the hydraulic routing routine. This option allows the inflow hydrographs, that is, the upstream and the tributaries, to be in other than hourly intervals and causes the time step to be constant, as specified by the user. The upstream boundary is always a discharge hydrograph and the downstream boundary is always a self-setting stage-discharge relationship. A reach can be divided into as many segments as needed.

COMPUTER PROGRAM

K-634 is designed as a stand-alone program, that is, it does not require any special computer files or utility programs. All of the input data enter via cards and all of the results return via a line printer.

The general model operational sequence is schematized with a flow chart in Attachment A. A source code listing is given in Attachment B. The data input and conversion, the executive part of the finite-difference algorithm and the printing of most results are performed by MAIN. There are 10 subroutines to perform special and generally repetitive computational tasks. Their titles and functions are also given in Attachment B. A

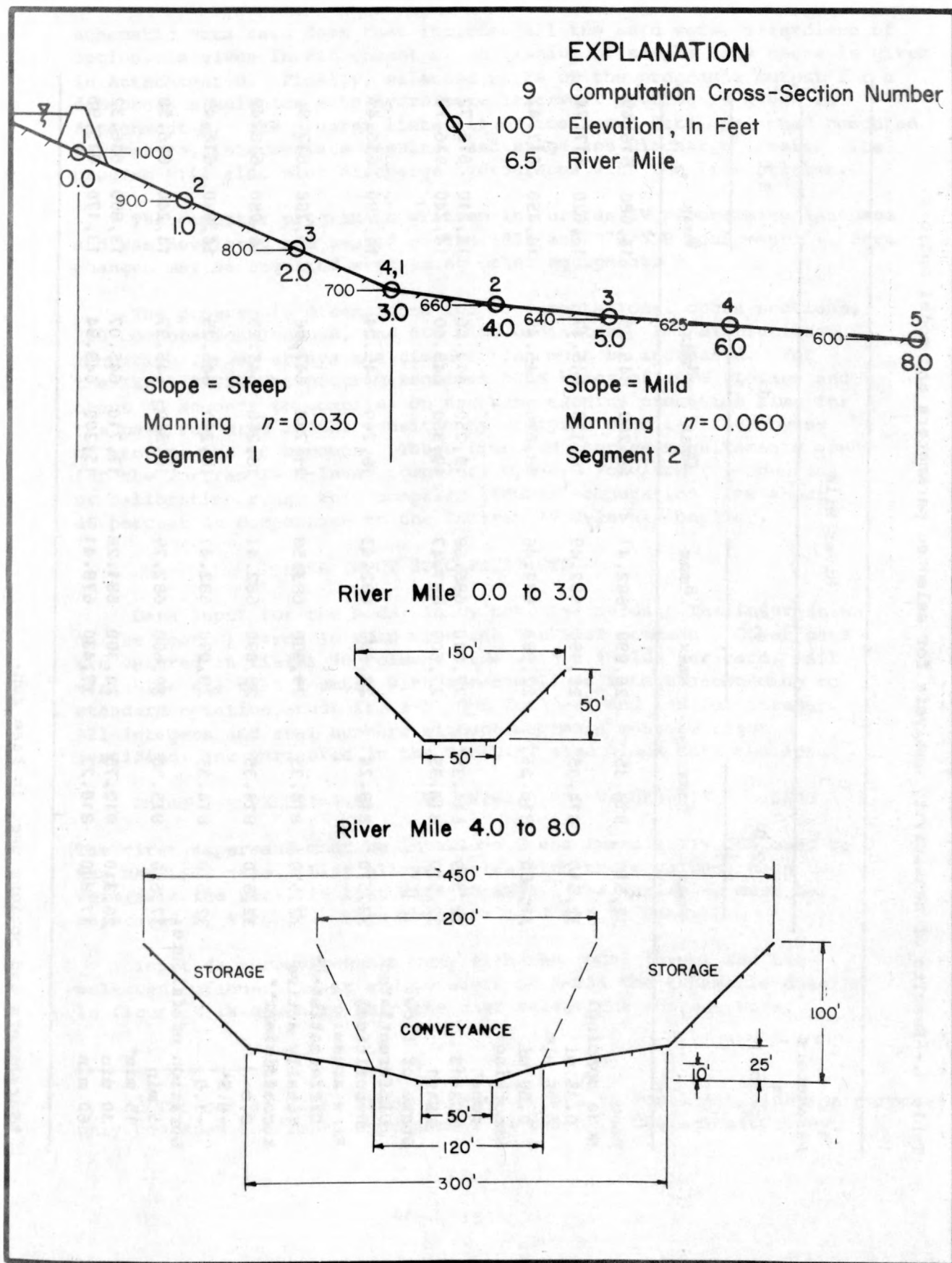


Figure 3.--Channel profile and the cross-sectional geometry of the example data set.

Table 1.--Results of sensitivity analysis for selected parameters and model options.

Parameters or Option	River Mile							
	2.0		4.0		6.0		8.0	
	Q _{max}	H _{max}	Q _{max}	H _{max}	Q _{max}	H _{max}	Q _{max}	
Base	32,510	814.35	28,090	682.41	18,260	645.25	14,080	616.49
Node spacing:								
0.05 mi	32,510	814.35	28,190	682.49	18,130	645.17	13,620	617.74
0.25 mi*								
0.50 mi	31,860	814.35	27,980	682.46	18,620	645.45	14,450	617.42
Smoothing:								
None*								
KSA=15	32,510	814.35	27,840	686.68	19,250	643.56	14,210	616.72
KSA=1	32,510	814.35	27,600	687.47	19,350	643.60	14,240	616.74
State of flow:								
Differentiated*								
Subcritical	32,510	819.24	28,280	682.43	18,240	645.24	14,090	616.49
Flow areas:								
Differentiated*								
Totally active	32,510	814.35	29,900	683.58	21,740	647.06	16,700	617.95
k coefficient**								
0.0	32,510	814.35	28,090	682.41	18,260	645.25	14,080	616.49
-0.5*								
-1.0	32,510	814.35	28,090	682.41	18,260	645.25	14,080	616.49
Duration of failure:								
5 min	37,650	815.56	29,600	682.79	18,540	645.37	14,240	616.58
15 min*								
30 min	26,310	812.75	24,300	681.28	17,710	645.07	13,800	616.32
60 min	17,840	810.23	17,430	678.41	15,200	643.94	13,170	615.95

*Parameters and options used in base run.

**k coefficient is applied only to subreach 1 of segment 2. It affected the stages in subreach 1 of segment 2 less than +0.10 ft.

schematic data card deck that includes all the card sets, regardless of option, is given in Attachment C. A listing of sample data decks is given in Attachment D. Finally, selected parts of the program's output for a dam-break simulation with hydrologic reservoir routing is given in Attachment E. The program lists all of the input data, selected computed parameters, intermediate results, and stage and discharge crests. The program will also plot discharge hydrographs with the line printer.

The computer program is written in Fortran IV programming language and was developed and tested on IBM 3033 and 370/158 equipment^{1/}. Some changes may be required when using other equipment.

The program is dimensioned for 90 computational cross sections, 200 computational nodes, and 600 time ordinates. For simulations requiring larger arrays the dimensioning must be increased. For the IBM 370/158 the program requires 500K bytes of core storage and about 40 seconds to compile. On the same machine execution time for the base run used in the sensitivity analysis required 250K bytes of storage and 60 seconds. These time and storage requirements are for the Fortran IV H-level compiler, Opt=2. For larger production or calibration runs, this compiler reduces computation time about 40 percent in comparison to the Fortran IV G-level compiler.

DATA INPUT SPECIFICATIONS

Data input for the model is by computer cards. The information on the control cards is read with the NAMELIST command. Other data are entered in fields 10 columns wide with 8 fields per card. All variables are real (number with a decimal) or integer according to standard notation, that is, A-H, O-Z for real and I-N for integer. All integers and real numbers without decimals must be right justified. The variables in the NAMELIST name block have the form

```
&name      VALUE1=1.0,    VALUE2=2.0,    VALUE3=3.0    &END
```

The first ampersand must be in column 2 and immediately followed by the NAMELIST name. List all variables with their values, then terminate the variable list with an &END. The variables must be separated by a comma. More than one card can be used.

Input data requirements vary with the model layout and the selected options. As an aid to users of K-634 the schematic diagram in figure 4 is given to help the user select the correct sets.

^{1/}The use of brand names in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

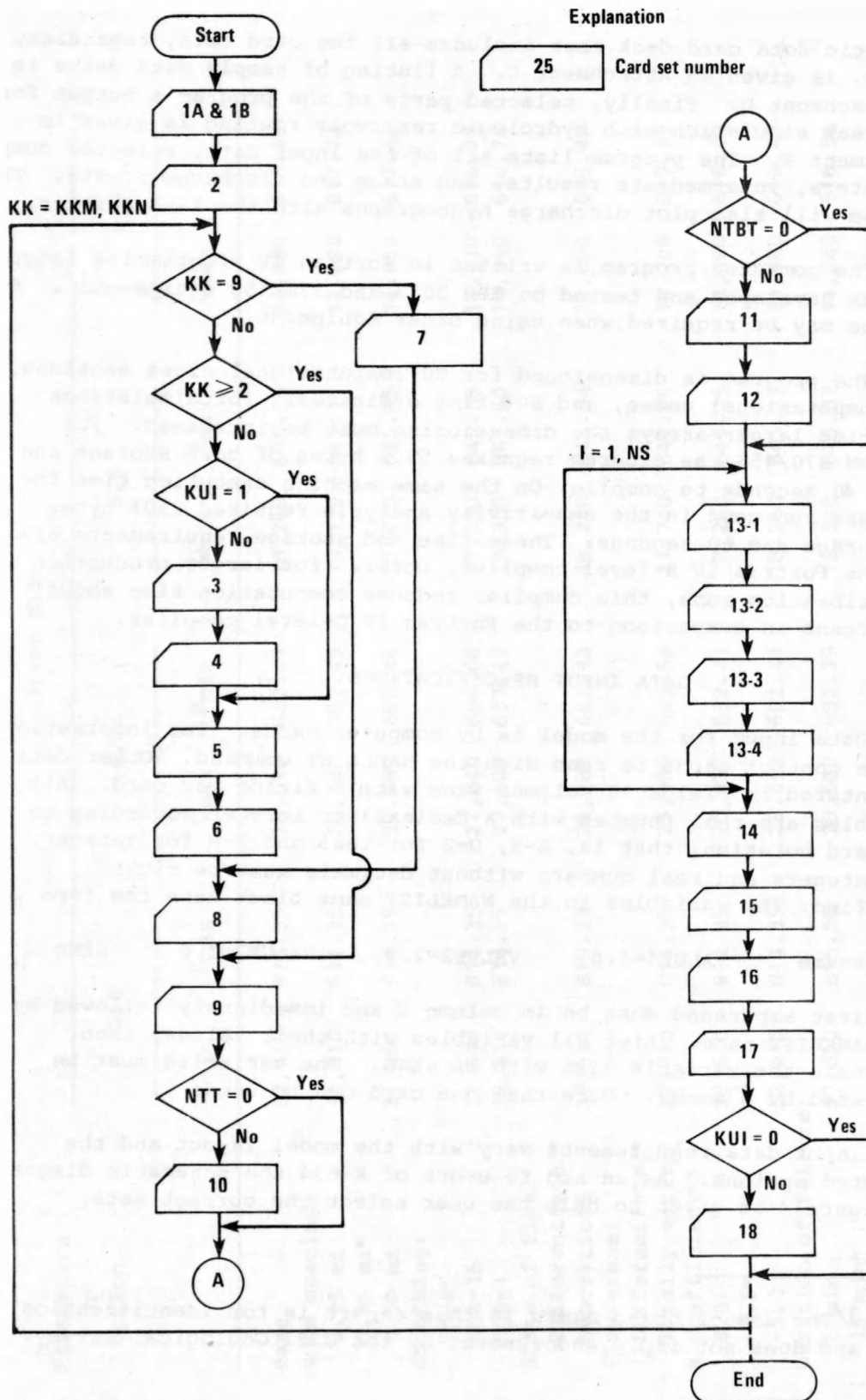


Figure 4.--Flow diagram showing which card sets are required for various model options.

A description of the data input, sequence and arrangement follows.
Discharge is in ft^3/s , length is in feet, and time in hours, except as noted.

<u>Card Set No.</u>	<u>Variable</u>	<u>Description</u>
1A	MRSVR	Name of reservoir, center in columns 1-20.
	MRVR	Name of river, center in columns 21-40.
	MNAME	Modeler's name and agency, center in columns 41-80.
1B	MESSAGE	Comment, columns 1-80.
2	CARD2	Primary option controls.
	KKN	Number of reservoir and river segments with hydraulic simulations. For a run without a dam-break simulation add 8, making $KKN \geq 9$. This is the code to select the streamflow simulation option without the dam-break feature.
	KUI	Is the reservoir routing by the hydraulic method? For streamflow simulation only, use $KUI = 0$. 0 = no 1 = yes
3	SA(K)	Table of surface areas, in acres, for reservoir. Code up to 8 values in descending order. Omit when $KKN \geq 9$ or $KUI = 1$.
4	HSA(K)	Table of elevation values corresponding to the SA array in card set 3.
5	CARD5	Reservoir parameters. Omit when $KKN \geq 9$.
	YO	Initial water-surface elevation in reservoir. This value should be slightly less than HF.
	Z	Side slope of breach in dam (horizontal/vertical).
	TEH	Duration of simulation, in hours.
	YBMIN	Elevation of breach's crest at end of failure.
	BB	Width of breach's crest at end of failure.

<u>Card Set No.</u>	<u>Variable</u>	<u>Description</u>
	TFH	Duration of breach development, in hours.
	DATUM	Reference elevation to the datum used for vertical control. Suggest using mean sea level (0.0).
6	CARD6	Structure parameters. Omit when $KKN \geq 9$.
	HF	Elevation of water surface when breach begins to occur.
	QT	Discharge through turbines. Can be used to establish base flow in river.
	HD	Elevation of dam's crest.
	CD	Coefficient of 'flow over dam' equation: $Q_{dam} = CD(H-HD)^{1.5}$
	HSP	Elevation of uncontrolled spillway's crest.
	CS	Coefficient of 'flow over spillway' equation: $Q_{spillway} = CS(H-HSP)^{1.5}$
	HGT	Elevation of center of gate openings.
	CG	Coefficient of 'flow through gate' equation: $Q_{gate} = CG(H-HGT)^{0.5}$
7	CARD7	Streamflow routing parameters. Omit <u>except</u> when $KKN \geq 9$.
	TEH	Duration of simulation, in hours.
	DHF	Time interval between all input hydrograph ordinates, in hours.
	DT9	Time interval of computations, in hours.
8	QI(J)	Upstream discharge hydrograph. The inflow must be great enough to cause the initial water level YO to rise above the elevation of failure HF. First value is at $t=0$.

<u>Card Set No.</u>	<u>Variable</u>	<u>Description</u>
		Intervals are hourly for dam-break simulations and DHF for other simulations. Code only as many as needed to span the simulation, maximum = 600.
9	CARD9	Cross-sectional parameters.
	NS	Number of computational cross sections defining this segment. Include the uppermost computational cross section even if it repeats the lowermost computational cross section of the upper segment. Minimum = 2, maximum = 90.
	NTT	Number of discharge hydrograph line-printer plots, maximum of 6.
	JNK	Code to select the quantity of printout. 1 = very limited; input data, crests and plots, 2 = as 1 plus limited results at each time line, 3 = as 2 plus results of data manipulations and more results at each time line, 9 = most extensive.
	KSA	Code for cross-section smoothing. A smoothed value in an array is equal to 50 percent of its original value and 25 percent of each of the two adjacent original values. See text for more information. -1 = smooth BS and BSS arrays vertically, 0 = none, 1 = smooth BS and BSS arrays vertically and horizontally plus the HS array horizontally, 14 = smooth BS array horizontally, 15 = smooth HS array horizontally.
	KSUPC	Is the flow supercritical for this segment? 0 = no 1 = yes
	NTBT	Number of tributaries entering this segment, maximum of 2.
10	NT(L)	Computational cross sections where discharge hydrographs are to be plotted, maximum of 6. Omit if NTT = 0.
11	NTB(L)	Subreach number where tributaries enter stream, maximum of 2. Omit if NTBT = 0.

<u>Card Set No.</u>	<u>Variable</u>	<u>Description</u>
12	QTB(L,J)	Tributary discharge hydrograph(s). Complete the coding of one tributary before starting second on a new card. See card set 8 for more details. Omit when NTBT = 0.
13		Cross-sectional geometry. The number of sets equals NS. There are 4 cards per set. Code in downstream direction.
-1	XS(I)	Stream distance from some upstream reference point, generally the dam, in miles to computational cross section I.
-2	HS(K,I)	Elevation array at cross section I where top widths are defined. Code in ascending order. The number of values and their vertical spacing intervals should be nearly constant or have smooth transitions from one computational cross section to the next. This is desirable when automatically inserting computational nodes and smoothing the elevation and top width arrays.
-3	BS(K,I)	Top width of the active flow (conveyance) portion of channel cross section corresponding to elevation HS(K,I).
-4	BSS(K,I)	Top width of the off-channel (dead storage) portion of channel cross section corresponding to elevation HS(K,I).
14	CM(K,I)	Manning n corresponding to the elevations HS(K,I) and HS(K,I+1) for each subreach. The value represents the effective roughness up to the corresponding elevation. Maximum of 8 values per subreach. One subreach per card. Number of cards equals NS-1.
15	DSM(I)	Distance in miles, between computational nodes for subreach (I). The value is rounded to give a constant Δx between the computational cross sections. The total number of nodes must be less than 200. One value is required for each subreach. Code 8 values per card and use as many cards as necessary.

<u>Card Set No.</u>	<u>Variable</u>	<u>Description</u>
16	FKC(I)	Contraction-expansion coefficient. Contraction values vary from 0.1 to 0.3, expansion values from -0.5 to -1.0. If considered to be negligible use 0.0. A value is required for each subreach. Code 8 values per card. And use as many cards as necessary.
17	CARD17	Downstream flow parameters.
	QMAXD	Estimated discharge at downstream end of segment. If 0.0 is coded, the value is estimated automatically. Used to estimate lateral outflow.
	QOD	Initial discharge at end of segment. Used with the sum of the flow through the dam's structures or the initial outflow from the upstream segment to establish initial discharges along the segment. Not used when KUI = 1.
	QLL	Maximum lateral inflow in $\text{ft}^3/\text{s}/\text{ft}$ of segment length. When water is lost from the stream system into the ground, QLL is negative (-) because the water leaves the stream.
	DTHM	Code to select the method of computing the time step. 0.0 selects Δt on the basis of TFH. 1.0 $\pm$ selects Δt on the basis of TFH and the location of the flood wave in the stream segment.
	YDN	Initial elevation of water surface at downstream end of segment and selects a backwater routine to compute initial conditions. 0.0 selects a routine that computes the normal depth at each computational node for the initial conditions.
18	CARD18	Downstream submergence parameters. Omit <u>except</u> for a dynamic reservoir segment (KUI = 1).
	UPSH	Critical depth at upstream computational cross section of reservoir.

<u>Card Set No.</u>	<u>Variable</u>	<u>Description</u>
	SOM	Slope of channel below dam, feet per mile.
	CMN	Estimated effective Manning <u>n</u> value for channel below dam.

NOTE: If the simulation has more than one segment with hydraulic routing, repeat card sets 9 through 17 for each segment.

HINTS FOR CORRECTING MODEL RUN FAILURES

Although K-634 is designed to accept major channel irregularities, abrupt changes in flow, and a wide variation of problems, it will fail to perform for a variety of reasons and circumstances. Hints for diagnosing and remedying common failures are given below. First, run the model with JNK = 9 to obtain the most detailed printout.

<u>Failure</u>	<u>Diagnosis and Remedy</u>
All	Check for errors in the coding of field data and miscellaneous information. To aid the model user, the program usually prints the information of each card set before moving to the next card set. With this program design errors can often be found by reviewing the printout. Also, the results of each time line are printed before moving to the next time line. It is usually helpful to get a computer listing of the data cards when checking for data errors.
To start	The most common reasons for the model's failure to start are errors in the initial conditions and different states of flow in the segment. To correct these problems, try (1) using the expansion-contraction coefficients, (2) smoothing the elevation top-width arrays with the KSA parameter, (3) smoothing the thalweg elevations and abrupt geometry changes outside the model, (4) selecting a different computational node spacing, usually smaller, (5) increasing the base flow, (6) changing the Manning <u>n</u> value, (7) changing the TFH value, if possible, and (8) using the alternate routine for computing the initial conditions. At least the first 3 lines in the results section are for t=0. The first

Failure

Diagnosis and Remedy

	one is for the initial conditions. The others are the results of hydrodynamic simulations which are trying to remove any inconsistencies from the initial conditions, before the actual simulation begins.
Nonconvergence	The most common cause of the problem is the model computing different states of flow, either with time or space, in a segment. This problem can be identified with $JNK = 3$ or 9 . Items 1-7 in the <u>To Start</u> section are applicable for this problem. Also, try the alternate method of computing the time step size.
Irregularities along the surge front	Often in front of a sharp surge, the discharge and water level will have a considerable dip. A small amount is normal; however, a major dip can usually be reduced by decreasing the computational node spacing.

As a suggestion to reduce the computer costs in getting the model operational, try routing the dam-break flood through each segment before assembling all of the segments for a complete simulation run. This eliminates unnecessary computations in trying to get a run for one of the lower segments.

SUGGESTIONS FOR EMERGENCY SIMULATIONS

One of the first liberties that a user takes in making an emergency simulation is the use of a sketchy data set. The design of K-634 allows the modeler to exercise this prerogative by limiting the refinement of the reservoir and channel geometry data. If need be, the reservoir's geometry can be represented by two pairs of elevation and surface area values; a river segment can be represented by two computational cross sections. The geometry of a computational cross section can be defined with two sets of elevation and active and inactive top width values. If more than one segment is needed, the computational cross section that is common to the two segments can be reused.

Quick preparation of a data set can be greatly facilitated with topographic maps. The modeler can use the maps as an aid in laying out the model and to determine the values of the parameters that define the geometry. A suggested procedure of laying out the model and preparing channel geometric data include at least the following steps: plot the streambed profile using information from the maps; attempt to identify the segments where supercritical and subcritical flow occur; select as few cross sections as possible for coding but include the ones where the elevation of the flood crest is of importance; adjust the bottom elevation of the

computational cross sections so that the streambed profile is reasonably smooth; and if the slope gradually changes between two segments, adjust the bottom elevations of the computational cross sections so that the slope trends of the two segments are maintained. Other suggestions include omitting such refinements as tributaries, lateral inflow, contraction-expansion coefficients, and dam outflow structures, except the turbines (QT) which should be used to establish the base flow in the stream.

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At various points in the history of the United States, the Federal Government has been called upon to assist in the control of floods. The Federal Government has been successful in many instances, but in many others it has been unable to do so. The Federal Government has been successful in many instances, but in many others it has been unable to do so.

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ATTACHMENTS

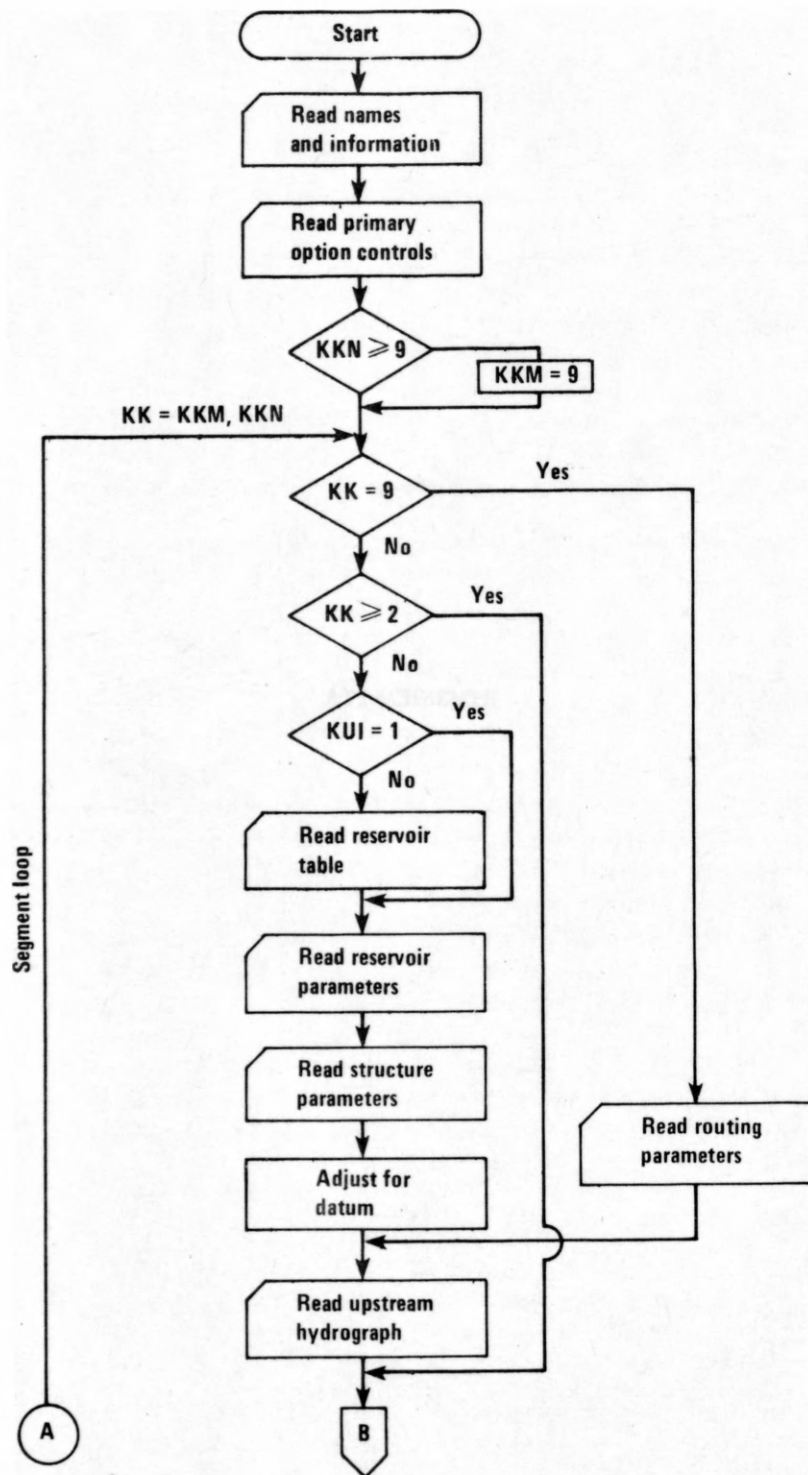
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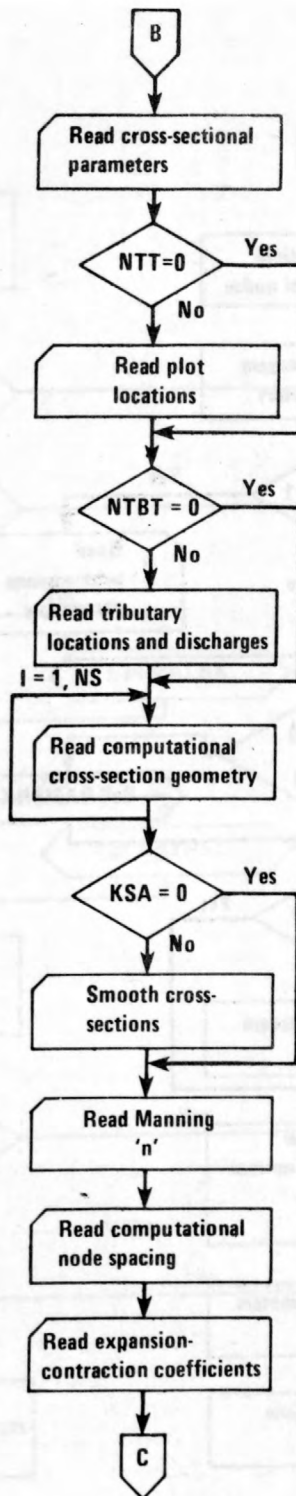
1950, Evaluation of selected four-point flood-wave routing by using field data, U.S. Geological Survey Water Resources Investigations 50-44, 45 p.

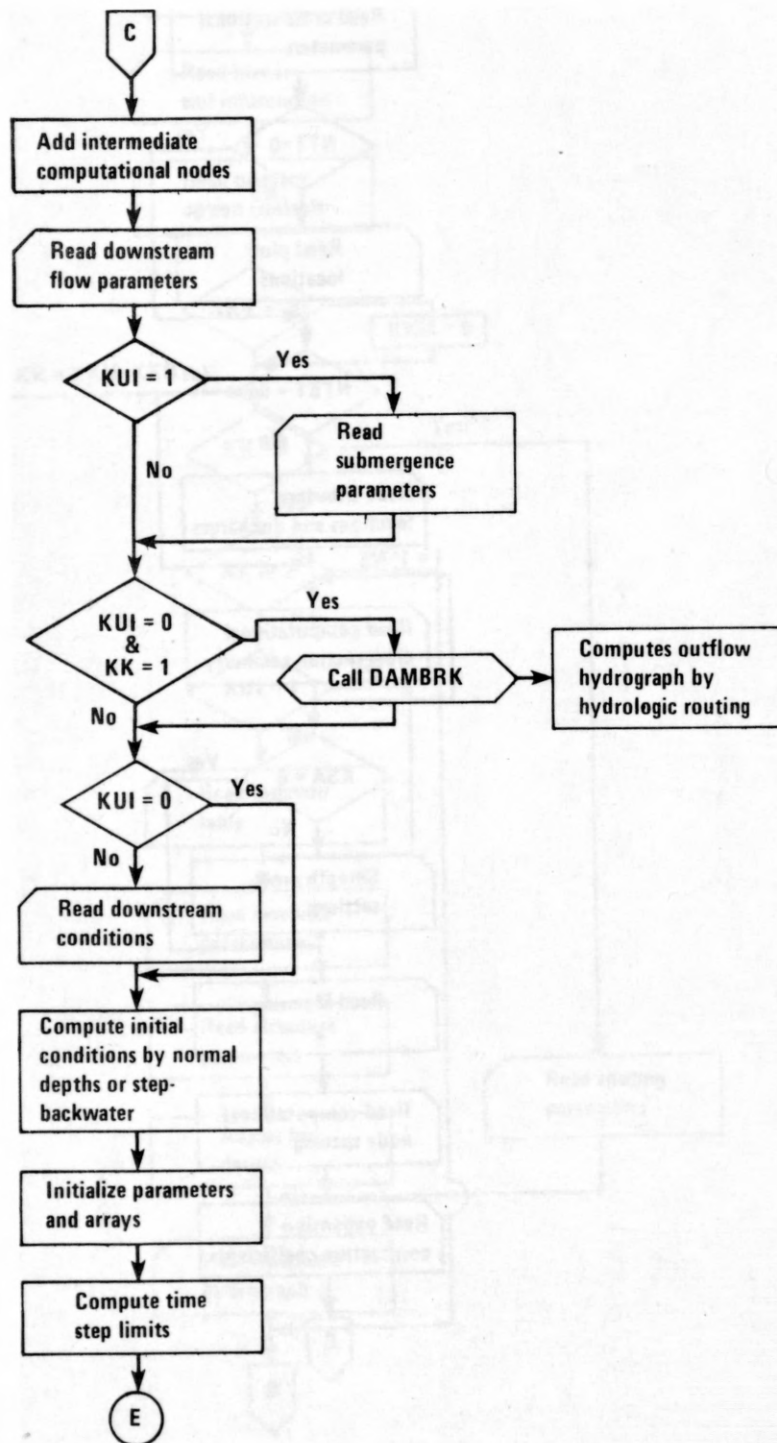
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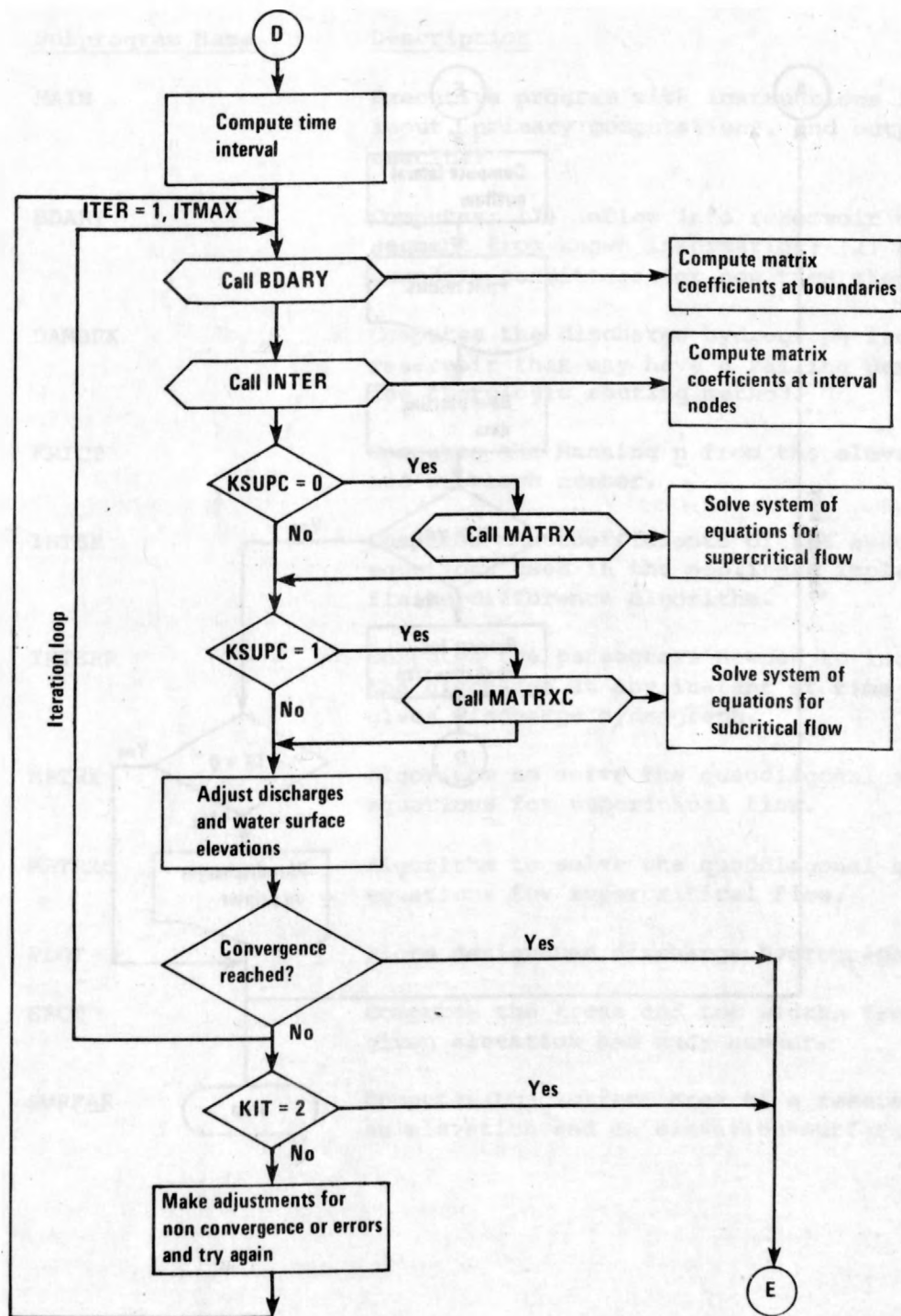
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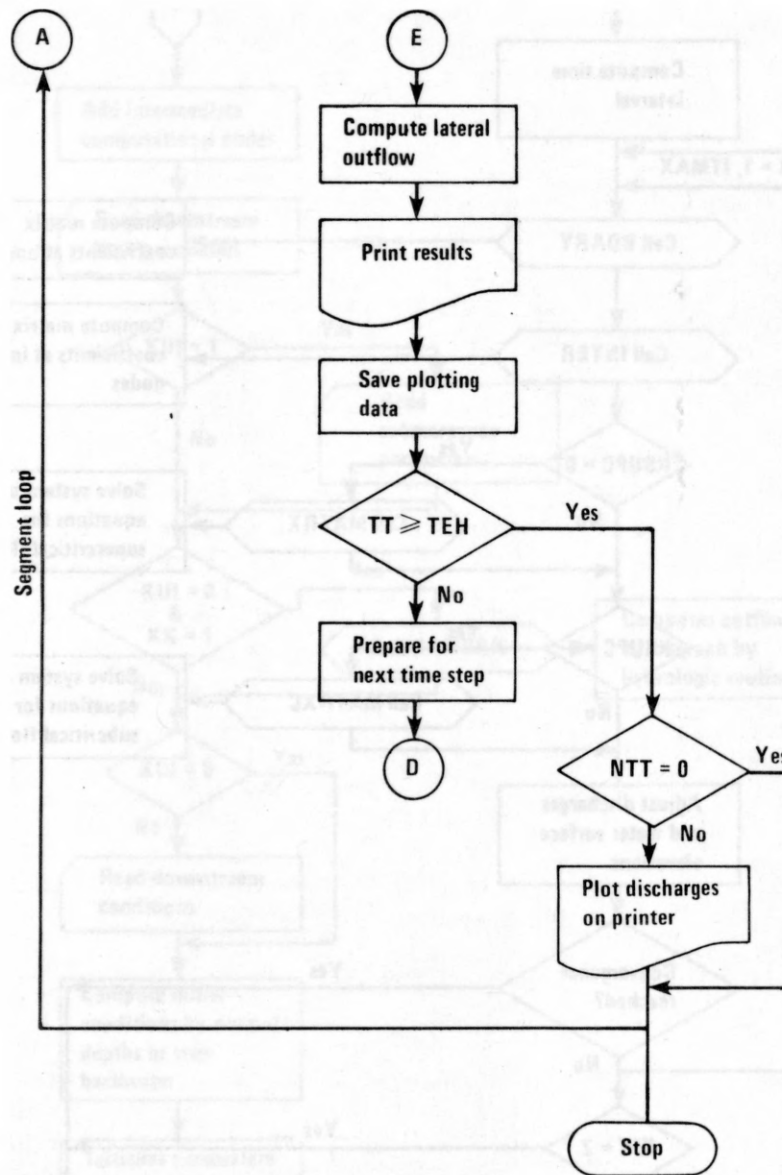
A. GENERALIZED FLOW CHART











B. COMPUTER PROGRAM

<u>Subprogram Name</u>	<u>Description</u>
MAIN	Executive program with instructions for data input, primary computations, and output of results.
BDARY	Computes: (1) inflow into reservoir or stream segment from known information; (2) other boundary conditions for new time step.
DAMBRK	Computes the discharge hydrograph from a reservoir that may have a failing dam by the hydrologic routing method.
FRICT	Computes the Manning n from the elevation and subreach number.
INTER	Computes the coefficients of the system of equations used in the nonlinear implicit finite-difference algorithm.
INTERP	Computes the parameters needed to interpolate the discharge at any instant of time from a given discharge hydrograph.
MATRX	Algorithm to solve the quaddiagonal system of equations for subcritical flow.
MATRXC	Algorithm to solve the quaddiagonal system of equations for supercritical flow.
PLOT	Plots designated discharge hydrographs.
SECT	Computes the areas and top widths from a given elevation and node number.
SURFAR	Computes the surface area of a reservoir from an elevation and an elevation-surface area table.

```

*****
*
* K634 -- SIMULATION OF A DAM BREAK FLOOD USING A
*          NONLINEAR, IMPLICIT FINITE-DIFFERENCE MODEL.
*          BASIC MODEL WAS DEVELOPED BY:
*          DANNY L. FLEAD
*          HYDROGRAPHIC RESEARCH LABORATORY
*          NOAA - NWS
*          SILVER SPRING, MARYLAND
*
*          MODIFICATIONS HAVE BEEN MADE BY:
*          LARRY F. LAND
*          GULF COAST HYDROSCIENCE CENTER
*          USGS - WRD
*          VSTL STATION, MISSISSIPPI
*
*          DATE OF LAST REVISION: FEB 12, 1981
*****

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```

COMMON/SJPC/ KSJPC
COMMON/SIM/ Q(500),TI(600),QI(600),YO,SOM,CMY,YBMIV,BB,Z,TFH,TEH
1  ,NU,JNK,QU,QMAX,QMI(200),QDI(200),QLL,UPSH,KUI
2  ,HF,HJ,HSP,HGT,CS,CG,CD,QT,TP,KK,KTMX
COMMON/SURF/ SA(8),HSA(8)
COMMON/M1/ QU(200),QJ(200),YJ(200),YD(200),JDX(200),FKC(200),G,DT
1  ,TT,ITER,KIT,VSESV
COMMON/SS/ HS(8,200),BS(8,200),BSS(8,200),AS(8,200),ASS(8,200),NCS
COMMON/FRIC/CM(8,200)
COMMON/MTX/ D(500,4),XX(500),C(600),V,KJ,NIT
1  ,NL,KKN,DTHI,DTHII,DTC,DTH,TFD
COMMON /GRAF/ QC(600,6),YC(500,6),TTP(500)
COMMON /NAMES/ MNAME(10),MRSVR(5),MRVR(5)
COMMON /NEGA/ YNEG,NEGI
COMMON /TRIB/ QTB(2,600),TJ(500),VTB(2),QTB1,QTB2,VTBT

```

```

DIMENSION XS(90),X(200),VT(5),VN(90)
1  ,BST(8,90),BSST(8,90),HST(8,90)
2  ,YI(200),DXM(90),CAT(8,200),FFKC(90)
3  ,YM(200),QMX(200),TM(200),YMQ(200),QS(600)
DIMENSION MESSAGE(20)
DIMENSION QCM(500,5)

```

```

DATA LJS, KKM, ITDIM /5,1,500/

```

OPTIONS AVAILABLE TO DAMBREAK PROGRAM

```

*****

```

RESERVOIR ROUTING:

A FLOOD HYDROGRAPH AT THE DAM CAN BE COMPUTED BY EITHER STORAGE-CONTINUITY (KJI=0) OR DYNAMIC (KUI=1) COMPUTATIONAL METHODS.

CHANNEL ROUTING:

THE CHANNEL BELOW THE RESERVOIR CAN BE DIVIDED INTO EIGHT (8) OR LESS SEGMENTS. ANY SEGMENT MAY HAVE SUBCRITICAL (KSUPC=0) OR SUPERCRITICAL (KSUPC=1) FLOW, BUT

NOT BOTH. IF THE RESERVOIR ROUTING IS BY THE DYNAMIC METHOD, IT COUNTS AS ONE OF THE SEGMENTS. A STREAMFLOW SIMULATION CAN BE MADE WITHOUT THE RESERVOIR.

DEFINITION OF INPUT PARAMETERS

***** CARD SET 1A *****

MRSVR NAME OF RESERVOIR

MRVR NAME OF RIVER

MNAME MODELER'S NAME AND AGENCY

***** CARD SET 1B *****

MESSAGE COMMENT

***** CARD SET 2 *****

KKN TOTAL NUMBER OF RESERVOIR AND RIVER SEGMENTS WITH DYNAMIC SIMULATION. FOR A RUN WITHOUT A DAM-BREAK SIMULATION ADD EIGHT (8), MAKING KKN .GE. 9.

KU1 DYNAMIC RESERVOIR ROUTING METHOD WANTED? NO(0), YES(1).

***** CARD SET 3 *****

SA(K) SURFACE AREA, IN ACRES, OF RESERVOIR.
CODE IN DECREASING ORDER.

***** CARD SET 4 *****

HSA(K) CORRESPONDING ELEVATION VALUES OF SA.

***** CARD SET 5 *****

Y0 INITIAL ELEVATION OF WATER SURFACE IN RESERVOIR.

Z SIDE SLOPE OF BREACH IN DAM (H/V).

TEH DURATION OF DYNAMIC SIMULATION, IN HOURS.

YBMIN ELEVATION OF BREACH CREST AT END OF FAILURE.

B3 WIDTH OF BREACH BASE AT END OF FAILURE.

TFH DURATION OF DAM FAILURE, IN HOURS.

DATUM ELEVATION OF REFERENCE MARK, MAY BE SEA LEVEL (0.0).

***** CARD SET 6 *****

HF ELEVATION OF WATER WHEN BREACH BEGINS TO OCCUR.

QT DISCHARGE THROUGH TURBINES.

HJ ELEVATION OF DAM'S CREST.

CJ COEFFICIENT OF 'FLOW OVER DAM' EQUATION.

HSP ELEVATION OF UNCONTROLLED SPILLWAY CREST.

CS COEFFICIENT OF 'FLOW OVER SPILLWAY' EQUATION.

HGT ELEVATION OF CENTER OF GATE OPENINGS.

CG COEFFICIENT OF 'FLOW THROUGH GATE' EQUATION.

***** CARD SET 7 *****

TEH SEE ABOVE

DFH TIME INTERVAL BETWEEN HYDROGRAPH ORDINATES.

DT9 TIME STEP, IN HOURS

***** CARD SET 8 *****

QI(J) UPSTREAM DISCHARGE HYDROGRAPH. HOURLY INTERVALS
EXCEPT WHEN KKN .GE. NINE (9).

***** CARD SET 9 *****

NS NUMBER OF COMPUTATIONAL CROSS SECTIONS DEFINING SEGMENT.

NTT NUMBER OF HYDROGRAPH PLOTS.

JNK CODE TO IDENTIFY QUANTITY OF INTERMEDIATE OUTPUT.

KSA CODE FOR CROSS SECTION SMOOTHING, NONE(0).

KSUPC SUPERCRITICAL FLOW FOR THIS STREAM SEGMENT? NO(0) YES(1)

NTBT NUMBER OF TRIBUTARIES ENTERING THIS STREAM SEGMENT.

***** CARD SET 10 *****

NT(L) C. CROSS SECTION NUMBERS WHERE HYDROGRAPHS ARE PLOTTED.

***** CARD SET 11 *****

NTB(L) SUBREACH NUMBERS AT WHICH TRIBUTARIES ENTER STREAM.

```

***** CARD SET 12 *****
QTBC( *J) TRIBUTARY DISCHARGE HYDROGRAPH(S), HOUR INTERVALS.
***** CARD SET 13 *****
----- SUBSET 1 -----
XS(I)   STREAM DISTANCE FROM SOME UPSTREAM REFERENCE, IN MILES.
----- SUBSET 2 -----
HS(K,I) ELEVATIONS CORRESPONDING TO X-SECT TOP WIDTHS.
----- SUBSET 3 -----
BS(K,I) ACTIVE FLOW TOP WIDTHS CORRESPONDING TO HS(K,I).
----- SUBSET 4 -----
BSS(K,I) DEAD STORAGE TOP WIDTHS CORRESPONDING TO HS(K,I).
***** CARD SET 14 *****
CM(K,I-1) MANNING 'N' CORRESPONDING TO EACH HS(K,I).
***** CARD SET 15 *****
DXM(I-1) MINIMUM DX DISTANCE, IN MILES, BETWEEN GIVEN X-SECT.
***** CARD SET 16 *****
FKC(I-1) CONTRACTION - EXPANSION COEFFICIENT.
***** CARD SET 17 *****
QMAXD   ESTIMATED MAX DISCHARGE AT LAST X-SECT DURING SIMULATION.
QLL     MAXIMUM LATERAL OUTFLOW (CFS/FT).
DTHM    CODE 0.0 TO COMPUTE DTH FROM SIX (6) INSTREAM HYDROGRAPHS
        (+) TO COMPUTE STRICTLY ON BASIS OF TFH.
YDN     CODE 0.0 NORMAL DEPTHS AS INITIAL CONDITIONS;
        (+) INITIAL DOWNSTREAM DEPTH FOR BACKWATER ROUTINE.
***** CARD SET 18 *****
UPSH    CRITICAL DEPTH OF UPSTREAM BOUNDARY TO RESERVOIR.
SDM     SLOPE OF CHANNEL BELOW DAM.
CMN     MANNING 'N' OF CHANNEL BELOW DAM.

```

```

*****

```

``` NAMELIST STATEMENTS ***** ```

```

NAMELIST /CARD2/ KKN,KUI
NAMELIST /CARD5/ YD,Z,TEH,YBMIV,BB,TFH,DATUM
NAMELIST /CARD6/ HF,QT,HJ,CJ,HSP,CS,HGT,CG
NAMELIST /CARD7/ TEH,DHF,DT9
NAMELIST /CARD9/ NS,VTT,JNK,KSA,KSUJC,VTBT
NAMELIST /CARD17/ QMAXD,QOD,QLL,DTHM,YDN
NAMELIST /CARD18/ UPSH,SDM,CMN

```

```

*****

```

```

****
READ (LU5,10,END=1350) MRSVR,MRVR,MNAME
****
READ 10, MESSAGE
****
READ (LU5,CARD2)
****

```

```

10  FORMAT(20A4)
    PRINT 15, MRSVR,MRVR,MNAME,MESSAGE
15  FORMAT (1H1,90(1H*),//,1X,
1    27X,'DAM-BREAK FLOOD SIMULATION',//,1X,
2    37X,'BY A',//,1X,
3    18X,'NONLINEAR, IMPLICIT FINITE-DIFFERENCE MODEL',//,1X,
*   31X,'LAST REVISED FEBRUARY 12, 1981',//,1X,
4    23X,'FLOOD RESULTED FROM DAM FAILURE OF',//,31X,5A4,//,1X,

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5 38X,'OV',/,31X,5A4,///,1X,
6 35X,'ANALYSIS ',/,1X,
7 38X,'BY',/,1X,19X,10A4,////,1X,
8 1X,'COMMENT: ',20A4,/,2X,7(1H*),////,1X,90(1H*))
C
PRINT 25
PRINT 25
C
PRINT 20, MRSVR,KKN,KUI
20 FORMAT(21X,29HINPUT CONTROL PARAMETERS FOR ,5A4,/,
1 10X,9HPARAMETER,42X,8HVARIALE,6X,5HVALUE,/,
2 9X,51(1H*),2X,6(1H*),5X,7(1H*),//,
3 10X,33HNUMBER OF DYNAMIC ROUTING REACHES,20X,3HKKN,10X,12,/,
4 10X,25HTYPE OF RESERVOIR ROUTING,28X,3HKUI,11X,11,/)
C
25 FORMAT(////)
NCS=8
KTMAX=ITDIM-2
IF(KKN.GE.9) KKM=9
C
*****
C BEGIN STEPIING THROUGH STREAM SYSTEM BY SEGMENTS
C
DO 1250 KK=KKM,KKN
IF(KK.EQ.9) GO TO 125
IF(KK.GE.2) GO TO 190
IF(KUI.EQ.1) GO TO 95
C
C READ RESERVOIR SURFACE AREA - ELEVATION TABLE
C
C ****
C READ 1300, SA
C ****
C READ 1300, HSA
C ****
C PRINT 85, MRSVR
85 FORMAT(31X,5A4,10H RESERVOIR,/,
2 27X,37HELEVATION (FT) SURFACE AREA (ACRES),/,
3 31X,6HSA(K),14X,5HSA(K),/,
4 26X,16(1H*),1X,22(1H*),/)
PRINT 90, (HSA(I),SA(I),I=1,8)
90 FORMAT(30X,F8.2,10X,F10.1)
95 CONTINUE
C
C READ RESERVOIR PARAMETERS
C
C ****
C READ (LU5,CARD5)
C ****
C READ (LU5,CARD5)
C ****
C
PRINT 1285
PRINT 100, MRSVR,YO,Z,TEH,YBMV,33,TFH,DATJM
100 FORMAT(19X,5A4,32H RESERVOIR AND BREACH PARAMETERS,/,
1 10X,9HPARAMETER,35X,15HUNITS VARIABLE,6X,5HVALUE,/,
2 9X,43(1H*),1X,7(1H*),2X,6(1H*),2X,11(1H*),//,
4 10X,26HELEVATION OF WATER SURFACE,19X,
5 2HFT,6X,24YU,5X,F10.2,/,
6 10X,20HSIDE SLOPE OF BREACH,33X,1HZ,5X,F10.2,/,

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7 10X,29HTIME FLOOD ROUTING TERMINATES,16X,
8 2HHR,6X,3HTEH,4X,F10.2,/,
9 10X,29HELEVATION OF BOTTOM OF BREACH,16X,
A 2HFT,6X,5HYBMIN,2X,F10.2,/,
B 10X,23HWIDTH OF BASE OF BREACH,22X,2HFT,6X,2H3B,5X,F10.2,/,
C 10X,27HTIME TO MAXIMUM BREACH SIZE,18X,
D 2HHR,6X,3HTFM,4X,F10.2,/,
E 10X,32HELEVATION (MSL) OF BOTTOM OF DAM,13X,
F 2HFT,6X,5HDATUM,2X,F10.2,/)

C
PRINT 105, HF,DT,HD,CD,HSP,CS,HGT,CG
105 FORMAT(10X,32HELEVATION OF WATER WHEN BREACHED,13X,
1 2HFT,6X,2HMF,5X,F10.2,/,
E 10X,23HDISCHARGE THRU TURBINES, 22X,
F 3HCFS,5X,2HQT,5X,F10.2,/,
2 10X,23HELEVATION OF TOP OF DAM,22X,
3 2HFT,6X,2HTD,5X,F10.2,/,
C 10X,42HDISCHARGE COEF. FOR UNCONTROLLED WEIR FLOW,
D 11X,2HCD,5X,F10.2,/,
4 10X,40HELEVATION OF UNCONTROLLED SPILLWAY CREST,
5 5X,2HFT,5X,3HSP,4X,F10.2,/,
8 10X,41HDISCHARGE COEF. FOR UNCONTROLLED SPILLWAY,
9 12X,2HCS,5X,F10.2,/,
6 10X,36HELEVATION OF CENTER OF GATE OPENINGS,
7 9X,2HFT,5X,3HHGT,4X,F10.2,/,
A 10X,29HDISCHARGE COEF. FOR GATE FLOW,
B 24X,2HCG,5X,F10.2,/)

C
DO 115 I=1,8
HX=HSA(I)
HX=HX-DATUM
HSA(I)=HX
115 CONTINUE

C
YO=YD-DATUM
YBMIN=YBMIN-DATUM
HF=HF-DATUM
HD=HD-DATUM
HSP=HSP-DATUM
HGT=HGT-DATUM
DHF=1.0
GO TO 135

C
C READ VALUES NEEDED WHEN ROUTING WITHOUT RESERVOIR
C
C *****
125 READ (L05,CARD7,END=1350)
C *****
PRINT 25
PRINT 130, TEH,DHF,DT9
130 FORMAT(10X,9HPARAMETER,35X,15HUNITS VARIABLE,6X,5HVALUE,/,
1 9X,43(1H*),1X,7(1H*),2X,5(1H*),2X,11(1H*),/,
2 10X,29HTIME FLOOD ROUTING TERMINATES,
3 16X,2HHR,6X,3HTEH,4X,F10.3,/,
4 10X,43HINTERVAL BETWEEN INPUT HYDROGRAPH ORDINATES,
5 2X,2HHR,5X,3HDHF,4X,F10.3,/,
6 10X,1TIME STEP,35X,1HR,6X,1DT9,4X,F10.3)

C
135 NU=TEH/DHF+1.01
IF(NU.LE.1) NU=2

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      ITEM=NU
      DO 140 K=1,NU
      TI(K)=(K-1)*DHF
140    TJ(K)=TI(K)
C
C    READ UPSTREAM HYDROGRAPH
C
      LB=1
      LE=8
C    ****
150    READ 1300, (QI(K),K=LB,LE)
C    ****
      DO 155 K=LB,LE
      I=K
      IF(I.GE.ITEM) GO TO 170
      IF(QI(I).LE.0.001) GO TO 160
155    CONTINUE
      LB=LB+5
      LE=LE+8
      IF(LE.GT.ITEM) LE=ITEM
      GO TO 150
C
160    L=I+1
      DO 165 K=L,ITEM
      I=K
      QI(I)=0.00
165    CONTINUE
C
170    CONTINUE
      Q0=QI(1)
      Q(1)=Q0
C
      PRINT 175, MRSVR
175    FORMAT(////////,10X,21HINFLOW HYDROGRAPH TO ,5A4,/,
1      9X,43(1H*),/)
      PRINT 180, (QI(K),K=1,ITEM)
180    FORMAT(12X,6F8.0)
C
C    READ CROSS-SECTIONAL PARAMETERS
C
190    CONTINUE
C    ****
      READ (LU5,CARD9,END=1350,ERR=190)
C    ****
      IF(NS.EQ.0) GO TO 190
C
      PRINT 1285
      IF(KUI.EQ.0) PRINT 192, MRVR,MRSVR
      IF(KUI.EQ.1) PRINT 194, MRSVR
      PRINT 195, NS,VCS,NTT,JVK,KSA,KSJPC,NTBT
192    FORMAT(20X,32HC. CROSS-SECTION PARAMETERS FOR ,5A4,/,
1      46X,64HBELOW ,5A4,/)
194    FORMAT(20X,32HC. CROSS-SECTION PARAMETERS FOR ,5A4,/)
195    FORMAT(10X,9HPARAMETER,42X,8HVARIBLE,5X,5HVALUE,/,
3      9X,51(1H*),2X,6(1H*),5X,7(1H*),/)
4      10X,38HNUMBER OF COMPUTATIONAL CROSS-SECTIONS,15X,2HNS,10X,15,
5      ,10X,28HMAXIMUM NUMBER OF TOP WIDTHS, 25X,3HNCS,9X,15,/,
6      10X,29HNUMBER OF HYDROGRAPHS TO PLOT,
7      24X,3HNTT,9X,15,/,
8      10X,14HTYPE OF OUTPUT,28X,

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9      11X,3HJNK,9X,I5,/,
A      10X,35HCROSS-SECTIONAL SMOOTHING PARAMETER,13X,
B      5X,3HKSA,9X,I5,/,
C      10X,25HSUPERCRITICAL FLOW OR NOT,
D      28X,5HKSJPC,7X,I5,/,
E      10X,21HNUMBER OF TRIBUTARIES,
F      32X,4HNTBT,8X,I5,/)

C
      DO 202 K=1,ITEH
      QT3(1,K)=0.00
202    QT3(2,K)=0.00
      NT3(1)=0
      NT3(2)=0

C
      IF(NTT.EQ.0) GO TO 212

C
      READ C. CROSS-SECTION NUMBERS AT WHICH HYDROGRAPH PLOTS ARE DESIRED.
C
      ****
      READ 1290,(NT(K),K=1,NTT)
C
      ****
      PRINT 210,(NT(K),K=1,NTT)
210    FORMAT(10X,'C. CROSS-SECTION NUMBERS WHERE HYDROGRAPH DESIRED',/,
1      19X,31H(MAX NUMBER OF HYDROGRAPHS = 6),/,9X,50(1H*),/,
2      20X,6I5)
212    IF(NTBT.EQ.0) GO TO 222

C
      READ SUBREACH NUMBER AT WHICH TRIBUTARIES EXIST
C
      ****
      READ 1290,(NTB(K),K=1,NTBT)
C
      ****
      PRINT 25
      PRINT 214,(NTB(K),K=1,NTBT)
214    FORMAT (10X,41HNUMBER OF SUBREACH WHERE TRIBUTARY ENTERS,/,
1      19X,31H(MAX NUMBER OF TRIBUTARIES = 2),/,
2      9X,50(1H*),/,20X,2I5)

C
      READ TRIBUTARY INFLOW HYDROGRAPH(S)
C
      DO 222 M=1,NTBT
      LB=1
      LE=8
C
      ****
216    READ 1300,(QT3(M,K),K=LB,LE)
C
      ****
      DO 217 K=LB,LE
      I=K
      IF(I.GE.ITEH) GO TO 220
      IF(QT3(M,I).LE.0.00) GO TO 218
217    CONTINUE
      LB=LB+8
      LE=LE+8
      IF(LE.GT.ITEH) LE=ITEH
      GO TO 216

C
218    L=I+1
      DO 219 K=L,ITEH
      I=K
219    QT3(M,I)=0.0

```

```

C
220 CONTINUE
    PRINT 221, NTB(M)
221 FORMAT (////,10X,28HTRIBUTARY INFLOW IN SUBREACH,I3,/,
1    9X,38(1H*),/)
    PRINT 180, (QT3(M,K),K=1,ITEH)
222 CONTINUE
C
C READ COMPUTATIONAL CROSS-SECTIONS
C
    PRINT 1245
    PRINT 224
224 FORMAT(15X,25HCROSS-SECTIONAL VARIABLES,/,
2    10X,94PARAMETER,35X,54UNITS,2X,8HVARIBLE,/,
3    9X,42(1H*),2X,7(1H*),2X,5(1H*),/)
    PRINT 225
225 FORMAT(10X,28HLOCATION OF C. CROSS-SECTION,17X,24MI,6X,5HXS(I),/,
7    10X,36HELEV CORRESPONDING TO EACH TOP WIDTH,
8    9X,2HFT,5X,7HHS(K,I),/,
9    10X,36HTOP WIDTH CORRESPONDING TO EACH ELEV,9X,
A    2HFT,5X,7HBS(K,I),/,15X,21H(ACTIVE FLOW PORTION),/,
B    10X,36HTOP WIDTH CORRESPONDING TO EACH ELEV,9X,2HFT,
C    4X,8HBSS(K,I),/,15X,21H(OFF-CHANNEL PORTION),/,
H    10X,39HNUMBER OF COMPUTATIONAL CROSS-SECTIONS,15X,1HI,/,
I    10X,25HNUMBER OF ELEVATION LEVEL,28X,1HK)

C
DO 305 I=1,NS
C
C ****
C READ 1300, XS(I)
C
C ****
C READ 1300, (HS(K,I),K=1,NCS)
C
C ****
C READ 1300, (BS(K,I),K=1,NCS)
C
C ****
C READ 1300, (BSS(K,I),K=1,NCS)
C
C ****
DO 230 K=2,NCS
    IF(HS(K,I).EQ.0.0) HS(K,I)=HS(K-1,I)+10.0
    IF(BS(K,I).EQ.0.0) BS(K,I)=BS(K-1,I)
    IF(BSS(K,I).EQ.0.0) BSS(K,I)=BSS(K-1,I)
230 CONTINUE
    PRINT 235, I,XS(I)
235 FORMAT(/,10X,14HCROSS-SECTION ,I2,2X,6(1H.),2X,8HXS(I) = ,F7.3)
    PRINT 245, (HS(K,I),K=1,NCS)
245 FORMAT(10X,8HHS ... ,8F9.1)
    PRINT 295, (BS(K,I),K=1,NCS)
295 FORMAT(10X,8HBS ... ,8F9.1)
    PRINT 300, (BSS(K,I),K=1,NCS)
300 FORMAT(10X,8HBSS ... ,8F9.1)
C
305 CONTINUE
C
C SMOOTHING OPERATIONS OF COMPUTATIONAL CROSS-SECTIONS
C
C KSA = 0 ... NO SMOOTHING
C
C KSA = -1 ... SMOOTH BS ARRAY VERTICALLY
C
C KSA = +1 ... SMOOTH BS ARRAY VERTICALLY AND ALONG CHANNEL,
C             PLUS HS ARRAY ALONG CHANNEL
C
C KSA = 14 ... SMOOTH BS ARRAY ALONG CHANNEL
C
C KSA = 15 ... SMOOTH HS ARRAY ALONG CHANNEL
C

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DO 310 I=1,NS
DO 310 K=1,NCS
HST(K,I)=HS(K,I)
BST(K,I)=BS(K,I)
BSST(K,I)=BSS(K,I)
310 CONTINUE
C
IF(KSA.GT.0.AND.KSA.LT.15) GO TO 315
GO TO 360
C
315 DO 350 I=1,NS
IF(I.EQ.1) GO TO 320
IF(I.GT.1.AND.I.LT.NS) GO TO 330
IF(I.EQ.NS) GO TO 340
320 DO 325 K=1,NCS
BST(K,1)=0.75*BS(K,1)+0.25*BS(K,2)
BSST(K,1)=0.75*BSS(K,1)+0.25*BSS(K,2)
325 CONTINUE
GO TO 350
330 DO 335 K=1,NCS
BST(K,I)=0.25*BS(K,I-1)+0.50*BS(K,I)+0.25*BS(K,I+1)
BSST(K,I)=0.25*BSS(K,I-1)+0.50*BSS(K,I)+0.25*BSS(K,I+1)
335 CONTINUE
GO TO 350
340 DO 345 K=1,NCS
BST(K,NS)=0.25*BS(K,NS-1)+0.75*BS(K,NS)
BSST(K,NS)=0.25*BSS(K,NS-1)+0.75*BSS(K,NS)
345 CONTINUE
350 CONTINUE
C
DO 355 I=1,NS
DO 355 K=1,NCS
BS(K,I)=BST(K,I)
BSS(K,I)=BSST(K,I)
355 CONTINUE
C
360 IF(KSA.LT.14) GO TO 365
GO TO 405
365 IF(KSA.EQ.0) GO TO 405
C
C SMOOTH TOP WIDTHS
C
FKSA=KSA
FAC=ABS(FKSA)*50.
DO 370 I=1,NS
DO 370 K=2,NCS
BX=FAC*(HS(K,I)-HS(K-1,I))
BT=BST(K-1,I)+BX
IF(BT.GT.BS(K,I)) GO TO 370
BST(K,I)=BT
BSST(K,I)=BSS(K,I)+BS(K,I)-BT
370 CONTINUE
C
PRINT 375
375 FORMAT(//////,11X,35SMOOTHED CROSS-SECTIONAL TOP WIDTHS,/11X,
1 35(1+*),/)
DO 395 I=1,NS
M=I
PRINT 385, M, (BST(K,I),K=1,NCS)
385 FORMAT(140,10X,'CROSS SECTION ',I3,3X,9HBST ... ,8F8.1)

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      PRINT 390, (BSST(K,I),K=1,NCS)
390  FORMAT(31X,9HBSST ... ,8F8.1)
395  CONTINUE
C
405  IF(KSA.EQ.15) GO TO 410
      IF(KSA.GT.0.AND.KSA.LT.14) GO TO 410
      GO TO 445
C
C  SMOOTH ELEVATIONS
C
410  DO 420 I=1,NS
      DO 420 K=1,NCS
        IF(K.GT.1) GO TO 415
        IF(I.EQ.1) HST(1,1)=HS(1,1)
        IF(I.GT.1.AND.I.LT.NS) HST(1,I)=0.25*HS(1,I-1)+0.5*HS(1,I)+0.25*
1      HS(1,I+1)
        IF(I.EQ.NS) HST(1,NS)=HS(1,NS)
        GO TO 420
415  HST(K,I)=HST(K-1,I)+(HS(K,I)-HS(K-1,I))
420  CONTINUE
C
      PRINT 25
      PRINT 425
425  FORMAT(14 ,10X,35HSMOOTHED CROSS-SECTIONAL ELEVATIONS,/,11X,
1  35(14*),/)
      DO 435 I=1,NS
        M=I
        PRINT 430, M, (HST(K,I),K=1,NCS)
430  FORMAT(14 ,10X,'CROSS SECTION ',I3,3X,9HST ... ,8F8.1)
435  CONTINUE
C
      END SMOOTHING OPERATIONS OF COMPUTATIONAL CROSS-SECTIONS
C
C  READ MANNING N CORRESPONDING TO EACH ELEVATION
C
445  PRINT 1285
      PRINT 455
455  FORMAT(15X,'SUBREACH VARIABLES',/,
*  10X,20HMANING N ROUGHNESS ,
1  37HCOEFFICIENTS FOR THE GIVEN SUBREACHES,/,
2  17X,43H(CM(K,I),K=1,NCS) WHERE I = SUBREACH NUMBER,/,
3  9X,59(1H*),/)
C
460  NSM=NS-1
      DO 470 I=1,NSM
C
      ****
      READ 1300,(CM(K,I),K=1,NCS)
C
      ****
      DO 463 K=2,NCS
        IF(CM(K,I).EQ.0.0) CM(K,I)=CM(K-1,I)
463  CONTINUE
        M=I
        PRINT 465, M, (CM(K,I),K=1,NCS)
465  FORMAT(' ',10X,9HSUBREACH ,I2,5H ... ,9(F5.3,2X))
470  CONTINUE
C
C  READ 1) DISTANCE BETWEEN COMPUTATIONAL NODES
C  2) CONTRACTION - EXPANSION COEFFICIENTS
C
C
      ****
      READ 1300, (DXM(I),I=1,NSM)

```



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C      ****
      READ 1300, (FKC(I), I=1, NSM)
C      ****
      PRINT 25
      PRINT 475
475  FORMAT(1H, 10X, 'COMPUTATIONAL NODE SPACING', 19X, 2HMI,
5     5X, 5HDXM(I), //,
6     10X, 36HCONTRACTION - EXPANSION COEFFICIENTS, 17X, 6HFKC(I), /,
7     9X, 59(1H*), //,
8     18X, 15HSUBREACH NUMBER, 8X, 6HDXM(I), 4X, 6HFKC(I), /,
9     17X, 17(1H*), 5X, 8(1H*), 2X, 8(1H*))
C
      DO 485 I=1, NSM
      M=I
      PRINT 480, M, DXM(M), FKC(M)
480  FORMAT(' ', 26X, I2, 13X, F6.3, 4X, F6.3)
485  CONTINUE
C
      DO 495 K=1, NCS
495  CM(K, NS)=CM(K, NSM)
      FKC(NS)=FKC(NSM)
      DO 500 I=1, NS
      FFKC(I)=FKC(I)
      DO 500 K=1, NCS
500  CMT(K, I)=CM(K, I)
C
C      ADD INTERMEDIATE STATIONS
C
      VN(1)=1
      X(1)=XS(1)
      I=1
      DO 520 K=2, NS
      TL=XS(K)-XS(K-1)
      NX=TL/DXM(K-1)+0.501
      IF(NX.EQ.0) NX=1
      FNX=TL/NX
      DO 515 L=1, NX
      I=I+1
515  X(I)=X(I-1)+FNX
      VN(K)=I
520  CONTINUE
      N=I
      PRINT 535, N
535  FORMAT(////, 10X, 'NUMBER OF COMPUTATIONAL NODES (N) =', I4,
1     5X, 'MIN = 5      MAX = 200')
C
      PRINT 25
      IF(N.GT.200) PRINT 538
538  FORMAT(10X, 'TOO MANY COMPUTATIONAL NODES, INCREASE DXM SO THAT TOT
      IAL NUMBER IS LESS THAN 200')
C
      IF(JWK.LE.2) GO TO 540
      PRINT 25
C
      PRINT 539
539  FORMAT(30X, 33(1H*), /, 30X, 33(1H*), /,
1     30X, 3(1H*), 27X, 3(1H*), /,
2     30X, 33H*** EXPANDED CHANNEL DATA ***/,
3     30X, 3(1H*), 27X, 3(1H*), /,
4     30X, 33(1H*), /, 30X, 33(1H*))

```

```

      PRINT 25
C
540  CONTINUE
      DO 550 L=1,NTT
      KL=0
      DO 545 K=1,NS
      IF(NT(L).EQ.K) KL=1
      IF(NT(L).EQ.K) NT(L)=NN(K)
      IF(KL.EQ.1) GO TO 550
545  CONTINUE
550  CONTINUE
C
      IF(NTBT.EQ.0) GO TO 554
      DO 553 L=1,NTBT
      KL=0
      DO 552 K=1,NS
      IF(NTB(L).EQ.K) KL=1
      IF(NTB(L).EQ.K) NTB(L)=NV(K)
      IF(KL.EQ.1) GO TO 553
552  CONTINUE
553  CONTINUE
C
554  DO 555 I=1,NSM
      NJ=NV(I)
      DO 555 K=1,NCS
555  CM(K,NJ)=CMT(K,I)
C
      DO 560 K=1,NCS
560  CM(K,N)=CMT(K,NSM)
      AS(1,1)=0.0
      ASS(1,1)=0.0
C
      DO 570 I=2,NS
      NJ=NV(I)
      DO 565 K=1,NCS
      BS(K,NJ)=BST(K,I)
      HS(K,NJ)=HST(K,I)
565  BSS(K,NJ)=BSST(K,I)
      ASS(1,NJ)=0.0
570  AS(1,NJ)=0.0
C
      DO 575 I=1,NS
      NJ=NV(I)
575  FKC(NJ)=FFKC(I)
C
C      INTERPOLATE C. CROSS-SECTION PROPERTIES FOR COMPUTATIONAL NODES
C
      DO 590 I=1,NSM
      N0=NV(I)
      N1=N0+1
      N2=NV(I+1)
      FKC(N0)=FFKC(I)
      IF(N1.EQ.N2) GO TO 590
C
      DO 585 L=N1,N2
      FX=(X(L)-X(N0))/(XS(I+1)-XS(I))
C
      DO 580 K=1,NCS
      DELHS=HS(K,N2)-HS(K,N0)
      DELBS=BS(K,N2)-BS(K,N0)

```

```

      DELBSS=BSS(K,N2)-BSS(K,N0)
      HS(K,L)=HS(K,N0)+DELS*FX
      BS(K,L)=BS(K,N0)+DELS*FX
      BSS(K,L)=BSS(K,N0)+DELBSS*FX
      DELCM=CM(K,N2)-CM(K,N0)
      CM(K,L)=CM(K,N0)+DELCM*FX
580  CONTINUE
C
      AS(1,L)=0.0
      ASS(1,L)=0.0
      IF(L.NE.N2) FKC(L)=FKC(N0)
585  CONTINUE
590  CONTINUE
C
      NM=N-1
      DO 595 I=1,NM
595  DDX(I)=ABS(X(I+1)-X(I))*5280.
C
      DO 600 I=1,N
      DO 600 K=2,NCS
      L=K-1
      AS(K,I)=AS(L,I)+0.5*(BS(L,I)+BS(K,I))*(HS(K,I)-HS(L,I))
600  ASS(K,I)=ASS(L,I)+0.5*(BSS(L,I)+BSS(K,I))*(HS(K,I)-HS(L,I))
C
      IF(JWK.LE.2) GO TO 695
      PRINT 510
610  FORMAT(7X,1H1,4X,4HX(I),5X,17H(HS(K,I),K=1,NCS),/,
1    4X,5(1H*),1X,7(1H*),4X,19(1H*),/)
      DO 615 I=1,N
615  PRINT 520, I,X(I),(HS(K,I),K=1,NCS)
620  FORMAT(5X,I3,F3.3,2X,8F10.1)
C
      PRINT 25
      PRINT 525
625  FORMAT(7X,1H1,4X,4HX(I),5X,17H(BS(K,I),K=1,NCS),/,
1    4X,5(1H*),1X,7(1H*),4X,19(1H*),/)
      DO 630 I=1,N
630  PRINT 520, I,X(I),(BS(K,I),K=1,NCS)
C
      PRINT 25
      PRINT 535
635  FORMAT(7X,1H1,4X,4HX(I),5X,19H(BSS(K,I),K=1,NCS),/,
1    4X,5(1H*),1X,7(1H*),4X,20(1H*),/)
      DO 640 I=1,N
640  PRINT 520, I,X(I),(BSS(K,I),K=1,NCS)
C
      PRINT 25
      PRINT 555
655  FORMAT(7X,1H1,5X,6HFKC(I),10X,2HX/,
1    4X,5(1H*),2(1X,11(1H*)),/)
      DO 660 I=1,NM
      DX=ABS(X(I+1)-X(I))
660  PRINT 565, I,FKC(I),DX
665  FORMAT(6X,I3,1X,F10.2,2X,F10.3)
C
      PRINT 25
      PRINT 570
670  FORMAT(7X,1H1,4X,4HX(I),5X,17H(CM(K,I),K=1,NCS),/,
1    4X,5(1H*),1X,7(1H*),4X,19(1H*),/)
      DO 675 I=1,N

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675 PRINT 680,I,X(I),(CM(K,I),K=1,NCS)
680 FORMAT(5X,I3,F8.3,2X,8F10.4)
C
PRINT 25
PRINT 685
685 FORMAT(7X,1HI,4X,4HX(I),5X,17H(AS(K,I),K=1,NCS),/,
1 4X,5(1H*),1X,7(1H*),4X,19(1H*),/)
DO 690 I=1,N
690 PRINT 620, I,X(I),(AS(K,I),K=1,NCS)
PRINT 25
C
C READ DOWNSTREAM FLOW PARAMETERS
C
695 CONTINUE
C
****
READ (LU5,CARD17)
C
****
NDTH=0
IF(DTHM.GT.0.0001) NDTH=1
PRINT 1285
PRINT 598, QMAXD,QOD,QLL,DTHM,YDN
698 FORMAT(20X,'DOWNSTREAM BOUNDARY FLOW PARAMETERS',//,
2 10X,9HPARAMETER,35X,5HUNITS,2X,8HVARIBLE,6X,5HVALUE,/,
3 9X,42(1H*),2X,7(1H*),2X,6(1H*),2X,13(1H*),//,
4 10X,37HMAX DISCHARGE AT DOWNSTREAM EXTREMITY,9X,
5 3HCFS,4X,5HMAXD,2X,F9.1,/,
6 10X,41HINITIAL DISCHARGE AT DOWNSTREAM EXTREMITY,
7 5X,3HCFS,4X,3HQOD,5X,F8.1,/,
8 10X,35HMAX LATERAL OUTFLOW PRODUCING LOSSES,
9 8X,6HCFS/FT,3X,3HQLL,5X,F10.3,/,
A 10X,25HINITIAL SIZE OF TIME STEP,
B 21X,2HHR,5X,4HDTHM,9X,F5.3,/,
C 10X,42HINITIAL WATER SURFACE ELEVATION DOWNSTREAM,
D 4X,2HFT,5X,3HYDN,5X,F8.2,///)
C
C CALL SUBROUTINE FOR COMPUTING OUTFLOW FROM BREACHED DAM
C
M=N/3
IF(M.LE.1) M=2
SOM=(HS(1,1)-HS(1,M))/ABS(X(1)-X(M))
CMN=0.333*(CM(1,1)+CM(1,2)+CM(1,3))
IF(KK.EQ.1.AND.KJ1.EQ.0) CALL DAMBRK
****
700 CONTINUE
C
C READ INITIAL CONDITIONS FOR DYNAMIC RESERVOIR ROUTING
C
IF(KK.GE.9) GO TO 725
IF(KJ1.EQ.0) GO TO 735
C
****
READ (LU5,CARD18)
C
****
PRINT 25
PRINT 715, MRVR,MRSVR,UPSH,SOM,CMN
715 FORMAT(24X,23HINITIAL CONDITIONS FOR ,5A4,/,
1 41X,6HBELOW ,5A4,//,
2 10X,9HPARAMETER,35X,5HUNITS,2X,8HVARIBLE,6X,5HVALUE,/,
3 9X,42(1H*),2X,7(1H*),2X,6(1H*),2X,13(1H*),//,
4 10X,35HCRITICAL DEPTH OF UPSTREAM BOUNDARY,11X,
5 2HFT,5X,4HUPSH,4X,F9.2,/,

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6 10X,27HSLOPE OF DOWNSTREAM CHANNEL,17X,
7 5HFT/MI,4X,3HSDM,5X,F11.4,/,
8 10X,38HAVE MANNING'S N FOR DOWNSTREAM CHANNEL,15X,
9 3HCMN,5X,F11.4)
C
DO 725 K=1,N
QMI(K)=5000000.
725 CONTINUE
C
728 DO 730 K=1,NU
Q(K)=QI(K)
TI(K)=(K-1)*DH=
730 CONTINUE
TP=TFH
735 CONTINUE
C
QO=Q(1)
C
IF(KJ1.EQ.1) GO TO 755
GO TO 760
755 QSP=0.00
QGT=0.00
QOB=0.00
IF(YDN.GT.(HSP+0.01)) QSP=CS*(YDV-HSP)**1.5
IF(YDN.GT.(HGT+0.01)) QGT=CG*(YDV-HGT)**0.5
IF(YDN.GT.(HD+0.01)) QOB=CD*(YDN-HD)**1.5
QOD=QI+QSP+QGT+QOB
760 CONTINUE
IF(QOD.LT.0.1) QOD=QO
C
QQ=0.00
Q1=QOD-(QTB(1,1)+QTB(2,1))
DO 765 I=1,N
QDI(I)=QO-(QO-Q1)/ABS(X(V)-X(1))*ABS(X(1)-X(I))
IF(I-1.EQ.NTB(1)) QO=QO+QTB(1,1)
IF(I-1.EQ.NTB(2)) QO=QO+QTB(2,1)
765 QDI(1)=QDI(I)+QQ
C
PRINT 25
PRINT 25
IF(KJ1.EQ.0) PRINT 770, MRVR
IF(KJ1.EQ.1) PRINT 770, MRSVR
770 FORMAT(10X,'INITIAL CONDITIONS IN ',5A4)
IF(YDN.GE.0.01) GO TO 780
PRINT 772
772 FORMAT (' ',20X,'METHOD: NORMAL DEPTHS',/,10X,70(1H*),//,
1 10X,'PARAMETER',42X,'VARIABLE',/,
2 9X,40(1H*),12X,8(1H*),//,
3 10X,'COMPUTATIONAL CROSS-SECTION NUMBER',19X,'I',/,
4 10X,'NUMBER OF ITERATIONS',33X,'K',/,
5 10X,'LOCATION OF CROSS SECTION',28X,'X(I)',/,
6 10X,'ELEV OF WATER SURFACE',32X,'YD(I)',/,
7 10X,'DISCHARGE',44X,'QDI(I)',/,
8 10X,'CHANNEL SLOPE',40X,'SOM',//,
9 14X,'I',9X,'K',9X,'X(I)',9X,'YD(I)',9X,'QDI(I)',9X,'SOM',/,
A 13X,3(1H*),7X,3(1H*),7X,6(1H*),7X,7(1H*),7X,8(1H*),7X,5(1H*))
780 CONTINUE
C
IF(YDN.LT.0.01) GO TO 810

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      YD(N)=YDV
      DY=0.00
      NSI=N-1
C
      PRINT 782
782  FORMAT(' ',20X,'METHOD: STEP - BACKWATER',/,10X,70(1H*),/,
1    10X,'PARAMETER',42X,'VARIABLE',/,
2    9X,40(1H*),12X,8(1H*),//,
3    10X,'COMPUTATIONAL CROSS-SECTION NUMBER',19X,'I',/,
4    10X,'NUMBER OF ITERATIONS',33X,'K',/,
5    10X,'LOCATION OF CROSS SECTION',28X,'X(I)',/,
6    10X,'ELEV OF WATER SURFACE',32X,'YD(I)',/,
7    10X,'DISCHARGE',44X,'QDI(I)',//,
9    14X,'I',9X,'K',9X,'X(I)',9X,'YD(I)',9X,'QDI(I)',/,
A    13X,3(1H*),7X,3(1H*),7X,6(1H*),7X,7(1H*),7X,8(1H*)
C
C      APPLY STEP-BACKWATER ROUTINE (CONSERVATION OF MOMENTUM)
C
      LL=N
      K=0
      PRINT 850, LL,K,X(LL),YD(LL),QDI(LL)
      DO 805 L=1,NSI
      LR=N-L+1
      LL=LR-1
      YLR=YD(LR)
      CALL SECT(YLR,LR,A,B,DB,AT,BT)
      CALL FRICT(YLR,LL,CMU)
      QA=0.5*(QDI(LR)+QDI(LL))
      FA=-QDI(LL)*QDI(LL)
      FB=16.1
      FC=32.2/1.1*DDX(LL)*CMU*CMU*QA*QA
      FD=QDI(LR)*QDI(LR)/A
      IF(KUI.EQ.0) YLL=YLR+(HS(1,LL)-HS(1,LR))
      IF(YLL.LT.YLR) YLL=YLR
      IF(KUI.EQ.1) YLL=YLR+DY*1.0
C
      DO 790 K=1,25
      CALL SECT(YLL,LL,AJ,BJ,DB,AT,BT)
      AP=A+AJ
      BP=B+BJ
      F=FA/AJ+FB*AP*(YLR-YLL)+FC*BP** (4.0/3.0)/AP** (7.0/3.0)+FD
      FP=-FA*BJ/AJ+FB*(BJ*(YLR-YLL)-AP)+
1    FC/3.0*BP** (1.0/3.0)/AP** (10.0/3.0)*(4.0*DB*AP-7.0*BJ*BP)
      YLLN=YLL-F/FP
      IF(ABS(YLL-YLLN).LE.0.001) GO TO 795
790  YLL=YLLN
795  YD(LL)=YLLN
      DY=YD(LL)-YD(LR)
      PRINT 850, LL,K,X(LL),YD(LL),QDI(LL)
      IF(K.GE.25) PRINT 800
800  FORMAT(1H+,70X,'NO SOLUTION')
C
805  CONTINUE
      GO TO 860
C
C      APPLY NORMAL DEPTH COMPUTATION AT EACH NODE
C
810  SOM1=SOM
C
      DO 855 I=1,N

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      QQ=QDI(I)
      IF(I.LT.N) SOM=(-HS(1,I)-HS(1,I+1))/ABS(X(I)-X(I+1))
      IF(I.EQ.N) SOM=(-HS(1,N-1)-HS(1,N))/ABS(X(N-1)-X(N))
      IF(SOM.GT.0.) SOM1=SOM
      IF(SOM.LE.0.) SOM=SOM1
      FK=1.486*SQRT(SOM/5280.)
820  H=HS(1,I)+1.
C
      DO 825 K=1,2000
      CALL FRICT(H,I,CMU)
      CALL SECT (H,I,A,B,DB,AT,BT)
      QQ=FK*A**(5./3.)/B**(2./3.)/CMU
      IF(QQ.GE.QQ) GO TO 830
825  H=H+0.1
830  HS1=H
835  CONTINUE
      S=SOM/5280.
C
      DO 840 K=1,25
      CALL FRICT(HS1,I,CMU)
      FK=1.486/CMU*SQRT(S)
      CALL SECT (HS1,I,A,B,DB,AT,BT)
      F=30*B**(2./3.)-FK*A**(5./3.)
      FP=2./3.*QQ*DB/B**(1./3.)-5./3.*FK*A**(2./3.)*B
      HS2=HS1-F/FP
      YD(I)=HS2
      IF(ABS(HS2-HS1).LT.0.001) GO TO 845
840  HS1=HS2
845  CONTINUE
      PRINT 850, I,K,X(I),HS2,QQ,SOM
850  FORMAT(10X,I5,I10,F14.3,F14.2,F15.0,F12.2)
      IF(K.GE.25) PRINT 853
853  FORMAT(1H+,85X,'NO SOLUTION')
855  CONTINUE
860  CONTINUE
C
      DO 890 I=1,N
      QD(I)=QDI(I)
      QU(I)=QD(I)
      YU(I)=YD(I)
890  YI(I)=YU(I)
C
      IF(KK.NE.9) GO TO 896
      QMAX=0.0
      DO 894 K=1,ITE1
      IF(QMAX.LT.QI(K)) QMAX=QI(K)
894  CONTINUE
896  CONTINUE
      IF(KJ1.EQ.1) GO TO 915
      QMAXJ=QMAX
      IF(QMAXD.LT.0.1) QMAXD=QMAXJ/10
      DO 900 I=1,N
      QMI(I)=QMAXD+QMAXJ*((X(N)-X(I))/X(N))**4
900  CONTINUE
C
      PRINT 25
      IF(JNK.EQ.9) PRINT 910, (QMI(I),I=1,N)
910  FORMAT(10X,'(QMI(I),I=1,N)',4X,'(ESTIMATED MAXIMUM FLOW)',/,
1  9X,44(1H*),//,(10X,8F12.2))
915  G=32.2

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```

QO=Q(1)
ITERR=0
ITMAX=10
EPSY=0.01
EPSQ=100.
QKMX=0.0
KIT=0
KIIP=0
KERS=0
NITT=0
IF(KSUPC.EQ.1) SUM=(YD(1)-YD(2))/ABS(X(2)-X(1))
IF(KJ1.EQ.0.AND.)<SUPC.EQ.0) SUM=(YD(N-1)-YD(N))/ABS(X(N)-X(N-1))
NPRT=1
IF(N.GT.20 .AND. N.LT.40) NPRT=2
IF(N.GE.40 .AND. N.LT.60) NPRT=3
IF(N.GE.60) NPRT=N/20+1
<TIME=0
VSFSV=0
J=1
VQIN=0.0
VQOUT=0.0
VQLLT=0.0
VQTHT=0.0
VCHLS=0.0
VCHLE=0.0
TT=0.
IF(KK.LT.9) GO TO 930
Q(1)=QI(1)
QMM=Q(1)
C
DO 925 K=2,ITEH
925 Q(K)=QI(K)
C
TFH=1.0
TP=99999.
TFJ=99999.
DTJ=DT9
DTFM=DT9
QAM=Q(1)*0.001
VDTH=1
GO TO 950
930 CONTINUE
TFJ=TP-TFH
IF(TFJ.LT.0.0) TFJ=0.0
DTJ=0.25
IF(KUI.EQ.1.AND.)DTFM.LT.0.00001) DTFM=TFH/10
IF(DTFM.GT.0.00001) GO TO 950
BM=B3+Z*Y0
BR=BM/BS(2,1)
YMAX=4./9.*Y0*BR+HS(1,1)
CALL SECT (YMAX,1,A,B,DB,AT,BT)
BMAX=B
Y00=YI(1)
CALL SECT (Y00,1,A,B,DB,AT,BT)
B00=B
DTFM=1.0*TFH*(Q0*BMAX/QMAX/B00)**0.60
C
IF(JVK.LE.2) GO TO 950
PRINT 1285
PRINT 25

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      PRINT 25
      PRINT 940, Q0, QMAX, QMAX, 300, DTHM
940  FORMAT (25X, 'PARAMETERS USED IN TIME STEP COMPUTATION', //, 1X,
*      10X, 9HPARAMETER, 35X, 15HUNITS VARIABLE, 6X, 5HVALUE, /,
1      9X, 43(1H*), 1X, 7(1H*), 2X, 5(1H*), 2X, 11(1H*), //,
3      10X, 12HINITIAL FLOW, 41X, 2HQ0, 3X, F12.2, /,
4      10X, 13HMAX TOP WIDTH, 40X, 4HBMAX, 3X, F10.2, /,
5      10X, 8HMAX FLOW, 45X, 4HQMAX, 1X, F12.2, /,
6      10X, 9HTOP WIDTH, 44X, 3HQ0, 4X, F10.2, /,
7      10X, 32HTIME INTERVAL BETWEEN ITERATIONS, 21X, 4HDTM, 6X, F8.3)
950  NDTHM=TFH/DTHM
      IF(NDTHM.EQ.0) NDTHM=1
      DTH=TFH/NDTHM
      IF(DTH.GT.TFH/20) DTH=TFH/20
      IF(KK.GE.9) DTH=DT9
      DTHI=DTH
      DTHI1=DTHI
C
C  PRINT OUT TIME PARAMETERS OF OUTFLOW HYDROGRAPH IMMEDIATELY
C  DOWNSTREAM OF DAM
C
      PRINT 25
      PRINT 25
      IF(JWK.GE.2) PRINT 955, TFH, TFO, TP, DTHI
955  FORMAT(10X, 37HTIME PARAMETERS OF OUTFLOW HYDROGRAPH, //,
2      10X, 9HPARAMETER, 35X, 15HUNITS VARIABLE, 6X, 5HVALUE, /,
3      9X, 43(1H*), 1X, 7(1H*), 2X, 5(1H*), 2X, 11(1H*), //,
4      10X, 19HDURATION OF FAILURE, 27X, 2HHR, 6X, 3HTFH, 4X, F10.3, /,
5      10X, 42HTIME TO START OF RISING LIMB OF HYDROGRAPH,
6      4X, 2HHR, 6X, 3HTFO, 4X, F10.3, /,
7      10X, 12HTIME TO PEAK, 34X, 2HHR, 5X, 2HTP, 5X, F10.3, /,
8      10X, 14HTIME STEP SIZE, 32X, 2HHR, 6X, 4HDTHI, 3X, F10.3)
      IF(JWK.GE.2 .AND. KUI.EQ.0) PRINT 956, MRVR
      IF(JWK.GE.2 .AND. KUI.EQ.1) PRINT 956, MRSVR
956  FORMAT (1H1, //, 35X, 'RESULTS OF STREAMFLOW SIMULATION ALONG ',
1      15A4, //, 1X, 132(1H*), //)
      IF(JWK.EQ.2) PRINT 957
957  FORMAT(10X, 'PARAMETER', 42X, 'VARIABLE', /,
1      9X, 40(1H*), 12X, 8(1H*), //,
2      10X, 'TIME', 50X, 'TT', /,
3      10X, 'DURATION OF TIME STEP', 33X, 'DTH', /,
4      10X, 'NUMBER OF ITERATIONS', 34X, 'ITER', /,
5      10X, 'UPSTREAM DISCHARGE', 36X, 'QU(J)', /,
6      10X, 'UPSTREAM WATER SURFACE ELEV', 27X, 'YU(J)', /,
7      10X, 'DOWNSTREAM DISCHARGE', 34X, 'QU(N)', /,
8      10X, 'DOWNSTREAM WATER SURFACE ELEV', 25X, 'YU(N)', //,
9      5X, 'TT', 7X, 'DTH', 7X, 'ITER', 9X, 'QU(J)', 10X, 'YU(J)',
A      10X, 'QU(N)', 10X, 'YU(N)', /,
5      4X, '*****', 5X, '*****', 5X, 7(1H*), 7X, 7(1H*), 8X, 7(1H*),
C      8X, 7(1H*), 8X, 7(1H*), /)
      IF(JWK.EQ.3) PRINT 958
958  FORMAT(10X, 'PARAMETER', 42X, 'VARIABLE', /,
1      9X, 40(1H*), 12X, 8(1H*), //,
2      10X, 'TIME', 50X, 'TT', /,
3      10X, 'DURATION OF TIME STEP', 33X, 'DTH', /,
4      10X, 'NUMBER OF ITERATIONS', 34X, 'ITER', /,
*      10X, 'MIN AND MAX FROUDE NUMBER', 29X, 'FRDRNG', /,
*      10X, 'DISCHARGE OF LATERAL OUTFLOW (CFS/FT)', 17X, 'QLLT', /,
*      10X, 'TOTAL DISCHARGE OF TRIBUTARIES', 24X, 'QTBT', /,
5      10X, 'UPSTREAM DISCHARGE', 36X, 'QU(J)', /,

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6 10X,'UPSTREAM WATER SURFACE ELEV',27X,'YU(J)',/,
7 10X,'DOWNSTREAM DISCHARGE',34X,'QU(N)',/,
8 10X,'DOWNSTREAM WATER SURFACE ELEV',25X,'YU(N)',/,
9 5X,'TT',7X,'DTH',4X,'ITER',7X,'FRDRNG',9X,'QLLT',8X,'QTBT',
A 10X,'QU(J)',10X,'YU(J)',10X,'QU(N)',10X,'YU(N)',/,
B 4X,'****',5X,'*****',2X,7(1H*),4X,10(1H*),6X,6(1H*),6X,6(1H*),
C 8X,7(1H*),8X,7(1H*),8X,7(1H*),8X,7(1H*),/

```

C

```

DO 960 I=1,N
YI(I)=YU(I)
YM(I)=0.
QMX(I)=0.
TM(I)=0.
960 CONTINUE
DT=DTH*3600.0
DO 963 K=1,NU
IF(TI(K).LT.TFO) GO TO 963
QAM=Q(K)*0.001
GO TO 964
963 CONTINUE
964 CONTINUE
GO TO 1040

```

C

C

C

C

INITIAL CONDITION UNSTEADY FLOW SOLUTION WITH BOUNDARY
CONDITIONS HELD CONSTANT

```

965 KIT=KIT+1
KER=0
KSIT=0
IF(KSUPC.EQ.1 .AND. DTH.GT.(TFH/40.0)) DTH=TFH/40.0
IF(KSUPC.EQ.1 .AND. KK.GE.9) DTH=DT9*0.5
DT=DTH*3600.
DO 975 I=1,N
975 YI(I)=YU(I)
GO TO 995

```

C

C

C

UNSTEADY FLOW SOLUTION BEGINS

```

980 KIT=KIT+1
KER=0
KSIT=0

```

C

C

C

DETERMINE TIME STEP SIZE

```

DTH=DTHI
IF(TT.-T.(TFO-DTH)) DTH=DTHI
IF(KUI.EQ.1.AND.TT.GT.(TFO+TFH)) DTH=1.01*DTHI
IF(KUI.EQ.1) GO TO 985
IF(NDTH.EQ.0) GO TO 981
IF(TT.GE.(TFO+2*TFH).AND.TT.LT.(TFO+10*TFH)) DTH=DTHI*1.01
IF(TT.GE.(TFO+10*TFH)) DTH=DTHI*1.02
GO TO 985
981 IF(TT.LT.(TFO+2*TFH).OR.KUI.EQ.1) GO TO 985
DO 983 L=1,6
K=5-L+1
KMX=0
QMAXI=2*QAM
KX=0
DO 982 KL=1,KTIME
IF(QCM(KL,K).GT.QMAXI) KMX=KL

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      IF(QCM(KL,K).GT.QMAXI) QMAXI=QCM(KL,K)
      IF(QCM(KL,K).GT.2*QAM.AND.KX.EQ.0) KX=KL
982 CONTINUE
      IF(KX.EQ.0.OR.KMX.GT.KTIME-2) GO TO 983
      GO TO 984
983 CONTINUE
984 DTH=(TTP(KMX)-TTP(KX))/20
      IF(DTH.LT.DTHI) DTH=DTHI
      IF(DTH.LT.DTHT) DTH=DTHT
      IF(K.GE.3.AND.K.LT.6) DTH=1.01*DTH
      IF(K.EQ.6) DTH=1.02*DTH
985 CONTINUE
      IF(DTH.GT.DT0) DTH=DT0
986 TT=TT+DTH
990 DT=DTH*3500.0
      IF(DTH.LT.0.00001) GO TO 1290
C
C      DETERMINE IF COMPUTATIONS ARE TO TERMINATE
C
      IF(TT.GT.TEH) GO TO 1150
C
C      SOLUTION PROCEDURE
C
995 DO 1005 ITER=1,ITMAX
      ITER=ITER-1
      NIT=0
      CALL BDARY(J)
      IF((N-J).LE.3) GO TO 1147
      NITT=NITT+NIT
      IF(NIT.EQ.1) GO TO 1010
      CALL INTER(J)
      NITT=NITT+NIT
      IF(NIT.EQ.1) GO TO 1010
      IF(KSUPC.EQ.1) CALL MATRXC
      IF(KSUPC.EQ.0) CALL MATRX
      ICIT=0
      II=0
C
      DO 1000 I=J,N
      II=II+1
      QU(I)=QU(I)+XX(II)
      IF(ABS(XX(II)).GE.EPSQ) ICIT=1
      II=II+1
      YU(I)=YU(I)+XX(II)
      IF(ABS(XX(II)).GE.EPSY) ICIT=1
1000 CONTINUE
C
      IF(TT.LT.TFO .AND. ICIT.EQ.0) GO TO 1040
      IF(ICIT.EQ.0.AND.KER.EQ.0) DTHI=DTH
      IF(ICIT.EQ.0) GO TO 1040
1005 CONTINUE
      KSIT=KSIT+1
      IF(KSIT.EQ.2) GO TO 1040
C
1010 CONTINUE
      IF(NITT.GE.5) GO TO 1018
      IF(KER.EQ.0) DTHI=DTH
      IF(KER.EQ.0) KERS=KERS+1
      TT=TT-DTH
      IF(TT.LE.0.0) TT=0.0

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```

C      DO 1015 I=J,N
      QU(I)=QD(I)
1015  YU(I)=YD(I)
C
      DTH=DTH*0.50
      IF(KERS.EQ. 5 .AND. KER.EQ.0) DTHI=DTH
      IF(KERS.EQ.10 .AND. KER.EQ.0) DTHI=DTH
      KER=1
      IF(TT.LE.1.00.AND.DTH.GE.DTHI) DTH=DTHI*0.5
      IF(KERS.LT.5.AND.TT.EQ.0) GO TO 990
      IF(KERS.LT.15) GO TO 986
      PRINT 1017
1017  FORMAT(////,5X,35HTOO MANY NO SOLUTIONS HAVE OCCURRED,/)
      PRINT 1025
      PRINT 1030
      GO TO 1280
C
1018  PRINT 1020, NEG1,YNEG
      PRINT 1025
      PRINT 1030
      GO TO 1280
1020  FORMAT (////,5X,10(14*),' THE WATER SURFACE HAS BEEN COMPUTED BELOW
1  THE STREAM BED TOO MANY TIMES. ',10(14*),//,1X,
2  15X,' THE LAST ONE OCCURRED AT CROSS-SECTION',I3,
3  ' WITH AN ELEVATION OF ',F10.2,'.')
1025  FORMAT(//,15X,28HCHECK INPUT DATA FOR ERRORS.)
1030  FORMAT (//,15X,'SUGGESTED CHANGES INCLUDE:',/,1X,
1  20X,'1) RUN CROSS-SECTION SMOOTHING OPTIONS',/,1X,
2  20X,'2) TRY A DIFFERENT TFH VALUE',/,1X,
3  20X,'3) ADD INTERMEDIATE CROSS-SECTIONS',/,1X,
4  20X,'4) INCREASE BASE FLOW BY INCREASING QT ',/,1X,
5  25X, 'THIS MAY REQUIRE INCREASING Q1 TOO',/,1X,
6  20X,'5) CHECK FOR DIFFERENT STATES OF FLOW',/,1X,
7  20X,'6) USE FKC COEFFICIENT, IF APPLICABLE')
1040  CONTINUE
C
C      PRINT STAGE, VELOCITIES, DISCHARGES, ETC. AT (KITPR) TIME STEP
C      INTERVALS DURING THE COMPUTATIONS
C
      DO 1065 I=1,N
      IF(KU1.EQ.0.AND.YU(I).LT.Y1(I)) YJ(I)=Y1(I)
      IF(QU(I).GT.QMX(I)) YMJ(I)=YJ(I)
      IF(QJ(I).GT.QMX(I)) QMX(I)=QJ(I)
      IF(YU(I).GT.YM(I)) TM(I)=TT
      IF(YU(I).GT.YM(I)) YM(I)=YU(I)
      IF(QJ(I).GT.QKMX) QKMX=QJ(I)
1065  CONTINUE
      EPSQ=QKMX*0.001
      IF(EPSQ.LT.1.) EPSQ=1.0
      IF(EPSQ.GT.100.) EPSQ=100.
      QKMX=0.0
      FRDMIN=1000.
      FRDMAX=0.0
      DO 1066 I=J,N
      CALL SECT(YU(I),1,A,B,DB,AT,BT)
      FRD=(QJ(I)/A)/SQRT(G*(A/B))
      IF(FRD.GT.FRDMAX) FRDMAX=FRD
      IF(FRD.LT.FRDMIN) FRDMIN=FRD
1066  CONTINUE

```



```

      IF(TT.GT.0.0) GO TO 1069
      VCHLS=0.0
      CALL SECT(YU(J),J,A,B,DB,AT1,BT)
      J1=J+1
      DO 1067 I=J1,N
      CALL SECT(YU(I),I,A,B,DB,AT2,BT)
      VCHLS=VCHLS+DDX(I-1)*(AT1+AT2)/2.
1067 AT1=AT2
      VCHLS=VCHLS/43560.
      GO TO 1075
1069 CONTINUE
      VQIN=VQIN+0.5*(QU(J)+QU(J1))*DT/43560.0
      VQOUT=VQOUT+0.5*(QU(N)+QU(N1))*DT/43560.0
1075 CONTINUE
      IF(JNK.EQ.2) PRINT 1077,
1      TT,DT,ITERR,QU(J),YU(J),QU(N),YU(N)
1077 FORMAT(1H ,F8.3,2X,F7.4,4X,I3,2X,F15.0,F15.2,F15.0,F15.2)
      IF(JNK.EQ.2 .AND. KSIT.EQ.2) PRINT 1078
1078 FORMAT(1H+,95X,'NO SOLUTION')
C
      IF(JNK.NE.9) GO TO 1089
      NNPR=VPR
      IF(KSIT.EQ.2) NNPR=1
      DO 1085 I=J,N,NNPR
      Y=YU(I)
      WAVEHT=YU(I)-YI(1)
      CALL SECT(Y,I,A,B,DB,AT,BT)
      QQ=0.001*QU(I)
      V=QU(I)/A
      DH=A/B
      FRD=V/SQRT(G*DH)
      CALL FRICT(Y,I,CMM)
      IF(I.EQ.J) PRINT 1080, TT,DT,ITERR,FRDMIN,FRDMAX
1080 FORMAT(1H ,10X,3HIT=,F7.3,10X,4HDH=,F7.4,10X,6HITERR=,I3,
1      10X,13HFRD RANGE=,F5.2,4H TO ,F5.2)
      IF(I.EQ.J .AND. KSIT.EQ.2) PRINT 1082
1082 FORMAT(1H+,80X,'NO SOLUTION')
      IF(1.EQ.J) PRINT 1085
      PRINT 1087, X(I),Y,V,A,B,BT,QU,CMM,FKC(1),WAVEHT,DH,FRD
C
1085 CONTINUE
1086 FORMAT(1H0,5X,4HX(I),7X,1HY,9X,1HV,9X,1HA,9X,1HB,9X,
1      2HBT,4X,9H J X 1000,4X,3HCMM,3X,3HFKC,6X,5HWAVEHT,
2      5X,2HDH,4X,3HFRD,4X,/,
3      4X,7(1H*),1X,9(1H*),3X,7(1H*),2X,8(1H*),2X,8(1H*),3X,
4      7(1H*),2X,9(1H*),2X,8(1H*),3X,7(1H*),3X,7(1H*),1X,
5      6(1H*),1X,6(1H*))
1087 FORMAT(2X,F8.3,2X,F8.2,4X,F5.2,3X,F7.0,3X,
1      F7.0,4X,F6.0,3X,F8.3,3X,F7.4,4X,F6.2,3X,
2      F7.2,2X,F5.1,2X,F5.2,3X,F7.0)
      QQ=QU(N)/1000.
      IF(I-NNPR.NE.N.AND.JNK.EQ.9) PRINT 1088, X(N),YU(N),QQ
1088 FORMAT (2X,F8.3,2X,F8.2,43X,F8.3)
C
1089 IF(JNK.EQ.9) PRINT 25
C
      SVOL=0.0
      VZ=N-1
      DO 1090 I=J,NZ
      QQA=0.5*(QU(I)+QU(I+1))

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      QDA=0.5*(QDI(I)+QDI(I+1))
      QMA=0.5*(QMI(I)+QMI(I+1))
      QLT=(QQA-QDA)/(QMA-QDA)*QLL
      IF (ABS(QLT).GT.ABS(QLL)) QLT=QLL
      IF (QLT.GT.0.0) QLT=0.0
      VOL=QLT*DDX(I)*DT/43560.
      SVOL=SVOL+VOL
1090 CONTINUE
C
      IF (TT.GT.0.0) VQLLT=VQLLT+SVOL
      QTBT=QTBT1+QTBT2
      IF (KIT.EQ.0) QTBT=QTBT(1,1)+QTBT(2,1)
      IF (TT.GT.0.0) VQTBT=VQTBT+QTBT*DT/43560.
C
      IF (JNK.EQ.3) PRINT 1095, TT, DTH, ITERR, FRDMIN, FRDMAX, QLT, QTBT,
      *      QJ(J), YJ(J), QJ(N), YJ(N)
1095 FORMAT(14, F8.3, 2X, F7.4, 4X, I2, 6X, F5.2, F6.2, F12.3, F12.0, F15.0,
1      F15.2, F15.0, F15.2)
      IF (JNK.EQ.3 .AND. KSIT.EQ.2) PRINT 1098
1098 FORMAT(14, 19X, 'NO SOLUTION')
C
C      STORE STAGE AND DISCHARGE FOR PLOTTING
C
      IF (KTIME.GT.599) GO TO 1160
      KTIME=KTIME+1
      TTP(KTIME)=TT
      QS(KTIME)=QU(N)
      VNP=V/4
      IF (VNP.LE.0) VNP=1
      II=J
      DO 1103 K=1,6
      QCM(KTIME,K)=QJ(II)*0.001
      II=II+VNP
      IF (II.GT.N) II=N
1103 CONTINUE
C
1105 CONTINUE
      IF (NTT.EQ.0) GO TO 1120
      DO 1115 K=1,NTT
      DO 1110 I=J,N
      IF (I.NE.NT(K)) GO TO 1110
      YC(KTIME,K)=YU(I)
      QC(KTIME,K)=QU(I)*0.001
1110 CONTINUE
1115 CONTINUE
C
1120 CONTINUE
C
      FACI=0.5
      DO 1145 I=J,N
      DQ=QJ(I)-QD(I)
      DY=YJ(I)-YD(I)
      QP=QJ(I)+DQ*FACI
      YP=YJ(I)+DY*FACI
      YD(I)=YU(I)
      YU(I)=YP
      QD(I)=QU(I)
      QU(I)=QP
1145 CONTINUE
C

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C      RETURN FOR ANOTHER TIME STEP
C
C      IF(KIT.LE.1) GO TO 955
C      GO TO 980
C
C      END SOLUTION ROUTINE
C
1147 PRINT 1148
1148 FORMAT(140,////,10X,'NOT ENOUGH COMPUTATIONAL NODES, MINIMUM OF 5.
      * REDUCE JXM OR POSSIBLY JPSH. ')
      GO TO 1350
1150 CONTINUE
      VCHLE=0.0
      CALL SECT(YU(J),J,A,B,DB,AT1,BT)
      J1=J+1
      DO 1157 I=J1,N
      CALL SECT(YU(I),I,A,B,DB,AT2,BT)
      VCHLE=VCHLE+DDX(I-1)*(AT1+AT2)/2.
1157 AT1=AT2
      VCHLE=VCHLE/43560.
      PRINT 25
      VERROR=-1.0*(VQIN+VQBTBT+VQLLT-VQOUT+(VCHLS-VCHLE))
      IF(JNK.GE.3) PRINT 1158, VCHLS,VCHLE,VQIN,VQOUT,VQLLT,VQBTBT,VERROR
1158 FORMAT(10X,'MASS BALANCE',/,9X,14(1H*),/,48X,'AC-FT',/,
      1 10X,'CHANNEL VOLUME AT START',5X,F12.1/,
      2 10X,'CHANNEL VOLUME AT END',10X,F12.1/,
      3 10X,'INFLOW VOLUME',15X,F12.1/,
      4 10X,'OUTFLOW VOLUME',17X,F12.1/,
      5 10X,'LATERAL LOSS VOLUME',12X,F12.1/,
      6 10X,'TRIBUTARIES INFLOW VOLUME',6X,F12.1,/,
      7 10X,'VOLUME ERROR',19X,F12.1)
      IF(JNK.LE.2) GO TO 1170
      PRINT 25
1160 PRINT 1165, KTIME,TT
1165 FORMAT(/10X,64KTIME=,I3,5X,194A_LOWABLE KTIME=600,10X,3HTT=,F6.1)
C
C PRINT PROFILE OF DOWNSTREAM CRESTS AND TIMES
C
1170 CONTINUE
      PRINT 1285
      PRINT 1180
1180 FORMAT(///,15X,'PROFILE OF CRESTS AND TIMES',/,
      2 7X,424RVR MILE      MAX ELEV  MAX DEPTH  MAX FLOW,
      3 3X,304TIME MAX      MAX VEL    MAX VEL, /,
      4 7X,424FROM DAM      (FT)        (FT)        (CFS) ,
      5 3X,304ELEV(42)      (FT/SEC)    (MI/HR), /,
      6 6X,10(1H*),2X,9(1H*),2X,9(1H*),2X,10(1H*),2X,3(1H*),
      7 2X,10(1H*),2X,9(1H*),/)
1185 CONTINUE
C
      DO 1200 I=1,N
      Y=YM(I)
      CALL SECT(Y,I,A,B,DB,AT,BT)
      VM=QMX(I)/A
      IQ=QMX(I)
      VMM=VM*0.6818
      DEPM = YM(I) - HS(1,I)
      PRINT 1195, X(I),YM(I),DEPM,IQ,TM(I),VM,VMM
1195 FORMAT(7X,F8.3,4X,F7.2,4X,F7.2,4X,I8,4X,F6.2,5X,F6.2,5X,F6.2)

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1200 CONTINUE
C
      IF (NTT.EQ.0) GO TO 1245
C
C   TABULATE AND PLOT DESIGNATED HYDROGRAPHS (MAX OF 6)
C
      PRINT 1285
      PRINT 25
      PRINT 1210
1210  FORMAT(5X,'STAGE HYDROGRAPHS AT SELECTED CROSS SECTIONS',/,/,1X,
*      6X,1HK,4X,6HTTP(K),6X,16MYC(K,I),I=1,NTT),/,
1      4X,5(1H*),1X,8(1H*),4X,18(1H*),/)
      DO 1220 K=1,KTIME
      PRINT 1215, K,TTP(K),(YC(K,I),I=1,NTT)
1215  FORMAT(5X,I3,2X,F7.3,6(F12.2))
1220  CONTINUE
      PRINT 25
      PRINT 25
      PRINT 1225
1225  FORMAT(5X,'DISCHARGE HYDROGRAPHS AT SELECTED CROSS SECTIONS',/,/,
*      7X,1HK,4X,6HTTP(K),6X,16MQC(K,I),I=1,NTT),/,
1      4X,5(1H*),1X,8(1H*),4X,18(1H*),/)
      DO 1230 K=1,KTIME
      PRINT 1216, K,TTP(K),(QC(K,I),I=1,NTT)
1216  FORMAT( 5X, I3, 2X, F7.3, 3P6F12.1 )
1230  CONTINUE
1235  CONTINUE
      DO 1240 K=1,NTT
      NTS=NT(K)
      XMI=X(NTS)
      GAZERO=HS(1,NTS)
      FLDST=0.0
      JJNK=JNK
      CALL PLOT(K,KTIME,NTS,XMI,GAZERO,FLDST,JJNK)
1240  CONTINUE
C
1245  DO 1250 K=1,KTIME
      Q(K)=QS(K)
      TI(K)=TTP(K)
1250  CONTINUE
C
      QMAX=Q(1)
      DO 1260 K=2,KTIME
      IF (Q(K).GT.QMAX) TP=TI(K)
      IF (Q(K).GT.QMAX) QMAX=Q(K)
1260  CONTINUE
C
      IF (JNK.GE.3) PRINT 1265, TP,QMAX
1265  FORMAT(////////,5X,5HTP = ,F10.2,10X,7HQMAX = ,F12.2,////////)
C
      NU=KTIME
      KUI=0
1280  CONTINUE
      PRINT 1285
1285  FORMAT(1H1)
      GO TO 5
C
1290  FORMAT(8I10)
1300  FORMAT(8F10.0)
1350  STOP
      END

```


SUBROUTINE BDARY(J)

BDARY -- COMPUTES:

- 1) INFOW DISCHARGES FOR CURRENT TIME STEP
- 2) OTHER BOUNDARY CONDITIONS FOR CURRENT TIME STEP

COMMON/SUPC/ KSUPC

COMMON/SIM/ Q(500),TI(600),QI(600),YO,SUM,CMN,YBMIN,BB,Z,TFH,TEH

1 ,NU,JVK,QO,QMAX,QMI(200),QDI(200),QLL,UPSH,KUI

2 ,HF,HJ,HSP,HGT,CS,CG,CD,QT,TP,KK,KTMAX

COMMON/M1/ QU(200),QD(200),YJ(200),YD(200),JDX(200),FKC(200),G,DT

1 ,TT,ITER,KIT,VFSV

COMMON/SS/ HS(8,200),BS(8,200),BSS(8,200),AS(8,200),ASS(8,200),NCS

COMMON/MTX/ Q(500,4),XX(500),C(600),V,KU,NIT

1 ,NL,KKN,UTHI,UTHII,UTD,UTH,TFD

COMMON /TRIB/ QTB(2,500),TJ(500),VTB(2),QTB1,QTB2,VTBT

QTB1=0.0

QTB2=0.0

KL=0

NL=2*N

IF(KUI.LE.0) GO TO 5

IF(YJ(J).LE.(HS(1,J)+UPSH)) J=J+1

IF(J.GT.1) QU(J)=QO(J)

IF(J.GT.1) C(1)=0.0

IF(J.GT.1) GO TO 8

5 CALL INTERP(TINP,IT1,IT2,TT,KL)

QU(1)=Q(IT2)+(Q(IT1)-Q(IT2))*TINP

IF (QU(1).LT.QDI(1)) QU(1)=QDI(1)

8 IF(VTBT.EQ.0) GO TO 10

KL=1

CALL INTERP(TINP,IT1,IT2,TT,KL)

QTB1=QTB(1,IT2)+(QTB(1,IT1)-QTB(1,IT2))*TINP

QTB2=QTB(2,IT2)+(QTB(2,IT1)-QTB(2,IT2))*TINP

10 C(1)=0.

D(1,1)=1.0

D(1,2)=0.

IF(KUI.EQ.1) GO TO 20

GO TO 40

20 IF(TT.LE.0.001) T=0.00

QWY=0.

QWQ=0.

Y=YU(V)

IF(TT.LE.0.01.AND.Y.LT.HF) VFAIL=0

IF(NFAIL.EQ.1) GO TO 25

IF(Y.GE.(HF-0.5) .AND. Y.LE.HF) TFO=TT

IF(Y.GE.(HF-0.5) .AND. Y.LE.HF) DTD=DTTHI

IF(Y.GE.(HF-0.5) .AND. Y.LE.HF) DTHI=DTTHI

IF(Y.GE.(HF-0.5) .AND. Y.LE.HF) DTH=DTTHI

IF(Y.GE.HF) NFAIL=1

IF(TT.LE.0.001 .AND. VFAIL.EQ.1) QN=Q(1)

IF(NFAIL.EQ.0) YB=HD

IF(NFAIL.EQ.0) QW=0.00

IF(NFAIL.EQ.0) GO TO 30

25 IF(ITER.EQ.1) T=T+DT/3600.0

HB=AMIN1(HF,HD)

YB=HB-(HB-YBMIN)*T/TFH

IF(YB.LE.YBMIN) YB=YBMIN

IF(YB.LE.YBMIN) JT=0.00

```

IF(Y.LE.YB) GO TO 30
CALL SECT(Y,N,A,B,DB,AT,BT)
FK=CMN/(1.486*SQR(SOM/5280.0)*B)
DD=(QN*FK)**0.50+HS(1,N)
IF(DD.LE.YB) SUB=1.00
IF(DD.LE.YB) SUB1=1.00
IF((DD-YB).GT..67*(Y-YB)) SUB=1.-27.8*((DD-YB)/(Y-YB)*0.67)**3
IF(SUB.GT.SUB1) SUB=SUB1
SUB1=SUB
C1=3.08*RB*SUB
C2=2.44*7*SUB
QW=C1*(Y-YB)**1.5+C2*(Y-YB)**2.5
DQNY=1.5*C1*(Y-YB)**0.5+2.5*C2*(Y-YB)**1.5
DQVQ=0.
30 QNSP=0.
   QNGT=0.
   QNOB=0.
   DQSP=0.
   DQGT=0.
   DQOB=0.
   IF(Y.GT.HSP) QNSP=CS*(Y-HSP)**1.5
   IF(Y.GT.HSP) DQSP=1.5*CS*(Y-HSP)**0.5
   IF(Y.GT.HGT) QNGT=CG*(Y-HGT)**0.5
   IF(Y.GT.HGT) DQGT=0.5*CG*(Y-HGT)**0.5
   IF(Y.GT.HD) QNOB=CD*(Y-HD)**1.5
   IF(Y.GT.HD) DQOB=1.5*CD*(Y-HD)**0.5
   QN=QW+QGT+QNSP+QNGT+QNOB
   DQNY=DQNY+DQSP+DQGT+DQOB
   DQVQ=0.
   GO TO 50
40 M=N
   IF(KSUPC.EQ.1) M=1
   Y=YU(M)
   CALL SECT(Y,M,A,B,DB,AT,BT)
   CALL FRIC(Y,M,CMJ)
   YP=YU(M)
   CALL SECT(YP,M,AP,BP,DBP,ATP,BTP)
   ML=M-1
   IF(M.EQ.1) ML=2
   YPU=YU(ML)
   CALL SECT(YP,ML,APJ,BPJ,DBPJ,ATJ,BTU)
   IF(M.EQ.1) SF=(YU(1)-YU(2))/DDX(1)-1./G/DT*(QU(1)/A-QD(1)/AP)-1./G
1/DXX(1)*QD(1)/AP*(QD(2)/APJ-QD(1)/AP)
   IF(M.GT.1) SF=(YU(ML)-YU(M))/DDX(ML)-1./G/DT*(QU(M)/A-QD(M)/AP)-1.
1/G/DDX(ML)*QD(M)/AP*(QD(M)/AP-QD(ML)/APJ)
   PSFY=0.
   IF(KSUPC.EQ.1) SF=SOM/5280.
   IF(KIT.GE.9) GO TO 45
   IF(KSUPC.EQ.1) GO TO 45
   IF(QU(N).GT.(1.1*QDI(N))) NSFSV=1
   IF(QU(N).LT.(0.9*QDI(N))) NSFSV=1
45 IF(NSFSV.EQ.1) SF=SOM/5280.0
   IF(SF.GT.0.) SF1=SF
   IF(SF.LE.0.00) SF=SF1
   IF(A.LE.0.00.OR.B.LE.0.00) VIT=1
   IF(A.LE.0.00.OR.B.LE.0.00) RETURN
   R=(A/B)**(2./3.)
   DR=2./3.*R*(B/A-DB/B)
   DQVQ=0.
   PNH=0.

```

```

QN=1.486/CMU*A*R*SQRT(SF)
DQNY=QN*(DR/R+3/A+0.5/SF*PSFY+PN4)
IF(KSUPC.EQ.1) GO TO 55
50 NL=2*(N-J+1)
   C(NL)=- (QU(N)-QN)
   D(NL,3)=1.0-DQNY
   D(NL,4)=-DQNY
   GO TO 50
55 C(2)=- (QU(1)-QN)
   D(2,1)=1.-DQNY
   D(2,2)=-DQNY
60 RETURN
END

```

SUBROUTINE DAMBRK

DAMBRK -- COMPUTES THE FLOOD WAVE HYDROGRAPH FROM A RESERVOIR
THAT MAY HAVE A FAILING DAM. THE ALGORITHM
USES THE PRINCIPLE OF STORAGE-CONTINUITY.

```
COMMON/SIM/ Q(500),TI(600),JI(600),YD,SOM,CMN,YBMIN,BB,Z,TFH,TEH
1  ,NU,JNK,QD,QMAX,QMI(200),QDI(200),QLL,UPSH,KUI
2  ,HF,HJ,HSP,HGT,CS,CG,CD,AT,TP,KK,KTMAX
COMMON/SJRA/ SA(8),HSA(8)
COMMON/SS/ HS(8,200),BS(8,200),BSS(8,200),AS(8,200),ASS(8,200),NCS
COMMON /NAMES/ MNAME(10),MRSVR(5),MRVR(5)
DIMENSION TTP(500)
```

```
SVOL=0.
RH=0.
DO 5 K=2,8
SVOL=SVOL+0.5*(SA(K-1)+SA(K))*(HSA(K-1)-HSA(K))
5  RH=RH+(HSA(K-1)-HSA(K))
VOL=0.
Y1=YD
CALL SJRFAR (Y1,A1,D1)
10 Y2=Y1-1.0
CALL SJRFAR (Y2,A2,D2)
VOL=VOL+0.5*(A1+A2)*(Y1-Y2)
IF(Y2.LT.(HSA(8)+1.)) GO TO 15
Y1=Y2
A1=A2
GO TO 10
15 IF(ABS(RH-YD).LT.1.00) VOL=SVOL
C
IF(JNK.LE.1) GO TO 30
PRINT 25, MRSVR,VOL
25 FORMAT(5X,32HTOTAL VOLUME IN RESERVOIR BEHIND,/,
2  14X,5A4,3H = ,F10.1,10H ACRE-FEET)
```

```
30 TI(1)=0.0
ITEH=TEH+1.01
DO 35 K=2,ITEH
35 TI(K)=TI(K-1)+1.
NU=ITEH
DT=TFH*0.02
DISVOL=0.
SUB1=1.00
I=1
TT=0.
T=0.
KT=0
SUB=1.0
VCDR=1.0
H1=YD
TTP(1)=0.
YD=(HS(2,1)+HS(1,1))/2.0
CALL SECT (YD,1,4,30,03,AT,BT)
FK=CMN/(1.486*SQR(SOM/5280.))
H2=YD
QSP=0.
QGT=0.
QDQ=0.
```



```

IF(H2.GT.HSP) QSP=CS*(H2-HSP)**1.5
IF(H2.GT.HGT) QGT=CG*(H2-HGT)**0.5
IF(H2.GT.HD) QDD=CD*(H2-HD)**1.5
Q(1)=QSP+QGT+QDD+QT
Q1=Q(1)
Q1=Q(1)
Q2=Q1
YB=HD
D=(Q2*FK/B0)**0.50
K=0
NFAIL=0
IF(H2.GE.HF) NFAIL=1
IF(NFAIL.EQ.0) DTH=0.1
IF(NFAIL.EQ.1) DTH=0.02*TFH

C
IF(JNK.LE.1) GO TO 70
40 PRINT 55
45 FORMAT(////////)
PRINT 50
50 FORMAT(12X,24HDEFINITION OF VARIABLES ,
1 24HIN RESERVOIR DEPLETION TABLE,/,
2 10X,94HPARAMETER,35X,54HUNITS,2X,8HVARIABLE,/,
3 9X,42(1H*),2X,7(1H*),2X,5(1H*),/,
4 10X,32HTIME STEP FROM START OF ANALYSIS,23X,14H1,/,
5 10X,44HITERATIONS NECESSARY TO SOLVE FLOW EQUATIONS,11X,14HK,/,
6 10X,35HELAPSED TIME FROM START OF ANALYSIS,
7 10X,3HHRS,4X,6HTTP(1),/,
8 10X,19HOUTFLOW FROM BREACH,26X,3HCFPS,5X,4HQ(1),/,
9 10X,33HELEVATION OF WATER SURFACE AT DAM,13X,2HFT,6X,2HH2,/,
A 10X,29HELEVATION OF BOTTOM OF BREACH,17X,2HFT,6X,2HYB,/,
B 10X,40HEST DEPTH OF FLOW IMMEDIATELY DOWNSTREAM,
C 5X,2HFT,7X,14H,/,
D 10X,23HSUBMERGENCE COEFFICIENT,31X,3HSUB,/,
E 10X,19HVELOCITY CORRECTION,34X,4HVCOR,/,
F 10X,49HTOTAL VOLUME DISCHARGED FROM TIME OF BREACH AC-FT,
G 3X,6HOUTVOL)
55 FORMAT(141)
PRINT 50
60 FORMAT(////////,28X,25HRESERVOIR DEPLETION TABLE,/,
1 5X,14H1,3X,5HK TTP(1),5X,4HQ(1),6X,2HH2,7X,2HYB,8X,14H,
2 5X,3HSUB,2X,4HVCOR,4X,6HOUTVOL,/,
3 4X,3H***,2X,2H**,1X,5(1H*),2X,8(1H*),2X,7(1H*),2X,7(1H*),
4 2X,7(1H*),2X,4H****,2X,4H****,2X,9(1H*),/)

C
IQ=Q(1)
PRINT 55, I,K,TTP(1),IQ,H2,YB,D,SUB,VCOR,DISVOL
65 FORMAT(4X,I3,2X,12,F7.3,110,3F9.2,2F6.2,F11.1)

C
70 H2=H1-(H1-H2)
IF(H2.GE.HF) NFAIL=1
IF(NFAIL.EQ.0) GO TO 75
IF(KT.EQ.0) DTH=0.02*TFH
IF(T.GT.(4.0*TFH)) KT=1
IF(KT.EQ.1) DTH=DTH*1.1
IF(DTH.GT.0.25) DTH=0.25
IF(T.GE.TEH) GO TO 200
IF(I.GE.598) GO TO 200
T=T+DTH
75 TT=TT+DTH
IF(TT.GT.(1.5*TEH)) GO TO 200

```

```

HB=AMIN1(HD,HF)
IF(NFAIL.EQ.1) YB=HB-(HB-YBMIN)*T/TFH
IF(YB.LE.YBMIN) YB=YBMIN
CALL INTERP (TINP,IT1,IT2,TT)
QI2=QI(IT2)+(QI(IT1)-QI(IT2))*TINP
IF(T.GT.TFH) QT=0.
FCON=1-QI1-QI2+QT
DTS=DT+3600.
CALL SURFAR (H1,SA1,DAH1)
C
DO 95 K=1,25
FSP=0.
FPSP=0.
IF(H2.GT.HSP) FSP=CS*(H2-HSP)**1.5
IF(H2.GT.HSP) FPSP=1.5*CS*(H2-HSP)**0.5
FGT=0.
FPGT=0.
IF(H2.GT.HGT) FGT=CG*(H2-HGT)**0.5
IF(H2.GT.HGT) FPGT=0.5*CG/(H2-HGT)**0.5
FDD=0.
FPDD=0.
IF(H2.GT.HD) FDD=CD*(H2-HD)**1.5
IF(H2.GT.HD) FPDD=1.5*CD*(H2-HD)**0.5
FF=FSP+FPGT+FDD
FPP=FPSP+FPGT+FPDD
IF(H2.LE.(YBMIN+0.1)) GO TO 145
CALL SURFAR (H2,SA2,DAH2)
DS=(SA1+SA2)*(H2-H1)*0.5*43560.
DDSH=((SA1+SA2)*0.5+(H2-H1)*0.5*DAH2)*43560.
IF(NFAIL.EQ.1) GO TO 85
F=2.*DS/DTS+FCON
FP=2./DTS*DDSH
GO TO 90
85 FB=H2-YB
IF(FB.LE.0.0) FB=0.0001
DF=3.08*38*SUB*VCUR
EF=2.44*7*SUB*VCUR
F=2.*DS/DTS+DF*FB**1.5+EF*FB**2.5+FCON
FP=2./DTS*DDSH+1.5*DF*FB**0.5+2.5*EF*FB**1.5
90 F=F+FF
FP=FP+FPP
H2V=H2-F/FP
IF(ABS(H2N-H2).LE.0.0001) GO TO 100
95 H2=H2V
C
100 H2=H2V
QSP=0.
QGT=0.
QDD=0.
IF(H2.GT.HSP) QSP=CS*(H2-HSP)**1.5
IF(H2.GT.HGT) QGT=CG*(H2-HGT)**0.5
IF(H2.GT.HD) QDD=CD*(H2-HD)**1.5
IF(NFAIL.EQ.0) QC=0.
IF(NFAIL.EQ.1) Q2=DF*(H2-YB)**1.5+EF*(H2-YB)**2.5
IF(QSP.GT.0.0.OR.QGT.GT.0.0) GO TO 105
IF(Q2.GT.0.0.OR.QDD.GT.0.0) GO TO 105
IF(QT.GT.0.0) GO TO 105
GO TO 145
105 CONTINUE
Q2=Q2+QT+QSP+QGT+QDD

```

```

FK=1.486/CMN*(SQRT(SOM/5280.))
YD=HS(1,1)+D
IF(I.EQ.1) QQ=(Q2+Q(1))/2.0
IF(I.GT.1) QQ=(Q2+Q(I-1)+Q(1))/3.0
C
DO 110 K2=1,10
CALL SECT (YD,1,4,3,DB,AT,BT)
F=QQ*B**(2.0/3.0)-FK*A**(5.0/3.0)
FP=(2.0/3.0)*QQ*DB/H**(1.0/3.0)-(5.0/3.0)*FK*B*A**(2.0/3.0)
YD1=YD-F/FP
IF(YD1.LE.HS(1,1)) GO TO 115
IF(ABS(YD1-YD).LE.0.01) GO TO 115
110 YD=YD1
C
115 D=YD1-HS(1,1)
IF(D.LE.0.00) D=(QQ/(FK*0.5*(HS(1,1)+HS(2,1))))**0.60
IF(D.LE.YB) SUB=1.0
IF(D.LE.YB) GO TO 120
IF(D.GE.0.98*H2) GO TO 120
IF((D-YB).GT..57*(H2-YB)) SUB=1.-27.8*((D-YB)/(H2-YB)-0.67)**3
120 YR=HS(1,1)+H2
IF(SUB.GT.SUB1) SUB=SUB1
SUB1=SUB
CALL SECT (YR,1,4,3,DB,AT,BT)
IF(NFAIL.EQ.0) VCOR=1.0+0.023*QQ*QQ/(B*B*H2*H2*(H2-HSP))
IF(NFAIL.EQ.1) VCOR=1.0+0.023*QQ*QQ/(B*B*H2*H2*(H2-YB))
IF(VCOR.GT.1.5) VCOR=1.5
I=I+1
IF(Q2..LT.Q(1)) Q2=Q(1)
Q(1)=Q2
TTP(I)=TT
H1=H2
Q11=Q12
Q1=Q2
IF(T.EQ.0) DISVOL=0.0
IF(T.EQ.0) GO TO 125
DISVOL=DISVOL+0.5*(Q(1)+Q(I-1))*T*H*3600./43560.
125 CONTINUE
C
IF(JWK.LE.1) GO TO 70
IQ=Q(1)
140 PRINT 65, I,K,TTP(I),IQ,H2,YB,D,SUB,VCOR,DISVOL
C
GO TO 70
145 IF(T.GT.TEH) GO TO 200
I=I+1
IF(I.GE.598) GO TO 195
Q(I)=Q(I-1)*0.90
IF(Q(1)..LT.Q(1)) Q(1)=Q(1)
TTP(I)=TT
IF(T.GT.(4.0*T*H)) DTH=DTH*1.1
T=T+DTH
TT=TT+DTH
C
IF(JWK.LE.1) GO TO 145
IQ=Q(I)
PRINT 165,I,K,TTP(I),IQ,DISVOL
165 FORMAT(4X,I3,2X,I2,F7.3,I10,3X,F11.1)
C
GO TO 145

```

```

195  Q(I)=Q(I-2)
      TTP(K)=TEH
200  CONTINUE
      QM=Q(1)
      NU=I
      DO 210 K=1,NU
        TI(K)=TTP(K)
        IF(Q(K).GT.QM) TP=TTP(K)
        IF(Q(K).GT.QM) QM=Q(K)
210  CONTINUE
      QMAX=QM
C
      IF(JNK.LE.2) RETURN
      PRINT 45
      PRINT 220, Q(1),QM,Q(NU),TP,NU,DISVOL
220  FORMAT(29X,'RESERVOIR SUMMARY',//,1X,
*      10X,9HPARAMETER,35X,15HUNITS VARIABLE,5X,5HVALUE,/,
1      9X,43(1H*),1X,7(1H*),2X,5(1H*),2X,11(1H*),/,
2      10X,12HINITIAL FLOW,33X,3HCFS,5X,4HQ(1)3X,F10.0,/,
3      10X,8HMAX FLOW,37X,3HCFS,5X,2HQM,5X,F10.0,/,
4      10X,10HFINAL FLOW,35X,3HCFS,5X,5HQ(NU),2X,F10.0,/,
5      10X,16HTIME TO MAX FLOW,29X,3HHRS,5X,2HTP,9X,F6.2,/,
6      10X,20HNUMBER OF TIME STEPS,33X,2HNJ,11X,I4,/,
7      10X,39HTOTAL VOLUME DISCHARGED FROM RESERVOIR,
8      5X,5HAC-FT,3X,5HDISVOL,2X,F10.0)
      RETURN
      END

```


SUBROUTINE FRIC(Y,I,CMM)

FRIC -- COMPUTES THE MANNING N FROM THE ELEVATION
AND SUBREACH NUMBER.

COMMON/FRIC/CM(8,200)

COMMON/SS/ HS(8,200),BS(8,200),BSS(8,200),AS(8,200),ASS(8,200),

IF(Y.LE.HS(1,I)) CMM=CM(1,I)

IF(Y.LE.HS(1,I)) GO TO 15

IF(Y.GE.HS(NCS,I)) CMM=CM(NCS,I)

IF(Y.GE.HS(NCS,I)) GO TO 15

DO 5 J=2,NCS

K=J

IF(Y.LE.HS(K,I)) GO TO 10

CONTINUE

L=K-1

DCM=(CM(K,I)-CM(L,I))/(HS(K,I)-HS(L,I))

CMM=CM(L,I)+DCM*(Y-HS(L,I))

RETURN

END

SUBROUTINE INTER(J)

INTER -- COMPUTES THE COEFFICIENTS OF THE SYSTEM OF EQUATIONS
USED IN THE NONLINEAR, IMPLICIT SOLUTION.

COMMON/SUPC/ KSUPC

COMMON/SIM/ Q(500),TI(600),QI(500),YO,SOM,CMN,YBMIV,BB,Z,TFH,TEH

1 ,NU,JNK,QO,QMAX,QMI(200),QDI(200),QLL,UPSH,KUI

2 ,HF,HD,HSP,HGT,CS,C3,CD,QT,TP,KK,KTMAX

COMMON/M1/ QU(200),QD(200),YJ(200),YD(200),DDX(200),FKC(200),G,DT

1 ,IT,ITER,KIT,VSFSV

COMMON/MTX/ D(500,4),XX(500),C(600),N,KU,NIT

1 ,NL,KKN,DTHI,DTHII,DTD,DTH,TFD

COMMON /TRIB/ QTB(2,500),TJ(500),VTB(2),QTB1,QTB2,VTBT

L1=2

L2=1

L3=4

L4=3

NS=N-1

DO 90 I=J,NS

L=I+1

QTRIB=0.00

IF(I.EQ.VTB(1)) QTRIB=QTB1

IF(I.EQ.VTB(2)) QTRIB=QTB2

IF(I.GT.J) GO TO 10

II=2

IF(KSUPC.EQ.1) II=3

GO TO 15

II=II+1

II2=II+1

DO 80 K=1,4

GO TO(20,25,30,35),K

Y=YD(1)

IS=I

GO TO 40

Y=YU(1)

IS=I

GO TO 40

Y=YD(L)

IS=L

GO TO 40

Y=YU(L)

IS=L

CALL SECT(Y,IS,A,B,DB,AT,BT)

IF(A.LE.0.00 .OR. B.LE.0.00) NIT=1

IF(A.LE.0.00) PRINT 45, L,K,Y,A

FORMAT(///,5X,4HNEGATIVE AREA ENCOUNTERED IN SUBROUTINE INTER(J),

1 /,10X,7HNODE = ,I4,5X,4H = ,I4,5X,14HWATER LEVEL = ,F10.2,

2 5X,7HAREA = ,F10.1)

IF(A.LE.0.00 .OR. B.LE.0.00) RETURN

GO TO(55,60,65,70),K

ATDL=AT

BTDL=BT

ADL=A

```

        BDL=B
        GO TO 75
60      AUL=A
        BUL=B
        DBJL=DB
        ATUL=AT
        BTJL=BT
        GO TO 75
65      ATDR=AT
        BTDR=BT
        ADR=A
        BDR=B
        GO TO 75
70      AUR=A
        BUR=B
        BTJR=BT
        ATJR=AT
        DBJR=DB
75      CONTINUE
80      CONTINUE
C
      YQJ=0.5*(YU(I)+YU(L))
      YQJ=0.5*(YD(I)+YD(L))
      CALL FRIC (YQJ,1,CMJ)
      CALL FRIC (YQJ,1,CMJ)
      F1=0.60
      IF(KSUPC.EQ.1) F1=1.00
      PNL=0.
      PNR=0.
      DX=DDX(I)
      QUL=QU(I)
      QUR=QU(L)
      QDL=QD(I)
      QDR=QD(L)
      FE=FKC(I)
      FXT=0.5*DX/DT
      QAJ=0.5*(QUL+QUR)
      QAD=0.5*(QDL+QDR)
      BAJ=0.5*(BUL+BJR)
      BAD=0.5*(BDL+BJR)
      AAJ=0.5*(AUL+AJR)
      AAD=0.5*(ADL+AJR)
      RAJ=(AAJ/BAJ)**(2./3.)
      RAD=(AAD/BAD)**(2./3.)
      SFJ=CMJ*CMU*ABS(QAJ)*QAJ/(AAJ*AAJ*RAJ*RAJ*2.208)
      SFJ=CMJ*CMD*ABS(QAD)*QAD/(AAD*AAD*RAD*RAD*2.208)
      PSFHL=2.*SFU*(PNL-5.*BUL/6./AAJ+3*BUL/3./BAJ)
      PSFHR=2.*SFU*(PNR-5.*BUR/6./AAJ+3*BJR/3./BAJ)
      PSFQL=SFJ/QAJ
      PSFQR=SFJ/QAJ
      VUL=QUL/AUL
      VUR=QUR/AUR
      VDL=QDL/ADL
      VDR=QDR/ADR
      HLJ=(VJL-VUR)**2/64.4*FKC(I)
      HLD=(VDL-VDR)**2/64.4*FKC(I)
      HDJ=YU(L)-YU(I)+HLJ
      HDJ=YD(L)-YD(I)+HLD
      QQ=0.5*(QDI(L)+QDI(I))
      QMIX=0.5*(QMI(L)+QMI(I))

```

```

QLT=(QAU-QQ)/(QMX-QQ)*Q_L
IF(ABS(QLT).GT.ABS(QLL)) QLT=QLL
C(II)=- (F1*(QUR-QUL)+(1.-F1)*(QDR-QDL)+FXT*(ATUL+ATUR-ATDL-ATDR)
1-QLT*DX-QTR18)
D(II,L1)=FXT*BTUL
D(II,L2)=-F1
D(II,L3)=FXT*BTUR
D(II,L4)=F1
C(II2)=- (FXT*(QUL+QUR-QDL-QDR)+F1*(QUR*QUR/AUR-QUL*QUL/AUL+G*AAU
1*(HOU+DX* SFU ))+(1.-F1)*(QDR*QDR/ADR-QDL*QDL/ADL+G*AAD*(HDO+
2DX*SFU)))
D(II2,L1)=F1*( QUL*QUL*BUL/AUL/AUL+G*AAU*(-1.+DX* PSFHL )+
10.5*G*3UL*(HOU+DX* SFU))
D(II2,L2)=FXT+F1*(-2. *QUL/AUL+G*AAU*DX* PSFQL )
D(II2,L3)=F1*(- QUR*QUR*3UR/AUR/AUR+G*AAJ*(1.+DX* PSFHR )+
10.5*G*3UR*(HOU+DX* SFU))
D(II2,L4)=FXT+F1*(2. *QUR/AUR+G*AAJ*DX* PSFQR )
90 CONTINUE
RETURN
END

```


SUBROUTINE INTERP(TINP,IT1,IT2,TT,KL)

```

C
C      INTERP -- COMPUTES THE PARAMETERS NEEDED TO INTERPOLATE
C              THE DISCHARGE AT ANY INSTANT OF TIME FROM
C              A DISCHARGE HYDROGRAPH.
C
COMMON/SIM/ Q(500),TI(500),JI(500),YD,SOM,CMV,YBMIN,BB,Z,TFH,TEH
1  ,NU,JNK,QO,QMAX,QMI(200),QDI(200),QLL,UPSH,KUI
2  ,HF,HJ,HSP,HGT,CS,C6,CD,QT,TP,KK,KTMAX
COMMON /TRIB/ QTB(2,500),TJ(500),NTB(2),QTB1,QTB2,NTBT
C
C      IF(KL.EQ.1) GO TO 30
C
      DO 5 I=1,NU
      K=I
      IF(TT.LE.TI(K))GO TO 10
5     CONTINUE
10    IT1=K
      IT2=K-1
      IF(IT2.GT.0)GO TO 15
      IT2=K
      TINP=0.
      GO TO 20
15    TINP=(TT-TI(IT2))/(TI(IT1)-TI(IT2))
20    RETURN
C
30    DO 35 I=1,NU
      K=I
      IF(TT.LE.TJ(K)) GO TO 40
35    CONTINUE
40    IT1=K
      IT2=K-1
      IF(IT2.GT.0)GO TO 45
      IT2=K
      TINP=0.
      GO TO 50
45    TINP=(TT-TJ(IT2))/(TJ(IT1)-TJ(IT2))
50    RETURN
      END

```

```

SUBROUTINE MATRX
C
C   MATRX -- ALGORITHM FOR THE SOLUTION OF THE QUAD-DIAGONAL
C           SYSTEM OF EQUATIONS FOR SUBCRITICAL FLOW.
C
COMMON/MTX/ D(500,4),XX(500),C(500),N,KU,NIT
1   ,NL,KKN,DTH1,DTH11,DTC,DTH,TFD
C
N2=NL
MM=N2-2
K=0
C
DO 5 I=2,MM,2
IM=I-1
IP=I+1
L1=K+1
L2=K+2
B=-D(I,1)/D(IM,L1)
D(I,2)=B*D(IM,L2)+D(I,2)
C(I)=B*C(IM)+C(I)
B=-D(IP,1)/D(IM,L1)
D(IP,2)=B*D(IM,L2)+D(IP,2)
C(IP)=B*C(IM)+C(IP)
B=-D(IP,2)/D(I,2)
D(IP,3)=B*D(I,3)+D(IP,3)
D(IP,4)=B*D(I,4)+D(IP,4)
C(IP)=B*C(I)+C(IP)
K=2
5 CONTINUE
C
I=N2-1
B=-D(N2,3)/D(I,3)
D(N2,4)=B*D(I,4)+D(N2,4)
C(N2)=B*C(I)+C(N2)
XX(N2)=C(N2)/D(N2,4)
10 XX(I)=(C(I)-D(I,K+2)*XX(I+1))/D(I,K+1)
IF(I-1)25,25,15
15 II=I-1
XX(II)=(C(II)-D(II,4)*XX(II+2)-D(II,3)*XX(II+1))/D(II,2)
I=I-2
IF(I-1)20,20,10
20 K=0
GO TO 10
25 CONTINUE
RETURN
END

```

SUBROUTINE MATRXC

```

C
C   MATRXC -- ALGORITHM FOR THE SOLUTION OF THE QUAD-DIAGONAL
C               SYSTEM OF EQUATIONS FOR SUPERCRITICAL FLOW.
C
COMMON/MTX/ D(500,4),XX(500),C(500),N,KU,NIT
1  ,NL,KKN,DTHI,DTHII,DTO,DTH,TFD
C
  N2=NL
  B=-D(2,1)/D(1,1)
  D(2,2)=B*D(1,2)+J(2,2)
  C(2)=B*C(1)+C(2)
  MM=N2-1
C
  DO 5 K=3,MM,2
    L=1
    J=2
    IF(K.GT.3) L=3
    IF(K.GT.3) J=4
    KK=K-2
    KL=K-1
    KK=K+1
    B=-D(K,1)/D(K2,L)
    D(K,2)=B*D(K2,J)+D(K,2)
    C(K)=B*C(K2)+C(K)
    B=-D(KK,1)/D(K2,L)
    D(KK,2)=B*D(K2,J)+D(KK,2)
    C(KK)=B*C(K2)+C(KK)
    C(K)=-D(K,2)/D(K1,J)*C(K1)+C(K)
    C(KK)=-D(KK,2)/D(K1,J)*C(K1)+C(KK)
    B=-D(K,3)/D(K,3)
    D(KK,4)=B*D(K,4)+D(KK,4)
    C(KK)=B*C(K)+C(KK)
5  CONTINUE
C
  DO 10 I=1,N2,2
    L=N2-1+1
    IF(L.EJ.2) GO TO 15
    J=L-1
    XX(L)=C(L)/D(L,4)
    XX(J)=(C(J)-D(J,4)*XX(L))/D(J,3)
10  CONTINUE
C
15  XX(2)=C(2)/D(2,2)
    XX(1)=(C(1)-D(1,2)*XX(2))/D(1,1)
    RETURN
  END

```

```

      SUBROUTINE PLOT(K, KTIME, NTS, XMI, GAZERO, FLDST, JNK)
C
C  SUBROUTINE TO PLOT DESIGNATED HYDROGRAPHS
C
      COMMON /GRAF/ QC(600,6),YC(500,6),TTP(500)
      COMMON /NAMES/ MNAME(10),MRSVR(5),MRVR(5)
C
      DIMENSION MPLOT(51)
C
      INTEGER BLANK,EYE,STAR
      DATA BLANK,EYE,STAR/1H ,1H1,1H*/
C
C  DETERMINE CREST FLOW, STAGE, AND TIME TO CREST
C  ALSO DETERMINE A BASE FLOW ...
C  AVE OF FIRST 5 FLOWS IN QC + 0.20 * AVE
C
      B=0.00
      CRSTQ=0.0
      CRSTE=0.00
      CRSTS=0.0
      CRSTET=0.00
      CRSTQT=0.00
      DO 15 I=1,KTIME
      Q=QC(I,K)
      IF(I.GT.5) GO TO 5
      B=B+Q
5    S=YC(I,K)
      T=TTP(I)
      IF(Q.LE.CRSTQ) GO TO 10
      CRSTQ=Q
      CRSTQT=T
10   IF(S.LE.CRSTE) GO TO 15
      CRSTE=S
      CRSTET=T
15   CONTINUE
      CRSTS=CRSTE-GAZERO
      B=1.20*(B/5.00)
C
C  DETERMINE BEGINNING AND ENDING OF FLOOD WAVE
C
      IBGN=1
      DO 20 II=1,KTIME
      I=II
      Q=QC(I,K)
      IF(Q.GE.B) GO TO 25
20   CONTINUE
25   IBGN=I
      IF(IBGN.GT.0) IBGN=IBGN-1
      IBGN=IBGN
C
      IEND=I(KTIME)
      IEND=KTIME
      DO 30 II=1,KTIME
      I=IEND
      Q=QC(I,K)
      IF(Q.GE.B) GO TO 35
      IEND=IEND-1
30   CONTINUE
35   IEND=IEND

```



```

C
C DETERMINE INCREMENTAL HOUR OF HYDROGRAPH
C DESIRE MAX OF 49 LINES IN THE HYDROGRAPH
C
HDIF=HEND-HBGN
IF(HDIF.GT.192.0) HINCR=5.00
IF(HDIF.LT.193.0) HINCR=4.00
IF(HDIF.LT.145.0) HINCR=3.00
IF(HDIF.LT.97.0) HINCR=2.00
IF(HDIF.LT.48.0) HINCR=1.00
IF(HDIF.LT.25.0) HINCR=0.50
IF(HDIF.LT.12.0) HINCR=0.25
IF(HDIF.LT.10.0) HINCR=0.20
IF(HDIF.LT.5.0) HINCR=0.10
IF(HDIF.LT.2.5) HINCR=0.05
IF(HDIF.LT.0.5) HINCR=0.01
IF(HEND.LT.(HINCR*49.0)) HEND=HINCR*49.0-HBGN

C
C DETERMINE SCALE OF HYDROGRAPH
C
MAXFLO=CRSTQ*1000.0+0.5
IF(MAXFLO.GT.25000000) ISCL=MAXFLO/5
IF(MAXFLO.LE.25000000) ISCL=5000000
IF(MAXFLO.LE.10000000) ISCL=2000000
IF(MAXFLO.LE.5000000) ISCL=1000000
IF(MAXFLO.LE.2500000) ISCL=500000
IF(MAXFLO.LE.1000000) ISCL=200000
IF(MAXFLO.LE.500000) ISCL=100000
IF(MAXFLO.LE.250000) ISCL=50000
IF(MAXFLO.LE.100000) ISCL=20000
IF(MAXFLO.LE.50000) ISCL=10000
IF(MAXFLO.LE.25000) ISCL=5000
IF(MAXFLO.LE.10000) ISCL=2000
IF(MAXFLO.LE.5000) ISCL=1000
IF(MAXFLO.LE.2500) ISCL=500
IF(MAXFLO.LE.1000) ISCL=200
IF(MAXFLO.LE.500) ISCL=100
IS1=ISCL
IS2=IS1+IS1
IS3=IS2+IS1
IS4=IS3+IS1
IS5=IS4+IS1

C
C PRINT HEADINGS ON HYDROGRAPH
C
PRINT 40
40 FORMAT(141)
C
PRINT 50, MRVR,VIS,MRSVR,XMI
60 FORMAT(///,7X,25HDISCHARGE HYDROGRAPH FOR ,5A4,
1 20H ... STATION NUMBER ,I3,/,
2 20X,64HELOW ,5A4,94 AT MILE ,F5.2,/)
PRINT 65, GAZERO,CRSTE
65 FORMAT(7X,12HGAZE ZERO = ,F7.2,5X,
1 38HMAX ELEVATION REACHED BY FLOOD WAVE = ,F7.2)
PRINT 80, CRSTS,CRSTET,MAXFLO,CRSTJT
80 FORMAT(20X,12HMAX STAGE = ,F7.2,5X,10HAT TIME = ,F5.2,6H HOURS,/,
1 20X,12HMAX FLOW = ,I8,4X,10HAT TIME = ,F5.2,5H HOURS)
PRINT 85, IS1,IS2,IS3,IS4,IS5
85 FORMAT(/,6X,22H+ STAGE FLOW 0,5110)

```

```

C
C PLACE GRAPHING SYMBOLS ON HYDROGRAPH ... ONE LINE AT A TIME ...
C
C
      H=HSGN
      LINE=0
      DO 125 I=1,KTIME
90    T=TTP(I)
      S=YC(I,K)
      Q=QC(I,K)
      IQ=Q*1000.0+0.5
C
      IF(T.EQ.4) GO TO 95
      IF(T.LT.4) GO TO 125
C
C T .GT. 4 ... INTERPOLATE TO OBTAIN VALUES ON FINDER HOURS
C
      IM1=I-1
      TM1=TTP(TM1)
      IF((T-TM1).EQ.0.00) GO TO 125
      SLP=(H-TM1)/(T-TM1)
      QM1=QC(IM1,K)
      SM1=YC(IM1,K)
      Q=QM1+SLP*(Q-QM1)
      S=SM1+SLP*(S-SM1)
      IQ=Q*1000.0+0.5
C
95    DO 100 M=1,51
      MPLOT(M)=BLANK
100   CONTINUE
C
      DO 105 M=1,51,10
      MPLOT(M)=EYE
105   CONTINUE
C
      SCALE=ISCL
      N=Q*1000.0*10.0/SCALE+1.5
      IF(N.LT.1) N=1
      MPLOT(N)=STAR
C
      S=S-GAZERO
      IH=H
      IF(HINCR.EQ.0.01) PRINT 110, H,S,IQ,MPLOT
      IF(HINCR.EQ.0.05) PRINT 110, H,S,IQ,MPLOT
      IF(HINCR.EQ.0.10) PRINT 115, H,S,IQ,MPLOT
      IF(HINCR.EQ.0.20) PRINT 115, H,S,IQ,MPLOT
      IF(HINCR.EQ.0.25) PRINT 110, H,S,IQ,MPLOT
      IF(HINCR.EQ.0.50) PRINT 115, H,S,IQ,MPLOT
      IF(HINCR.GT.0.50) PRINT 120, H,S,IQ,MPLOT
110   FORMAT(3X,F6.2,F7.1,I9,2X,51A1)
115   FORMAT(4X,F5.1,F7.1,I9,2X,51A1)
120   FORMAT(5X,I3,F5.1,I9,2X,51A1)
C
      IF(LINE.GT.49) RETURN
      LINE=LINE+1
      IF(H.GE.HEND) RETURN
      H=H+HINCR
      IF(T.GT.4) GO TO 90
125   CONTINUE
      RETURN

```

SUBROUTINE SECT(Y,I,A,B,DB,AT,BT)

SECT -- COMPUTES THE AREAS AND TOP WIDTHS FROM A GIVEN
ELEVATION AND NODE NUMBER.

COMMON/SS/ HS(8,200),BS(8,200),BSS(8,200),AS(8,200),ASS(8,200),NCS
COMMON /NEGA/ YNEG,NEGI

IF(Y.GE.HS(1,I)).GO TO 5
IF(BS(1,I).EQ.0.0) B=0.5*(BS(1,1)+BS(2,1))
IF(BS(1,I).GT.0.0) B=BS(1,I)
A=(HS(1,I)-Y)*3
BT=B
AT=A
DB=0.
DBS=0.0
YNEG=Y
NEGI=1
GO TO 25

DO 10 K=2,NCS
IF(Y.LE.HS(K,I))GO TO 15
CONTINUE

K=NCS
DB=0.
DBS=0.
L=K
GO TO 20
15 L=K-1
DB=(BS(K,I)-HS(L,I))/(HS(K,I)-HS(L,I))
DBS=(BSS(K,I)-BSS(L,I))/(HS(K,I)-HS(L,I))
20 B=BS(L,I)+DB*(Y-HS(L,I))
A=AS(L,I)+0.5*(B+BS(L,I))*(Y-HS(L,I))
BSSS=BSS(L,I)+DBS*(Y-HS(L,I))
ASSS=ASS(L,I)+0.5*(BSSS+BSS(L,I))*(Y-HS(L,I))
BT=B+BSSS
AT=A+ASSS
25 RETURN
END

```

C
C
C
C
SUBROUTINE SURFAR (H,A,DAH)

SURFAR -- COMPUTES THE SURFACE AREA OF A RESERVOIR FROM
          AN ELEVATION AND RATING TABLE.

COMMON/SJRA/ SA(5),-SA(5)
DO 5 I=2,8
K=I
IF(H.GE.HSA(K)) GO TO 10
5 CONTINUE
10 J=K-1
DAH=(SA(J)-SA(K))/(HSA(J)-HSA(K))
A=SA(J)-DAH*(HSA(J)-H)
RETURN
END

```


D. LISTING OF SAMPLE INPUT CARD DECKS

a. Dam-break simulation with hydrologic reservoir routing.

```

HYPOTHETICAL DAM      EXAMPLE RIVER      LARRY F. LAND      USGS - WRD
FAILURE OF HYPOTHETICAL DAM ON EXAMPLE RIVER  HYDROLOGIC RESERVOIR ROUTING
&CARD<  KKN=2,      KUI=0                                &END
      100.      80.      70.      55.      40.      25.      10.      1.
      1050.      1045.      1040.      1035.      1030.      1025.      1020.      1000.
&CARD>  YO=1035., Z=0.50,  TEH=3.0,  YBMIN=1000.,      BB=50.0,
      TFH=0.25,  DATUM=0.0                                &END
&CARD>  HF=1035.0, QT=0.0,  HD=1050.0, CD=0.0,  HSP=1038., CS=0.0,
      HGT=1010., CG=250.                                &END
      1000.      5000.      3000.      2000.      1500.
&CARD>  NS=4,      NTT=1,  JVK=3,  KSA=0,  KSUPC=1,  NTBT=1      &END
1
3
      100.      100.      100.      100.      100.
      0.000
      1000.0      1010.0      1025.0      1050.0
      50.0      70.0      100.0      150.0
      0.0      0.0      0.0      0.0
      1.000
      900.0      910.0      925.0      950.0
      50.0      70.0      100.0      150.0
      0.0      0.0      0.0      0.0
      2.000
      800.0      810.0      825.0      850.0
      50.0      70.0      100.0      150.0
      0.0      0.0      0.0      0.0
      3.000
      700.0      710.0      725.0      750.0
      50.0      70.0      100.0      150.0
      0.0      0.0      0.0      0.0
      0.030      0.030      0.030      0.030
      0.030      0.030      0.030      0.030
      0.030      0.030      0.030      0.030
      0.25      0.25      0.25
      0.0      0.0      0.0
&CARD17  QMAXD=0.0, QOD=1350., QLL=0.0,  JTHM=0.0,  YDN=0.0      &END
&CARD>  NS=5,      NTT=0,  JVK=3,  KSA=0,  KSUPC=0,  NTBT=1      &END
2
      200.      200.      200.      200.      200.
      3.000
      700.0      710.0      725.0      750.0      800.0
      50.0      70.0      100.0      150.0      250.0
      0.0      0.0      0.0      0.0      0.0
      4.000
      650.0      670.0      685.0      710.0      760.0
      50.0      120.0      140.0      155.0      200.0
      0.0      0.0      160.0      220.0      250.0
      5.000
      640.0      650.0      665.0      690.0      740.0
      50.0      120.0      140.0      155.0      200.0
      0.0      0.0      160.0      220.0      250.0
      6.000
      625.0      635.0      650.0      675.0      725.0
      50.0      120.0      140.0      155.0      200.0
      0.0      0.0      160.0      220.0      250.0
      8.000
      600.0      610.0      625.0      650.0      700.0
      50.0      120.0      140.0      155.0      200.0
      0.0      0.0      160.0      220.0      250.0
      0.050      0.050      0.060      0.060      0.050
      0.050      0.050      0.060      0.060      0.050
      0.050      0.050      0.060      0.060      0.050
      0.050      0.050      0.060      0.060      0.050
      0.25      0.25      0.25      0.25
      -0.5      0.0      0.0      0.0
&CARD17  QMAXD=0.0, QOD=1550., QLL=0.0,  JTHM=0.0,  YDN=504.5      &END

```

b. Dam-break simulation with hydraulic reservoir routing.

```

HYPOTHETICAL DAM      EXAMPLE RIVER      LARRY F. LAND      USGS - WRD
FAILURE OF HYPOTHETICAL DAM ON EXAMPLE RIVER      HYDRAULIC RESERVOIR ROUTING
&CARD2  KKN=3,      KUI=1                                &END
&CARD3  Y0=1035., Z=0.50,      TE=3.0,      YBMV=1000.,      BB=50.0,                                &END
&CARD5  TFH=0.25, DATUM=0.0
HF=1036.0, DT=0.0,      TD=1050.0, CD=0.0,      MSP=1038., CS=0.0,                                &END
HGT=1010., CG=250.
1000.      5000.      3000.      2000.      1500.
&CARD9  NS=2,      NTT=0,      JVK=3,      KSA=0,      KSUPC=0,      NTBT=0                                &END
-1.000
1020.0      1030.0      1045.0      1070.0      1120.0
20.0      70.0      100.0      150.0      250.0
0.0      0.0      0.0      0.0      0.0
0.0000
1000.0      1010.0      1025.0      1050.0      1100.0
20.0      120.0      140.0      155.0      200.0
0.0      0.0      0.0      0.0      0.0
0.030      0.030      0.030      0.030      0.030
0.10
-0.50
&CARD17  QMAXD=0.0, QOD=1250., JLL=0.0,      DTMM=0.0,      YDN=1035.                                &END
&CARD18  UPMH=2.0, SUM=100.0,      CMV=0.030
&CARD9  NS=4,      NTT=1,      JVK=2,      KSA=0,      KSUPC=1,      NTBT=1                                &END
1
3
100.      100.      100.      100.      100.
0.000
1000.0      1010.0      1025.0      1050.0
20.0      70.0      100.0      150.0
0.0      0.0      0.0      0.0
1.000
900.0      910.0      925.0      950.0
20.0      70.0      100.0      150.0
0.0      0.0      0.0      0.0
2.000
800.0      810.0      825.0      850.0
20.0      70.0      100.0      150.0
0.0      0.0      0.0      0.0
3.000
700.0      710.0      725.0      750.0
20.0      70.0      100.0      150.0
0.0      0.0      0.0      0.0
0.030      0.030      0.030      0.030
0.030      0.030      0.030      0.030
0.030      0.030      0.030      0.030
0.25      0.25      0.25
0.0      0.0      0.0
&CARD17  QMAXD=0.0, QOD=1350., JLL=0.0,      DTMM=0.0,      YDN=0.0                                &END
&CARD9  NS=5,      NTT=2,      JVK=9,      KSA=0,      KSUPC=0,      NTBT=1                                &END
1
5
200.      200.      200.      200.
3.000
700.0      710.0      725.0      750.0      800.0
20.0      70.0      100.0      150.0      250.0
0.0      0.0      0.0      0.0
4.000
650.0      670.0      685.0      710.0      760.0
20.0      120.0      140.0      155.0      200.0
0.0      0.0      160.0      220.0      250.0
5.000
640.0      650.0      665.0      690.0      740.0
20.0      120.0      140.0      155.0      200.0
0.0      0.0      160.0      220.0      250.0
6.000
625.0      635.0      650.0      675.0      725.0
20.0      120.0      140.0      155.0      200.0
0.0      0.0      160.0      220.0      250.0
8.000
600.0      610.0      625.0      650.0      700.0
20.0      120.0      140.0      155.0      200.0
0.0      0.0      160.0      220.0      250.0
0.050      0.050      0.060      0.060      0.050
0.050      0.050      0.060      0.060      0.050
0.050      0.050      0.060      0.060      0.050
0.050      0.050      0.060      0.060      0.050
0.25      0.25      0.25      0.25
-0.5      0.0      0.0      0.0
&CARD17  QMAXD=0.0, QOD=1550., JLL=0.0,      DTMM=0.0,      YDN=604.5                                &END

```

c. Streamflow simulation without dam-break.

```

HYPOTHETICAL DAM      EXAMPLE RIVER      LARRY F. LAND      USGS - WRD
EXAMPLE OF STREAMFLOW ROUTING OPTION WITHOUT DAM-BREAK
&CARD2  KKN=10,      KUI=0                                &END
&CARD7  TEH=2.0,      DHF=0.50, DT9=0.10                  &END
      1000.      5000.      3000.      2000.      1500.
&CARD9  NS=4,      NTT=1,      JNK=3,      KSA=0,      KSUPC=1,      NTBT=1      &END
      1
      3
      100.      100.      100.      100.      100.
      0.000
      1000.0      1010.0      1025.0      1050.0
      50.0      70.0      100.0      150.0
      0.0      0.0      0.0      0.0
      1.000
      900.0      910.0      925.0      950.0
      50.0      70.0      100.0      150.0
      0.0      0.0      0.0      0.0
      2.000
      800.0      810.0      825.0      850.0
      50.0      70.0      100.0      150.0
      0.0      0.0      0.0      0.0
      3.000
      700.0      710.0      725.0      750.0
      50.0      70.0      100.0      150.0
      0.0      0.0      0.0      0.0
      0.030      0.030      0.030      0.030
      0.030      0.030      0.030      0.030
      0.030      0.030      0.030      0.030
      0.25      0.25      0.25
      0.0      0.0      0.0
&CARD17 QMAXD=0.0,QOD=1350.,QLL=0.0,      DTHM=0.0,      YDN=0.0      &END
&CARD9  NS=5,      NTT=2,      JNK=9,      KSA=0,      KSUPC=0,      NTBT=1      &END
      1
      2
      200.      200.      200.      200.      200.
      3.000
      700.0      710.0      725.0      750.0      800.0
      50.0      70.0      100.0      150.0      250.0
      0.0      0.0      0.0      0.0      0.0
      4.000
      650.0      670.0      685.0      710.0      760.0
      50.0      120.0      140.0      155.0      200.0
      0.0      0.0      160.0      220.0      250.0
      5.000
      640.0      650.0      665.0      690.0      740.0
      50.0      120.0      140.0      155.0      200.0
      0.0      0.0      160.0      220.0      250.0
      6.000
      625.0      635.0      650.0      675.0      725.0
      50.0      120.0      140.0      155.0      200.0
      0.0      0.0      160.0      220.0      250.0
      8.000
      600.0      610.0      625.0      650.0      700.0
      50.0      120.0      140.0      155.0      200.0
      0.0      0.0      160.0      220.0      250.0
      0.060      0.060      0.060      0.060      0.060
      0.060      0.060      0.060      0.060      0.060
      0.060      0.060      0.060      0.060      0.060
      0.060      0.060      0.060      0.060      0.060
      0.25      0.25      0.25      0.25
      -0.5      0.0      0.0      0.0
&CARD17 QMAXD=0.0,QOD=1550.,QLL=0.0,      DTHM=0.0,      YDN=504.5      &END

```


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 DAM-BREAK FLOOD SIMULATION
 BY A
 NONLINEAR, IMPLICIT FINITE-DIFFERENCE MODEL
 LAST REVISED FEBRUARY 12, 1981

FLOOD RESULTED FROM DAM FAILURE OF
 HYPOTHETICAL DAM
 ON
 EXAMPLE RIVER

ANALYSIS
 BY
 LARRY F. LAND USBS - WRD

COMMENT: FAILURE OF HYPOTHETICAL DAM ON EXAMPLE RIVER HYDROLOGIC RESERVOIR ROUTING

 INPUT CONTROL PARAMETERS FOR HYPOTHETICAL DAM

PARAMETER	VARIABLE	VALUE
NUMBER OF DYNAMIC ROUTING REACHES	KKN	2
TYPE OF RESERVOIR ROUTING	KUI	0

HYPOTHETICAL DAM RESERVOIR

ELEVATION (FT)	SURFACE AREA (ACRES)
HA(K)	SA(K)
1050.00	100.0
1045.00	80.0
1040.00	70.0
1035.00	55.0
1030.00	40.0
1025.00	25.0
1020.00	10.0
1000.00	1.0

HYPOTHETICAL DAM RESERVOIR AND BREACH PARAMETERS

PARAMETER	UNITS	VARIABLE	VALUE
ELEVATION OF WATER SURFACE	FT	Y0	1035.00
SIDE SLOPE OF BREACH		Z	0.50
TIME FLOOD ROUTING TERMINATES	HR	TEH	3.00
ELEVATION OF BOTTOM OF BREACH	FT	YBMIN	1000.00
WIDTH OF BASE OF BREACH	FT	BB	50.00
TIME TO MAXIMUM BREACH SIZE	HR	TFH	0.25
ELEVATION (MSL) OF BOTTOM OF DAM	FT	DATUM	0.0
ELEVATION OF WATER WHEN BREACHED	FT	HF	1036.00
DISCHARGE THRU TURBINES	CFS	QT	0.0
ELEVATION OF TOP OF DAM	FT	HD	1050.00
DISCHARGE COEF. FOR UNCONTROLLED WEIR FLOW		CD	0.0
ELEVATION OF UNCONTROLLED SPILLWAY CREST	FT	HSP	1038.00
DISCHARGE COEF. FOR UNCONTROLLED SPILLWAY		CS	0.0
ELEVATION OF CENTER OF GATE OPENINGS	FT	HGT	1010.00
DISCHARGE COEF. FOR GATE FLOW		CG	250.00

INFLOW HYDROGRAPH TO HYPOTHETICAL DAM

1000. 5000. 3000. 2000.

[illegible]

PARAMETER	VARIABLE	VALUE
*****	*****	*****
NUMBER OF COMPUTATIONAL CROSS-SECTIONS	NS	4
MAXIMUM NUMBER OF TOP WIDTHS	NCS	8
NUMBER OF HYDROGRAPHS TO PLOT	NTT	0
TYPE OF OUTPUT	JNK	3
CROSS-SECTIONAL SMOOTHING PARAMETER	KSA	0
SUPERCritical FLOW OR NOT	KSUPC	1
NUMBER OF TRIBUTARIES	NTBT	1

NUMBER OF SUBREACH WHERE TRIBUTARY ENTERS
(MAX NUMBER OF TRIBUTARIES = 2)

3

TRIBUTARY INFLOW IN SJBREACH 3

100. 100. 100. 100.

CROSS-SECTIONAL VARIABLES

PARAMETER	UNITS					VARIABLE			
*****					*****	*****			
LOCATION OF C. CROSS-SECTION	MI					XS(I)			
ELEV CORRESPONDING TO EACH TOP WIDTH	FT					HS(K,I)			
TOP WIDTH CORRESPONDING TO EACH ELEV (ACTIVE FLOW PORTION)	FT					BS(K,I)			
TOP WIDTH CORRESPONDING TO EACH ELEV (OFF-CHANNEL PORTION)	FT					BSS(K,I)			
NUMBER OF COMPUTATIONAL CROSS-SECTIONS						I			
NUMBER OF ELEVATION LEVEL						K			
CROSS-SECTION 1		XS(I) =			0.0				
HS ...	1000.0	1010.0	1025.0	1050.0	1060.0	1070.0	1080.0	1090.0	
BS ...	50.0	70.0	100.0	150.0	150.0	150.0	150.0	150.0	
BSS ...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CROSS-SECTION 2		XS(I) =			1.000				
HS ...	900.0	910.0	925.0	950.0	960.0	970.0	980.0	990.0	
BS ...	50.0	70.0	100.0	150.0	150.0	150.0	150.0	150.0	
BSS ...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CROSS-SECTION 3		XS(I) =			2.000				
HS ...	800.0	810.0	825.0	850.0	860.0	870.0	880.0	890.0	
BS ...	50.0	70.0	100.0	150.0	150.0	150.0	150.0	150.0	
BSS ...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CROSS-SECTION 4		XS(I) =			3.000				
HS ...	700.0	710.0	725.0	750.0	760.0	770.0	780.0	790.0	
BS ...	50.0	70.0	100.0	150.0	150.0	150.0	150.0	150.0	
BSS ...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

SUBREACH VARIABLES

MANNING N ROUGHNESS COEFFICIENTS FOR THE GIVEN SUBREACHES
(CM(K,I),K=1,NCS) WHERE I = SUBREACH NUMBER

SUBREACH	1	...	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
SUBREACH	2	...	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
SUBREACH	3	...	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030

COMPUTATIONAL NODE SPACING

MI DXM(I)

CONTRACTION - EXPANSION COEFFICIENTS

FKC(I)

SUBREACH NUMBER	DXM(I)	FKC(I)
*****	*****	*****
1	0.250	0.0
2	0.250	0.0
3	0.250	0.0

NUMBER OF COMPUTATIONAL NODES (N) = 13 MIN = 5 MAX = 200

DEFINITION OF VARIABLES IN RESERVOIR DEPLETION TABLE

PARAMETER	UNITS	VARIABLE
*****	*****	*****
TIME STEP FROM START OF ANALYSIS		I
ITERATIONS NECESSARY TO SOLVE FLOW EQUATIONS		K
ELAPSED TIME FROM START OF ANALYSIS	HRS	TTP(I)
OUTFLOW FROM BREACH	CFS	Q(I)
ELEVATION OF WATER SURFACE AT DAM	FT	H2
ELEVATION OF BOTTOM OF BREACH	FT	YB
EST DEPTH OF FLOW IMMEDIATELY DOWNSTREAM	FT	D
SUBMERGENCE COEFFICIENT		SUB
VELOCITY CORRECTION		VCOR
TOTAL VOLUME DISCHARGED FROM TIME OF BREACH AC-FT		OUTVOL

RESERVOIR DEPLETION TABLE

I	K	TTP(I)	Q(I)	H2	YB	D	SUB	VCOR	OUTVOL
***	**	*****	*****	*****	*****	*****	****	****	*****
1	0	0.0	1250	1035.00	1050.00	1.95	1.00	1.00	0.0
2	2	0.100	1250	1034.99	1050.00	2.16	1.00	1.00	0.0
3	3	0.200	1251	1035.04	1050.00	2.16	1.00	1.00	0.0
4	3	0.300	1253	1035.16	1050.00	2.16	1.00	1.00	0.0
5	3	0.400	1258	1035.33	1050.00	2.16	1.00	1.00	0.0
6	3	0.500	1263	1035.55	1050.00	2.17	1.00	1.00	0.0
7	3	0.600	1270	1035.83	1050.00	2.17	1.00	1.00	0.0
8	3	0.700	1278	1036.16	1050.00	2.18	1.00	1.00	0.0
9	2	0.705	1411	1036.18	1035.28	2.23	1.00	1.00	0.6
10	2	0.710	1606	1036.20	1034.56	2.34	1.00	1.00	1.2
11	2	0.715	1852	1036.21	1033.84	2.52	1.00	1.00	1.9
12	2	0.720	2143	1036.22	1033.12	2.74	1.00	1.00	2.7
13	2	0.725	2472	1036.24	1032.40	2.98	1.00	1.00	3.7
14	2	0.730	2836	1036.24	1031.68	3.24	1.00	1.00	4.8
15	2	0.735	3233	1036.25	1030.96	3.52	1.00	1.00	6.0
16	2	0.740	3660	1036.25	1030.24	3.80	1.00	1.00	7.4
17	2	0.745	4116	1036.25	1029.52	4.08	1.00	1.00	9.1
18	2	0.750	4598	1036.25	1028.80	4.38	1.00	1.00	10.9
19	2	0.755	5106	1036.25	1028.08	4.67	1.00	1.00	12.9
20	2	0.760	5639	1036.24	1027.36	4.96	1.00	1.00	15.1
21	2	0.765	6195	1036.22	1026.64	5.26	1.00	1.00	17.5
22	2	0.770	6773	1036.21	1025.92	5.56	1.00	1.00	20.2
23	2	0.775	7373	1036.18	1025.20	5.85	1.00	1.00	23.1
24	2	0.780	7994	1036.16	1024.48	6.15	1.00	1.00	26.3
25	2	0.785	8633	1036.13	1023.76	6.45	1.00	1.00	29.7
26	2	0.790	9292	1036.10	1023.04	6.74	1.00	1.00	33.4
27	2	0.795	9969	1036.06	1022.32	7.03	1.00	1.00	37.4
28	2	0.800	10663	1036.01	1021.60	7.33	1.00	1.00	41.7
29	2	0.805	11374	1035.96	1020.88	7.62	1.00	1.00	46.2
30	2	0.810	12100	1035.91	1020.16	7.90	1.00	1.00	51.1
31	3	0.815	12840	1035.85	1019.44	8.19	1.00	1.00	56.2
32	2	0.820	13595	1035.79	1018.72	8.48	1.00	1.00	61.7
33	3	0.825	14363	1035.72	1018.00	8.76	1.00	1.00	67.5
34	2	0.830	15144	1035.64	1017.28	9.04	1.00	1.00	73.6
35	3	0.835	15937	1035.56	1016.56	9.32	1.00	1.00	80.0
36	3	0.840	16740	1035.47	1015.84	9.59	1.00	1.00	86.8
37	3	0.845	17554	1035.38	1015.12	9.86	1.00	1.00	93.8

210	2	1.710	3739	1008.05	1000.00	4.14	1.00	1.00	1001.4
211	2	1.716	3726	1008.03	1000.00	4.13	1.00	1.00	1003.2
212	2	1.723	3713	1008.01	1000.00	4.12	1.00	1.00	1005.3
213	2	1.730	3697	1007.99	1000.00	4.11	1.00	1.00	1007.5
214	3	1.738	3681	1007.97	1000.00	4.10	1.00	1.00	1010.0
215	2	1.747	3662	1007.94	1000.00	4.09	1.00	1.00	1012.7
216	2	1.757	3642	1007.91	1000.00	4.08	1.00	1.00	1015.6
217	2	1.768	3621	1007.88	1000.00	4.07	1.00	1.00	1018.8
218	2	1.780	3596	1007.85	1000.00	4.05	1.00	1.00	1022.3
219	3	1.793	3570	1007.81	1000.00	4.04	1.00	1.00	1026.2
220	2	1.807	3541	1007.77	1000.00	4.02	1.00	1.00	1030.4
221	3	1.822	3509	1007.73	1000.00	4.00	1.00	1.00	1034.9
222	3	1.840	3474	1007.68	1000.00	3.98	1.00	1.00	1039.9
223	2	1.859	3436	1007.62	1000.00	3.95	1.00	1.00	1045.4
224	2	1.880	3394	1007.56	1000.00	3.93	1.00	1.00	1051.2
225	3	1.903	3347	1007.50	1000.00	3.90	1.00	1.00	1057.6
226	3	1.928	3297	1007.42	1000.00	3.87	1.00	1.00	1064.6
227	3	1.956	3241	1007.34	1000.00	3.83	1.00	1.00	1072.1
228	3	1.986	3179	1007.25	1000.00	3.80	1.00	1.00	1080.2
229	3	2.020	3115	1007.16	1000.00	3.75	1.00	1.00	1089.0
230	3	2.057	3054	1007.07	1000.00	3.71	1.00	1.00	1098.4
231	3	2.098	2998	1006.98	1000.00	3.67	1.00	1.00	1108.6
232	3	2.142	2944	1006.90	1000.00	3.63	1.00	1.00	1119.6
233	3	2.192	2889	1006.82	1000.00	3.59	1.00	1.00	1131.4
234	3	2.246	2831	1006.73	1000.00	3.55	1.00	1.00	1144.2
235	3	2.305	2770	1006.64	1000.00	3.50	1.00	1.00	1158.0
236	3	2.371	2703	1006.53	1000.00	3.46	1.00	1.00	1172.9
237	3	2.443	2631	1006.42	1000.00	3.41	1.00	1.00	1188.8
238	3	2.522	2551	1006.29	1000.00	3.36	1.00	1.00	1205.8
239	3	2.610	2464	1006.15	1000.00	3.29	1.00	1.00	1223.8
240	3	2.706	2367	1006.00	1000.00	3.23	1.00	1.00	1243.0
241	3	2.811	2261	1005.82	1000.00	3.15	1.00	1.00	1263.2
242	3	2.927	2145	1005.62	1000.00	3.07	1.00	1.00	1284.3
243	3	3.055	2017	1005.40	1000.00	2.97	1.00	1.00	1306.3
244	3	3.196	1876	1005.16	1000.00	2.87	1.00	1.00	1328.9
245	3	3.350	1721	1004.87	1000.00	2.74	1.00	1.00	1351.9
246	3	3.520	1550	1004.55	1000.00	2.61	1.00	1.00	1374.9
247	3	3.707	1363	1004.19	1000.00	2.45	1.00	1.00	1397.4

RESERVOIR SUMMARY

PARAMETER	UNITS	VARIABLE	VALUE
*****	*****	*****	*****
INITIAL FLOW	CFS	Q(1)	1250.
MAX FLOW	CFS	QM	35386.
FINAL FLOW	CFS	Q(NU)	1363.
TIME TO MAX FLOW	HRS	TP	0.95
NUMBER OF TIME STEPS		NU	247
TOTAL VOLUME DISCHARGED FROM RESERVOIR	AC-FT	DISVOL	1397.

INITIAL CONDITIONS IN EXAMPLE RIVER
METHOD: NORMAL DEPTHS

PARAMETER VARIABLE

COMPUTATIONAL CROSS-SECTION NUMBER	I				
NUMBER OF ITERATIONS	K				
LOCATION OF CROSS SECTION	X(I)				
ELEV OF WATER SURFACE	YD(I)				
DISCHARGE	QDI(I)				
CHANNEL SLOPE	SOM				
I	K	X(I)	YD(I)	QDI(I)	SOM
***	***	*****	*****	*****	*****
1	2	0.0	1002.16	1250.	100.00
2	2	0.250	977.16	1250.	100.00
3	2	0.500	952.16	1250.	100.00
4	2	0.750	927.16	1250.	100.00
5	2	1.000	902.16	1250.	100.00
6	2	1.250	877.16	1250.	100.00
7	2	1.500	852.16	1250.	100.00
8	2	1.750	827.16	1250.	100.00
9	2	2.000	802.16	1250.	100.00
10	2	2.250	777.26	1350.	100.00
11	2	2.500	752.26	1350.	100.00
12	2	2.750	727.26	1350.	100.00
13	2	3.000	702.26	1350.	100.00

PARAMETERS USED IN TIME STEP COMPUTATION

PARAMETER	UNITS	VARIABLE	VALUE
*****	*****	*****	*****
INITIAL FLOW		Q0	1250.00
MAX TOP WIDTH		BMAX	150.00
MAX FLOW		QMAX	35386.05
TOP WIDTH		B00	54.32
TIME INTERVAL BETWEEN ITERATIONS		DTIM	0.062

TIME PARAMETERS OF OUTFLOW HYDROGRAPH

PARAMETER	UNITS	VARIABLE	VALUE
*****	*****	*****	*****
DURATION OF FAILURE	HR	TFH	0.250
TIME TO START OF RISING LIMB OF HYDROGRAPH	HR	TFO	0.700
TIME TO PEAK	HR	TP	0.950
TIME STEP SIZE	HR	DTHI	0.012

RESULTS OF STREAMFLOW SIMULATION ALONG EXAMPLE RIVER

PARAMETER

VARIABLE

TIME
DURATION OF TIME STEP
NUMBER OF ITERATIONS
UPSTREAM DISCHARGE
UPSTREAM WATER SURFACE ELEV
DOWNSTREAM DISCHARGE
DOWNSTREAM WATER SURFACE ELEV

TT
DTH
ITERR
QU(J)
YU(J)
QU(N)
YU(N)

TT ****	DTH *****	ITERR *****	QU(J) *****	YU(J) *****	QU(N) *****	YU(N) *****
0.0	0.0125	0	1250.	1002.16	1350.	702.26
0.0	0.0062	1	1250.	1002.16	1349.	702.26
0.0	0.0062	1	1250.	1002.16	1355.	702.26
0.250	0.2500	1	1253.	1002.16	1353.	702.26
0.500	0.2500	1	1264.	1002.17	1358.	702.26
0.512	0.0125	1	1255.	1002.18	1363.	702.26
0.525	0.0125	1	1255.	1002.18	1367.	702.26
0.537	0.0125	0	1256.	1002.18	1369.	702.26
0.550	0.0125	0	1257.	1002.18	1370.	702.26
0.562	0.0125	0	1258.	1002.18	1370.	702.26
0.575	0.0125	0	1259.	1002.18	1371.	702.26
0.587	0.0125	0	1270.	1002.18	1371.	702.26
0.600	0.0125	0	1271.	1002.18	1371.	702.26
0.612	0.0125	0	1272.	1002.18	1371.	702.26
0.625	0.0125	0	1273.	1002.18	1371.	702.26
0.637	0.0125	0	1274.	1002.19	1371.	702.26
0.650	0.0125	0	1275.	1002.19	1371.	702.26
0.662	0.0125	0	1276.	1002.19	1371.	702.26
0.675	0.0125	0	1277.	1002.19	1371.	702.26
0.687	0.0125	0	1278.	1002.19	1371.	702.26
0.700	0.0125	0	1279.	1002.19	1372.	702.26
0.712	0.0125	2	1730.	1002.62	1372.	702.26
0.725	0.0125	2	2473.	1003.24	1372.	702.26
0.737	0.0125	2	3447.	1003.94	1372.	702.27
0.750	0.0125	2	4599.	1004.67	1372.	702.27
0.762	0.0125	2	5917.	1005.41	1371.	702.27
0.775	0.0125	2	7374.	1006.15	1371.	702.26
0.787	0.0125	2	8953.	1006.89	1370.	702.26
0.800	0.0125	2	10654.	1007.62	1371.	702.26
0.812	0.0125	2	12470.	1008.34	1372.	702.26
0.825	0.0125	2	14354.	1009.04	1377.	702.27
0.837	0.0125	2	16339.	1009.73	1397.	702.29
0.850	0.0125	2	18377.	1010.41	1475.	702.36
0.862	0.0125	2	20471.	1011.07	1747.	702.61
0.875	0.0125	2	22604.	1011.70	2505.	703.25
0.887	0.0125	2	24764.	1012.32	4026.	704.29
0.900	0.0125	2	26935.	1012.92	6296.	705.57
0.912	0.0125	2	29101.	1013.49	9052.	706.89
0.925	0.0125	1	31247.	1014.04	12011.	708.12
0.937	0.0125	1	33367.	1014.56	14991.	709.23

JNK = 3

RESULTS OF STREAMFLOW SIMULATION ALONG EXAMPLE RIVER

PARAMETER *****					VARIABLE *****					
TIME					TT					
DURATION OF TIME STEP					DTH					
NUMBER OF ITERATIONS					ITERR					
MIN AND MAX FROUDE NUMBER					FRDRNG					
DISCHARGE OF LATERAL OUTFLOW (CFS/FT)					QLLT					
TOTAL DISCHARGE OF TRIBUTARIES					QTBT					
UPSTREAM DISCHARGE					QU(J)					
UPSTREAM WATER SURFACE ELEV					YU(J)					
DOWNSTREAM DISCHARGE					QU(N)					
DOWNSTREAM WATER SURFACE ELEV					YU(N)					
TT ****	DTH *****	ITERR *****	FRDRNG *****		QLLT *****	QTBT *****	QU(J) *****	YU(J) *****	QU(N) *****	YU(N) *****
0.0	0.0125	0	1.36	1.37	0.0	100.	1250.	1002.16	1350.	702.26
0.0	0.0062	1	1.35	1.37	0.0	100.	1250.	1002.16	1349.	702.26
0.0	0.0062	1	1.34	1.37	0.0	100.	1250.	1002.16	1355.	702.26
0.250	0.2500	1	1.34	1.37	0.0	100.	1253.	1002.16	1353.	702.26
0.500	0.2500	1	1.34	1.38	0.0	100.	1264.	1002.17	1358.	702.26
0.512	0.0125	1	1.34	1.38	0.0	100.	1265.	1002.18	1363.	702.26
0.525	0.0125	1	1.34	1.38	0.0	100.	1265.	1002.18	1367.	702.26
0.537	0.0125	0	1.34	1.39	0.0	100.	1266.	1002.18	1369.	702.26
0.550	0.0125	0	1.34	1.39	0.0	100.	1267.	1002.18	1370.	702.26
0.562	0.0125	0	1.34	1.39	0.0	100.	1268.	1002.18	1370.	702.26
0.575	0.0125	0	1.34	1.39	0.0	100.	1269.	1002.18	1371.	702.26
0.587	0.0125	0	1.34	1.39	0.0	100.	1270.	1002.18	1371.	702.26
0.600	0.0125	0	1.34	1.39	0.0	100.	1271.	1002.18	1371.	702.26
0.612	0.0125	0	1.34	1.39	0.0	100.	1272.	1002.18	1371.	702.26
0.625	0.0125	0	1.34	1.39	0.0	100.	1273.	1002.18	1371.	702.26
0.637	0.0125	0	1.34	1.39	0.0	100.	1274.	1002.19	1371.	702.26
0.650	0.0125	0	1.34	1.39	0.0	100.	1275.	1002.19	1371.	702.26
0.662	0.0125	0	1.34	1.39	0.0	100.	1276.	1002.19	1371.	702.26
0.675	0.0125	0	1.34	1.39	0.0	100.	1277.	1002.19	1371.	702.26
0.687	0.0125	0	1.34	1.39	0.0	100.	1278.	1002.19	1371.	702.26
0.700	0.0125	0	1.34	1.39	0.0	100.	1279.	1002.19	1372.	702.26
0.712	0.0125	2	1.34	1.40	0.0	100.	1730.	1002.62	1372.	702.26
0.725	0.0125	2	1.34	1.45	0.0	100.	2473.	1003.24	1372.	702.26
0.737	0.0125	2	1.35	1.49	0.0	100.	3447.	1003.94	1372.	702.27
0.750	0.0125	2	1.35	1.53	0.0	100.	4599.	1004.67	1372.	702.27
0.762	0.0125	2	1.35	1.57	0.0	100.	5917.	1005.41	1371.	702.27
0.775	0.0125	2	1.35	1.60	0.0	100.	7374.	1006.15	1371.	702.26
0.787	0.0125	2	1.35	1.63	0.0	100.	8963.	1006.89	1370.	702.26
0.800	0.0125	2	1.35	1.65	0.0	100.	10664.	1007.62	1371.	702.26
0.812	0.0125	2	1.35	1.67	0.0	100.	12470.	1008.34	1372.	702.26
0.825	0.0125	2	1.35	1.69	0.0	100.	14364.	1009.04	1377.	702.27
0.837	0.0125	2	1.36	1.71	0.0	100.	16339.	1009.73	1397.	702.29
0.850	0.0125	2	1.38	1.73	0.0	100.	18377.	1010.41	1475.	702.36
0.862	0.0125	2	1.42	1.74	0.0	100.	20471.	1011.07	1747.	702.61
0.875	0.0125	2	1.46	1.76	0.0	100.	22604.	1011.70	2505.	703.25
0.887	0.0125	2	1.53	1.77	0.0	100.	24764.	1012.32	4026.	704.29
0.900	0.0125	2	1.59	1.78	0.0	100.	26935.	1012.92	6296.	705.57

JNK = 9

RESULTS OF STREAMFLOW SIMULATION ALONG EXAMPLE RIVER

TT= 0.0		DTM= 0.0125		ITERR= 0		FROUDE RANGE= 1.36 TO 1.37					
X(I)	Y	V	A	B	BT	W X 1000	CMM	FKC	WAVMT	DM	FRD
0.0	1002.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
0.250	977.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
0.500	952.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
0.750	927.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
1.000	902.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
1.250	877.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
1.500	852.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
1.750	827.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
2.000	802.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
2.250	777.26	11.42	118.	55.	55.	1.350	0.0300	0.0	0.0	2.2	1.37
2.500	752.26	11.42	118.	55.	55.	1.350	0.0300	0.0	0.0	2.2	1.37
2.750	727.26	11.42	118.	55.	55.	1.350	0.0300	0.0	0.0	2.2	1.37
3.000	702.26	11.42	118.	55.	55.	1.350	0.0300	0.0	0.0	2.2	1.37

TT= 0.0		DTM= 0.0062		ITERR= 1		FROUDE RANGE= 1.35 TO 1.37					
X(I)	Y	V	A	B	BT	W X 1000	CMM	FKC	WAVMT	DM	FRD
0.0	1002.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
0.250	977.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
0.500	952.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
0.750	927.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
1.000	902.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
1.250	877.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
1.500	852.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
1.750	827.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
2.000	802.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
2.250	777.27	11.28	119.	55.	55.	1.338	0.0300	0.0	0.01	2.2	1.35
2.500	752.26	11.43	118.	55.	55.	1.352	0.0300	0.0	0.0	2.2	1.37
2.750	727.29	11.33	119.	55.	55.	1.350	0.0300	0.0	0.02	2.2	1.35
3.000	702.26	11.41	118.	55.	55.	1.349	0.0300	0.0	0.0	2.2	1.37

TT= 0.0		DTM= 0.0062		ITERR= 1		FROUDE RANGE= 1.34 TO 1.37					
X(I)	Y	V	A	B	BT	W X 1000	CMM	FKC	WAVMT	DM	FRD
0.0	1002.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
0.250	977.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
0.500	952.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
0.750	927.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
1.000	902.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
1.250	877.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
1.500	852.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
1.750	827.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
2.000	802.16	11.09	113.	54.	54.	1.250	0.0300	0.0	0.0	2.1	1.36
2.250	777.28	11.26	119.	55.	55.	1.339	0.0300	0.0	0.00	2.2	1.34
2.500	752.26	11.44	118.	55.	55.	1.353	0.0300	0.0	0.0	2.2	1.37
2.750	727.29	11.33	120.	55.	55.	1.358	0.0300	0.0	0.00	2.2	1.35
3.000	702.26	11.46	118.	55.	55.	1.355	0.0300	0.0	0.0	2.2	1.37

TT= 0.250

DT= 0.2500

ITER= 1

FROUDE RANGE= 1.34 TO 1.37

X(I)	Y	V	A	B	BT	Q X 1000	CMM	FKC	WAVHT	DH	FRD
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
0.0	1002.16	11.10	113.	54.	54.	1.253	0.0300	0.0	0.00	2.1	1.36
0.250	977.16	11.10	113.	54.	54.	1.252	0.0300	0.0	0.00	2.1	1.36
0.500	952.16	11.10	113.	54.	54.	1.252	0.0300	0.0	0.00	2.1	1.36
0.750	927.16	11.10	113.	54.	54.	1.252	0.0300	0.0	0.00	2.1	1.36
1.000	902.16	11.10	113.	54.	54.	1.252	0.0300	0.0	0.00	2.1	1.36
1.250	877.16	11.10	113.	54.	54.	1.252	0.0300	0.0	0.00	2.1	1.36
1.500	852.16	11.10	113.	54.	54.	1.251	0.0300	0.0	0.00	2.1	1.36
1.750	827.16	11.09	113.	54.	54.	1.251	0.0300	0.0	0.00	2.1	1.36
2.000	802.16	11.09	113.	54.	54.	1.251	0.0300	0.0	0.00	2.1	1.36
2.250	777.29	11.28	120.	55.	55.	1.351	0.0300	0.0	0.02	2.2	1.34
2.500	752.26	11.43	118.	55.	55.	1.351	0.0300	0.0	0.0	2.2	1.37
2.750	727.29	11.31	120.	55.	55.	1.352	0.0300	0.0	0.0	2.2	1.35
3.000	702.26	11.44	118.	55.	55.	1.353	0.0300	0.0	0.0	2.2	1.37

TT= 0.500

DT= 0.2500

ITER= 1

FROUDE RANGE= 1.34 TO 1.38

X(I)	Y	V	A	B	BT	Q X 1000	CMM	FKC	WAVHT	DH	FRD
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
0.0	1002.17	11.14	113.	54.	54.	1.264	0.0300	0.0	0.01	2.1	1.36
0.250	977.17	11.13	113.	54.	54.	1.263	0.0300	0.0	0.01	2.1	1.36
0.500	952.17	11.13	113.	54.	54.	1.262	0.0300	0.0	0.01	2.1	1.36
0.750	927.17	11.13	113.	54.	54.	1.261	0.0300	0.0	0.01	2.1	1.36
1.000	902.17	11.13	113.	54.	54.	1.260	0.0300	0.0	0.01	2.1	1.36
1.250	877.17	11.12	113.	54.	54.	1.260	0.0300	0.0	0.01	2.1	1.36
1.500	852.17	11.12	113.	54.	54.	1.259	0.0300	0.0	0.01	2.1	1.36
1.750	827.17	11.12	113.	54.	54.	1.258	0.0300	0.0	0.01	2.1	1.36
2.000	802.17	11.12	113.	54.	54.	1.258	0.0300	0.0	0.01	2.1	1.36
2.250	777.30	11.30	120.	55.	55.	1.357	0.0300	0.0	0.02	2.2	1.34
2.500	752.26	11.49	118.	55.	55.	1.358	0.0300	0.0	0.0	2.2	1.37
2.750	727.29	11.33	120.	55.	55.	1.358	0.0300	0.0	0.01	2.2	1.35
3.000	702.26	11.49	118.	55.	55.	1.358	0.0300	0.0	0.0	2.2	1.38

TT= 0.512

DT= 0.0125

ITER= 1

FROUDE RANGE= 1.34 TO 1.38

X(I)	Y	V	A	B	BT	Q X 1000	CMM	FKC	WAVHT	DH	FRD
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
0.0	1002.18	11.14	114.	54.	54.	1.265	0.0300	0.0	0.01	2.1	1.36
0.250	977.17	11.13	113.	54.	54.	1.263	0.0300	0.0	0.01	2.1	1.36
0.500	952.17	11.13	113.	54.	54.	1.262	0.0300	0.0	0.01	2.1	1.36
0.750	927.17	11.13	113.	54.	54.	1.262	0.0300	0.0	0.01	2.1	1.36
1.000	902.17	11.13	113.	54.	54.	1.261	0.0300	0.0	0.01	2.1	1.36
1.250	877.17	11.12	113.	54.	54.	1.260	0.0300	0.0	0.01	2.1	1.36

PROFILE OF CRESTS AND TIMES

RVR MILE FROM DAM *****	MAX ELEV (FT) *****	MAX DEPTH (FT) *****	MAX FLOW (CFS) *****	TIME MAX ELEV(HR) *****	MAX VEL (FT/SEC) *****	MAX VEL (MI/HR) *****
0.0	1015.04	15.04	35385	0.95	36.16	24.66
0.250	989.80	14.80	34380	0.96	35.84	24.44
0.500	964.71	14.71	34029	0.96	35.75	24.38
0.750	939.63	14.63	33695	0.97	35.62	24.29
1.000	914.55	14.55	33318	0.99	35.49	24.19
1.250	889.50	14.50	33145	0.99	35.44	24.16
1.500	864.45	14.45	32908	1.00	35.35	24.10
1.750	839.38	14.38	32650	1.00	35.27	24.05
2.000	814.35	14.35	32511	1.01	35.22	24.01
2.250	789.36	14.36	32402	1.02	35.07	23.91
2.500	764.27	14.27	32218	1.02	35.13	23.95
2.750	739.24	14.24	32081	1.04	35.06	23.90
3.000	714.20	14.20	31885	1.05	34.99	23.86

TP = 1.05 QMAX = 31885.38

DISCHARGE HYDROGRAPH FOR EXAMPLE RIVER ... STATION NUMBER 1
 BELOW HYPOTHETICAL DAM AT MILE 0.0

GAGE ZERO = 1000.00 MAX ELEVATION REACHED BY FLOOD WAVE = 1015.04
 MAX STAGE = 15.04 AT TIME = 0.95 HOURS
 MAX FLOW = 35386 AT TIME = 0.95 HOURS

HR	STAGE	FLOW	0	10000	20000	30000	40000	50000
0.0	2.2	1250	I*	I	I	I	I	I
0.1	2.2	1251	I*	I	I	I	I	I
0.2	2.2	1252	I*	I	I	I	I	I
0.3	2.2	1255	I*	I	I	I	I	I
0.4	2.2	1259	I*	I	I	I	I	I
0.5	2.2	1264	I*	I	I	I	I	I
0.6	2.2	1271	I*	I	I	I	I	I
0.7	2.2	1279	I*	I	I	I	I	I
0.8	7.6	10664	I	I*	I	I	I	I
0.9	12.9	26935	I	I	I	*	I	I
1.0	13.8	30260	I	I	I	*	I	I
1.1	11.0	20248	I	I	*	I	I	I
1.2	7.4	10024	I	*	I	I	I	I
1.3	5.4	5971	I	*	I	I	I	I
1.4	4.7	4689	I	*	I	I	I	I
1.5	4.5	4250	I	*	I	I	I	I
1.6	4.3	3981	I	*	I	I	I	I
1.7	4.1	3761	I	*	I	I	I	I
1.8	4.0	3555	I	*	I	I	I	I
1.9	3.9	3353	I	*	I	I	I	I
2.0	3.7	3154	I	*	I	I	I	I
2.1	3.6	2996	I	*	I	I	I	I
2.2	3.5	2880	I	*	I	I	I	I
2.3	3.5	2776	I	*	I	I	I	I
2.4	3.4	2675	I	*	I	I	I	I
2.5	3.3	2574	I	*	I	I	I	I
2.6	3.2	2474	I	*	I	I	I	I
2.7	3.2	2374	I	*	I	I	I	I
2.8	3.1	2273	I	*	I	I	I	I
2.9	3.0	2173	I	*	I	I	I	I



WATER RESOURCES DIVISION

**Gulf Coast Hydroscience Center
NSTL Station, Mississippi**