Summary of Enhancements and Additions to the Branch-Network (BRANCH) Dynamic Flow Model

Version 4.2 March 6, 1997

The branch-network dynamic flow model (BRANCH) was first announced in the Techniques of Water-Resources Investigations (TWRI) report of the United States Geological Survey, Book 7, Chapter C3, published in 1981. Since then, various enhancements and additions have been incorporated in the model, as described in several informal memorandum. This write-up combines the contents of those memorandums with documentation of features added to the current version and summaries of features incorporated in previous BRANCH versions. This write-up, when used in conjunction with the TWRI, provides the input preparation and execution instructions for BRANCH. (Compatibility of input formats between model versions has been preserved where possible.)

SOME CONSIDERATIONS FOR PROPER MODEL IMPLEMENTATION:

(Note: these and others are all identified and discussed in the TWRI)

In defining and organizing the channel geometry for implementing BRANCH the following conditions, in particular, should be considered and observed:

- ❑ Cross-sectional data need to be correctly identified as piece-wise-linear functions of water-surface elevation in terms of conveyance area, conveyance width, storage width for those cross sections defining channel segments that contain flood-plain storage capacity, and wetted perimeter for those cross sections in branches where hydraulic radius is required in the computations rather than hydraulic depth. It is recommended that the piece-wise-linear functions be verified graphically to ensure that they are hydraulically representative of the conditions of the prototype.
- ❑ ALL cross-sectional data—and boundary-value data (BVD)—need to be ACCURATELY referenced to a common vertical datum.
- ❑ The lengths of all branches in the network should be chosen to be approximately equal. Likewise, channel segment lengths (the distance between successive cross sections) should be approximately equal. A rule-of-thumb is that the longest segment should not be more than four times the shortest. If cross-section geometry data are not available to meet this condition, subdivide the long segment(s) by interpolating an intermediate cross section at the midpoint. (As always a sufficient number of cross sections should be defined to properly quantify the conveyance potential of the branches comprising the open-channel network.)
- ❑ Channel segment lengths need to be accurately defined so that the sum of segment lengths between junctions correctly represents the branch length in the prototype.
- ❑ For most applications there should be no more than five cross sections, in other words no more than four channel segments per branch.
- ❑ An internal junction needs to be defined at the approximate location of the principal inflow/outflow source for a side-channel embayment, for example, a storage empoundment.
- ❑ An external junction (a location constituting an open boundary condition for BRANCH), consists of a single connecting branch. In other words, an external junction defines a branch that terminates at a boundary-condition (for example, stage gage) data location.

These are some principal factors pertaining to channel geometry that need to be considered in setting up a BRANCH input data set. In order to achieve a reasonably successful model calibration, there generally is no room for compromise or disregard of these principal factors.

An additional reason for exercising care in the collection and analysis of the prototype data and in the implementation of the model itself is, of course, that model/prototype flow discrepancies—as well as data idiosyncrasies—will ultimately need to be explained, either in District project reviews or at report review time.

It is also necessary to carefully scrutinize the time-series data (water-surface-elevation and discharge BVD) being used to drive the BRANCH model. Although BRANCH can successfully compute flows using BVD containing a few spurious readings, resultant model computations need to be analyzed and evaluated for accuracy. BRANCH will give some indication it is having difficulty with errant BVD by producing excessive iterations. It always is necessary to ensure that the data being used to implement and execute BRANCH are accurate and of high quality. Use a graphics package, such as the Time-Dependent Data System (TDDS) DAPLOT routine, to examine the BVD and correct readings that are in error prior to input to BRANCH. Erroneous data, caused by recorder malfunctions, clogged intakes, or boat traffic, are very common with some water-surface-elevation recording equipment. Such errant data will invalidate BRANCH model results if they are not identified, corrected, and (or) eliminated.

Although ‘synthesized’ data can be used as input to BRANCH—not good practice—these data cannot be recognized, identified, and treated as such by BRANCH. BRANCH always expects that input data accurately reflect real conditions in the prototype.

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March 7, 1997 -- BRANCH version 4.2

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Added three computation-control variables: GPRBCH (global flag to override values set for PRTBCH and PRTSUM for each branch to print results for all or none of the branches), GPLBCH (global flag to override values set for PLTBCH and PPLTBH for each branch to plot results for all or none of the branches), and GPRTXS (global flag to override values set for PRTXSG for each branch to print input geometry for all or none of the branches).

Added use of new CalComp to INTERACTOR library included in LIBUTL version 6.0 so that hard-copy graphics output is available for DOS versions.

Added option (IMODFW=2) to cause BRANCH to read but ignore MODBRNCH specific input records.

Improved labeling of graphics.

Changed metric minimum (2000 meters) and maximum (8000 meters) segment lengths at which a warning message is printed.

Fixed print of input boundary-value definition as equation to print without adding the stage computational datum.

Increased default number of cross section from 150 to 175.

Important code correction: Fixed code so that the model correctly retrieves data from a data base for simulations of longer than 30 days. This problem was introduced in version 3.11.

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October 15, 1996 -- BRANCH version 4.1
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Corrected program error that wrote incorrect results to user-table output file.

The file name of the user-table output is now retained as the last entry in the “master” file.

Fixed incorrect multiplication by 100 of computed results to be stored in a Time-Dependent Data Base (TDDB) or Watershed Data Management (WDM) data base (error introduced in version 3.11).

Lahey F90[1] compiler dependencies added.

Fixed incorrect indexing of observed data in multiple-day, computed-versus-measured, line-printer plots.

Fixed labeling of metric output when data are input in English units.

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March 4, 1996 -- BRANCH version 4.0
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DSPRSN field width increased.

Added computation of storage area for output to BLTM.FLW file.

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November 1, 1995 -- BRANCH version 3.11
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Input of wetted perimeter as piece-wise-linear functions of water-surface elevation is added to the Cross-Sectional Geometry Data records. Wetted perimeter is read from the location (columns 41 to 50) that previously contained functional eta. Functional eta, QA, and TA are moved over 10 columns on these records. Data sets coded in the old format must be manually edited to account for this change. Wetted perimeter is used in the flow equations to compute hydraulic radius for evaluation of frictional-resistance effects. If wetted perimeter is not specified, hydraulic radius is approximated by the hydraulic depth (area/width). If wetted perimeter is specified for one cross section in a branch, it must be specified for every cross section in that branch. You may mix use of hydraulic radius and hydraulic depth within a network but not within a branch.

Output of results at each time step (IPROPT=0) has a new format. Each line of this format gives the results for a single cross section and is approximately 80-characters wide. The old format (results for two cross sections on a line) is selectable by specifying the new computational-control parameter IPRMFT as 1.

Considerable restructuring, modularization, and clean-up of the code has been accomplished in this version.

A new user-defined table of results has been added to allow for selective postprocessing, such as with a graphics or spreadsheet package, of simulation results. When the parameter OTFILE (replaces old computational-control parameter OTTDDB) is set to 5, a new record is read from the computation-control file after any Particle-Tracking records and before the Constant Nodal-Flow records. This record can specify up to four data sets (parameter type and cross-section location) to be included in the output file. This file is named as the base name of the computation-control file plus the suffix .pst.

Added new Initial Condition record for data (row, column, and layer in MODFLOW model that coincides with the cross section and leakage coefficient and channel bottom elevation) as needed by coupled MODFLOW/BRANCH simulations.

Eta optimization improved.

Added error message routines to make messages more consistent in appearance.

Made changes to fix possibility of inconsistent equality comparisons of floating-point numbers.

Three-parameter rating for culverts added.

Added input of hydraulic structures for MODFLOW/BRANCH simulations. New input file that contains an alternate set of structure operation rules defined. The operations of a structure can be specified based on water levels anywhere in the model, surface water, or ground water, with this alternate data set. This data set is activated when the structure identification number (Istrm(3,ij)) is set double, for example -11 instead of -1.

Allow input of time step increment in seconds (IDTM < 0 indicates time increment in seconds).

Allow boundary condition to be input by SIN equation and flood wave hydrograph.

Summary of changes made since March 10, 1992, to the BRANCH input format are:

Computation-Control record 1:

- changed meaning of NBND to include only the number of external boundaries in the network (no longer includes internal-station locations as these are specified on the Cross-Section Geometry records)
- changed meaning of IDTM such that if specified as a negative value, then IDTM is time increment in seconds
- changed meaning and name of OTTDDB to OTFILE, which now specifies the type of filed results among Time-Dependent Data Base (TDDB), Branched Lagrangian Transport Model (BLTM), simulation results at each cross section for each time step (MAP), Network Common Data Form (NetCDF), and user-table options; OTFILE also replaces OTBLTM and OTMAP from Computation-Control record 2.
- changed meaning and name of ISMOPT to IWMOPT; this flag now controls printing of two types of warning messages (nonconvergence and segment length)
- added variables IMODFW (flag to signal that this is a coupled MODFLOW/BRANCH simulation), IPRMFT (to select the narrow or wide printed results format), and KTCONS (number of constituents to be defined for transport computation—note, transport computation is not fully implemented in this version)

Computation-Control record 2:

- removed OTBLTM and OTMAP flags as now incorporated in OTFILE flag on Computation-Control record 1

- added variables DCFM (multiplier for the friction term in the momentum equation when a channel becomes dry), AIRDEN (air density), H2OSAL (global default salinity value), H2OTMP (global default water temperature), DSPRSN (global default longitudinal dispersion coefficient)

Initial-Condition record 2:

- added variables QLAT (initial lateral discharge) and ULAT (initial lateral velocity)

Initial-Condition record 3:

- NEW—input for coupled MODFLOW/BRANCH simulations only. This record specifies the location of the BRANCH segment within the MODFLOW grid (ISTRM), the segment leakage coefficient (CLK), and the elevation of the channel bottom (ZBOT)

Cross-Section Geometry records 1:

- moved GDATUM from column positions 66-72 to positions 64-70
- added variable FVFLG to indicate inclusion of results at a cross section in flow-volume summary output (IPROPT=4) in column positions 71-72

Cross-Section Geometry records 2:

- moved variables ETA, QA, and TA over 10 columns from positions 41-50, 51-60, and 61-70 to positions 51-60, 61-70, and 71-80, respectively
- added variable WP (the wetted perimeter as a function of water-surface elevation) in column positions 41-50

User_Table Results record:

- NEW—specifies cross sections whose results are output to a text file for postprocessing using a graphics or spreadsheet package

Boundary-Value Data-Definition record:

- deleted variables IFVBCH and IFVSEC as replaced by the specification of FVFLG on the Cross-Section Geometry records
- added variable STYPE (data storage type of data to be retrieved from a TDDB)
- added specification of a boundary-conditions as a SIN equation

Time-Varying Nodal-Flow Data-Definition record:

- added variable NFSTYP (data storage type of data to be retrieved from a TDDB)

Time-Varying Wind Data-Definition record:

- added variable WSTYP (data storage type of data to be retrieved from a TDDB)

Measured Data-Definition record:

- added variable MDSTYP (data storage type of data to be retrieved from a TDDB)

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September 1, 1994 -- BRANCH version

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Updated Modular Three-Dimensional Finite-Difference Ground-Water Flow Model (MODFLOW) interface developed by E. D. Swain and E. J. Wexler (Open-File Report 92-138).

Pressure gradient term added to account for constant density variations.

Lateral flow implemented. There are two different types of network-internal flow sources accommodated by the BRANCH model, nodal flows at junctions (see TWRI 7-C3, p. 65) and lateral flows (with rate defined by QLAT in cubic foot per second per foot of channel and velocity defined by ULAT in foot per second) occurring along the channel reach between cross sections. Nodal flows (inflows signed positive and outflows negative) can be specified as a constant rate or time varying. At present, lateral flows (similarly inflows signed positive and outflows negative) can be specified only as constant rates. These constants are input on the second Initial-Condition record. Because lateral flows are channel-specific properties, any assigned lateral flow on the last cross-section definition within a branch is ignored.

Eta optimization added.

Code reordering and restructuring accomplished.

In addition to global-default and cross-section definition of initial values of density and salinity, specification of global-default and channel-segment values for the longitudinal dispersion coefficient will be needed. Whereas density and salinity values apply to the cross section, dispersion coefficients apply to the channel segment.

Global default values updated and expanded (air density, water temperature, longitudinal dispersion). This change may account for some minor differences in simulation results using earlier default values.

Real and double-precision data (four- and eight-byte floating-point values, respectively) can now be input from a Time-Dependent Data Base (TDDB). BRANCH results are now output to TDDB and Watershed Data Management (WDM) data bases as four-byte floating-point values.

Printing of frictional-resistance coefficient (eta) value of current time step rather than previous time step for IPROPT options 0 and 1 corrected.

Value of frictional-resistance coefficient (eta) for first time step printed for piece-wise-linear functions of eta corrected.

Particle tracking problem when a particle was exactly at a cross-section location identified and corrected.

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March 1, 1992 -- BRANCH version

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This version is compatible with Data General AViiON and other UNIX-based workstations, for example Sun SPARCstations and IBM RISC6000. Interactive prompting has been improved to be more readable and consistent (use of mixed case in messages) and to provide default values and additional help messages to aid the user in determining appropriate values for responses. Single line user queries are displayed in upper case. Much of the printed output has been modified to display in an 80-column format. The TDDS data base now allows data intervals of 180 and 120 minutes (8 and 12 values per day).

The TRKPLOT program has been updated and is now available on workstations. TRKPLOT is an interactive program to plot the paths-of-travel of injected index particles computed by BRANCH and output in the particle tracking output (.pto) file.

A new program (SET_DIMENS) has been added to allow interactive update of the DIMENS.CMN file. This program displays the current values assigned to the array dimension parameters and permits users to selectively update these values. The program must be executed while attached to the directory containing the DIMENS.CMN file (usually the BRANCH source directory). After using SET_DIMENS, BRANCH must be recompiled and loaded in order for any changes made to the dimens.cmn parameters to be implemented.

New features and other extensions to BRANCH include:

- ❑ The particle tracking feature has been expanded to allow for tracking particles through more than one path in a single simulation and to allow injected particles to be specified to start at any location in the path—do not need to start at a cross-section location. As with all variable dimensions in BRANCH, the number of particles per path and number of paths can be readily changed to suit user needs by editing the include file DIMENS.CMN. Currently assigned limits are 10 particles per path and 5 paths per simulation. Three new Particle-Track records are required to define each additional travel path. The first new record defines the number of branches in the path. The second new record defines the downstream sequence of branch numbers—separated by a blank or comma—defining the path. The third new record defines the starting locations of particles referenced to the upstream end. Initial particle locations are specified in feet or meters referenced to the upstream end of the path. See Appendix I below for coding instructions. As with the original particle-location output, computed particle locations are in river miles or kilometers referenced to the upstream end of each travel path, which is designated by a downstream sequence of branch numbers. The first travel path can be comprised of any number of branches, as long as the path can be defined in downstream order as consecutive branch numbers.
- ❑ A default initial-condition capability has been added to facilitate cold start-up. If initial-condition water-surface elevations and discharges are not specified, i.e. Z and Q blank in Initial-Condition records, the model will apply any specified global-default values, i.e. GLICZ and GLICQ on the second Computation-Control record, or mean values it determines from the initial input boundary-value data. These values will be applied at internal junctions and initial conditions for intermediate cross sections between junctions will be linearly interpolated by weighted distance. For most typical model applications, i.e. single branch or sequential multiple branches, in which water-surface-elevation boundary conditions are employed, it should only be necessary to assign an estimated global default discharge via GLICQ and let the model assign initial-condition water-surface elevations from the initial-input, boundary-value data. For more complex model applications, i.e. dendritic or looped networks, it may also be desirable to assign estimated initial-condition water-surface elevations and discharges at internal junctions and let the model interpolate initial conditions at intermediate cross sections. As always, if true initial-condition values are known, they should be assigned; and initial conditions saved from a prior model simulation are always useful in starting up the model. For all simulations in which estimated, or otherwise approximated, initial conditions are used, ample time should be allowed for the model to converge to the true solution.
- ❑ A collection of graphics routines, called DIGSGKS were developed to permit BRANCH to be linked to a Graphical Kernel System (GKS) graphics library. These routines convert the

CalComp graphic calls of BRANCH to GKS calls. Included in DIGSGKS is an interactive output device configuration package which allows users to selectively choose output devices, plot size, colors, line types, and other plotting parameters. Values chosen are then stored in a configuration file for use in subsequent model executions. In this way, users can customize the type of digital graphic output produced by BRANCH. The menu shown below is the interface which allows the user to change plotting parameters or continue with the current values with minimal prompting. The default values for all plotting parameters are set to values which enable BRANCH graphics to be produced in an X-window on a Data General AViiON workstation. DIGSGKS allows users to open up to nine output devices during a single execution. For example, it is possible to produce a POSTSCRIPT file, a CGM file, and see the plots on your terminal during a single model execution by setting the workstation type parameters to appropriate values.

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         ** PLOT CONFIGURATION UPDATE MENU **

       Code                Activity
         0  --  Finished, save current values
         1  --  Update all values
         2  --  Computer and GKS workstation types
         3  --  Graphics image page size
         4  --  Plot offset and factor
         5  --  Color device, table, and background
         6  --  Line types
         7  --  Marker symbols
         8  --  Font name and precision
         9  --  Display plot configuration values

ENTER VALUE FOR SELECTION CODE (0-9)
CURRENT VALUE:      0
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- Initial time-step values for unknowns constituting boundary conditions at open-boundary locations are no longer extrapolated. Non-open-boundary unknowns are extrapolated as before for IEXOPT equal one.
- The geometry routine (ARBALL) to determine the area, hydraulic radius, conveyance width, and storage width at a given water-surface elevation and to extrapolate values for a given cross section has been rewritten to more efficiently index through the geometry arrays.
- Default dimensions of model arrays have been increased to allow for 30 branches and junctions, 100 cross sections, 5 measured data locations, 5 time-varying nodal flow locations, and instream input of 3000 water-surface-elevation boundary-value data and 1500 discharge boundary-value data or wind vectors. Note, that dimensions of all arrays can be readily changed by editing the DIMENS.CMN include file.
- The TDDS data base now allows for data intervals of 180 and 120 minutes (8 and 12 values per day).

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September 1, 1991 -- BRANCH version
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The BRANCH model code has been improved in efficiency (run-time speed) and should now execute at least 10 percent faster (the percentage increase will be greater for complex networks), with up to a 20% improvement possible on personal computers. The code has also been further modularized to improve readability and maintainability. This version of BRANCH was converted to be compatible with UNIX-based workstations. This basically involved the adoption of the convention to use lower-case letters to reference file names, such as FORTRAN include file names and program input and output file names. This was necessary as the UNIX operation system is case sensitive in regards to file names and also because applications such as FTP, by default, generate file names with lower-case letters. One exception, was to leave the BRANCH.MTR file name in upper case. Some FORTRAN unit numbers were also changed as a result of porting the code to UNIX-based platforms. The following summarizes important changes to BRANCH.

- ❑ The matrix solver routine (GEMXP), where 80% of the execution time is spent, has been revised to increase execution speed.
- ❑ The main routine (BRANCH) has been split into 5 routines to improve code modularity, increase run-time efficiency, and remove redundancies.
- ❑ The geometry routine (ARB) to determine the area, hydraulic radius, conveyance width, and storage width at a given water-surface elevation and to extrapolate values for a given cross section has been rewritten and split into two routines (ARBALL and XSTRAP) to compute the above properties for all cross sections in a single call.
- ❑ A new option has been added to allow output of snapshot maps of BRANCH computations to a sequential file. This option is controlled by the new computation-control variable OTMAP. Computed results are output at the simulation time increment for every cross section. To change the output format, users need only modify a short FORTRAN source routine, DTMAP.
- ❑ The functionality of NSTEPS (the number of time steps to be computed) has been enhanced, such that when a non-zero value is specified, the number of time steps computed by the model is limited to this value, unless this value exceeds the allowable time steps based on the simulation time step (IDTM) and the time span specified on the first Boundary-Value Data-Definition record.
- ❑ Specification of the simulation date and time (coded on the first Boundary-Value Data-Definition record) is only required when retrieving values from a data base or when NSTEPS is not specified. The default beginning date is the current system date. The default beginning time is INHR and INMN, also from the Computation-Control record, unless they are both set to zero, in which case the begin hour is set to the system hour and the begin minute is set to an integer multiple of IDTM less than or equal to the system minute. The ending date and time is then computed based on the beginning date and time, NSTEPS, and IDTM.
- ❑ Computation-control and initial-condition printout has been repositioned in order to be displayed as 80-column records.
- ❑ The elapsed clock time is computed and displayed at the conclusion of the simulation.
- ❑ Diagnostics have been improved to detect the potential presence of an extra Constant Nodal Flow record and to ensure that the boundary-value data recorded at the greatest frequency

are specified on the first Data-Definition record input when data are to be retrieved from a data base.

- ❑ FORTRAN INCLUDE file names are specified in lower-case letters.
- ❑ Default input unit has been changed from 5 to 55.
- ❑ Readability of printed output has been improved, for example, more separation (white space) has been added between computed values and leading zeros are now included in printed dates and times.
- ❑ File name specifications for the new map and BLTM output files are now included in the BRANCH.MTR file (master file). Users must recreate existing master files in order to use this new version of BRANCH (this is done automatically during interactive execution of the model).
- ❑ Postscript output is now available as plotter device number 9, when BRANCH is linked with the DIGSDISSPLA graphic routines on PRIME computers.
- ❑ Messages printed upon the detection of errors in Data-Definition records have been improved to include more information and to be more specific.

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October 29, 1990 -- BRANCH version

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The following summarizes important changes to BRANCH. The major change was the adoption of a 16-digit station identifier to supplement the old USGS-style 8-digit station number format. Station identifiers are now stored in CHARACTER*16 variables as opposed to INTEGER*4 variables used previously. Station identifier's can now be alphabetic names, numerics, e.q. latitudes and longitudes, or mixed alpha-numerics of varied lengths. This change required modification to the structure of the Time-Dependent Data Base (TDDB) and Data-Station Reference (DSR) files that are integral parts of the Time-Dependent Data System. Therefore, "old" TDDB and DSR files must be converted to be compatible with the "new" system. This can be accomplished by:

1) creating a backup copy of the "old" TDDB using the "old" TDDS BACKUP routine,
2) using the "new" TDDS ALLOCATE routine to convert the DSR file and allocate a "new" TDDB, and then
3) restoring the backup copy of the TDDB using the "new" TDDS BACKUP routine.

Downward compatibility with old input formats has been maintained to the maximum extent possible in order that old program control and data files can still be used with the "new" system. Old 8-digit station numbers will automatically be converted to the new 16-digit format, if coded according to the old format specifications. This conversion involves right justifying the specified 8 digits in the 16-digit field and removing leading zeros. In fact, every station identifier, regardless of the number of digits specified, is now automatically right justified (trailing blanks removed) in the 16-digit field and leading zeros are replaced with blanks as long as the specified station identifier has digits in the 11th-16th positions or is an integer field and specified using the coding conventions of previous model versions (8-digit, USGS-style station numbers).

Error messages issued have been improved and now have a more consistent format. Other system changes include more descriptive messages in interactive prompts, range checking of values requested in interactive prompts, and increased program modularity and system integration due to elimination of duplicate code.

Other extensions to BRANCH include:

- ❑ Graphics for BRANCH have been completely rewritten. References (calls) to DISSPLA graphics subroutines are replaced by calls to CalComp-like graphic subroutines to improve portability of the code.
- ❑ Graphics are now functional on PC's and workstations.
- ❑ Routines have been developed to allow retrieval of time-series data and storage of model results from (to) ANNIE WDM files.
- ❑ Energy conservation at internal junctions is now optionally considered.
- ❑ Various minor bugs have been fixed, such as: logical variables that were uninitialized are now initialized; retrieval times computed incorrectly for long simulations that spanned a calendar year corrected; and minor scaling problems in graphics fixed.
- ❑ Default dimensions of the model have been changed and new dimensioning parameters have been added to increase flexibility in sizing the code.
- ❑ The file (BSTORAGE.TXT) is now included to aid model user in customizing dimensions to optimize memory usage by the BRANCH source code.
- ❑ The station identifier for any Data-Definition record (boundary-value, nodal-flow, wind, or measured data) are specified identically. They may be either specified right-justified in columns 10-17 as has always been the case or specified anywhere in columns 8-23, as long as part of the station identifier is coded in columns 18-23. The variable specifying data recording interval (DT) is no longer available on Data-Definition records when using the new coding conventions, as the 16-digit station identifier now occupies the record positions previously used for DT. This means that the previously optional value for readings per day must be specified on Data-Definition records. The number of data per day are specified in columns 62-65. Note, the old format is still acceptable (DT specified in columns 8-9, and an integer station identifier specified in columns 10-17). BRANCH will assume you are using the old Data-Definition record format if columns 18-23 are blank, and will try to read DT and an 8-digit station number.

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February 8, 1989 -- BRANCH version

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BRANCH has recently undergone additional modification to increase functionality and ease of use. All file-opening is now isolated and hard-coded in this new version of the model, dated February 8, 1989. Important constants such as logical-unit file numbers are initialized in a BLOCK DATA (BLDBRN.F77) routine so that the model can more quickly be adapted to varied computer systems. All dimensioning parameters are located in an include file (DIMENS.CMN), therefore, to change the dimensions of the general model simply edit one short file (comprised of approximately 10 executable statements), recompile, and reload the new model version.

In addition, this model version is fully PC-microcomputer compatible. The Time-Dependent Data System (TDDS) is now fully functional on PC-microcomputers, thus providing complete data base support for the BRANCH model. PC versions of the DISSPLA graphics software are available that will allow the generation of digital-CRT or mechanical-pen graphical plots on PC systems thus enabling use of the digital-graphics plot options of BRANCH. The PC model version has been implemented and tested on a variety of IBM-compatible microcomputers (80286 as well as 80386 based machines having 80287 or 80387 math coprocessor) operating under Microsoft DOS 3.20 and Fortran 77 compiler versions 3.31, 4.01, and 4.1. The PC model, presently dimensioned for a maximum of 20 branches, 20 junctions, l00 cross sections, and a minimum computation frequency of 5 minutes, requires approximately 490K bytes of internal memory.

Other extensions to BRANCH include:

- ❑ Input measured data, for computational comparisons using model plot-generation options, can now span up to MAXMZQ/MDREAD number of days, where MAXMZQ is the assigned maximum number of measured data that can be input per location and MDREAD is the number of measured data recorded per day. The model can now produce plots of measured versus computed data for multiple days, at multiple measured-data locations, and for measured data input at any valid recording interval. All sets of measured data must still be input at the same beginning date and time within the time span of the flow simulation.
- ❑ Time-varying wind conditions can now be retrieved from the time-dependent data base by the model.
- ❑ Time-varying nodal-flow data can be input to the model, either instream or from the time-dependent data base.
- ❑ Overbank storage has been added to the model formulation. (This necessitated a shift of piece-wise-linear functions of eta 10 columns to the right on input Cross-Sectional Geometry Data records to allow for specification of the storage portion of the total channel width.)
- ❑ Storage widths are output in the tabular printout produced by printout option zero.
- ❑ ETAMIN, ETAMAX, and TOLERR parameters have been added to the second Computation-Control record. (These are controls on an automatic calibration procedure--not yet implemented--that is being evaluated for use in BRANCH.)
- ❑ Time-varying boundary-value, wind, and nodal-flow data-definition information is now printed out for all flow simulations.
- ❑ Resolution of time-varying boundary-value data has been improved so that parabolic interpolation of data input at other than the simulation time frequency is also performed for the time steps immediately preceding and following data retrievals from the time-dependent data base (TDDB).
- ❑ Application of the datum adjustment for model-computed water-surface elevations stored in the TDDB has been corrected.
- ❑ Statistics for plots of computed versus measured data have been improved.
- ❑ The capability to specify the time interval for printed output has been incorporated for printout options 0, 1, and 5 through 8. The desired printed-output time interval, in minutes, is specified on the second Computation-Control record.
- ❑ Date and time of the model execution are now indicated in the printed output for all flow simulations.
- ❑ water-surface-elevation/discharge rating tables can now be specified for external boundary conditions.

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June 20, 1986 -- BRANCH version

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The operational version of BRANCH, dated June 20, 1986, has been totally restructured to a more modular framework comprised of a main program, 28 subprograms, and 25 common block units.

This new modular structure more easily facilitates adaptation of the general model to network flow systems having variable dimension needs, special boundary-condition requirements, and (or) other unique computational demands.

In addition, this model version is PC-microcomputer compatible, although not yet providing time-dependent data base (TDDB) support or availing the generation of digital-CRT or mechanical-pen graphical plots on PC systems. The full, operational, model version, including the TDDB link and digital plotting subprograms, has, however, been completely checked out on the USGS/WRD Prime and USGS/ISD Amdahl computer systems using their resident F77 compilers. The PC model version has been implemented on an IBM-compatible 8088-based microcomputer with an 8087 coprocessor and 640k bytes of memory operating under Microsoft DOS 2.11 and FORTRAN 77 compiler version 3.20. The PC model, presently dimensioned for a maximum of 25 branches, 25 junctions, l00 cross sections, and a minimum computation frequency of l0 minutes, requires approximately 440k bytes of internal memory.

An interactive update procedure for the computation control file has been developed and added to BRANCH. This procedure facilitates modification of existing Network-name, Comment, and (or) Computation-Control records interactively during the model initiation process. An interactive file designation procedure has also been developed to facilitate execution of the model. (These procedures are described elsewhere.)

Other extensions to this version of BRANCH include:

- ❑ Input measured data, for computational comparisons using model plot-generation options, can now span two calendar days and are no longer restricted to the computational time-step frequency.
- ❑ The number of external boundary-condition locations can equal the number of junctions in the network, with up to five (can be readily increased) specifiable as sets of time-varying water levels and (or) discharges.
- ❑ Self-setting external boundary-condition options have been developed. In conjunction with the self-setting options, minimum condition values can be specified to facilitate the simulation of a submerged weir or gate, as special cases. Self-setting boundary conditions are designated by setting the data type of the first Boundary-Value Data (BVD) record for the junction to ‘ZP’ or ‘QP’ for water levels or flow discharges, respectively, and assigning the appropriate junction number. Optional minimum conditions can be designated by assigning the number of BVD input as ‘l’ on the first BVD record and inserting a second BVD record with the desired minimum value coded in positions l-l0. These new self-setting boundary-condition options supplement the existing time-dependent and equation type boundary-condition specifications. (Care must be exercised in the selection of mathematically consistent combinations of external boundary conditions. Furthermore, additional emphasis is placed on the need for greater accuracy in the initial conditions, particularly when using self-setting boundary-condition options.)
- ❑ Courant numbers are computed, using the specified initial conditions, channel geometry data, and computational time step value, and printed for the segment and branch yielding the greatest values. This information should be helpful in schematizing the channel network and subsequently defining the most appropriate finite-difference approximation.
- ❑ Default values can be specified for the velocity-distribution coefficient, beta, and the flow-resistance coefficient, eta. This can be accomplished by coding a ‘l’ in position 80 of the original (first) Computation-Control record and inputting a second Computation-Control record with beta and (or) eta values coded in positions l-4 and 5-9, respectively. The specified default coefficient values are printed in the Computation-Control record summary

table that precedes the simulation output, thus helping document trial calibration runs. This feature is most useful for model applications in which universally constant velocity-distribution and flow-resistance conditions are sufficient for conducting flow simulations.

- ❑ An option has been added to print the assigned dimensions of arrays in the general model version as well as the dimension requirements of the particular model application being conducted. In addition, all arrays whose dimensions are assigned according to a particular variable and the program element (COMMON block or MAIN) in which the arrays reside are identified in the tabular printout. This information serves to facilitate the customizing of the general model code to the particular prototype waterbody being simulated. This optional printout is invoked by coding a ‘1’ in position 77 of the first Computation-Control record.

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November 1, 1985 -- BRANCH version

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New features and capabilities incorporated into the November 1, 1985, version of BRANCH are summarized as follows:

- ❑ An option has been added to suppress the printing of segment-length warning messages. (See ISMOPT variable of the Computation-Control record.)
- ❑ Extrapolation for cross-sectional area and top width is performed whenever a computed water-surface elevation lies outside the range of values given in the cross-sectional geometry table. The simulation is terminated, however, if a computed water-surface elevation is outside the defined range (i.e. if the computed water-surface elevation is less than the minimum or greater than the maximum water-surface elevation specified in the cross-sectional geometry table) by more than 20 percent. Quadratic extrapolation is employed if sufficient water-surface-elevation/area/top-width coordinates are available, otherwise linear extrapolation is used. Whenever a computed water-surface elevation at a cross section lies outside the range of the geometry table at some time step, but was immediately preceded at the previous time step by a computed water-surface elevation that was within range, a warning message is printed. Similarly, a message is printed upon reentry to the geometry table from a previous time step in which a computed water-surface elevation was outside the geometry-table range.
- ❑ The flow-resistance coefficient can also be specified as a linear or quadratic function of water-surface elevation. Set the TYPETA variable of the Computation-Control record to 7 and provide equation coefficients for the flow-resistance relationship on the first Initial-Condition record for the upstream cross section defining each branch segment. As with the previous version of BRANCH, specification of TYPETA, whether it be 7 or another value, establishes the type of parametric relationship that will be used to define the flow-resistance coefficient for all branch segments of the model application.
- ❑ The flow-resistance relationship can be defined and input as a piece-wise-linear function of temperature, hydraulic depth, discharge, Froude number, Reynolds number, or water-surface elevation for any given branch segment. Set TYPETA to the appropriate value and provide the piece-wise-linear functions on the Cross-Sectional Geometry Data records. The model will expect to find flow resistance defined as a piece-wise-linear function for a particular segment whenever a value is input for the flow-resistance coefficient on the first Cross-Sectional Geometry Data record of the upstream cross section defining the segment. In other words, specification of a piece-wise-linear flow-resistance function on the input Cross-Sectional Geometry records for any particular segment will cause these piece-wise-linear functions to be used to define the flow-resistance relationship. Moreover, a specified

piece-wise-linear function will supersede a relationship (if any) defined by equation (constant, linear, or quadratic) on the Initial-Condition record for the segment. Whenever a piece-wise-linear function is selected for a branch segment, the model expects that a complete table will be input for the flow-resistance coefficient and its specific dependent variable parameters, i.e., values must be specified for every Cross-Sectional Geometry Data record. (If the eta value of the first Cross-Sectional Geometry Data record input for a cross section is not specified, or is set to zero, all other eta values specified for the cross section are ignored.) Parameters defining the dependent variables must be defined and input in the order required for Cross-Sectional Geometry records. Hydraulic depths for depth-dependent eta relationships are determined from input cross-sectional area divided by top width. Froude number relationships are determined from input cross-sectional area, top width, and discharge. Reynolds number relationships require cross-sectional area, top width, discharge, and temperature to be specified. Linear interpolation is used to obtain flow-resistance coefficients between specified values of the piece-wise-linear function.

- ❑ Output can now be generated on selected digital graphics devices supported by the USGS/WRD Prime computer systems. To accommodate digital output via DISSPLA (which uses Fortran file unit numbers 6 and 11), printer output, as well as branch identification and Initial-Condition records (when input from an external file), are now assigned to Fortran file unit numbers 66 and 67, respectively, on the Prime version of the BRANCH model. Users must allow for this change in their Prime CPL programs which designate the unit numbers and open the input/output files for executing BRANCH. (NOTE: Subsequent revisions to this CPL program have removed the necessity to assign unit numbers and open files.)
- ❑ Four new digital graphics devices are supported by the model. In addition to previous device types, plots can be produced on HP-7475 pen-type plotters, TAB graphical terminals, as well as on Tektronix model 4014 and 4105 terminals. Other device drivers available through DISSPLA can also be called by incorporating appropriate code changes in the new DEVSET subroutine of BRANCH.
- ❑ It is now possible to produce graphical output on any available plotter device (except line printers) in combination with any printout option. If line-printer plots are desired, the printout option must specify ‘no tabular printout’, i.e. IPROPT must equal 3. (The previously documented output option variable (IOTOPT) is hereafter referred to as the printout option variable (IPROPT).)

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May 20, 1983 -- Memorandum

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Memorandum, entitled COMPUTATION--Instructions for Use of the Time-Dependent Data Base Storage Option of the Branch-Network Flow Model, provided instructions for storing computed results in the Time-Dependent Data Base (TDDB), as described in the input-preparation instructions. (The Time-Dependent Data System (TDDS) can handle data-time increments of 1, 2, 5, 6, 10, 15, 30, and 60 minutes.) Only data from the complete time span of a simulation can be stored using this facility. No data will be stored for a given location and parameter if data already exist in the TDDB coincident, in whole or in part, with the time span of the simulation. The operational version of BRANCH, dated May 12, 1983, incorporated all of the above enhancements and additions.

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October 29, 1981 -- Memorandum

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Memorandum, entitled COMPUTATION--Changes to the Branch-Network Flow Model, provided information on the following additional capabilities:

- ❑ Options to control detailed printing of intermediate results.
- ❑ Correction factor for multiplying input discharge boundary-value data by a constant factor, thus permitting input discharges to be increased or decreased by a specified percentage.
- ❑ Revised specification of flow-volume summary requests.

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October 6, 1981 -- Memorandum

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Memorandum, entitled COMPUTATION--New Features, Changes, and Additional Capabilities Incorporated in the Branch-Network Flow Model, described new or improved model options to:

- ❑ Input boundary-value data instream with multiple values on each record.
- ❑ Input time-varying wind conditions instream.
- ❑ Produce printout in varied formats as identified in the input-preparation instructions.
- ❑ Save final results of a flow simulation in a file for use as initial conditions in a subsequent simulation.
- ❑ Input initial conditions from an external file.

In addition, it was pointed out in the memorandum that, in the equation of motion near the bottom of the left-hand column of page 5 of the TWRI, the $\delta A/\delta x$ partial derivative should be written as $(\delta A/\delta x)|z$ to emphasize that the rate of change of area with respect to longitudinal distance is evaluated at a fixed water-surface elevation.

[1]Any use of trade names herein is for identification purposes only and does not constitute endorsement by the United States Geological Survey.

Network-Name Record
Computation-Control Record(s)
Optional Comment Records: Up to 9
Branch 1: Identification Record
Branch 1: Cross Section 1: Initial Condition Record 1
Branch 1: Cross Section 1: Initial Condition Record 2
Optional Branch 1: Cross Section 1: Initial Condition Record 3 for MODFLOW/BRANCH interface
Branch 1: Cross Section 1: Data Count [IPT(IJ)] Record
Branch 1: Cross Section 1: IPT(IJ) Data Records
.....
.....
Branch 1: Cross Section NSEC(I): Initial Condition Record 1
Branch 1: Cross Section NSEC(I): Initial Condition Record 2
Optional Branch 1: Cross Section NSEC(I): Initial Condition Record 3 for MODFLOW/BRANCH interface
Branch 1: Cross Section NSEC(I): Data Count [IPT(IJ)] Record
Branch 1: Cross Section NSEC(I): IPT(IJ) Data Records
Branch 2: Identification Record
.....
.....
Optional Particle Tracking Record 1
Optional Particle Tracking Record 2
Optional Multi-Path Particle Tracking Record 1
Optional Multi-Path Particle Tracking Record 2
Optional Multi-Path Particle Tracking Record 3
.....
.....
Optional User-Defined Table Results Output Record
Constant Nodal Flow Record(s) (10 Junctions per record)
Time-Dependent Data-Base List-Index Record
Boundary Condition 1: Data-Definition Record
Boundary Condition 1: (optional) (NDATA(1)-1)/NOPCRD+1 BVD Records
Boundary Condition 1: (or optional) One Record of Equation Coefficients
Boundary Condition 1: (or optional) (|NDATA(1)|-1)/4+1 Rating Table Records
Boundary Condition 2: Data-Definition Record
.....
.....
Optional Time-Varying Nodal-Flow Condition 1: Data-Definition Record
Optional Time-Varying Nodal-Flow Condition 1: (Optional) (NNDAT(L)-1)/NOPCRD+1 Data Records
Optional Time-Varying Nodal-Flow Condition 2: Data-Definition Record
.....
.....
Optional Time-Varying Wind-Condition Data-Definition Record
Optional Time-Varying Wind-Condition (NWDATA-1)/4+1 Data Records
Optional Measured Data 1: Data-Definition Record
Optional Measured Data 1: (optional) (MDATA(L)-1)/NOPCRD+1 Data Records
Optional Measured Data 2: Data-Definition Record
.....
.....

Figure 15.--Input-record order for the branch-network flow model (revised TWRI 7-C3).

Appendix I[1]

Program Control-Record Format

There are 14 record types used for input to the branch-network flow model. Eight record types are required; six others, that is, Comment, Particle-Tracking, User-Table Results, Time-Varying Nodal Flow, Wind-Condition, and Measured Data records are optional. All available parameter defaults can be taken simply by having the appropriate record column(s) blank. If all parameters on a particular record have acceptable defaults, the defaults can be exercised by inserting a blank record. As is identified in the table below, both metric and inch-pound equivalent default parameter values are available. The order of record input is illustrated by Figure 15(revised). The functional purpose of each record is given as follows:

Network-Name record identifies the network being simulated.

Computation-Control record(s) defines the network dimensions, assigns the computation time increment, specifies the iteration and convergence criteria, signifies the choice of input/output units, assigns various constants and coefficients, and selects the type of output desired.

Comment record(s) are printed before the computation-control-record printout and may be used to describe and identify the particular simulation run.

Branch-Identity record identifies each branch by name and number and indicates the positive flow direction, as well as the number of cross sections to be input to define the channel segments and their geometry (one such record for each branch in the network).

Initial-Condition records (two or three records for each of the cross sections in the identified branch) assign the segment lengths, water temperature, flow-resistance coefficients, wind direction, and momentum coefficient, in addition to the initial values of water-surface elevation and discharge. The third record (optionally input when IMODFW>0) is input for coupled MODFLOW/BRANCH simulations. This record defines the column, row, and layer number of the MODFLOW cell containing the river reach, the leakage coefficient for the reach, and the elevation of the river bed.

Cross-Sectional Geometry records constitute a set of data records (preceded by one record identifying the number of data records input) defining the particular cross-sectional geometry relationships and may optionally define flow resistance as a function of water-surface-elevation, discharge, and/or temperature (one set for each cross section in the identified branch).

Particle-Tracking records define the location of the main channel of the network and the initial position of index particles for purposes of permitting the tracking of such particles throughout the simulation.

User-Table Results records (optionally input when OTFILE=5) define the type, branch, and section number for outputting selected results of a simulation to a file.

Nodal-Flow record(s) assigns constant external inflows (outflows, if negative) at each internal junction.

List-Index record controls identification of data stored in the time-dependent data base, and thereby available as boundary-value data.

Boundary-Value Data records consist of one record identifying the boundary-value data (required at each external junction) by type, station identifier, external junction number, recording frequency, and beginning and ending dates and times and are optionally followed by boundary-value data records (if such data are to be input instream), by one coefficient record (if the boundary condition is to be specified by an equation), or by water-surface-elevation/discharge rating-table records (if the boundary condition is to be specified by rating table).

Time-varying nodal-flow records consist of an initial record defining the external inflow or outflow by internal junction number, station identifier, and recording frequency and are optionally followed by records containing the nodal-flow values (outflows are input as negative values).

Wind-condition records consist of an initial record identifying the time-varying wind data by station identifier and recording frequency and are optionally followed by records containing the wind speed and direction values.

Measured data records consist of an initial record identifying the measured data (used for plotting versus computed results) by type, station identifier, junction or branch and cross-section numbers, recording frequency, and beginning and ending dates and times and are optionally followed by records containing the measured values.

Abbreviations used within the Appendix:

BLTM -Branched Lagrangian Transport Model

BVD -Boundary-Value Data

BVDD - Boundary-Value Data-Definition

DSR - Data-Station Reference

EN - English (inch-pound) system of units

GKS - Graphical Kernel System

ME - Metric system of units

NetCDF - Network Common Data Form

TDDB - Time-Dependent Data Base

TDDS - Time-Dependent Data System

WDM - Watershed Data Management

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[1]Supersedes Appendix I as published in TWRI 7-C3, A model for simulation of flow in singular and interconnected channels, R. W. Schaffranek, R. A. Baltzer, and D. E. Goldberg, July 1981.

Variable	Default	Position	Format	Notes	Definition
Network-Name record (one required per execution)					
NETNAM	blanks	1-80	A80	--	Name of the open-channel network used to annotate simulation results
Computation-Control record 1 (one required per execution)					
IUNIT	EN	1-2	A2	--	System of units of input data EN - in/lbs; ME - metric
NBCH	-----	3-4	I2	--	Number of branches in network (0<NBCH≤MXBH)
NJNC	-----	5-6	I2	--	Number of junctions (both internal and external) in network (1<NJNC≤MXJN)
NBND	-----	7-8	I2	1	Number of open boundaries (1<NBND≤MXJN)
NSTEPS	-----	9-12	I4	2	Number of time steps to be computed
OUNIT	EN	13-14	A2	--	System of units of output results EN - in/lbs; ME - metric
IRDGEO	0	15	I1	--	Option for input of cross-sectional geometry data 0 - read from computation-control file (.ctl); 1 - read from a separate file (.geo)
IMODFW	0	16	I1	--	Option for coupled MODFLOW/BRANCH simulation and input of MODBRNCH initial condition data 0 - regular BRANCH simulation, no MODFLOW/ BRANCH initial condition input; 1 - coupled MODFLOW/BRANCH simulation, MODFLOW/BRANCH initial-condition input required; 2 - regular BRANCH simulation, MODFLOW BRANCH initial-condition input required but ignored
NIT	5	17-18	I2	3	Maximum number of iterations per time step (usually 2<NIT<6)
IPROPT	0	19	I1	--	Printout option of computed results 0 - at each time step; 1 - at each iteration; 2 - as daily summaries; 3 - no tabular printout; 4 - as monthly flow-volume summaries; 5 - of terms at each time step; 6 - of terms at each iteration; 7 - at every time step in debug mode; 8 - at each iteration in debug mode; 9 - particle locations
IPLOPT	0	20	I1	--	Plot option of computed results 0 - no plots; 1 - computed discharge; 2 - computed water-surface elevation; 3 - computed versus measured discharge; 4 - computed versus measured water-surface elevation
IPLDEV	0	21	I1	4,5	Plotter device option 0 - line printer; 1-9 - installation dependent digital output devices
IPRMSG	0	22	I1	6	Option to print the TDDS diagnostic messages 0 - no; 1 - yes

Variable	Default	Position	Format	Notes	Definition
IPLMSG	0	23	I1	--	Option to print plotter software diagnostic messages 0 - no; 1 - yes
IEXOPT	0	24	I1	--	Option to extrapolate initial values for unknowns from present time-step values 0 - no; 1 - yes
TYPETA	1	25	I1	--	Type of functional flow-resistance (η) relationship 1 - constant; 2 - temperature; 3 - depth; 4 - discharge; 5 - Froude number; 6 - Reynolds number; 7 - water-surface elevation
INHR	-----	26-27	I2	7	Hour of initial-value data
INMN	-----	28-29	I2	7	Minute of initial-value data
IDTM	-----	30-33	I4	8	Simulation time increment > 0 in minutes; < 0 in seconds
THETA	1.0	34-36	F3.2	--	Finite-difference weighting factor (θ) for the spatial derivatives (usually $0.6 \leq THETA \leq 1.0$)
QQTOL	-----	37-41	F5.1	9	Discharge convergence criterion in feet^3 or meters^3 per second
ZZTOL	0.011/ .003	42-46	F5.3	--	Water-surface-elevation convergence criterion in feet or meters
WSPEED	0.0	47-51	F5.2	--	Wind speed in miles or kilometers per hour
WSDRAG	0.0026	52-56	F5.4	--	Water-surface drag coefficient
H2ODEN	1.9617/ 1.011	57-61	F5.4	--	Water density in slugs per cubic feet or grams per cubic centimeter
CHI	THETA	62-64	F3.2	10	Weighting factor (χ) for function values in the flow equations (usually CHI=THETA)
IWRTIC	0	65	I1	--	Option to write results at end of simulation to a file (.ico) for subsequent input as initial conditions 0 - no; 1 - yes
IENIBC	0	66	I1	11	Option to use conservation of energy as boundary condition at all internal junctions instead of water-surface-elevation compatibility 0 - no; 1 - yes
IRDIC	0	67	I1	--	Option for input of Branch Identification and Initial-Condition data 0 - read from computation-control file (.ctl); 1 - read from a separate file (.ici)
NUMCOM	0	68	I1	--	Number of Comment records following the Computational-Control record(s)
WDIREC	0.0	69-73	F5.1	--	Constant wind direction measured clockwise from true North
INWIND	0	74	I1	--	Time-varying wind input 0 - no; 1 - yes

Variable	Default	Position	Format	Notes	Definition
OTFILE	0	75	I1	33	Option to output results at each time step to a file 0 - no filed output; 1 - TDDB option: selected data sets, by cross section and parameter types (Z, Q, A, and (or) B) saved to a TDDB (.tdd); 2 - BLTM option: Q, A, and B data for all cross sections saved to a BLTM flow file (BLTM.FLW); 3 - map file option: Z, Q, A, B, and BS data for all cross sections saved to a text file (.map); 4 - NetCDF option: Z, Q, A, and B data for all cross section saved to a NetCDF formatted file (br.*date*.cdf, where *date* is the simulation start date); 5 - User-table option: selected data sets, by cross section and parameter types (Z, Q, A, B, BS, and (or) V) saved to a text file (.pst)
IWMOPT	0	76	I1	--	Option to suppress segment-length and (or) nonconvergence warning messages 0 - no; 1 - nonconvergence only; 2 - segment-length only; 3 - both
IARDEM	0	77	I1	--	Option to print model array dimensions 0 - no; 1 - yes
IPRFMT	0	78	I1	--	Option to select width of printed simulation results 0 - 80 character; 1 - 132 character
KTCONS	0	79	I1	--	Number of constituents to be defined for transport computations (transport not fully implemented in this version) 0 - none; 1 - salinity
IRDNXT	0	80	I1	--	Option to read second Computation-Control record 0 - no; 1 - yes
Computation-Control record 2 (one required when IRDNXT=1)					
GLBETA	1.0	1-4	F4.2	--	Global default momentum (BETVEL) coefficient
GLETA	0.0	5-9	F5.4	--	Global default flow-resistance (ETA) coefficient
ETAMIN	0.0	10-14	F5.3	--	Minimum eta value for flow-resistance optimization
ETAMAX	0.0	15-19	F5.3	--	Maximum eta value for flow-resistance optimization
TOLERR	0.0	20-23	F4.2	--	Error tolerance for flow-resistance optimization
IPRTDT	0	24-27	I4	8	Time increment in minutes at which tabular printout is produced
GLICQ	0.0	30-37	F8.1	32	Global default initial discharge
GLICZ	0.0	38-43	F6.2	32	Global default initial water-surface elevation
DCFM	0.0	44-49	F6.2	--	Multiplier for the friction term in momentum equation when a channel becomes dry
AIRDEN	.002338/ .001205	50-57	F8.6	--	Air density
H2OSAL	0.0	58-63	F6.3	--	Global default initial water salinity
H2OTMP	68.0/20.0	64-69	F6.3	--	Global default water temperature in degrees Fahrenheit or degrees Celsius
DSPRSN	0.0	70-76	F7.1	--	Global default longitudinal-dispersion coefficient

Variable	Default	Position	Format	Notes	Definition
GPRBCH	0	77	I1	--	Global print flag to override PRTBCH and PRTSUM 0 - do not override; 1 - override to not print results for every branch; 2 - override to print results for every branch;
GPLBCH	0	78	I1	--	Global plot flag to override PPLTBH and PLTBCH 0 - do not override; 1 - override to not plot results for every branch; 2 - override to plot results for every branch;
GPRTXS	0	79	I1	--	Global print flag to override PRTXSG 0 - do not override; 1 - override to not print geometry for every cross section; 2 - override to print geometry for every cross section;
Comment record (zero to nine optional)					
COMMNT	blanks	1-80	A80	--	Comments to annotate printed output file
Branch-Identification records (one required per branch)					
IJF	0	1-2	I2	--	Junction number identifying the source of positive flow for the branch ($0<IJF\leq NJNC$)
IJT	0	3-4	I2	--	Junction number identifying the outlet of positive flow for the branch ($0<IJT\leq NJNC$)
NSEC	0	5-6	I2	12	Number of cross sections input to define the geometry of the branch
NAME	blanks	7-48	A40	--	Name of branch
IJFEN	0	74	I1	13	Option to use water-surface-elevation compatibility instead of conservation of energy as boundary condition at this branch junction 0 - use conservation of energy; 1 - use water-surface-elevation compatibility
IJTEN	0	75	I1	13	Option to use water-surface-elevation compatibility instead of conservation of energy as boundary condition at this branch junction 0 - use conservation of energy; 1 - use water-surface-elevation compatibility
PRTBCH	0	76	I1	--	Option to suppress print of simulation results for this branch 0 - no; 1 - yes
PRTSUM	0	77	I1	--	Option to suppress print of daily summaries of simulation results for this branch 0 - no; 1 - yes
PPLTBH	0	78	I1	--	Option to suppress line-printer plot of simulation results for each cross section of this branch 0 - no; 1 - yes
PLTBCH	0	79	I1	--	Option to suppress digital plot of simulation results for each cross section of this branch 0 - no; 1 - yes
PRTXSG	0	80	I1	--	Option to suppress print of input cross-sectional geometry for each cross section of this branch 0 - no; 1 - yes

Variable	Default	Position	Format	Notes	Definition
Initial-Condition records (two required per cross section, third record required when IMODFW≠0)					
----- First Initial-Condition record for the cross section -----					
Z	0.0001	1-10	F10.3	14	Initial water-surface-elevation value
Q	0.01	11-20	F10.3	--	Initial discharge value
RHO	1.9617/ 1.011	21-30	F10.4	--	Initial water-density value in slugs per cubic feet or grams per cubic centimeter
DX	0.0001	31-40	F10.2	--	Segment length, the distance to the next cross section
T	68.0/20.0	41-50	F10.2	--	Water temperature, in degrees Fahrenheit or Celsius
RN	0.0	51-80	3E10.4	--	Coefficients of flow-resistance relationship used in the following equation: $\eta(x) = RN(1) + RN(2)*x + RN(3)*x^2$
----- Second Initial-Condition record for the cross section -----					
ORIENT	0.0	1-10	F10.3	--	Segment orientation measured clockwise from true North
BETVEL	GLBETA	11-20	F10.3	--	Momentum coefficient
QLAT	0.0	21-30	F10.4	--	Initial lateral-discharge value
ULAT	0.0	31-40	F10.4	--	Initial lateral-velocity value
----- Third Initial-Condition record for the cross section (input when IMODFW≠0—used in couple MODFLOW/BRNACH simulations only) -----					
ISTRM	0	1-9	3I3	34	Row, column, and layer of aquifer model cell that corresponds to channel segment
CLK	0.0	10-19	F10.4	--	Leakage coefficient (K'/b')
ZBOT	0.0	20-29	F10.4	--	Elevation of channel bottom
Cross-sectional geometry records (one set required per cross section)					
----- First Geometry record identifies the number of input data records -----					
IPT	0	1-2	I2	15	Number of cross-sectional geometry data records (1<IPT≤MXPT)
XSTATN	0	4-19	A16	16, 17, 26	Station identifier of cross-section location
GDATUM	0.0	64-70	F7.3	--	Datum correction for water-surface-elevation reference of cross-section data
FVFLG	blanks	71-72	A2	26	Flag to indicate inclusion of the simulation results for this cross section in the flow-volume summary output (IPROPT=4); set to 'FV' or 'fv' to include
ITYPEO	blanks	73-80	4A2	33	Type of data to be output at cross section to a TDDB or WDM file ' Z' - water-surface elevation; ' Q' - discharge; ' A' - area; ' B' - top width)
----- IPT number of Cross-Sectional Geometry Data records -----					
ZA	0.0	1-10	F10.3	18	Water-surface elevation at which corresponding area and top width were measured (lowest elevation first)
AA	0.0	11-20	F10.3	--	Conveyance area at specified water-surface elevation

Variable	Default	Position	Format	Notes	Definition
BB	0.0	21-30	F10.3	--	Conveyance width at specified water-surface elevation
BS	0.0	31-40	F10.3	--	Storage width at specified water-surface elevation, not including conveyance width
WP	0.0	41-50	F10.3	--	Wetted perimeter at specified water-surface elevation
ETA	0.0	51-60	E10.4	--	Dependent flow resistance coefficient at specified water-surface elevation, hydraulic depth (AA/BB), discharge, Reynolds Number (QA/AA)*(AA/BB)/NU(T), temperature, or Froude Number ((QA/AA)/(G*AA/BB)**1/2) (Temperature-dependent kinematic viscosity (NU) is model determined by quadratic equation)
QA	0.0	61-70	F10.3	19	Discharge for specified ETA value
TA	0.0	71-80	F10.3	19	Temperature for specified ETA value
Particle-Tracking records (required when IPROPT=9)					
----- First Particle-Tracking record -----					
ITBCUS	blanks	1-2	A2	--	Type of BVD supplied at upstream end of main channel
IBCHUS	0	6-7	I2	--	Branch number of upstream boundary
ITBCDS	blanks	12-13	A2	--	Type of BVD supplied at downstream end of main channel
IBCHDS	0	17-18	I2	--	Branch number of downstream boundary
KTPATH	1	24-25	I2	--	The number of paths
----- Second Particle-Tracking record -----					
XPART	0.0	1-80	10F8.2	--	Initial particle locations (measured from upstream boundary location)
----- Third Particle-Tracking record (required when KTCONS > 0) -----					
C	0.0	1-80	10F8.2	--	Initial concentration at each particle locations (MXPART number of concentrations are input)
Multi-Path Particle-Tracking records (required when KTPATH > 1)					
----- First Multi-Path Particle-Tracking record -----					
KTPTBR	none	free	I	--	The number of branches in the path to be coded on next record
----- Second Multi-Path Particle-Tracking record -----					
IBRPT	none	free	I	--	Branch numbers included in the path, KTPTBR values are specified in downstream order with each value separated by a blank space or comma.
----- Third Multi-Path Particle-Tracking record -----					
XPART	0.0	1-80	10F8.2	--	Initial particle locations (measured from upstream boundary location)
----- Fourth Multi-Path Particle-Tracking record (required when KTCONS > 0) -----					
C	0.0	1-80	10F8.2	--	Initial concentration at each particle locations (MXPART number of concentrations are input)

Variable	Default	Position	Format	Notes	Definition
User-Table Results record (one record, required when OTFILE=5, up to NUMTBL (default=4) triplets allowed)					
UTTYP	blank	1-2, 13-14 25-26 37-38	A2	--	Parameter type to output for cross section
UTBCH	0	3-7 15-19 27-31 39-43	I5	--	Branch number of cross section
UTSEC	0	8-12 20-24 32-36 44-48	I5	--	Cross-section number within the branch
Constant Nodal-Flow records (one value per junction; 10 values per record)					
W	0.0	1-80	10F8.2	20	External flow (inflows are specified as positive flows and outflow or withdrawals as negative flows) at junction (constant nodal flow for duration of simulation assumed)
List-Index record (one required per execution)					
LISTB	0	38-39	I2	--	Option to list the data base directory index before simulation begins -1 - print chronological summary and directory list; 0 - do not print; 1 - print only directory list
LISTA	0	46-47	I2	--	Option to list the data base directory index after simulation is completed -1 - print chronological summary and directory list; 0 - do not print; 1 - print only directory list
Boundary-Value Data records (one set required per external junction)					
----- First record of each BVD set is a Data-Definition record -----					
ITYPE	‘ Z’	1-2	A2	21	Type of data to be input at junction ‘ Z’ - water-surface elevation; ‘ Q’ - discharge; ‘ZP’ or ‘QP’ - self-setting options; ‘ZE’ or ‘QE’ - equation; ‘ZS’ or ‘QS’ - sin equation)
IBJNC	0	3-4	I2	--	Junction number of external boundary location (0 < IBJNC≤NJNC)
NDATA	0	5-7	I3	22	Data input option (when NDATA=0 it is set to the value specified for ND in columns 73-77) 0 - retrieve from a data base (TDDB or WDM); 1 - equation is specified on the next record, either constant, up to third order, or sin equation; >1 - read from records following this record, with ND equal to the number of data values; <0 - rating table is specified on the next record(s); the absolute value of ND equals the number of water-surface-elevation/discharge relations in the table input
ISTATN	blanks	8-23	A16	16, 17	Station identifier for data location

***Note, pre 16-digit station identifier format for this record had the following two parameters instead of the one above, this format is still acceptable. The removal of DTT means IRDPDY must be specified for 16-digit coding.)

Variable	Default	Position	Format	Notes	Definition
DTT	0.0	8-9	F2.0	23	Recording interval in minutes
ISTATN	0	10-17	I8	17	Station identifier for data location
ITIME	-----	25-39	5(I2,1X)	24	Beginning date and time of time-series, in the format YR/MO/DY HR:MN
NTIME	-----	45-59	5(I2,1X)	24	Ending date and time of time-series, in the format YR/MO/DY HR:MN
NOPCRD	1	60	I1	--	Number of values coded in F10.3 format on each record following this record that specify the data for this time-series (NDATA>1)
IRDPDY	0	62-65	I4	23	Number of values recorded per day
DATUM	0.0/1.0	66-72	F7.3	25	Datum correction for water-surface-elevation data (default=0.0), multiplicative factor for discharge data (default=1.0)
ND	0	73-77	I5	--	Number of BVD input. (ND is used when NDATA must be specified with a value greater than 999. ND overrides any value specified for NDATA when ND is specified greater than 0)
STYPE	‘I2’ for ‘Z’ data, else ‘I4’	79-80	A2	--	Data storage type (required to get data from a TDDB) ‘I2’ - Two-byte Integer; ‘I4’ - Four-byte Integer ‘R4’ - Four-byte Real; ‘R8’ - Eight-byte Real
----- Boundary-Value Data records if input in computation control file ((NDATA-1)/NOPCRD+1 number) -----					
ZQ	0.0	1-80	8F10.3	--	Water-surface-elevation or discharge boundary value
----- Water-surface-elevation/discharge rating-table records if boundary condition is specified by rating table ((NDATA-1)/4+1 number) -----					
ZT	0.0	1-10 21-30 41-50 61-70	E10.4	--	Water-surface elevation of water-surface-elevation/ discharge rating table
QT	0.0	11-20 31-40 51-60 71-80	E10.4	--	Discharge of water-surface-elevation/discharge rating table
----- Equation record containing coefficient if boundary condition is specified by equation (NDATA=1) -----					
ZQVBCO	0.0	1-40	4E10.4	--	Coefficients of the boundary-value equation:

Constant value

Z or Q = ZQBVCO(1)

Third-order equation for ITYPE = ‘ Z’

$Z(Q) = ZQBVCO(1) + ZQBVCO(2)*Q + ZQBVCO(3)*Q^2 + ZQBVCO(4)*Q^3$

Third-order equation for ITYPE = ‘ Q’

$Q(Z) = ZQBVCO(1) + ZQBVCO(2)*Z + ZQBVCO(3)*Z^2 + ZQBVCO(4)*Z^3$

Sin equation for ITYPE = ‘ZS’ or ‘QS’

Z or Q = ZQBVCO(1) + (ZQBVCO(2)/2)*SIN(.01745329*((M*DT/ZQBVCO(3)*180)+ZQBVCO(4)))

where QBVCO(1) = mean water-surface elevation (‘ZS’) or mean discharge (‘QS’); ZQBVCO(2) = amplitude; ZQBVCO(3) = phase; ZQBVCO(4) = offset; M = time-step number; and DT = time step in seconds

Variable	Default	Position	Format	Notes	Definition
----- Minimum Value record containing minimum water-surface-elevation or discharge value for self-setting boundary-condition option (NDATA=1 and ITYPE=’ZP’ or ‘QP’): Note, if ITYPE=’ZP’ or ‘QP’ and NDATA≠1 no other records are input for that external boundary and ZQPMIN is set to -9999999.0 -----					
ZQPMIN	0.0	1-10	E10.4	--	Minimum discharge value if ITYPE=’QP’ or minimum water-surface-elevation value if ITYPE=’ZP’

Time-Varying Nodal-Flow data records (up to MXTDNF, default=2, sets required for each junction at which constant nodal flow is assigned the value -9999999)

Variable	Default	Position	Format	Notes	Definition
----- First record of each nodal-flow data set is a Data-Definition record -----					
NFTYPE	‘ Q’	1-2	A2	--	Type of data to be input at junction (‘ Q’ - discharge)
INJNC	0	3-4	I2	--	Junction number of internal nodal flow location (0<INJNC≤NJNC)
NNDAT	0	5-7	I3	27	Data input option (when NNDAT=0 it is set to the value specified for NND in columns 73-77) 0 - retrieve from a data base (TDDB or WDM); >1 - read from records following this record, with NNDAT equal to the number of data values
NSTATN	blanks	8-23	A16	17	Station identifier for data location
***Note, pre 16-digit station identifier format for this record had the following two parameters instead of the one above, this format is still acceptable. The removal of DTTN means IRDPDY must be specified for 16-digit coding.)					
DTTN	0.0	8-9	F2.0	23	Recording interval in minutes
NSTATN	0	10-17	I8	17	Station identifier for data location
NFTIME	-----	25-39	5(I2,1X)	24	Beginning date and time of time-series, in the format YR/MO/DY HR:MN
MTIME	-----	45-59	5(I2,1X)	24	Ending date and time of time-series, in the format YR/MO/DY HR:MN
NOPCRD	1	60	I1	--	Number of values coded in F10.3 format on each record following this record that specify the data for this time-series (NNDAT>1)
IRDPDY	0	62-65	I4	23	Number of values recorded per day
DATMNF	1.0	66-72	F7.3	25	Multiplicative factor
NND	0	73-77	I5	--	Number of BVD input. (NND is used when NNDAT must be specified with a value greater than 999 and is only used when NNDAT=0)
NFSTYP	‘I2’ for ‘Z’ data, else ‘I4’	82-83	A2	--	Data storage type (required to get data from a TDDB) ‘I2’ - Two-byte Integer; ‘I4’ - Four-byte Integer ‘R4’ - Four-byte Real; ‘R8’ - Eight-byte Real
----- Nodal-Flow Data records if input instream ((NNDAT-1)/NOPCRD+1 number) -----					
WT	0.0	1-80	8F10.3	--	Nodal-flow values

Variable	Default	Position	Format	Notes	Definition
Time-Varying Wind Data records (one set required when INWIND=1)					
----- First record of each wind condition data set is a Data-Definition record -----					
IWTYPE	‘ W’	1-2	A2	--	Type of data (‘ W’ - wind speed and direction)
NWDATA	0	5-7	I3	28	Data input option 0 - retrieve from a data base (TDDB or WDM); >1 - read from records following this record, with NWDATA equal to the number of data values
IWSTAN	blanks	8-23	A16	16, 17	Station identifier for data location
***Note, pre 16-digit station identifier format for this record had the following two parameters instead of the one above, this format is still acceptable. The removal of WDTT means NWREAD must be specified for 16-digit coding.)					
WDTT	0.0	8-9	F2.0	23	Recording interval in minutes
ISTATN	0	10-17	I8	17	Station identifier for data location
IWTIME	-----	25-39	5(I2,1X)	24	Beginning date and time of time-series, in the format YR/MO/DY HR:MN
NWTIME	-----	45-59	5(I2,1X)	24	Ending date and time of time-series, in the format YR/MO/DY HR:MN
NWREAD	0	62-65	I4	23	Number of values recorded per day
WCDATM	1.0	66-72	F7.3	25	Multiplicative factor
WSTYP	‘I2’ for ‘Z’ data, else ‘I4’	82-83	A2	--	Data storage type (required to get data from a TDDB) ‘I2’ - Two-byte Integer; ‘I4’ - Four-byte Integer ‘R4’ - Four-byte Real; ‘R8’ - Eight-byte Real
----- Time-Varying Wind Condition Data records if data input instream ((NWDATA-1)/4+1 number) -----					
WINDSP	0.0	1-10 21-30 41-50 61-70	F10.3	--	Wind speed in miles per hour or kilometers per hour
WINDDR	0.0	11-20 31-40 51-60 71-80	F10.3	--	Wind direction measured clockwise from true North
Measured-Data records (Up to MXMD (default=5) sets optionally required when plotting computed versus measured data)					
----- First record of each measure-data set is a Data-Definition record -----					
MTYPE	‘ Z’	1-2	A2	29	Type of data to be input at junction or branch/cross-section ‘ Z’ - water-surface elevation; ‘ Q’ - discharge)
MJNC	0	3-4	I2	--	Junction number of measured-data location (0<MJNC≤NJNC)
MDATA	0	5-7	I3	31	Data input option (when MDATA=0 it is set to the value specified for MD in columns 73-77) 0 - retrieve from a data base (TDDB or WDM); >1 - read from records following this record, with MDATA equal to the number of data values
MSTATN	blanks	8-23	A16	17	Station identifier for data location

Variable	Default	Position	Format	Notes	Definition
***Note, pre 16-digit station identifier format for this record had the following two parameters instead of the one above, this format is still acceptable. The removal of CDTT means MDREAD must be specified for 16-digit coding.)					
CDTT	0.0	8-9	F2.0	23	Recording interval in minutes
ISTATN	0	10-17	I8	17	Station identifier for data location
MEITIM	-----	25-39	5(I2,1X)	24, 32	Beginning date and time of time-series, in the format YR/MO/DY HR:MN
MEKTIM	-----	45-59	5(I2,1X)	24, 32	Ending date and time of time-series, in the format YR/MO/DY HR:MN
NOPCRD	1	60	I1	--	Number of values coded in F10.3 format on each record following this record that specify the data for this time-series (MDATA>1)
MDREAD	0	62-65	I4	23	Number of values recorded per day
CDATUM	0.0/1.0	66-72	F7.3	25	Datum correction for water-surface-elevation data (default=0.0), multiplicative factor for discharge data (default=1.0)
MD	0	73-77	I5	--	Number of BVD input. (MD is used when MDATA must be specified with a value greater than 999 and is only used when MDATA=0)
MBCH	0	78-79	I2	29, 30	Branch number of measured-data location (0<MBCH≤NBCH)
MSEC	0	80	I1	30	Cross-section number of measured-data location (0<MSEC≤NSEC)
MDSTYP	‘I2’ for ‘Z’ data, else ‘I4’	82-83	A2	--	Data storage type (required to get data from a TDDB) ‘I2’ - Two-byte Integer; ‘I4’ - Four-byte Integer ‘R4’ - Four-byte Real; ‘R8’ - Eight-byte Real
----- Measured-Data records if input in computation control file ((MDATA-1)/NOPCRD+1 number) -----					
ZQMEAS	0.0	1-80	8F10.3	--	Measured water-surface-elevation or discharge boundary value

1) Number external boundary conditions that can be specified as time-series of values is limited by parameter MXTDBC in DIMENS.CMN file, default is 15. This value no longer includes internal-station locations; these are now specified by setting the FVFLG flag to FV on the first Cross-Sectional Geometry record for each cross section to be included in the flow-volume summary output and are limited in number by MXFV in the DIMENS.CMN file.
2) If not specified, the number of time steps is computed from the simulation time increment and the time span specified on the first BVDD record.
3) Whenever the maximum number of iterations is exceeded, the simulation continues using the last values computed. A message is printed, however, identifying the maximum water-surface-elevation and discharge deviations and the location(s) of their occurrence.
4) This variable is only applicable for plot options other than zero. Set IPROPT to 3 for line-printer plotting.
5) Graphics for BRANCH are written using CalComp compatible graphic calls. A library of routines (DIGSGKS) is provided in the LIBUTL software distribution that converts these calls to Graphical Kernel System (GKS) calls. These routines allow the interactive selection of up to 9 output devices for each execution when IPLDEV>0. These routines are easily customized to match the output devices available with the resident GKS library. To designate other plotter device types that are supported by the local version of the GKS software, modify the GKSETWS routine of the DIGSGKS library by incorporating the appropriate GKS device nomination calls. For USGS Data General AViiON workstations with Prior GKS library, graphics can be displayed in an X-window (color or monochrome), postscript file (color, monochrome, or grey-scale), HPGL file

and CGM file. Another library (DIGSUBLH) is provided in the LIBUTL software distribution for personal computer applications that permits screen display of graphics using the graphics library supplied with the Lahey EM/32 Fortran compiler. An additional library (CALINTER) is also provided in the LIBUTL software distribution that converts the CalComp graphic calls to Interactive Software Service's INTERACTOR graphic calls which is available for DOS and UNIX-based systems.

6) When storing or retrieving data from a TDDB data base of the TDDS, it is recommended to set IPRMSG=1 (enables printout of TDDS diagnostic messages).
7) If not specified, the time of initial-value data is taken as the beginning time specified on the first boundary-value data record or the current system time.
8) If not specified, the time increment (time step) is set to the data recording interval on the first boundary-value data-definition record. Default value for IPRTDT is IDTM.
9) If not specified, the discharge convergence criterion is computed as 0.5 times the absolute value of the minimum, non-zero, initial discharge value. If all initial discharge values are specified as zero, it is set to 1.0.
10) If not specified, the CHI weighting factor is set equal to the THETA weighting factor for the spatial derivatives.
11) To override the meaning of IENIBC at selected internal junctions, use the IJFEN and IJTEN parameters on Branch-Identification records.
12) In general, it is recommended not to exceed five cross sections per branch. The total number of cross sections used to define the geometry of all branches comprising the network is limited by the parameter MAXS as set in the DIMENS.CMN file—dafault value = 175 (MAXS≥ NSEC(I)+NSEC(I+1)+...+NSEC(NBCH)).
13) In order for this option to be used the IENIBC option on the first Computation-Control record must be set to a value of 1.
14) Initial values at external boundary locations default to the first boundary value datum input.
15) The number of water-surface-elevation/area relationships used to define the geometry of each cross section is limited by the parameter MXPT as set in theDIMENS.CMN file—dafault value = 25
16) The station identifier must be supplied in order to store simulation results in the data base, either TDDB or WDM. If using a TDDB as a source for time-series data or as a destination to store simulation results, this identifier also must be defined in the DSR file.
17) The software automatically removes leading zeros from the station identifier and then right-justifies it in the 16-digit field. Thus, the old 8-digit format (coded in columns 4-11 with 12-19 blank) are still acceptable. Note, that the station identifier can be specified as any 16-digit alphanumeric string, though the preferred designation is a 16-digit, USGS-style, latitude/longitude number.
18) Water-surface-elevation/area/width relationships must be input in sequence starting with the values at the lowest water-surface elevation.
19) If flow resistance is defined as a piece-wise-linear function then a complete table of functional relationship values must be defined that agrees with the number of cross-sectional geometry data records input, i.e., values must be coded on each Cross-Sectional Geometry Data record.
20) Assign constant nodal-flow (inflows as positive and outflows as negative) values in sequence according to the junction numbering scheme. Code a value of -9999999 to indicate that time-varying nodal-flow is to be input at a junction as defined on a subsequent Nodal-Flow Data-Definition record.
21) If BVD sets are input from both a data base and instream, put the data base BVDD records first beginning with the BVD recorded at the greatest frequency (smallest time interval).
22) The number of time-varying data input instream is limited by parameter MAXZBD for water-surface elevation and MAXQBD for discharge data in DIMENS.CMN file, defaults of 6000 and 3000, respectively, with no limit on the number of data values that can be retrieved from a data base.
23) The recording interval and the number of values recorded per day need not both be specified; either is sufficient, for 16-digit station identifier coding the number of values recorded per day must be specified.
24) Specification of the beginning and ending date and time (simulation time span) is needed only on the first BVDD record and is required only when retrieving values from a data base or when NSTEPS is not specified. The default beginning date and time is the current computer system date and time. The default beginning time is INHR and INMN if specified. The ending date and time is then computed based on the beginning date and time, NSTEPS, and IDTM.
25) Appropriate uses of the DATUM (for input BVD), CDATUM (for input measured data), and DATMNF (for input nodal-flow data) adjustment factors are to change datum references or to correct for known or suspected errors in water-surface-elevation data. They are also used as multiplicative factors for increasing or decreasing input discharge data by a specified percentage. If not specified, these factors are set to 0.0 for water-surface-elevation data and 1.0 for discharge data.
26) This flag permits the accumulation and compilation of flow volumes at internal-station locations of the network. Flow-volume summaries for the cross sections flagged with 'FV' are computed. The station identifier must be provided to accommodate filing flow-volume summaries.

27) The number of time-varying nodal-flow data input instream is limited by parameter MXNODL in DIMENS.CMN file, default is 1500. There is no limit on the number of data values that can be retrieved from a data base.
28) The number of time-varying wind data input instream is limited by parameter MXWIND in DIMENS.CMN file, default is 1500. There is no limit on the number of data values that can be retrieved from a data base.
29) Only one set of measured data can be input per branch of the network.
30) The location of measured data can be defined either by junction number or by branch and cross-section numbers.
31) The number of time-varying measured data input instream is limited by parameter MAXMZQ in DIMENS.CMN file, default is 3000. There is no limit on the number of data values that can be retrieved from a data base.
32) All sets of measured data must begin and end at a common date and time within the time span of the simulation.
33) For OTFILE=1, select data sets for output to a TDDB or WDM file by specifying on the first Cross-Sectional Geometry record of each cross section whose simulation results are desired to be saved the parameter type(s) (using variable ITYPEO) and define a station identifier (using variable XSTATN). The station identifier must correspond to an identifier defined in the DSR file associated with the TDDB. There is no DSR file associated with a WDM file. For OTFILE=5, select data sets by specifying the parameter type, branch number, and cross-section number using the User-Table Results record. By default, up to four data sets can be selected. For information on how to increase the number of data sets that can be output for this option, see the include file USRTBL.CMN.
34) If Istrm(3,ij) is greater than zero, it specifies the layer of the aquifer in which the river is placed. If it is less than zero, the segment data are representing a hydraulic structure. If a structure is represented, BETVEL(ij) is not the momentum coefficient, as it would be in a channel segment, but is a structure parameter.

BRANCH-NETWORK DYNAMIC FLOW MODEL
(INTERACTIVE FILE-DESIGNATION PROCEDURE)

The first step in preparing to execute the Branch-Network unsteady flow model (BRANCH) is to code the required input Computation-Control and data records. This must be done according to the format specified in the latest revision of Appendix I, TWRI Book 7, Chapter C3 (as provided in the write-up). The number and content of required input files are dependent upon specific parameter assignments as defined principally on the two Computation-Control records.

All required input and output files must be defined to execute a BRANCH simulation. An interactive procedure is used to facilitate file-name definition and perform file opening operations. The BRANCH model stores input/output file names in a 'master' file, called "BRANCH.MTR", for subsequent retrieval in the directory from where BRANCH was initiated. (A master file is automatically created if one does not exist.) The purpose of the master file is to retain the file names used in the most recent flow simulation. During the interactive file-designation procedure the current file names in the master file are displayed. It is then possible to initiate execution of the model with these files via a response to a single prompt. The BRANCH.MTR file can be renamed or copied to another file in order to save for subsequent reuse. (Note, to reuse an old copy it must be renamed BRANCH.MTR.)

If a file named BRANCH.MTR does not exist in your current directory <or> is not in the format expected by the model <or> the displayed names need to be changed, the model issues prompts to define the names of files required for the simulation. These prompts display the current file name as given in the master file or as a default model-generated name (as defined below). To accept the displayed name, press the enter key (carriage return), otherwise type a file name and press enter. If it is desirable, all output file names can be automatically generated based on the computation-control file name by a response to a single prompt, thus eliminating the need to answer individual prompts for output file names. After all file names have been assigned, the master file is recreated using the specified or chosen file names. However, should initiation of the model be discontinued in the file-designation procedure the master file is not updated.

If a required file name is not defined in the master file the model generates a default name. The default name is created as follows. A 'base' name is determined from the computation-control file name by removing any (up-to-three-letter) suffix. If no such suffix ends the computation-control file name, the full name is used as the base name. The default, model-generated, name is then the base name plus a unique, model-assigned suffix.

User responses to all prompts are captured in the file "BRANCH.LOG" so that a branch execution can be repeated. The BRANCH.LOG file can be used as redirected input to remove the need to answer BRANCH prompts. For example, on a UNIX or DOS based computer system the following command could be used to begin a simulation: "branch < BRANCH.LOG".

The following shows the messages that appear on the display for initial prompts of a BRANCH execution. Note that all filenames are shown in this example—with branch as the base name—in order to show the suffixes assigned by BRANCH, normally only the names of files that were last used in a BRANCH simulation are displayed. Also, note the user response of "n" was entered to the first prompt, this was designated as n<cr> in bold with the <cr> symbol representing a enter key (carriage return) entered by the user.

```
 Welcome to the Branch-Network Dynamic Flow Model, Version: 4.2 1997/02/28

 You may enter “q” for any prompt to discontinue initiation of the model.  If
 the displayed or default value following a prompt is acceptable, a carriage
 return is sufficient response, otherwise a new value must be entered.
 The default response to a “yes/no” query is yes.

 These are the current input/output file names in your branch master file:

 Input computation controls  : branch.ctl
 Output printed flow results : branch.prt
 Input cross-sectional data  : branch.geo
 Input initial-condition data: branch.ici
 Input TDDS station reference: branch.dsr
 Input/Output TDDS data base : branch.tdd
 Output initial conditions   : branch.ico
 Output for TRKPLOT input    : branch.pto
 Output digital plots        : branch.dpo
 Output instantaneous volumes: branch.ivo
 Output cumulative volumes   : branch.cvo
 Output instantaneous flows  : branch.ifo
 Output map-formatted flows  : branch.map
 Output flows for BLTM input : BLTM.FLW
 Output user-table results   : branch.pst

 ARE THESE THE REQUIRED FILES FOR THIS SIMULATION [Y,n]?
n<cr>

 Prompts are issued for the file names of all required files.
 To accept the name as defined in the prompt, enter a carriage return.

 ENTER THE FILE NAME OF THE COMPUTATION-CONTROL INPUT.
 (OLD) branch.ctl:
```

A file-description table is given below that defines those files that are needed for a particular flow simulation option. Note, the file names BRANCH.MTR, BRANCH.LOG, and bryrmody.cdf (yrmody are assigned based on the begin time of the simulation) are fixed within BRANCH, the other filenames are defaults and can be changed by the user. However, the default names for these other files (except BLTM.FLW which is always the default) are generated based on the base-name of the computation-control file or the value read from the BRANCH.MTR when specified there.

Name	File Description	Required or Created for the following options
BRANCH.MTR	Files used in last simulation	Always required
BRANCH.LOG	Log of users responses to prompts	Always required
branch.ctl	Computation-control records	Always required
branch.prt	Printed output	Always required
branch.geo	Cross-sectional geometry	IRDGEO=1
branch.ici	Input initial conditions	IRDIC=1

Name	File Description	Required or Created for the following options
branch.dsr	Data-station reference file	OTFILE=1, LISTB≠0, LISTA≠0, NDATA=0, MDATA=0, NWDATA=0, or NNDAT=0
branch.tdd	Time-dependent data base	OTFILE=1, LISTB≠0, LISTA≠0, NDATA=0, MDATA=0, NWDATA=0, or NNDAT=0
branch.ico	Initial-condition output	IWRTIC=1
branch.pto	Particle-tracking output	IPROPT=9
branch.dpo	Digital-plotting output	0<IPLOPT<5 and IPLDEV>0
branch.ivo	Instantaneous flow-volume output	IPROPT=4
branch.cvo	Cumulative flow-volume output	IPROPT=4
branch.ifo	Instantaneous flow output	OTFILE=1 or IPROPT=4
branch.map	Flow conditions at each cross section at each time step	OTFILE=3
BLTM.FLW	Flow conditions in BLTM format	OTFILE=2
branch.pst	User-defined table of selected simulation results at selected cross sections at each time step	OTFILE=5
bryrmody.cdf	Flow conditions in NetCDF format	OTFILE=4

BRANCH-NETWORK DYNAMIC FLOW MODEL
(INTERACTIVE COMPUTATION-CONTROL UPDATE PROCEDURE)

An interactive update procedure can be used to change values assigned to parameters on the first three record types of the computation-control file, that is, the Network-Name, Comment, and Computation-Control records, as defined in the computation-control file, during the model initialization process. All other records in the computation-control file must be manually updated prior to model execution. First the model displays the values for the parameters assigned to the Computation-Control records. Then you may change or display brief descriptions of these parameters or of the Network-Name or Comment records or begin the simulation. When the Network-Name record is to be changed, the existing record is displayed in the prompt for a new value. When Comment record(s) are to be changed, existing Comment records are displayed and prompts are issued for the specified number of new Comment records. When the individual parameters of the Computation-Control record(s) are to be changed the current value is displayed in the prompt for the new value. If after requesting to change a parameter value you decide the original value is ok, it can be retained by simply entering a carriage return to the prompt for the new value. An example use of this procedure is shown below.

```
 This table shows the current values assigned to computational-variables based
 on values read in and program defaults.

 NO VARIABLE FORMAT VALUE   NO VARIABLE FORMAT VALUE   NO VARIABLE FORMAT VALUE
 ------------------------------------------------------------------------------
  1 IUNIT   (A2)       EN | 19 IDTM    (I4)       15 | 37 KTCONS  (I1)        0
  2 NBCH    (I2)       25 | 20 THETA  (F3.2)    0.60 | 38 IRDNXT  (I1)        1
  3 NJNC    (I2)       25 | 21 QQTOL  (F5.1)    25.0 | 39 GLBETA (F4.2)    1.00
  4 NBND    (I2)       10 | 22 ZZTOL  (F5.3)   0.010 | 40 GLETA  (F5.4)  0.0000
  5 NSTEPS  (I4)        0 | 23 WSPEED (F5.2)    0.00 | 41 ETAMIN (F5.3)   0.000
  6 OUNIT   (A2)       EN | 24 WSDRAG (F5.4)  0.0015 | 42 ETAMAX (F5.3)   0.000
  7 IRDGEO  (I1)        1 | 25 H2ODEN (F5.4)  1.9369 | 43 TOLERR (F4.2)    0.10
  8 IMODFW  (I1)        0 | 26 CHI    (F3.2)    0.60 | 44 IPRTDT  (I4)        0
  9 NIT     (I2)        5 | 27 IWRTIC  (I1)        0 | 45 GLICQ  (F8.1)     0.0
 10 IPROPT  (I1)        9 | 28 IENIBC  (I1)        0 | 46 GLICZ  (F6.2)    0.00
 11 IPLOPT  (I1)        0 | 29 IRDIC   (I1)        1 | 47 DCFM   (F6.2)    0.00
 12 IPLDEV  (I1)        0 | 30 NUMCOM  (I1)        5 | 48 AIRDEN (F8.6)0.002338
 13 IPRMSG  (I1)        1 | 31 WDIREC (F5.1)     0.0 | 49 H2OSAL (F6.3)   0.000
 14 IPLMSG  (I1)        0 | 32 INWIND  (I1)        1 | 50 H2OTMP (F6.3)  68.000
 15 IEXOPT  (I1)        1 | 33 OTFILE  (I1)        0 | 51 DSPRSN (F7.1)     0.0
 16 TYPETA  (I1)        1 | 34 IWMOPT  (I1)        0 | 52 GPRBCH (I1)         0
 17 INHR    (I2)        0 | 35 IARDEM  (I1)        1 | 53 GPLBCH (I1)         0
 18 INMN    (I2)        0 | 36 IPRFMT  (I1)        0 | 54 GPRTXS (I1)         0

 ENTER UP TO 10 NUMBERS, N, T, H#, C, F, ?, OR <CR> TO CONTINUE:
?<cr>

 You may modify the first three record types of the computation-control file
 using the following options.  You may enter up to six of these options per
 response separated by a blank or comma, for example “H10 10 5,H11,T,C”

     Code                        Function
      N  --  To change the NETWORK-NAME record.
      T  --  To display a table identifying the values assigned to
             variables of the COMPUTATION-CONTROL records.
      #  --  To change the value of a variable, enter its NUMBER (as
             shown in the table) and the new VALUE when requested.
      H# --  To display a HELP message for a variable.
      C  --  To change the COMMENT records.
      F  --  When FINISHED (saves changes and begins simulation, default)
      ?  --  To redisplay this message.

 ENTER UP TO 10 NUMBERS, N, T, H#, C, F, ?, OR <CR> TO CONTINUE:
```

BRANCH-NETWORK DYNAMIC FLOW MODEL
MODEL DIMENSION INFORMATION

The table below identifies BRANCH parameters that set maximum dimensions of arrays in BRANCH. Maximum dimension parameters are initialized in the “dimens.cmn” Fortran include file. To change array dimensions modify the parameter values in the dimens.cmn file either using the supplied SETDIMEN program or using a text editor and then recompile BRANCH using the supplied Makefile (see README file for compiling instructions). Memory accounting for major dimensioning parameters, in bytes is also given below.

Parameter	Description
MXBH	Number of branches allowed in network
MXJN	Number of Junctions (internal and external) allowed in network
MAXS	Number of cross sections allowed in network
MXTFXS[3]	Number of cross sections using piece-wise-linear functions of frictional resistance (ETA) allowed
MXPT	Number of points defining the geometry for a cross section
MAXCZQ	Number of simulation time steps per day allowed
MAXDFR	Number of flow reversals allowed per day
MXFRPT	Number of flow reversals allowed when choosing printer plots
MXZQRT	Number of boundary conditions allowed to be specified as piece-wise-linear functions
MXTDBC	Number of boundary conditions allowed to be specified as time-series of values
MXZQRE	Number of data points allowed in tables that specify piece-wise-linear functions of boundary conditions
MXMD	Number of measured data locations
MXTDNF	Number of nodal-flow data locations allowed to be specified as time-series of values
MAXZBD[1]	Number of water-surface-elevation boundary condition values per location (number of discharge values allowed is equal to one-half MAXZBD)
MAXMZQ[2]	Number of measured-data values per location
MXNODL[1]	Number of nodal-flow-data values per location
MXWIND[1]	Number of wind-data values input
MXPART	Number of particles that can be specified per path
MXPATH	Number of paths allowed
MXTVLF	Number of lateral flows that can be specified as time-series of values
MXFV	Number of flow-volume summary locations
MAXSIM	Number of rows and columns in ETA optimization routine (SIMUL)

Notes:

1) For input of time-series data from the program control file, the values of MAXZBD, MXNODL, and MXWIND set the maximum number of values of each type that can be specified per data location. For input of time-series data from a data base (TDDB or WDM), the values of MAXZBD, MXNODL, and MXWIND set the number of values retrieved from the data base per retrieval. Smaller values result in more frequent retrievals. MAXMZQ, MXNODL, and MXWIND cannot be set greater than MAXZBD/2
2) For both input of measured data from the program-control file and data base, MAXMZQ sets the maximum number of values that can be input per location (that is, multiple retrievals from a data base are not supported)
3) MXTFXS should be set to MAXS if piece-wise-linear-functions of flow resistance are specified, otherwise it may be set to 1 to reduce memory requirements.

Parameter	Dimension	Formula	Bytes used	Bytes/unit
MXBH	50	4*(4*MXBH)**2 + (168 + 4*MXJN + 4*MXPATH)*MXBH (48 dynamic)	179,400	not linear
MXJN	50	76 + 4*MXBH	13,800	276
MAXS	175	720 + 24*MXPT + 4*MAXCZQ + 4*MXPATH	738,500	4,220
MXTFXS	175	16*MXPT	70,000	400
MXPT	25	24*MAXS + 16*MXTFXS	175,000	7,000
MAXCZQ	720	8 + 4*MAXS	509,760	708
MAXDFR	7	8 + 248*MXFV (8 dynamic)	8,736	1,248
MXFV	5	540 + 248*MAXDFR (512 dynamic)	10,140	2,028
MXFRPT	6	44 (44 dynamic)	264	40
MXZQRT	5	4 + 8*MXZQRE	1,020	204
MXTDBC	15	4*MAXZBD	360,000	24,000
MXZQRE	25	8*MXZQRT	1,000	40
MXMD	15	12 + 4*MAXMZQ	180,180	12,012
MXTDNF	15	34 + 4*MXNODL	90,510	6,034
MAXZBD	6000	2 + 4*MXTDBC	300,000	50
MAXMZQ	3000	12 + 4*MXMD	216,000	72
MXNODL	1500	4*MXTDNF	90,000	60
MXWIND	1500	8	12,000	8
MXPATH	5	20 + 4*MAXS + 4*MXBH + 44*MXPART	6,800	1,360
MXPART	10	4 + 44*MXPATH	2,240	224
MAXSIM	80	20	1,600	20

TOTAL memory used with the default dimensions (must subtract out duplicates)

179,400 + 3,800 + 738,500 + 70,000 + 5,760 + 8,736 + 2,700 + 264 + 1,020 + 360,000 + 180,180 + 90,150 + 12,000 + 36,000 + 12,000 + 2,300 + 40 + 1,600 = 1,704,450 bytes

Examples of dimension changes and the resultant change in memory requirement:

REDUCE MXBH FROM 50 TO 25 FREES 129,700 bytes

REDUCE MXPT FROM 25 TO 20 FREES 35,000 bytes

REDUCE MAXS AND MXTFXS FROM 175 TO 150 FREES 115,500 bytes

REDUCE MXPT AND MAXS AND MXTFXS BY 5 FREES 57,100 bytes