Water Rights Analysis Package (WRAP) Modeling System Users Manual

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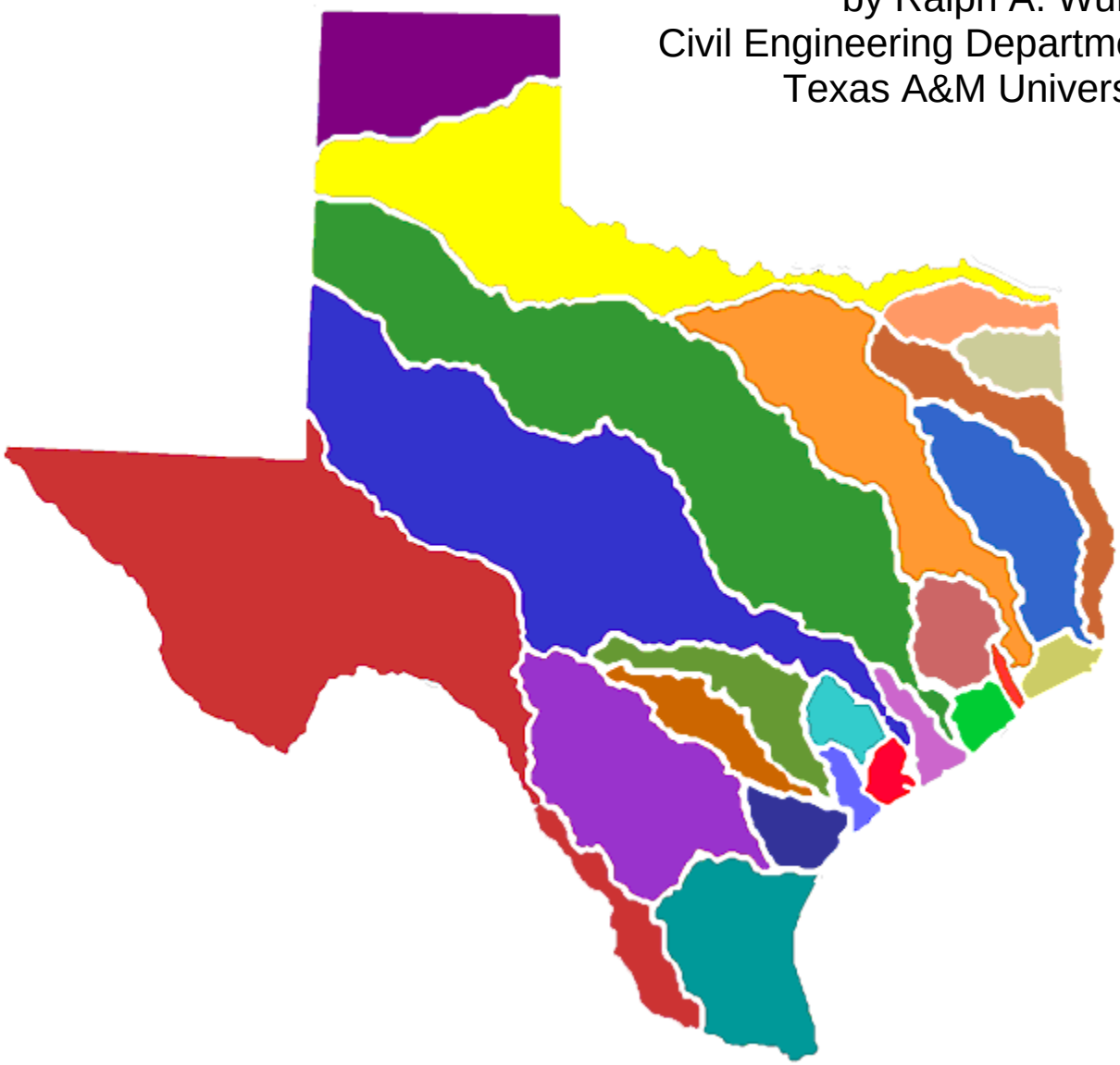

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Users Manual

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CHAPTER 1
WRAP MODELING SYSTEM

The Water Rights Analysis Package (WRAP) is documented by a *Reference Manual* and this *Users Manual*, a *Supplemental Manual* covering additional features, and a tutorial *Fundamentals Manual*. The *Reference Manual* explains WRAP capabilities and methodologies. This *Users Manual* provides the operational logistics for applying the model by explaining the organization of input and output files and the content and format of input records. The *Supplemental Manual* documents expanded capabilities recently added to WRAP that are not covered in this basic *Users Manual* and companion *Reference Manual*.

WRAP Programs

The software package documented by this basic *Users Manual* and accompanying *Reference Manual* includes the following programs.

WinWRAP is a user interface for applying the WRAP modeling system on personal computers with the Microsoft Windows operating system.

SIM simulates the river/reservoir water allocation/management system for input sequences of monthly naturalized flows and net evaporation rates.

TABLES develops frequency relationships, reliability indices, and various user-specified tables for organizing, summarizing, and displaying simulation results.

HYD assists in developing monthly naturalized stream flow and reservoir net evaporation rate data for *SIM* hydrology input files.

The following programs are not covered in the basic *Reference* and *Users Manuals* but rather are documented by the *Supplemental Manual* covering expanded modeling capabilities.

SIMD is an expanded version of *SIM* with additional features for sub-monthly time steps, flow forecasting and routing, and flood control operations.

DAY assists in developing sub-monthly (daily) time step hydrology input for *SIMD* including disaggregating monthly flows to sub-monthly time intervals and determining Muskingum routing parameters.

SALT reads a *SIM* or *SIMD* output file and a salinity input file and tracks salt constituents through the river/reservoir/water use system.

The Fortran programs are compiled and executed as separate individual programs, which are listed with the filenames for their executable files are as follows.

Programs Covered in this Manual		*Covered in Supplemental Manual*	
WRAP-SIM	SIM.exe	*WRAP-SIMD*	SIMD.exe
WRAP-HYD	HYD.exe	*WRAP-DAY*	DAY.exe
TABLES	TAB.exe	*WRAP-SALT*	SALT.exe
WinWRAP	WinWRAP.exe		

WinWRAP User Interface Program

The *WinWRAP* interface facilitates running the WRAP programs within Microsoft Windows in an integrated manner along with use of Microsoft programs to access and edit input and output files and use of HEC-DSSVue to graph and analyze simulation results. *WinWRAP* connects executable programs and data files. The WRAP programs (executable files) being used should be in the same folder as *WinWRAP*. A mouse click activates *WinWRAP*. The other programs are executed from *WinWRAP*, with the user providing the filename root of the input and output data files. The *WinWRAP* menu structure provides the user the options shown in Table 1.1.

Table 1.1 WinWRAP User Interface

WRAP Files	MS Programs	WRAP Programs	HEC-DSSVue	File Building Aids	Information
All WRAP Files	DOS Editor	SIM-TAB	HEC-DSSVue	TABLES TIN File	WinWRAP Instructions
Main Inputs	NotePad	SALT-TAB	HEC Website	SIM DAT Template	WinWRAP Version
Hydrology Inputs	WordPad	HYD		HYD DAT Template	WRAP Documentation
Special Outputs	Word	DAY			----------
Messages	Excel				TCEQ WAM
DAT Files					TWRI
OUT Files					TAMU WRAP
TIN Files					
TAB Files					

The *WRAP Files* and *MS Programs* pull-down menus in *WinWRAP* are used to activate NotePad, WordPad, Word, and Excel. These programs are distributed by the Microsoft Corporation with its Windows operating system and Office suite of software. WRAP has no graphics, and the *TABLES* TIN file editor is the only editing feature. The Microsoft programs are used to access and edit input and output files for the WRAP programs. Excel may be used to plot simulation results.

The *WRAP Programs* menu is used to execute the WRAP programs. Clicking a program selection activates a dialog box through which the user enters the root of the filenames for the input data files and output files. *TABLES* may be automatically executed along with *SIM*, *SIMD*, or *SALT*. Messages tracking the simulation are written to the monitor as the programs are executed.

Clicking on the *HEC-DSSVue* selection activates the program. Options in *TABLES* write *SIM*, *SIMD*, and *SALT* simulation results as Hydrologic Engineering Center (HEC) Data Storage System (DSS) files, which can be read and plotted or otherwise manipulated by HEC-DSSVue.

The *File Building Aids* menu provides access to optional aids for use in creating input data files. An optional set of interactive dialog boxes may be used to create *TABLES* input files. Copies of text file templates may be accessed to help start the creation of input files for the other programs.

The *Information* menu is divided into two sets of information. The *WinWRAP Instructions*, *WinWRAP Version*, and *WRAP Documentation* selections provide instructions for using *WinWRAP*, the date of the version being used, and a list of the WRAP manuals. The *TCEQ WAM*, *TWRI*, and *TAMU WRAP* selections activate websites for The Texas Commission on Environmental Quality (TCEQ) Water Availability Modeling (WAM) System, Texas Water Resources Institute (TWRI), and latest WRAP software and documentation available at Texas A&M University (TAMU).

WRAP-SIM Simulation Program

WRAP-SIM is a river/reservoir system water allocation simulation model that provides an accounting system for tracking stream flow sequences, subject to reservoir storage capabilities and net reservoir evaporation-precipitation and specified diversion, instream flow, and hydroelectric power requirements. Water balance computations are performed for each time step of the hydrologic simulation period. The model provides flexibility for adaptation to a broad range of modeling approaches. Typically, a simulation will be based on the following premises.

- River basin hydrology is represented by historical sequences of naturalized stream flows and reservoir net evaporation less precipitation rates.
- Annual water use requirements, distributed over the 12 months of the year, are met as long as water is available from stream flow and/or reservoir storage. Water use targets may also vary as a function of storage or stream flow.

The *SIM* model simulates capabilities for meeting water management and use requirements (water rights) during a hypothetical repetition of historical natural hydrology. For example, a simulation might be concerned with assessing reliabilities in meeting a specified set of annual water use requirements (with seasonal variations over the 12 months of the year) during a repeat of historical hydrology represented by sequences of naturalized stream flows and reservoir net evaporation rates for each month of the 780-month 1940-2004 hydrologic period-of-analysis. The historical naturalized stream flows and net evaporation rates are assumed to be statistically representative of future river basin hydrology. The annual water supply diversions, environmental instream flow requirements, and hydroelectric energy demands have a specified seasonal distribution. They also may vary with reservoir storage content and/or stream flow.

Chapters 3 and 4 of the *Reference Manual* describe the component features of the *SIM* simulation model, which are organized in two categories.

- *River basin hydrology* includes naturalized stream flows, reservoir net evaporation-precipitation, and channel losses (Chapter 3 of the *Reference Manual*).
- *Water rights* include all aspects of water management including water supply diversions, return flows, environmental instream flow requirements, hydroelectric energy generation, reservoir storage, multiple-reservoir/river system operations, off-channel storage, and intrabasin and interbasin conveyance (*Ref. Manual* Chapter 4).

The model-user must create or obtain previously created files describing the hydrology and water rights for the river basin or region of concern. This *Users Manual* provides instructions for developing and modifying sets of records for the input files. Input files may be developed following the instructions provided in this manual using the previously cited Microsoft programs activated from *WinWRAP* or any other editor, spreadsheet, or other software.

TABLES Post-Simulation Program

The program *TABLES* provides an array of tables and data tabulations in user-specified formats for organizing, summarizing, analyzing, and displaying simulation results from *SIM*, *SIMD*,

and *SALT*. Many of the options provided by *TABLES* involve rearranging simulation results as (1) convenient tables in a text file for reports and analyses, (2) tabulations in a text file to be read by Microsoft Excel, or (3) records in a binary file to be read by HEC-DSSVue. *TABLES* also provides a variety of computational options for developing tables of water supply reliability indices and stream flow and reservoir storage frequency relationships.

WRAP-HYD Pre-Simulation Program

The program *WRAP-HYD* facilitates developing *SIM* hydrology input files. *HYD* is a set of computational options designed to provide assistance in developing sequences of monthly naturalized stream flows (*IN* records) and reservoir net evaporation-precipitation rates (*EV* records) for *SIM* input files. *HYD* output files are read by *SIM* as input files. *HYD* also includes options for reading and writing stream flow and evaporation-precipitation data as columns in a table, which facilitates transferring data from and to spreadsheet programs such as Microsoft Excel. *HYD* is covered in Chapter 3 of the *Reference Manual* and Chapter 5 of this *Users Manual*.

Programs SIMD, DAY, and SALT

The WRAP programs *SIMD*, *DAY*, and *SALT* provide expanded modeling capabilities related to sub-monthly time steps, flow forecasting and routing, flood control operations, and salinity that are not covered in this *Users Manual*. The *SIMD*, *DAY*, and *SALT* programs are introduced in Chapter 1 of the *Reference Manual* and documented in detail in the *Supplemental Manual*. Conditional reliability modeling is also covered in the *Supplemental Manual*. *SIM* and *SIMD* provide the same simulation capabilities for conditional reliability modeling, with frequency and reliability analyses of simulation results being performed by routines in *TABLES*.

Auxiliary Software

The WRAP programs provide comprehensive computational capabilities but have no editing or graphics capabilities. The user's choice of auxiliary editing and graphics software may be adopted for use with WRAP. The only required auxiliary software is an editor such as Microsoft WordPad. However, WRAP modeling and analysis capabilities are enhanced by use of other supporting software for developing input datasets and plotting simulation results, such as Microsoft Excel, HEC-DSSVue, and ArcGIS.

Microsoft Programs

Programs distributed by the Microsoft Corporation with its Windows and Office Systems are routinely used on personal computers for an array of applications in offices and homes throughout the world. As previously discussed, Microsoft Excel, WordPad, Notepad, Word, and the DOS Editor may be activated directly from *WinWRAP* for use in editing WRAP input files and viewing simulation results. Excel provides both graphics and computational capabilities. *TABLES* has options for tabulating essentially any of the time series variables included in the *SIM*, *SIMD*, and *SALT* simulation results in a format designed to be conveniently read by Microsoft Excel for plotting or other purposes. Microsoft programs are described in detail by online documentation as well as by books published by Microsoft Press and other publishers.

Hydrologic Engineering Center (HEC) Data Storage System (DSS)

The HEC-DSS (Data Storage System) is combined routinely with the widely-applied suite of generalized hydrologic, hydraulic, and water management simulation models developed by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers (USACE). HEC-DSS is used with other non-HEC modeling systems as well. The graphics and data management capabilities provided by the HEC-DSS are shared by multiple simulation models. The original development of the HEC-DSS by the Hydrologic Engineering Center dates back to 1979. The HEC-DSS Visual Utility Engine (HEC-DSSVue) is a recently developed graphical user interface program for viewing, editing, and manipulating data in HEC-DSS files. HEC-DSS references are cited in the WRAP *Reference Manual*. The public domain HEC-DSSVue software and documentation may be downloaded from the Hydrologic Engineering Center website.

http://www.hec.usace.army.mil/

The WRAP program *TABLES* includes options for writing essentially any of the time series variables in the *SIM*, *SIMD*, or *SALT* simulation results as HEC-DSS files. Fields 2 and 3 of the *TABLES 2NAT, 2REG, 2UNA, 2CLO, 2CLC, 2STO, 2DEP, 2TAR, 2SHT, 2DIV, 2RFL, 2IFS, 2IFT,* and similar records described in Chapter 4 include options for writing *SIM* results in the following alternative formats:

1. A text file may be created that displays the simulation results in easy-to-read tables to be printed for analysis or exported to Microsoft Word for inclusion in a report.
2. A text file may be created that tabulates the simulation results in columns for export to Microsoft Excel for plotting or other manipulations.
3. A HEC-DSS file may be created to be read by HEC-DSSVue for plotting or other purposes.

A Microsoft Excel HEC-DSS data exchange add-in is also available from the HEC for transporting data between Excel and HEC-DSS (http://www.hec.usace.army.mil/). HEC-DSSVue provides capabilities for graphical displays of WRAP simulation results and computational routines that may also be pertinent to analysis of WRAP simulation results.

A HEC-DSS file is a direct access binary file that can be read only by HEC-DSS software such as HEC-DSSVue. The WRAP program *TABLES* is linked at compilation with a HECDSS library of routines allowing *TABLES* to store simulation results as HEC-DSS files. *TABLES* currently only creates and writes to HEC-DSS files but could be modified in the future to also read data from HEC-DSS files if needs arise. HEC-DSS references data records by their pathnames, which consist of six parts in the format /A/B/C/D/E/F/. The pathname is assigned automatically by *TABLES* as indicated below.

A – filename root of *TABLES* output files
B – identifier of control point, water right, reservoir, or water right group
C – record identifier for *TABLES* input record such as 2NAT, 2REG, 2STO, etc.
D – date of the beginning of the time series such as 01JAN1940
E – time interval = MON or YEAR
F – CP, WR, Res, or WRG (control point, water right, reservoir, water right group)

ESRI ArcGIS

As discussed in the *Reference Manual*, geographic information system (GIS) software such as ArcGIS is useful in dealing with spatial aspects of a river basin in compiling WRAP input data and displaying simulation results. The ArcGIS software system is marketed by the Environmental Systems Research Institute (http://www.esri.com). ArcGIS is described by online documentation as well as by manuals published by ESRI Press and other publishers. Arc Hydro is a data model that operates within ArcGIS and provides a set of tools designed specifically for water-related applications (http://www.crwr.utexas.edu/giswr/).

Chapters 1 and 3 of the *Reference Manual* include a discussion of use of ArcGIS in developing WRAP input datasets including watershed parameters for distributing flows from gaged to ungaged locations and the identification of the control point located immediately downstream of each control point. Chapter 6 of the *Supplemental Manual* describes use of ArcMap from ArcGIS for displaying WRAP simulation results. A dynamic link library with the filename Display.dll supplied with the WRAP software is used in ArcMap to display water supply reliabilities, flow and storage frequencies, and other simulation results by control point locations.

Input and Output Files

The WRAP programs are generalized for application any place, with the particular river basin hydrology and pertinent systems of rivers, reservoirs, water use requirements, and water management strategies and practices being described by sets of input data. The model-user provides input data files. The programs are connected through various input/output files. Certain programs create files that are read by other programs. File management is handled automatically within the software. Simulation results are written to files for analysis, incorporation into reports, or export to auxiliary programs for plotting or further manipulation, analysis, and display. With the exception of the binary HEC-DSS files, all of the input files read or output files created by WRAP programs are ordinary text files that may be read by any editor and easily viewed.

A simulation is performed with *SIM* using input files of water rights and hydrology data provided by the model user. *HYD* outputs hydrology input files for *SIM*. *TABLES* reads *SIM* output files and organizes the simulation results in optional formats specified in a *TABLES* input file. The organized simulation results are written to a *TABLES* output file. Likewise, application of *SIMD*, *DAY*, and *SALT* involve file creation and management. The executable WRAP programs and data files are interfaced through *WinWRAP* within the Microsoft Windows operating system in combination with use of Microsoft programs to access and edit WRAP input and output files.

Table 1.2 is a complete listing of the different types of data files used by the WRAP programs. Table 1.3 is a matrix of computer programs and input/output files. Input and output files associated with *SIM* are discussed in Chapter 2 of this *Users Manual*. *TABLES* and *HYD* files are covered in Chapters 4 and 5, respectively. Files associated with the programs *SIMD*, *DAY*, and *SALT* and the conditional reliability modeling features of *SIM* are covered in the *Supplemental Manual*. The corresponding *TABLES* input and output files associated with the expanded modeling capabilities are also discussed in detail in the *Supplemental Manual*.

Table 1.2 Input and Output Files

	SIM and *SIMD* Input Files
root1.DAT	required main input file containing all input ***dat***a, except the voluminous hydrology related data contained in the following files
root2.FLO	inflow *IN* records with naturalized stream ***flo***ws (optional filename root.INF)
root2.EVA	***eva***poration *EV* records with net evaporation-precipitation rates
root2.DIS	flow ***dis***tribution *FD & FC* and watershed parameter *WP* records for transferring flows from the *IN* records to other control points
root2.HYD	*IN* and *EV* records provided in a single ***hyd***rology file in modified format in lieu of the root.INF and root.EVA files
root2.FAD	***f***low ***ad***justment *FA* records for adjusting naturalized stream flows
root1.BES	***b***eginning and/or ***e***nding ***s***torage listing activated by *JO* record field 5
root2.DFL	***d***aily or other submonthly *SIMD* ***fl***ow data
	SIM and *SIMD* Output Files
root1.OUT	main simulation results ***out***put file read by *TABLES* and *SALT*
root1.MSS	***mess***ages reporting simulation progress and input data errors
root1.HRR	***h***ydropower and ***r***eservoir ***r***elease file read by *TABLES*
root1.YRO	***y***ield-***r***eliability ***o***utput table presenting the results of a *FY*-record analysis
root1.CRM	***c***onditional ***r***eliability ***m***odeling simulation results read by *TABLES*
root1.BES	***b***eginning and/or ***e***nding ***s***torage listing activated by *JO* record field 5 for use with beginning-ending-storage options
root1.BRS	***b***eginning ***r***eservoir ***s***torage listing activated by *FO* record field 9 to provide beginning reservoir storage for program *SALT* and *TABLES 2CR2* record routines
root1.SUB	*SIMD* ***sub***-monthly time step simulation results
root1.FFA	*SIMD* ***f***lood ***f***requency ***a***nalysis file with annual series of peak flow and storage
	SALT Input Files
root2.DAT	required main *SIM/SIMD* input file from which *CP* records are read
root2.OUT	required main *SIM/SIMD* ***out***put file with simulation results
root2.SIN	required ***s***alinity ***in***put file with concentrations or loads of entering flows
root2.BRS	***b***eginning ***r***eservoir ***s***torage file created by *SIM/SIMD* and read by *SALT* to provide beginning reservoir storage if specified by *JC* record field 8
root2.BRC	***b***eginning ***r***eservoir ***c***oncentration file created by *SALT* and also read by *SALT* as specified by *JC* record field 9
	SALT Output Files
root1.SAL	***sal***inity simulation results read by *TABLES*
root1.SMS	***s***alinity ***m***essage ***f***ile with simulation trace, error and warning messages, and intermediate and summary simulation results tables
root1.BRC	***b***eginning ***r***eservoir ***c***oncentration file created and read by *SALT* as specified by *JC* record field 9

Table 1.2 Input and Output Files (continued)

	TABLES Input Files
root3.TIN	required ***T****ABLES* ***in***put file with specifications regarding tables to be developed
root1.DAT	*SIM/SIMD* input DAT file
root1.OUT	*SIM/SIMD* output OUT file
root1.HRR	*SIM/SIMD* output HRR file
root1.DIS	*SIM/SIMD* input DIS file
root1.FFA	*SIMD* ***f***lood ***f***requency ***a***nalysis output file with annual series of peak flow and storage
root1.CRM	*SIM/SIMD* ***c***onditional ***r***eliability ***m***odeling output file
root1.SFF	***s***torage-***f***low-***f***requency file created by *TABLES 2CR1* record and read by *2CR2* record in conjunction with the SFF conditional reliability option
	TABLES Output Files
root4.TAB	***TAB****LES* output file with the tables developed by the various routines
root4.TMS	***T****ABLES* ***m******es***sage file
root4.DSS	HEC-***DSS*** file created by *TABLES*
root4.DSC	***c***atalog listing the pathnames of the records stored in a DSS file
root4.SFF	***s***torage-***f***low-***f***requency file created by *TABLES 2CR1* record and read by *2CR2* record in associated with the SFF conditional reliability option
	HYD Input Files
root5.TAB	***H***YD file with all ***in***put data not included in the following hydrology files
root5.FLO	inflow *IN* records with stream ***flo***ws
root5.EVA	***eva***poration *EV* records with net evaporation-precipitation rates
root5.DIS	flow ***dis***tribution *FD & FC* and watershed parameter *WP* records
root5.HYD	*IN* and *EV* records in single ***hyd***rology file in modified format
	HYD Output Files
root6.OUT	file with all ***out***put not included in the following files
root6.MSS	***m******es***sages tracing the computations and reporting input data errors
root6.FLO	inflow *IN* records with naturalized stream ***flo***ws
root6.EVA	***eva***poration *EV* records with net evaporation-precipitation rates
	DAY Input Files
root1.DIN	*SIM/SIMD* input file with inflow *IN* records with naturalized stream flows
root1.DAY	***d***aily or submonthly ***fl***ow input file
	DAY Output Files
root2.DAY	***DAY*** output file
root2.DMS	***D***AY ***m******es***sage file

Table 1.3 Matrix of Input/Output Files and Programs

File Name	File Function	WRAP Programs					
		SIM	SIMD	SALT	TABLES	HYD	DAY
	Main Required Input File for Each Program						
DAT	*SIM* and *SIMD* input data file	input	input				
SIN	*SALT* input file			input			
TIN	*TABLES* input file				input		
DAT	*HYD* input file					input	
DIN	*DAY* input file						input
	Hydrology Input Data						
FLO	*IN* record naturalized flows	input	input			in & out	input
EVA	*EV* record net evaporation	input	input			in & out	
DIS	flow distribution parameters	input	input			input	
HYD	hydrology, *IN* and *EV* records	input	input				
FAD	flow adjustments	input	input				
DFL	daily or sub-monthly flow data		input				
	Main Simulation Results Output File for Each Program						
OUT	*SIM* and *SIMD* output file	output	output	input	input		
CRM	conditional reliability model	output	output		input		
SUB	*SIMD* output file		output		input		
SAL	*SALT* output file			output	input		
TAB	*TABLES* output file				output		
DSS	*TABLES* output file				output		
DAY	*DAY* output file						output
	Message File for Each Program						
MSS	*SIM* and *SIMD* message file	output	output				
SMS	*SALT* message file			output			
TMS	*TABLES* message file				output		
MSS	*HYD* message file					output	
DMS	*DAY* message file						output
	Special Purpose Files						
HRR	hydropower and reservoir release	output	output		input		
YRO	yield reliability output	output	output				
BES	beginning/ending storage	in & out					
BRS	beginning reservoir storage	output	output	input	input		
BRC	beginning reservoir concentration			in & out			
SFF	storage-flow-frequency array				In & out		
FFA	flood frequency analysis		output		input		
DSC	HEC-DSS catalog				output		

Naming Files

Filenames are in the format *root.extension*. The 3-character extension is a designation of the type of data contained in the files. Extensions are set by naming conventions incorporated in the programs. The root is an arbitrary name assigned by the user. Programs and files are connected by *WinWRAP* with user-supplied filename roots when the programs are executed. The filename root is specified by the model-user through the beginning-of-execution log-in procedures managed by *WinWRAP*. Certain files used in a single execution must have the same filename root, and all of the files may have the same root. Common or different filename roots may be assigned to files as follows:

- The same root (root1 = root2 = root3 = root4 in Table 1.2) may be used for the filename of all files associated with a particular simulation. The extension differentiates the different types of files.

- Assigning a different root (root2 in Table 1.2) for hydrology files (FLO, EVA, HYD, FAD) may be convenient though not required in the common situation in which the hydrology files remain unchanged while the DAT file is varied in multiple simulations to reflect alternative plans or scenarios.

- Assigning different roots (root3 and root4 in Table 1.2) for *TABLES* input and output files may be convenient though not required when building specified sets of tables.

- Program *HYD* is applied separately from the other programs, with the input and output files differentiated with different roots (root5 and root6 in Table 1.2).

Format of Input Records

Files are composed of records or lines of data. The records contained in the input data files for the WRAP programs are organized by record type. A record identifier entered at the beginning of the input data record defines the type of record. The various input data record types for *SIM*, *TABLES*, and *HYD* are defined in Chapters 3, 4, and 5, respectively, of this manual. *SIM* and *HYD* input records begin with one of the two-character record identifiers listed in Tables 3.1 and 5.3. *TABLES* records begin with the four-character identifiers listed in Table 4.2.

Records are divided into fields. Tables found in Chapters 3, 4, and 5 define the data that is entered in each field. The tables in Chapters 3, 4, and 5 defining record fields describe the record format in terms of fixed-width fields. However, as indicated below, fields with integer *I* and real *F* numerical data formats may optionally be delimited with commas. The examples in the *Reference Manual* include comma-delineated as well as fixed-width records. However, essentially all actual applications of WRAP to date have used only the fixed-width format option.

Fixed Field Width Format

Most fields on *SIM* and *HYD* input records with numeric data have a width of eight characters. Some of the alphanumeric identifiers have six-character fields. The majority of the *TABLES* DAT file record fields are four characters wide. Various fields also have other widths.

The Fortran format specifications found in the fourth column of the record description tables in Chapters 3, 4, and 5 are defined as follows.

A6 − alphanumeric label in a field that is 6 characters wide

2x − skip two spaces (Fields with the spacing descriptor x are not read.)

F8.0 − real number in field of 8 characters with any number of digits to the right of the decimal (Either include decimal or right justify the number.)

5F8.0 − five real numbers, each having a F8.0 specification

I8 − integer number right justified in field of 8 characters (Decimal is not allowed.)

3I8 − three integer numbers with each right justified in field of 8 characters

Variables with integer (I) format specifications should be right-justified in the appropriate field with no decimal. Trailing blanks are read as zeros. Real variables (F format) should either be right justified or include the decimal. Input values for Fortran character variables (alphanumeric (A) specification) are normally right-justified in the appropriate field to preclude the problem of reading unwanted trailing blanks to the right of the identifiers. However, the WRAP code automatically removes trailing blanks for most of the alphanumeric character input variables. Thus, as long as the values are in the correct field, right-justification is not required.

As an example, the first *IN* record from Example 2 in *Reference Manual* Chapter 2 is reproduced below in the standard fixed-field width format (A2,A6,I4,I4,12F8.0).

```
IN  CP1   1954  10200   6540   3710   7350  15100    904    112    328    972   2650  17300   1290
```

Optional Comma-Delimited Format

Alternatively, this record could be written in comma-delineated format as follows.

```
IN  CP1,1954,10200,6540,3710,7350,15100,904,112,328,972,2650,17300,1290,
```

Note that the second field (CP1 in A6 format) can not be truncated with a comma since it has an alphanumeric A6 format. A comma delimits the third field, which is blank in integer I4 format. Both fixed-width and comma-delineated data may be combined in the same record as illustrated below.

```
IN  CP1   1954  10200 6540,3710,7350,15100, 904, 112,    328    972   2650  17300,1290,
```

Commas may be used only to truncate numeric (integer I and real F format) data, not character variables and spacing (A and X formats). A comma may be used to shorten the width of a field, but the number of characters in a field may not exceed that specified in this manual.

Period-of-Analysis and Time Step

The hydrologic period-of-analysis (simulation period) may encompass any number of years. There are no limits on the length in years of the period-of-analysis. The programs *SIM*, *HYD*, and *SALT* are limited to a monthly computational time step. The program *SIMD* (D for

daily) allows each of the 12 months of the year to be divided into any number of intervals (computational time steps) with the default being the number of days in each month.

SIM has no capabilities for forecasting future flows or routing flow adjustments across time steps, with the exception of the next-month return flow and hydropower release option. Forecasting and routing are not pertinent with a monthly time step but are significant with smaller time steps such as a day. *SIMD* looks forward over a forecast period, typically ranging from one day to perhaps as long as 30 days, in determining stream flows upon which to base diversion and reservoir operating decisions. *SIMD* uses an adaptation of the Muskingum method to route flow adjustments spatially downstream and forward in time.

SIM and *SIMD* include the same routines for performing conditional reliability modeling (CRM) simulations, with the results being used by *TABLES* to perform conditional frequency and reliability analyses. The default is a single long-term (non-CRM) simulation. The conditional reliability *CR* record activates the CRM mode of dividing the hydrologic period-of-analysis into multiple short-term hydrologic simulation periods with each simulation beginning with the same specified storage condition.

Dimension Limits

A *WRAP-SIM* model may include any number of control points, water rights, reservoirs, and other system components. No limits are imposed on the number of *CP*, *WR*, and *IF* records and most of the other types of records included in a data set. Arrays in the Fortran code are dimensioned to reserve memory space. Dynamic dimensioning allows array sizes to be set automatically by the program. The program *SIM* sets most of its array sizes internally based on either counting or reading data from the *CP*, *WR/IF*, *WS*, *UC*, *RF*, *TO/SO*, *DI*, *ML*, *MS*, and *JD* records in the DAT file and the *FD* records in the DIS file. The other programs likewise incorporate dynamic dimensioning. Several minor dimension limits are fixed at specified sizes which are noted at appropriate places in the manual.

Units of Measure

As discussed in the *Reference Manual*, the units adopted must be computationally consistent, but any units can be used. Often in typical WRAP applications, all input is entered in consistent units without needing conversions within the model. However, several input variables including multipliers entered on the *XL* record for *SIM* and *HYD* may be used as unit conversions. Most of the input data are volumes, areas, or depths, including annual and monthly diversion volumes, volume/month stream flow rates, reservoir storage volume and surface area, and net evaporation-precipitation depths. The various flows must have volume per month or per year units that are consistent with the reservoir storage volume units. Net evaporation volumes are depths multiplied by reservoir water surface areas. Typical English units requiring no conversion factors are acre-feet for storage volume and volume/month or volume/year quantities; acres for reservoir surface area; and feet for monthly net evaporation depths. Typical consistent metric units are million cubic meters for reservoir storage and volume per month or year quantities; square kilometers for reservoir area; and meters for monthly evaporation rates. Multipliers entered on the *XL* record or elsewhere are used as needed to convert the input data to a consistent set of units.

CHAPTER 2
WRAP-SIM FILES

Applying WRAP involves dealing with computer programs, data files, and data records. Input and output files for the program *SIM* are described in this chapter. The content and format of *SIM* input records are explained in Chapter 3. Chapters 2 and 3 cover all of the features of *SIM* except for the conditional reliability modeling capabilities covered in the *Supplemental Manual*.

Types of Input and Output Files

The types of *SIM* input and output files are listed in Table 2.1. Filenames are in the format *root.ext* with a user-specified *root* and a standard extension *ext* denoting the type of file. The extensions shown in Table 2.1 are used by both the software and we people to refer to the different file types. For example, we refer to an input file with a filename of root.DAT as the DAT file.

Table 2.1
Types of Input and Output Files

	Standard Default Input Files Read by SIM	
DAT	all input data except the hydrology data	Required
FLO	inflow *IN* records with naturalized streamflows	*JO* record field 2
EVA	evaporation *EV* records with net evaporation depths	*JO* record field 2
	Standard Default Output Files Created by SIM	
OUT	simulation results	
MSS	messages	
	Additional Optional Input Files Read by SIM	
DIS	flow distribution watershed parameters	*CP* record fields 6&9
FAD	*FA* record adjustments to naturalized flows	*JO* Record field 3
BES	input/output file for beginning-ending storage options	*JO* Record field 5
HYD	alternative to FLO and EVA hydrology files	*JO* Record field 2
	Additional Optional Output Files Created by SIM	
YRO	yield-reliability table with firm yield	*FY* Record
HRR	hydropower production and reservoir releases	*JO* Record field 4
BES	input/output file for beginning-ending storage options	*JO* Record field 5
CRM	conditional reliability modeling simulation results	*CR* record
BRS	beginning reservoir storage used by *TABLES* conditional reliability modeling routine and program *SALT*	*JO* Record field 6

All *SIM* input and output files are ordinary text files that can be read with Microsoft NotePad or WordPad or any other editor. Files are automatically opened or activated by *SIM* in response to options specified on the *JO* record or other input records in the DAT file.

The DAT input file (filename root.DAT) is the only absolutely required file. Either an OUT, YRO, or CRM file is required for output. *SIM* automatically creates either an OUT or CRM file but not both. A conditional reliability *CR* record entered in the DAT file activates a CRM output file. Otherwise, the OUT file is created by default. The table with yield-reliability analysis results is written to an YRO file automatically activated by a *FY* record. The model-user views the YRO file directly, without using *TABLES*. The OUT and CRM output files are normally read by the program *TABLES* with the model-user then viewing the *TABLES* output file.

SIM Input Files

The files provided by the model-user as input for *SIM* are comprised of the records described in the next chapter. All input other than the *IN*, *EV*, *FD*, *FC*, *WP*, and *FA* records are stored in the main *SIM* input file (filename root.DAT). Optionally, the *IN* and *EV* records may also be included in the DAT file. Since all data associated with the other input files are optional, the DAT file may contain all of the input records and is the only absolutely required *SIM* input file. However, typically the voluminous naturalized streamflow inflow *IN* records and net evaporation *EV* records are stored in separate FLO and EVA files. The parameters on *FD*, *FC*, and *WP* records for distributing naturalized flows from gaged to ungaged sites must be provided in a DIS file if flow distribution computations are performed.

FLO and EVA files (filenames root.FLO and root.EVA) are the defaults for storing the naturalized streamflow *IN* and net evaporation-precipitation *EV* records. Optionally, if specified in *JO* record field 2, the *IN* and *EV* records may be included in the DAT file. *SIM* also includes an option for combining the *IN/EV* records in a HYD file (filename root.HYD) in a format developed for the original version of the model but now seldom used. The extensions FLO and INF may be used interchangeably. The earlier extension INF was later replaced with FLO.

The flow distribution file (filename root.DIS) contains the set of all *FD/FC* records followed by the set of all *WP* records. These data are used in distributing naturalized streamflows from gaged (known flow) to ungaged (unknown flow) control points. A DIS file is opened automatically if flow distribution options are specified on one or more *CP* records (fields 5 or 9) or if the net evaporation-precipitation adjustment option is activated by the *JD* record field 10 that require the input data supplied by a DIS file.

An optional naturalized streamflow adjustment file (filename root.FAD) contains flow adjustment *FA* records. The flow adjustment feature is activated by field 3 of the *JO* record.

Beginning of simulation storage contents may be read from a BES file (filename root.BES), and ending storages may be written to the BES file. The beginning-ending-storage file is the only file that is both written (output) and read (input) by *SIM*. A BES file is opened automatically if pertinent beginning-ending-storage options are activated by *JO* record field 5. The beginning reservoir storage (BRS) file (*JO* record field 6) provides the storage contents of each reservoir at the beginning of the simulation in a format used by program *SALT* and a *TABLES* CRM routine.

SIM Output Files

The standard *SIM* simulation results are written to the OUT file (filename root.OUT). Messages to help locate errors and potential problems in the input data are written to the MSS file (filename root.MSS). Supplemental output related to multiple-reservoir system releases and hydroelectric energy generation is written to the optional HRR file if activate by *JO* record field 4. A yield-reliability and firm yield analysis option writes a table to an YRO output file. The beginning-ending-storage (BES) file is designed for starting a simulation with the storage contents from the end of a preceding simulation. The OUT, MSS, HRR, YRO, and BES files are described later in this chapter. The conditional reliability modeling file (filename root.CRM) and beginning reservoir storage file (filename root.BRC) are covered in the *Supplemental Manual*.

The program *TABLES* reads the *SIM* OUT, DAT, and HRR files, performs additional data manipulations and computations, and organizes the simulation results in user-specified tables. Additional computations, such as computing reliability and frequency statistics, are performed by *TABLES* in conjunction with organizing and presenting the *SIM* simulation results. Program *TABLES* is described in Chapter 4. The main *SIM* simulation results (OUT) file and HRR file may be viewed by the model-user but normally are not. Rather the simulation results are organized and summarized by *TABLES*, and the model-user works with a *TABLES* output file. However, the MSS and YRO files are viewed directly by the model-user without using *TABLES*.

Basic Simulation Results Output File

Although *TABLES* is usually used to organize the simulation results in the OUT file, the model-user may sometimes want to read this *SIM* output file (filename root.OUT) directly to track problems or better understand the program. Organization of the OUT file is outlined in Tables 2.2, 2.3, 2.4, and 2.5. An example OUT file is provided in Chapter 2 of the *Reference Manual*. The file begins with the five lines of information shown in Table 2.2. The one-line header is followed by the three title records (*T1*,*T2*,*T3*) read from the *SIM* input file. The fifth line contains the five integers defined in Table 2.2. The simulation results are then written in monthly blocks of data.

Within each month of simulation results, output records for user-specified water rights are written first, followed by selected control point output records, followed by the records for selected reservoir/hydropower projects. The monthly data associated with each specified water right, control point, or reservoir/hydropower project are listed in Tables 2.3, 2.4, and 2.5. These records are all optional. The model-user specifies in the DAT file which types of output records and which water rights, control points, and/or reservoirs to include.

The OUT file is designed to compactly store the voluminous output data in the order in which it is computed. Water right records are written in order of priority. Control point output records are in the same order as the *CP* records in the input file. The file can be examined directly by the model user and is useful for tracking problems occurring in the simulation. However, the format is not convenient for routinely interpreting simulation results. Program *TABLES* provides the capability to organize, tabulate, and summarize the simulation results in a variety of formats. The *TABLES* input record that builds standard tables for each type of data is listed in the last column of Tables 2.3, 2.4, and 2.5. These data are found in various other tables activated by other *TABLES* input records as well.

Table 2.2
Organization of Main SIM Output File

First Five Records of *WRAP-SIM* Output File

WRAP-SIM (August 2003 Version) Output File
TITLE1
TITLE2
TITLE3
YRST NYRS NCPTS NWROUT NREOUT

Definition of Variables on Fifth Record

YRST - first year of simulation
NYRS - number of years in simulation
NCPTS - number of control points in *SIM* output file
NWROUT - number of water rights in *SIM* output file
NREOUT - number of reservoirs in *SIM* output file

Block of Records Repeated for Each Period (Month)

water rights output records	(number of records = NWROUT)
control point output records	(number of records = NCPTS)
reservoir/hydropower output records	(number of records = NREOUT)

Total Number of Records in *WRAP-SIM* Output File

number of records = 5 + (12*NYRS) * (NWROUT + NCPTS + NREOUT)

Table 2.3
Water Right Output Record

Diversion/Storage Rights			TABLES	TABLES	Instream Flow Rights	
Field	Variable	Format	Record	Record	Variable	Format
1	Year	I4			IF	A2
2	Month	I2			Month	I4
3	diversion shortage	F9.3/F9.1	2SHT	2SHT	reservoir release shortage	F9.1
4	diversion target	F9.3/F9.1	2TAR	2TAR	required reservoir release	F9.1
5	Evaporation-precip volume	F9.1	2EVA	2EVA	evaporation-precip volume	F9.1
6	end-of-period storage	F9.1	2STO	2STO	end-of-period storage	F9.1
7	streamflow depletion	F9.1	2DEP	2DEP	streamflow depletion	F9.1
8	available streamflow	F10.1	2ASF	2ASF	available streamflow	F10.1
9	releases from other reservoirs	F9.1	2ROR	2ROR	releases from other reservoirs	F9.1
10	water right identifier	A16			water right identifier	A16
11	group identifier	A8		2IFT	instream flow target	F8.2/F8.1
12	group identifier	A8		2IFS	instream flow shortage	F8.2/F8.1
13	return flow	F8.1	2RFL			

Table 2.4
Control Point Output Record

Field	Variable	Format	Columns	TABLES
1	Control point identifier	A6	1-6	
2	diversion shortage	F9.1/9.3	7-15	2SHT
3	diversion target	F9.1/9.3	16-25	2TAR
4	reservoir evaporation-precip	F9.1	26-34	2EVA
5	end-of-period storage	F9.1	35-43	2STO
6	streamflow depletion	F9.1	44-51	2DEP
7	Unappropriated streamflow	F10.1	52-61	2UNA
8	return flows returning here	F9.1	62-70	2RFR
9	naturalized streamflows	F10.1	71-80	2NAT
10	regulated streamflows	F10.1	81-90	2REG
11	channel loss credits	F7.0	91-97	2CLC
12	channel losses	F6.0	98-103	2CLO
13	upstream reservoir releases	F7.0	104-110	2URR

Table 2.5
Reservoir/Hydropower Output Record

Field	Variable	Format	Columns	TABLES
1	reservoir identifier	A6	1-6	
2	hydropower shortage (+) or secondary energy (-)	F9.1	7-15	2HPS
3	energy generated	F9.1	16-24	2HPE
4	reservoir evaporation	F9.1	25-33	2EVA
5	end-of-period storage	F9.1	34-42	2STO
6	inflows to reservoir from streamflow depletions	F9.1	43-51	2RID
7	inflows to reservoir from releases from other reservoirs	F10.1	52-61	2RIR
8	releases from other reservoirs accessible to hydroelectric power turbines	F9.1	62-70	2RAH
9	releases from other reservoirs not accessible to hydroelectric power turbines	F10.1	71-80	2RNA
10	evaporation-precipitation depths	F10.3	81-90	2EPD

Notes: The format columns of the tables use Fortran format statement terminology, where data types include alphanumeric (A), integer (I), and real (F). A6 refers to a 6-character field reserved for an alphanumeric variable such as a control point or reservoir identifier. I4 refers to a 4-character field for an integer (no decimal) number. A real number in F9.1 format may contain up to nine characters counting decimal point and digits, with one digit to the right of the decimal point.

The last column lists the input record for program *TABLES* that results in the data being tabulated in a table in optional standard formats.

Some data are unique to either water right, control point, or reservoir/hydropower records. For example, naturalized, unregulated, and unappropriated flows, and channel losses are associated only with control points. Hydroelectric energy is recorded only on reservoir/hydropower records. Other data are repeated on two or three of the record types. For example, reservoir storage and evaporation are written to all three records. If one water right with one reservoir is located at a control point, reservoir storage will be identical on all three records. However, the control point records contain the summation of storage at all reservoirs assigned to the control point. Likewise, multiple water rights may be assigned to the same reservoir. Diversions and shortages on a control point record are the totals for all the diversion rights assigned to the control point. The diversions and shortages on a water right output record are associated with a single *WR* input record.

Water Right Output Records

Each record provides data for a water right for a given month. The records for all of the water rights are grouped together for a given month. The water right record for an instream flow requirement is different than the record for a regular diversion/storage right. As shown in Table 2.3, the 110 character output record for *WR* record rights contains 13 variables and the *IF* record has 12 variables stored in the format indicated by the following Fortran format statements.

instream flow rights: Format (A2,I4,5F9.1,F10.1,F9.1,A16, 2F8.1)
all other rights: Format (I4,I2,2F9.3,3F9.1,F10.1,F9.1,A16,2A8,F8.1)

Each regular water right output record contains, from left to right, year and month, diversion shortage, target diversion amount, net evaporation-precipitation volume, end-of-period reservoir storage, the streamflow depletion the water right made during the month, the streamflow available to the right before the streamflow depletion, all water that was released from secondary reservoirs to meet the diversion and/or refill storage, the three identifiers from the *WR* record, and return flows.

The difference between the diversion target and diversion shortage represents the diversion amount actually met from streamflow depletions and reservoir releases. These values are zero or positive. Target diversion and diversion shortage for a hydropower right are written as zero.

The evaporation and end-of-period storage in fields 5 and 6 represent the values that would occur assuming no other junior rights are associated with the reservoir. The values written for the most junior right at the reservoir are the actual values that occur for the reservoir. Any values written for senior rights at the reservoir are intermediate values only. The reservoir net evaporation minus precipitation volume is positive if evaporation rate exceeds precipitation and negative if precipitation is greater.

The streamflow depletion in field 7 represents the streamflow that the water right appropriated to meet the permitted diversion amount, account for reservoir net evaporation-precipitation, and/or refill storage. In months with a negative net evaporation-precipitation rate, the streamflow depletion may be a negative number. In this case, the water right actually makes water available to the basin by catching precipitation that falls onto the reservoir surface.

Releases from other reservoirs in field 9 are from secondary reservoirs to meet the storage and diversion requirements of the right. Releases from the primary reservoir are not included.

Instream flow rights may include releases from storage to meet the regulated flow requirement. In this case, the release from storage required to meet the instream flow requirement is recorded in field 4 in lieu of diversion target amount and the shortage in supplying the reservoir release is recorded in field 3.

Control Point Output Records

These records contain: (1) data not associated with a particular water right such as regulated and unappropriated flows and (2) water rights related data summed for all the water rights located at the control point. Each record provides data for a given month. The records for all the control points are grouped together for a given month. The 110-character record contains 13 variables stored in the format indicated by the following Fortran format statement.

Format (A6, 5F9.1, F10.1, F9.1, 2F10.1, F7.0,F6.0,F7.0)

As indicated in Table 2.4, each record begins with the control point identifier, sum of the shortages and permitted diversions for all water rights, evaporation-precipitation and end-of-period storage for all reservoirs, and streamflow depletions for all rights located at the control point. The next four fields contain the unappropriated flow remaining at the control point after all streamflow depletions have been made, the sum of the return flow returned at the control point from the current and previous month, and the naturalized and regulated streamflow. Fields 11 and 12 contain channel loss credits and channel losses. The last field has the portion of the regulated flow that originates as releases made from reservoirs located this control point or others located upstream to meet water right requirements at control points located further downstream.

Reservoir/Hydropower Output Records

Each record provides data for a reservoir and/or hydroelectric power plant for a given month. All the reservoir/hydropower records are grouped together for a given period. The 90 character record outlined in Table 2.5 contains ten variables stored in the following format.

Format (A6, 5F9.1,F10.1, F9.1,2F10.1)

The records include energy shortage at the reservoir, energy produced at the reservoir, evaporation-precipitation, end-of-period storage, streamflow depletions made available to the reservoir, releases from other reservoirs made available, releases from the reservoir through the outlet works, lakeside releases from the reservoir, and net evaporation-precipitation depths.

The hydroelectric energy produced at the reservoir in each month is calculated from the average water surface elevation of the reservoir, the tailwater elevation for the most junior hydropower right associated with the reservoir, and the total flow through the outlet works for all hydropower rights and other senior rights. Either a turbine flow capacity may be specified or the power produced may be computed assuming that the turbine capacity is unlimited. Hydropower shortages are calculated as the algebraic difference between primary energy target and the energy produced at the reservoir. Positive shortage values signify that insufficient water was released from the reservoir to produce the energy requirement of the most junior hydropower right at the reservoir. Negative shortages represent *secondary energy* that was produced by releases through the outlet works to meet water right diversion and storage requirements.

Streamflow depletions include amounts for diversions as well as depletions to refill storage and account for net evaporation-precipitation. Depletions for diversions are assumed to enter a primary reservoir and then are either diverted lakeside or released through the reservoir outlet works. The releases written to a reservoir output record include releases made both as a primary and a secondary reservoir.

Message File

The message file (filename root.MSS) provides trace messages tracking the progress of the simulation, error and warning messages, and other miscellaneous information. The extent of trace information to be provided is specified by input variable *ICHECK* entered on the *JD* record. The message file contains the following information designed to facilitate locating errors or problems in the input data:

- input trace messages and reproduction of input records to track which input records were successfully read
- error messages noting missing or erroneous input records with run termination and warning messages noting potential problems without stopping execution

Trace messages and input records are written as the input records are read. If program execution is terminated prior to completion of the simulation, the trace messages may be used to locate the last input record read prior to reaching the problem. *SIM* includes a number of data check routines that write error messages and stop program execution. Other routines in the model write the warning messages without terminating program execution. The use of messages written to the MSS file for locating errors is discussed further in the last section of this chapter.

Negative incremental streamflow options activated by the *JD* record cause negative incremental flows to be written to the message file. Dual simulation options specified by the *SO* record allow streamflow depletions to be written to the message file.

Hydropower and Reservoir Release File

The hydropower production and multiple-reservoir system release file (filename root.HRR) lists releases from primary and secondary reservoirs for each month of the simulation for each water right selected for output. The file also contains the energy target and amount of energy generated by each hydroelectric power right. The release from a primary reservoir is simply the diversion met by the right. This amount may include water from streamflow depletions and water released from secondary reservoirs as well as water taken from storage in the primary reservoir.

For each month, the data for each water right in the HRR file is written as two records. The second record is simply a list of identifiers for each reservoir associated with the right. Each reservoir identifier is found immediately below the corresponding release amount. The first record for each right contains the following data in the order listed below:

- water right or water right group identifier
- number of reservoirs associated with the right

- year and month
- energy target and energy generated
- reservoir releases listed in the same order as the *WS* records in the input file

The reservoir identifier for each release is below the release on the next record. The energy target and energy generated are written as zero for non-hydropower rights. This is the only information available regarding the energy generated by senior rights when several rights generate energy at the same reservoir.

The water right identifier in the first field of a HRR file output record optionally is either:

- the water right identifier from field 11 of the *WR* record or field 9 of the *IF* record
- a water right group identifier from field 12 or 13 of the *WR* record

The parameter *SYSOUT* from the *JO* record activates the HRR file and specifies the type of water right identifier to be included in the file.

The HRR file consists of rows of data for each month of the simulation. *TABLES 4SWR* and *4SGP* tables organize the reservoir releases into a more convenient-to-read columnar format.

Yield Versus Reliability File

The firm yield *FY* record activates a routine to develop a table of annual yield versus reliability, which is written to the YRO file (filename root.YRO). An annual water supply diversion target or hydroelectric energy generation target is entered in field 3 of the water right *WR* record as the input variable *AMT*. Model applications may require computing volume and period reliabilities for a range of different values for *AMT*. This may be accomplished simply by running *SIM* multiple times, manually changing the *AMT* entry in *WR* record field 3 for each run. The *FY* record option automates this procedure, with the model internally repeating the simulation multiple times with the annual target amount *AMT* being systematically changed for each simulation. The results also include the firm yield, defined as the maximum value of *AMT* that has a computed reliability of 100 percent. The firm yield is the last entry in the yield-reliability table written to the YRO file.

SIM repeats the simulation multiple times with the OUT and MSS files being restarted and rewritten each time. At the completion of the run, the simulation results from the last iteration of the iterative firm yield search are found in the OUT and MSS files along with the yield-reliability table found in the FYO file. Use of the *JD* and *CO/RO/WO/GO* records to minimize the output to the OUT file saves a little computer run time, since the output is written multiple times.

Beginning-Ending Storage File

The beginning-ending storage (BES) options controlled by BES parameter on the *JO* record involve writing end-of-simulation storages to the BES file and/or reading initial storages from the same file. BES options 1, 2, 3, 4, and 6 activate the file. The BES file consists of three columns: (1) integer reservoir identifier, (2) alphanumeric reservoir identifier, and (3) storage

volume. A BES file written by *SIM* includes all reservoirs listed in the conventional order established when the DAT file was read. A BES file read by *SIM* may include any number of the reservoirs but they must be listed in the order of the numeric identifiers. The BES file may be manually edited to change storage amounts or delete/add reservoirs. A reservoir may be removed either by entering a -1 for its storage amount or by deleting its entry from the file. If a BES file is read, for any reservoirs not included in the file, beginning storages are set by *WS* record fields 3 and 8 in the conventional manner.

Specification of Information to Include in the Simulation Results

As discussed earlier, *WRAP-SIM* simulation results are written to the main output file in the form of the following three sets of output records, which are repeated for each month.

1. regular water right and instream flow right output records
2. control point output records
3. reservoir/hydropower output records

Simulation result summaries developed with *TABLES* are based upon data included in the *SIM* OUT output file. In organizing simulation results with *TABLES*, the term *all* control points, *all* water rights, or *all* reservoirs in *TABLES* refers to *all* those included in the *SIM* output file. Most tables in *TABLES* also include options for selecting sets of individual control points, rights, or reservoirs from those in the *SIM* output file.

SIM output records may be provided for every water right, control point, and reservoir/hydropower project. However, simulation results may be extremely voluminous. The size of the output file may be limited by including only selected data. The *SIM* input file includes information specifying which water rights, control points, and reservoir/hydropower projects are to be included in the main output file.

JD record fields 5, 6, and 7 in combination with *WO*, *GO*, *CO*, and *RO* records are used to specify which water rights, control points, and reservoirs to include in the OUT file. The *JD* record may specify that all or none of the control points and/or water rights be included in the output file. Output records may be specified for up to 30 water rights, water right groups, control points, and/or reservoirs listed on *WO*, *GO*, *CO*, and *RO* records, respectively.

Control Point Output Records

The following alternative methods are provided for specifying which control point records to include in the simulation results.

- The *JD* record field 5 allows selection of either the *none* or *all* options. If a -1 is entered in field 5, all control points will be output. If field 5 is blank or zero and there is no *CO* record, no control point is output.
- The *JD* record field 5 also allows output of just those control points for which *INMETHOD* in field 6 of the *CP* record is 0, 1, or 2 to be output. These are

primary control points for which naturalized streamflows are entered on *IN* records rather than being synthesized. A -2 in field 5 activates this option.

- The *JD* record field 5 also allows the first any number of control points in the input file to be selected. For example, entering the integer 125 in field 5 of the *JD* record results in output records for the first 125 control points in the order that the *CP* records are found in the *SIM* input file.

- Control points listed on the *CO* record are included in the output along with those that may be specified by the *JD* record. *CO* records may be used alone (blank field 5 on *JD* record) or in combination with the two *JD* field 5 options.

Reservoir/Hydropower Output Records

The *RO* record provides the only means to specify reservoir/hydropower output records. The options are (1) all, (2) none, or (3) those reservoirs listed on *RO* records. Reservoir/hydropower output records are used to obtain information regarding hydroelectric power generation and reservoir inflows and releases. Reservoir storage and net evaporation-precipitation are included on the control point and water rights records as well as on the reservoir/hydropower records. Reservoir/hydropower records are typically included in the output only if the other information listed in Table 2.5 is of interest or if tables are to be created with program *TABLES* that require reservoir/hydropower records rather than the other output.

Water Right Output Records

As indicated in Tables 2.3 and 2.4, both the water right and control point output records include the following variables in common: diversion shortage, diversion target, evaporation-precipitation volume, storage, and streamflow depletion. The values for these variables on the control point output record reflect the summation for all rights at that control point. If only one water right is assigned to a particular control point, the values for these variables will be the same on the water right versus control point output records. Other variables pertain to either a water right or a control point but not both.

The following optional methods are provided for selecting the water rights to include in the simulation results.

- The *JD* record field 6 allows selection of either the *none* or *all* options.

- The *JD* record field 6 also allows the first any number of water rights in the input file to be selected. For example, entering the integer 125 in field 6 of the *JD* record results in output records for the first 125 water rights in the order that the *WR* records are entered in the *SIM* input file.

- *WO* records are used to list the 16-character water right identifiers found in field 11 or alternate field 14 of the *WR* records or field 9 of the *IF* records. All rights with the identifiers listed on the *WO* records are output in addition to any that may be specified by the *JD* record as noted above.

- Group output *GO* records are used to list the 8-character water right group identifier found in fields 12 and 13 or alternate fields 15 and 16 of the *WR* record. All rights with the identifiers listed on *GO* records are output as well as those listed on *WO* records or specified by the *JD* record.

Water Right Identifiers

A *WR*-record water right may have a water right identifier with a length of up to 16 characters and two group identifiers not exceeding 8 characters each. *IF* records allow only the 16-character water right identifiers, not the group identifiers. The 16-character water right identifier is unique to each water right. If the same 16-character identifier is entered on more than one *WR* or *IF* record, this identifier is ignored on the second and subsequent records. Any number of rights may have the same 8-character group identifier. The purpose of the group identifiers is to associate multiple rights together as a group. Water rights are not required to have identifiers; identifier fields on *WR* and *IF* records may be left blank. Any, all, or none of the identifier fields may be used for any water right. As noted below, two sets of the three identifiers may be entered on a *WR* record, but *SIM* only reads one set.

Two alternative sets of three water rights identifiers may be included in the last six fields of the *WR* records (fields 11, 12, 13 and alternate fields 14, 15, 16) . Only one of the two sets is read in a single execution of *SIM*. Input variable *IDSET* in field 7 of the *JD* record specifies whether the first or second set of three identifiers on the *WR* records are read in a particular run of the model.

Water right identifiers are not directly used within the *SIM* simulation other than in selecting output. This is different than control point identifiers that are used extensively in the model to assign locations to various features of water rights, delineate incremental watersheds, locate streamflows and evaporation rates, and otherwise define the spatial connectivity of the system.

The water right identifier fields on the *WR* and *IF* records do not have to be either right or left justified as long as the identifier stays within the specified field. The program automatically removes trailing blanks, thus internally treating the identifiers like they were right justified.

Water rights identifiers serve to identify rights in input and output files and tables created by program *TABLES*. *TABLES* also includes options to aggregate the data associated with all rights with the same group identifier. The diversion targets, shortages, diversions, streamflow depletions, reservoir storage contents, and net evaporation-precipitation volumes included in the output records for all water rights with the same group identifier in fields 12 and 13 or alternate fields 15 and 16 of the *WR* records may be summed within *TABLES* to obtain a set of aggregated total values.

For grouping purposes, all rights with the same identifier in either of the two group identifier fields (second or third identifiers with up to 8 characters) compose a group. The group identifiers serve three different purposes as follows.

1. All rights with an identifier listed on the *WO* record or *GO* record will be included in the *SIM* simulation results output file. Thus, multiple rights may be selected for inclusion in the output by including the same group identifier on each pertinent *WR* record and once on a *GO* record.

2. Program *TABLES* can read a *SIM* output file and create tables for either individual rights or for the summation of values for all rights with the same group identifier. For example, a table of diversion shortages (or streamflow depletions, etc) would show the total diversion shortage in each month for all rights with the same group identifier.

3. The identifiers also allow the model-user to simply label the rights for general information. Various naming schemes may be devised to use the set of identifiers to label and organize the rights by various categories.

Locating Errors in the Input Data

SIM input data sets are typically voluminous. Blunders can be expected in developing the input files. The following *SIM* features help detect missing and erroneous records. The model features outlined here facilitate finding many types of errors that violate format rules or result in detectable inconsistencies. However, the following discussion does not pertain to those situations in which incorrect simulation results are obtained from wrong numbers being input in the proper format.

Two types of *SIM* features facilitate locating errors.

1. features for tracking model progress in reading input and performing the simulation
2. error and warning messages

Input data errors result in *SIM* terminating execution itself with a message or, less likely, in the operating system terminating execution. Features for tracing the progress of reading input records and performing simulation computations up to program termination facilitate locating the input record causing the problem. Error checks are coded into the program that write error and warning messages. Program execution is terminated in conjunction with error messages but continues with warning messages. As noted in the following discussion, certain options related to these features are controlled by the variable *ICHECK* in field 4 of the *JD* record. Information to facilitate locating errors is written to the message file (filename root.MSS).

Tracking Simulation Progress

The following features trace the progress of the simulation.

- Messages appearing on the monitor during model execution provide a general overview of simulation progress.
- Input trace messages written to the message file confirm that various input records were read.
- The main output file shows intermediate results of the simulation computations.

SIM execution begins with an interactive session in which the root of the filenames is entered, and the files are opened. The program checks to confirm that the specified files do exist. If an input file is missing, a message to that effect appears on the monitor, and execution is terminated. An optional feature alerts the user if files with the output filenames already exist. The program requests verification from the user that these files are to be overwritten. The messages shown in Table 2.6 then appear on the monitor as the simulation is performed. Other similar messages related to specific modeling options appear only if those options are being used.

Table 2.6
Trace Messages on Monitor

```
Enter root of input and output file names
Opening input file _____
Opening output file _____
Reading the input data from file root.DAT
    ___ control points
    ___ water rights
    ___ reservoirs
Sorting water rights in priority order
Performing simulation for year _____
Performing simulation for year _____
  (repeated for each year)
Performing simulation for year _____

Input File:      root.DAT
Output File:    root.OUT
Message File: root.MSS

*****  Normal Completion of Program WRAP-SIM  *****
```

Progress in reading the input data is tracked by information written to the message file (filename root.MSS) showing which records were successfully read. If the entire DAT and DIS input files and the first year of *IN* and *EV* records are read without interruption, the pertinent messages shown in Table 2.7 will be found in the message file. If model execution is prematurely terminated, the last notation in the input trace message listing provides the approximate location in the input files at which a problem occurred. The problem record will be after those records confirmed as being read successfully.

Optional levels of input data traces are specified by input variable *ICHECK* in field 4 of the *JD* record. An *ICHECK* value of zero (blank field 4) or 1 results in the trace messages shown in Table 2.7. An *ICHECK* value greater than one results in the messages of Table 2.7 along with reproduction of a specified set of input records to the MSS file as they are read. The types of records copied to the message file with each value of *ICHECK* is shown in Table 2.8.

Table 2.7 SIM Trace Messages Written to Message File

WRAP-SIM MESSAGE FILE
*** Starting to read file root.DAT.
*** JD record was read.
*** JO record was read.
*** Starting to read UC records.
*** Finished reading UC records.
*** Starting to read CP records.
*** Finished reading CP records.
*** Starting to read IF/WR records.
*** Finished reading IF/WR records.
*** Starting to read SV/SA records.
*** Finished reading SV/SA records.
*** Starting to read PV/PE records.
*** Finished reading PV/PE records.
*** Starting to read DI/IS/IP records.
*** Finished reading DI/IS/IP records.
*** Finished reading file root.DAT.
*** Starting to open remaining files.
*** Opened file root.FLO
*** Opened file root.EVA
*** Opened file root.DIS
*** Opened file root.OUT
*** Starting to read FD/WP records from file root.DIS.
*** Finished reading ___ FD and ___ WP records.
*** Determined watershed parameters for ___ control points
with INMETHOD(cp)>3 and/or EWA(cp)<0.
*** Finished ranking water rights in priority order.
****
Title records from input file:
(Titles from T1,T2,T3 records are reproduced here.)
****
System components counted from input file:
___ control points (CP records)
___ instream flow rights (IF records)
___ all water rights except IF (WR records)
___ system water rights
___ hydropower rights
___ sets of water use coefficients (UC records)
___ reservoirs
___ storage-area tables (SV/SA records)
___ storage-elevation tables (PV/PE records)
___ drought indices (DI records)
___ dual simulation rights (SO record field 14)
___ maximum upstream gaged cpts on FD records
****
*** Finished determining initial drought index multiplier factors.

Table 2.7 SIM Trace Messages Written to Message File (Continued)

*** Beginning annual loop.
*** ___ IN and ___ EV records were read for the first year (____).
*** Flow distribution was performed for the first year.
*** Flow adjustments from FA records were applied for the first year.
*** Negative incremental flow adjustments were performed for the first year.
*** End of input data trace.
***** Normal Completion of Program WRAP-SIM *****

Table 2.8
Trace Information Copied to Message File for Various Values of ICHECK

ICHECK = -1	Minimal trace messages; many error detection routines in effect
ICHECK = 0	Messages shown in Table 2.7; many error detection routines in effect
ICHECK = 1	Messages shown in Table 2.7; all error and warning routines in effect
ICHECK = 2	Messages shown in Table 2.7 plus all *UC* and *RF* records as read
ICHECK = 3	Messages shown in Table 2.7 plus all *CP* records as read
ICHECK = 4	Messages shown in Table 2.7 plus all *WR* and *IF* records as read
ICHECK = 5	Messages shown in Table 2.7 plus all *SV* and *SA* records as read
ICHECK = 6	Messages shown in Table 2.7 plus all *IN* and *EV* records as read
ICHECK = 7	Messages shown in Table 2.7 plus all *FD*, *FC*, and *WP* records as read
ICHECK = 8	Messages shown in Table 2.7 plus all dual simulation information
ICHECK = 9	Messages shown in Table 2.7; Most error messages are in effect, but many of the warning messages are deactivated.

An *ICHECK* of one should normally be selected whenever a new or revised data set is initially run. If program execution is terminated by the operating system for some unknown reason, one of the other *ICHECK* options listed in Table 2.8 may be selected based on examining the *ICHECK*=1 trace in the message file.

If the model runs correctly, changing *ICHECK* to zero (blank *JD* record field 4) will save a little computer time by not performing the more time-consuming error checks. Most warning messages are printed only if 1 is entered for ICHECK. An *ICHECK* of -1 will deactivate the trace messages but should seldom if ever be used.

Program execution may be terminated due to a problem in an input record. As noted in the preceding paragraphs, the trace feature facilitates finding the erroneous record. *SIM* reads all the records in sequential order starting with the DAT file. The *ICHECK=1* trace shown in Table 2.7 is used to find the general location of the problem record based on where the trace stops. The program is then rerun with a different *ICHECK* value to check which records in the groups noted in Table 2.8 are read and copied correctly.

For ICHECK options 2 through 8, most of the error checks for *ICHECK*=1 are in effect. However, warning message checks and several of the error checks are in effect only if *ICHECK* is one. The records noted in Table 2.8 are written to the MSS file immediately after each record is read. The records are copied to the MSS file almost verbatim as read, except most real numbers are written in a F8.0 Fortran format with zero digits to the right of the decimal point. If the program reads some but not all records of a particular record type, the problem will typically be associated with either the last record read and copied to the MSS file or more likely the next record in the input file. The types of records listed in Table 2.8 account for a majority but certainly not all of the records in a *SIM* input set. ICHECK=6 applies to *IN/EV* records stored in DAT and INF/EVA files but does not apply to a HYD file.

ICHECK=8 relates to the dual simulation option. ICHECK=8 writes a list of rights with the dual option activated by the *DT* or *SO* records and the array of initial simulation streamflow depletions for rights with *DUAL* options of 3 or 4.

As discussed later, simulation results are written to the main output file (filename root.OUT) both as each individual water right is considered and at the end of each simulation month upon completion of the water rights priority loop. Thus, if execution is terminated after the input is read and the simulation computational loops begin, the computations can be tracked to approximately the point just before the computational problem. The root.OUT file may also be useful in analyzing computational problems that do not terminate execution.

Error and Warning Messages

Various error checks are performed as the input files are read and the simulation computations are performed. If data are missing or in the wrong format or inconsistencies are detected, program execution is stopped and an error message is written to the message file (filename root.MSS). Warning messages identify potential problems and are also written to the message file, but program execution is not terminated. Warning routines simply write messages without affecting the simulation. Error messages are generated within *SIM* in two ways:

1. The Fortran input/output status specifier *IOSTAT* is included in most of the read statements.

2. Many other specific error check algorithms are coded into various data input and computational routines.

If violation of a Fortran rule is indicated by the *IOSTAT* variable in a read statement, the following complete message is written to the message file, the first three lines of the message are displayed on the monitor, and execution is terminated.

ERROR: Fortran IOSTAT error occurred reading an input record with identifier CD of ___
IOSTAT status variable = ____
Stopped in (main program or subroutine name) due to error.
The first 80 characters of each of the last two records read are as follows:

The last two records read from the input file prior to termination of the program are written following this message. The message indicates the value for the *IOSTAT* variable as defined within the Fortran language compiler. A negative one (-1) means the end of file was reached without finding the data record. A -2 indicates the end of the record was reached without finding the data. A positive integer refers to Fortran error condition messages provided by the compiler. The most common values for the *IOSTAT* variable are 61 and 64, which mean input data is in the wrong format, such as a letter in a real or integer numeric field or a decimal in an integer field.

Various other error checking routines are coded into *SIM* with error or warning messages that are written to the message file. Some of these many error and warning messages are shown in Tables 2.9 and 2.10. The checks take various forms. For example, essentially any identifier connecting records are checked to verify that they are on the other record. The control point identifiers on *WR*, *IF*, *CI*, *FD*, and *WP* records are checked to ascertain that they match identifiers on the *CP* records. Likewise, water use identifiers on *WR* records are matched against those on the *UC* records. Reservoir identifiers on *SV*, *PV*, *MS*, and *DI* records are checked to ascertain that the reservoirs have been entered on *WS* reservoirs. Upstream control points on *FD* records must actually be upstream of the specified control point as defined by *CP* records. Some checks involve detecting missing records or data. Other types of checks are illustrated as well in Tables 2.9 and 2.10. As discussed in later in Chapter 5, *WRAP-HYD* provides additional checking of *IN* and *EV* records.

All error and warning checks are in effect for *ICHECK* (*JD* record field 4) of one. If option 1 is not selected for *ICHECK*, all warning checks and several of the error checks requiring the most computer time are not activated. Since error and warning messages are written as problems are detected along with the trace messages, their approximate originating location in the model is evident. Most error messages are followed in the message file by the statement below that identifies the module (subroutine or main program) from which the error was detected and execution terminated.

Stopped in Subroutine _____ due to error.

Locating Errors in the SIM Output File

Blunders are inevitable in compiling voluminous input datasets. Detecting and correcting input errors is fundamental to computer modeling. However, after an input dataset has been successfully debugged, irregularities in the *SIM* output OUT file should be rare. The following discussion addresses the situation in which *TABLES* will not read an OUT file from an apparently successful execution of SIM even though the *TABLES* TIN file is completely correct. This situation should be encountered by model users seldom, if ever.

The SIM simulation computations are outlined in Figure 2.2 of the *Reference Manual*. Water right output records are written to the OUT file as each water right is considered in priority order. Control point and reservoir/hydropower output records are written to the OUT file for each month at the end of the water right priority loop. The content and format of the output records are outlined earlier in this chapter in Tables 2.2, 2.3, 2.4, and 2.5.

Program *TABLES* includes a routine activated by the TEST record that performs a series of checks on a *SIM* output file. The TEST option in *TABLES* is designed for use in the unusual situation in which *TABLES* can not read an OUT file from a successful SIM simulation. The following tests are performed.

TABLES reads the first record of the OUT file, and an error message is written to the TMS message file if irregularities are encountered. The problem will most likely be that the OUT file is not an ordinary text file. The only type of file that can be read by *TABLES* is an ordinary text file with no enhancements. The fortran code in *SIM* always creates a text file in the correct format. However, if the model-user reads the OUT text file with WordPad or some other editor and inadvertently saves the file in another format that adds formatting characters, *TABLES* will not be able to read the file. The TEST routine will detect the problem.

As indicated by Tables 2.2, 2.3, 2.4, and 2.5, most of the data in an OUT file are numbers. The TEST routine checks whether letters or other characters appear in the fields that should numbers. Error messages are written to the TMS if improper characters are found. The most likely problem is the occurrence of either *NaN* or ********* in the OUT file. The *SIM* code includes checks to prevent these situations from occurring. The *TABLES* TEST routine provides another backup check.

The term *NaN*, meaning *not a number*, is written by a fortran program when an arithmetic operation is not defined. The undefined operation is usually dividing by zero. A number can not be divided by zero. The *SIM* code is written with checks to prevent divisions in which the denominator could be zero. However, if the safeguards fail, a *NaN* could written to the OUT file and detected by the *TABLES* TEST routine.

If a number has more digits than is allowed by a fortran format statement, the number is replaced with asterisks *********. *SIM* includes safeguards to prevent this situation. However, the *TABLES* TEST routine will detect asterisks if they occur.

The TEST routine also checks that all water right output records in the OUT file are in the correct chronological order by year and month. For control point and reservoir output records, the control point and reservoir identifiers are read for the first month and checked for consistency in all subsequent months. Thus, an incorrect ordering of records or incorrect number of records will be detected.

Table 2.9 SIM Error Messages

Written to Monitor from Subroutine FILINI before Opening MSS File

ERROR: Can not combine HYD with INF/EVA files.

Written to MSS File from main program

ERROR: CP output written for ___ control points but expecting ___
ERROR: TOTARGET of ____ on TO record is not valid. Water right: _____
ERROR: TOTARGET=10 can not be combined with TOCOMB=LIM. Water right: _____
ERROR: The ID for reservoir _____ from BES file should be _____
ERROR: Reservoir _____ from EA record could not be matched with WS record reservoir identifiers.
ERROR: Reservoir _____ could not be matched with EA record reservoir.
ERROR: Reached end of file without finding ED record.

Written to MSS File from Subroutine WRAPIN

ERROR: Read CD of ___ instead of T1.
ERROR: Missing JD record.
ERROR: Number of years on JD record must be at least one.
ERROR: ADJINC of ___ and NEGINC of ___ on JD record are not compatible.
ERROR: ADJINC of ___ on JD record is not valid.
ERROR: EPDADJ of ___ in JD field 10 is not valid.
ERROR: Invalid data in JO record field ___.
ERROR: Missing WO, GO, RO, or CO record.
ERROR: Use identifier ___ from UP record matches no identifier on UC records.
ERROR: FYIN(2) and FYIN(3) on FY record must be positive nonzero numbers. Read:_____
ERROR: The incremental decreases on FY record must each be less than previous level. Read:_____
ERROR: The YRO file must be open on the FO record for the FY record output table.
ERROR: Missing (UC, CP) record. Read CD of _____
ERROR: Control point _____ has an invalid INMETHOD of ___
ERROR: Downstream control point identifier [CPID(cp,2)] _____ on CP record for _____ matches no CPID(cp,1).
ERROR: Identifier _____ assigned to both control points ___ and ___
ERROR: Control point identifier ___ from (CI,WR,IF,SO) record ___ matches no control point identifier on CP records.
ERROR: Water use identifier _____ from WR or IF record matches no identifier on UC records.
ERROR: Return flow identifier _____ from WR record ___ matches no identifier on the RF records.
ERROR: Water rights _____ and _____ associated with reservoir _____ do not have cumulative storage capacities with respect to priorities.
ERROR: SO record field 6 is limited to blank or BACKUP, BFIRST, or RETURN. Read: _____
ERROR: ISHT of ___ in SO record field 9 is invalid.
ERROR: TO record field 10 is limited to blank or CONT. Read: _____
ERROR: TOTARGET=10 combined with TOCOMB=LIM is not valid. Water right:_____
ERROR: Reservoir identifier is missing from TO record field 8 for water right _____.
ERROR: Water right identifier is missing from TO record field 9 for water right _____.
ERROR: Reservoir _____ entered in field 8 of a TO record is not on any WS record.
ERROR: Water right _____ entered in field 9 of a TO record is not on any WR record.
ERROR: TOCOMB of ____ on TO record is not valid. Water right: _____
ERROR: Read CD of ___ instead of TO for a continuation TO record for water right: _____
ERROR: TS record is not valid for year ___ for water right _____ CD, TSYR1, TSYR2 read as follows:_____
ERROR: _____ read for TSL in field 2 of TS record for first year is not valid. Water right: _____
ERROR: ___ for K is TS record field 2 is not valid. Water right: _____.
ERROR: OR record is not valid for water right ____. For type 1 and hydropower rights, OR records are used only for secondary reservoirs.
ERROR: Missing (SV/SA,PV/PE,TQ/TE) record. Read CD of _____
ERROR: Missing or duplicate reservoir ID found while reading (SV/SA, PV/PE,TQ/TE) records.
ERROR: Both constant tailwater and tailwater rating table were specified for reservoir _____

Table 2.9 SIM Error Messages (Continued)

ERROR: Missing storage area or elevation table.
ERROR: Reservoir _____ on (MS,DI,EA) record is not on any WS record.
ERROR: EMPTY of ____ on DI record is not valid.
ERROR: Number of reservoirs on DI record must be 1 to 12 or all (-1).
ERROR: Read CD of ___ when expecting EF.
ERROR: Reservoir _____ on EA record is not on any WS record.
ERROR: No SV/SA records are assigned to reservoir ___ on EA record.
ERROR: Number of control points and water rights must be at least one.
ERROR: The following invalid record identifier (CD in field 1) was read: _____ This indicates either an incorrect CD, a missing record, or a blank record. The first 80 characters of each of the last two records read are as follows.
ERROR: IFMETH = 3 or 4 but there is no reservoir for IF right _____
ERROR: RFMETH is ___ for water right _____

Written to MSS File From Subroutine INFEVA
ERROR: In reading first IN record for first year _____ read NYR of ____ and PYR of _____
ERROR: In reading first IN record for first year, read CD of _____ instead of IN.
ERROR: In reading (IN, EV) records for control point _____ for year _____ read PYR of _____
ERROR: In reading (IN,EV) records for year ___ a CD of ___ was read.
ERROR: (IN,EV) record was not found for year ___ for control point identifier _____
ERROR: (CPIN, CPEV) in field (7, 8) of CP record for _____ was not found.

Written to MSS File From Subroutine RESCAL
ERROR: Reservoir ____ from EA record could not be matched with WS record reservoir identifiers.
ERROR: Reservoir ____ could not be matched with a EA record reservoir.

Written to MSS File from Subroutine IACNP
ERROR: Found CD of __ in the DIS file, when expecting FD, FC, or WP record.
ERROR: _____ from field 2 of FD record ___ matches no control point identifier on CP records.
ERROR: Upstream gage identifier _____ from FD record ___ matches no control point identifier on CP records.
ERROR: _____ on the __ WP record matches no control point identifier on CP records.
ERROR: On FD record for _____ the upstream gage _____ is not upstream of the downstream gage _____
ERROR: NG is -1 on FD record for _____ but the source gage _____ is not upstream of the ungaged control point.
ERROR: Upstream control point UGID(I) of _____ is repeated twice on FD record for CP _____
ERROR: The downstream gaged source control point associated with ungaged CP _____ is missing or not specified on a FD record.
ERROR: The drainage area for CP _____ is missing, zero, or negative: _____
ERROR: The incremental drainage area for CP _____ is zero or negative: _____

Written to MSS File from Subroutine FLDIST
ERROR: NRCS CN method can not be applied for zero or negative drainage area for CP _____
ERROR: Gaged CP _____ is not downstream of ungaged CP _____ as required by INMETHOD (6,8)

Written to MSS File from Subroutine Linear
ERROR: Value out of range in linear interpolation of table number _____ Given = _____
Year: _____ Month: _____ Water Right: _____

Written to MSS File from Subroutine DROUGHT
ERROR: Interpolation of drought index ___ is out of range.

Written to MSS File from Subroutine SPRING
ERROR: Control point identifier ___ in FAD file matches no control point identifier on CP records.
ERROR: Computations terminated due to error in FAD file. Error occurred at control point ___ during year ___

Table 2.10 SIM Warning Messages

Written to MSS File From Main Program

WARNING: The beginning of simulation storage specified for reservoir _____ exceeds its capacity. The initial storage is set at the capacity.

WARNING: The BES beginning storage of _____ for reservoir _____ exceeds its capacity of _____.

WARNING: Incorrect drought index identifier in field 2 of DI record.

WARNING: Incorrect NEA identifier in field 2 of EA record.

Written to MSS File from Subroutine WRAPIN

WARNING: No output is specified on JD, CO, RO, WO, and/or GO records.

WARNING: _____ on (CO,RO,WO,GO) record is not on any (CP,WS,WR) record.

WARNING: TQ/TE records are provided but not assigned to a reservoir.

WARNING: Incorrect NDI identifier in field 2 of DI record.

WARNING: Incorrect NEA identifier in field 2 of EA record.

WARNING: Water right and reservoir should be at the same control point for a type 1 right.
Reservoir:_____ Water right:_____

WARNING: There is a reservoir but IFMETH is not 3 or 4 for IF right _____

Written to MSS File from Subroutine RESCAL

WARNING: End-of-month storage did not converge to within 0.1 acre-feet in 50 iterations of iterative evaporation computations for water right _____
Reservoir: ___ CP: ___ Year: ___ Month: ___ Final Evap: ___

Written to MSS File from Subroutine RELEASE

WARNING: Unable to deliver releases to water right ____ from reservoir _____ due to channel loss factor of 1.0

Written to MSS File from Subroutine POWER

WARNING: Energy produced did not converge to within 0.01 percent of target in 50 iterations of iterative hydropower computations for water right _____.
Reservoir: ___ Year:___ Month:___ Energy target:____
BPSTOR: ____ 49th POWPRO _____ 50th POWPRO adopted: _____

Written to MSS File from Subroutines IACNP or FLDIST

WARNING: The incremental CN and/or mean precipitation MP is negative for gaged ___ or ungaged ___ gaged CN, ungaged CN, gaged MP, ungaged MP = ____ ____ ____ ____

WARNING: Convergence criterion of 0.5% was not met for flow distribution option 8 after 100 iterations at ungaged CP ____ for year ___ , month ____. Last flow computed of ____ was adopted.

WARNING: Evap-precip adjustment at control point ____ for EWA(cp) of ___ for year ___, month ____ Runoff Adjustment (feet) = _____

WARNING: The drainage area for CP ____ is missing, zero, or negative.

WARNING: The CN of CP ____ violates the CN bounds: ____ ____

Written to MSS File from Subroutine BISECT

WARNING: Subroutine BISECT stopped at 100 iterations in solving the NRCS CN equation for P.

CHAPTER 3
WRAP-SIM INPUT RECORDS

The system for organizing *SIM* input datasets is based on files, records types, and fields in each record. Input files contain a set of required and optional records controlling various simulation options and representing the stream/reservoir/rights system being modeled. The record types are labeled by a two-character identifier that is placed at the beginning of each record in the input files. These record types and associated identifiers provide a system for organizing the input datasets. The content and format of each type of *SIM* input record is described by this chapter. Example input files presented in the *Reference* and *Fundamentals Manuals* illustrate their use.

Types of Input Records

The record types are listed in Table 3.1. One each of five types of records (*JD*, *ED*, *CP*, *WR* or *IF*, and *IN*) are required. The other records are optional. Various fields on most records are either optional or have default values and thus may be left blank in many applications. Many typical applications will require only fundamental *SIM* capabilities using less than half of the 47 available record types. Other records are adopted to activate modeling options for various more complex or unusual water management situations. Ingenuity is applied in combining options activated by the different records to model unique situations. The system of record types is designed to create comprehensible, documented datasets that can be conveniently reviewed and modified by model-users as well as efficiently executed by the computer.

The *T1*, *T2*, *T3*, *JD*, *JO*, *CR*, *XL*, *FY*, *WO*, *GO*, *CO*, and *RO* records are included only once at the beginning of the DAT file. The other record types may be repeatedly used numerous times in a dataset. For example, A *CP* record is required for every control point, a *WR* or *IF* record is required for every water right, and at least one *WS* record is required for every reservoir. The total number of records contained in input files for typical river basin modeling applications range from less than a hundred to many thousands.

The record types are briefly described as follows. The sequential order of records and data contained in each field of each record are explained later.

Records in the DAT File

*Title **T1,T2,T3** Records*.- The DAT input file normally begins with a *T1* record followed by optional *T2* and *T3* records. The titles, headings, and/or comments provided on the title records are reproduced at the beginning of the output files created by *WRAP-SIM* and on the cover page created by *TABLES*. The title records may contain any descriptive information.

*Comment ***** Record*.- Comment records beginning with a double asterisk may be entered almost anywhere within the input data. The comments are notes written by the model-user for information only and are not read (other than the ** identifier) or used in any way by the program. Notes are very useful in documenting a dataset. The ** is also routinely used to deactivate records without actually deleting them. Various records may be activated or deactivated in alternative simulation runs by adding or deleting the **.

Table 3.1
Types of SIM Input Records

Basic Input File (filename root.DAT)

Records for organizing the simulation

T1, T2, T3	*T*itles or headings at the beginning of the file that are reproduced in the output
**	comments or notes not read by the computer that may be inserted throughout
JD	*J*ob control *D*ata with basic data and option switches
JO	*J*ob *O*ptions controlling various features of the simulation
FO	*F*ile *O*ptions specifying input and output files
CR	activation switch and specifications for *C*onditional *R*eliability modeling
XL	multiplication factors and parameter *L*imits
FY	*F*irm *Y*ield and yield-reliability table
WO, GO	*W*ater right and water right *G*roup *O*utput
CO, RO	*C*ontrol point and *R*eservoir/hydropower *O*utput
ED	*E*nd of *D*ata

Records for defining control point connectivity and providing information for each control point

CP	*C*ontrol *P*oint connectivity and naturalized flow, evaporation, and channel loss data
CI	*C*onstant *I*nflows or outflows entering or leaving system at a control point

Records for entering water rights information

UC	monthly water *U*se distribution *C*oefficients
UP	water *U*se type *P*riority adjustment factors
RF	monthly *R*eturn *F*low factors
WR	*W*ater *R*ight requirements
IF	*I*nstream *F*low requirements
SO	*S*upplemental water right *Options*
DT	*D*ual simulation options and *T*ransient water right options
TO	*T*arget *O*ptions
TS	*T*arget *S*eries
ML	*M*onthly *L*imits on streamflow depletions
WS	*W*ater right reservoir *S*torage
HP	*H*ydroelectric *P*ower parameters
OR	*O*perating *R*ules for secondary reservoirs in a multiple-reservoir system
DI	*D*rought *I*ndex reservoirs
IS/IP	drought *I*ndex *S*torage volumes (*IS* record) versus *P*ercentages (*IP* record) table
EA/EF	*E*vaporation *A*llocation options for reservoirs shared by multiple entities

Records for describing additional characteristics of reservoirs

SV/SA	*S*torage *V*olume (*SV* record) versus *S*urface *A*rea (*SA* record) table
PV/PE	*S*torage *V*olume (*PV* record) versus *E*levation (*PE* record) table for hydropower
TQ/TE	*T*ailwater discharge (*TQ* record) versus Elevation (*TE* record) table for hydropower
MS	*M*onthly varying *S*torage capacity defining seasonal rule curve operations

Table 3.1 (Continued)
Types of SIM Input Records

	Hydrology Files (filenames root.FLO, root.EVA, root.DIS, root.FAD)
IN	*IN*flows to the system (naturalized streamflows)
EV	*EV*aporation (reservoir net evaporation-precipitation depths)
	Flow Distribution File (filename root.DIS
FD	*F*low *D*istribution specifications for transferring flows from gaged to ungaged sites
FC	*F*low distribution *C*oefficients for certain flow distribution options
WP	*W*atershed *P*arameters used in the flow distribution computations
ED	*E*nd of *D*ata
	Flow Adjustment File (filename root.FAD)
FA	*F*low *A*djustments to be added to the streamflows

*Job Control Data **JD** and Job Options **JO** Records*.- The *JD* and *JO* records contain general information controlling the simulation. The number of years in the simulation and the year at which to start the simulation are specified. Information regarding several *SIM* computational features is entered, including negative incremental inflow options, system reservoir release decision options, beginning-ending storage options, and the natural priority option. Switches are provided for input and output options and input error checking.

*File Options **FO** Record*.- The *FO* record is now obsolete since its file activation functions have been automated or combined with the *JO* record in the latest version of the model. However, existing datasets with a *FD* record still run correctly in the newer version of *SIM*.

*Conditional Reliability **CR** Record*.- The *CR* record activates the conditional reliability modeling simulation mode that is described in the *Supplemental Manual*.

*Multiplication Factors and Parameter Limits **XL** Record*.- The *XL* record includes multiplier factors used primarily for unit conversions, a set of limits on watershed parameters used in the NRCS CN method for transferring naturalized flows, and a limit for a warning message associated with a net evaporation-precipitation adjustment option.

*Firm Yield and Yield-Reliability Table **FY** Record*.- The *FY* record activates an optional iterative simulation routine that creates a yield-reliability table including the firm yield.

*Output Specification **CO**, **WO**, **GO**, **RO** Records*.- There are three types of output records: control point, water right, and reservoir/hydropower. The *JD* record and *CO*, *WO*, *GO*, and *RO* records control the selection of control points, water rights, groups of water rights, and reservoir/hydropower projects to include in the output. Simulation results may be extremely voluminous. The output selection options allow the size of the output file to be controlled.

Table 3.2
Input Records Associated with Component Features of SIM

Organization of the Simulation	
file activation	JO fields 2, 3, 4, 5, 6
output control	WO, GO, CO, RO, JD
simulation period	JD fields 2, 3
error checks	JD field 4
unit conversion factors	XL, CP fields 4, 5, WP field 6
firm yield and yield-reliability analyses	FY
conditional reliability modeling	CR
comments and record deactivation	**
end of dataset	ED
Hydrology Features (Chapter 3 of Reference Manual)	
naturalized streamflows	IN, JO field2, CP fields 4, 6, 7
net reservoir evaporation-precipitation	EV, JO field2, CP fields 5, 8
net evaporation-precipitation adjustment	FD, WP, CP 9, JD 10
streamflow distribution to ungaged sites	FD, FC, WP, CP fields 6, 7, 11
streamflow adjustments	FA, JO field 3
channel losses	CP field 10
watershed flow option	SO field 2
negative incremental streamflow options	JD fields 8, 9
Water Rights Features (Chapter 4 of Reference Manual)	
water supply diversions and return flows	WR, UC, SO, DT, TO, RF, ML, TS
instream flow requirements	IF, UC, WS, TO, SO, TS
hydroelectric power	WR, HP, UC, PV, PE, TQ, TE, XL
water use targets	WR, UC, DI, TO, SO, TS
drought index	DI, IS, IP
water right priorities	WR, IF, UP, JO field 8, DT
reservoir storage	WS, SV, SA, PV, PE
reservoir system operating rules	WS, OR, MS, SO
monthly varying limits on storage capacity	MS
multiple owners of reservoir storage	WR, WS, EA, EF
limits on streamflow depletions	ML, SO fields 3, 4
limits on withdrawals from reservoir storage	SO fields 7, 8
streamflow depletions from multiple locations	SO field 5
backup diversion right	SO field 6
constant monthly inflows and outflows	CI

*Use Distribution Coefficient **UC** Record*.- Sets of 12 factors associated with water use types are used to distribute annual diversion, energy generation, or instream flow requirements over the 12 months of the year. The types of water use may be associated with particular uses, such as irrigation, municipal, and industrial water supply, or hydroelectric energy, or otherwise represent different distributions of annual requirements over the year. *SIM* sums the 12 factors and divides each by the total to transform them to decimal fractions summing to unity.

*Use Priority **UP** Record*.- Water right priorities entered on *WR* and *IF* records for a particular water use type can be replaced or adjusted by factors entered on a *UP* record. Diversion, instream flow, or hydropower targets on *WR* or *IF* records may also be adjusted by a multiplier from a *UP* record.

*Monthly Return Flow **RF** Record*.- One of the options for specifying return flows allows sets of 12 monthly return flow multipliers to be specified on *RF* records. With this option, the portion of a diversion returned to the stream is computed within *SIM* by multiplying the diversion amount by the monthly return flow factor from the appropriate *RF* record.

*Control Point **CP** Record*.- A *CP* record is required for each control point. This record contains the six-character alpha-numeric identifier of the control point, the identifier of the next control point located immediately downstream, information related to sources of naturalized streamflow and net evaporation-precipitation rate data for the control point, and the channel loss factor for the river reach below the control point. The location of all system components is based on entering control point identifiers on various records that reference back to the spatial configuration defined by the control points and next downstream control points listed on the *CP* records.

*Constant Inflows **CI** Record*.- A set of 12 monthly inflows or outflows may be entered on a *CI* record. For each year of the simulation, the constant flows are added to the naturalized flows at the control point designated on the *CI* record and at all downstream control points. Any number of CI records may be assigned to a control point. The *CI* record flows could represent return flows from water users supplied from groundwater, diversions from or to the control point not otherwise reflected in the water rights, or losses not otherwise reflected in channel loss factors.

*Water Right **WR** Record*.- In *SIM*, a water right is defined as a *WR* or *IF* record with associated attached records with supplemental information. Although an actual water right permit may be represented by a set of several *WR* records, in *WRAP* nomenclature, each *WR* or *IF* record is a water right and each right has one *WR* record or *IF* record. The *WR* record contains the water right identification, control point location, annual permitted diversion or energy generation amount, use type (connection to *UC* records) for distributing the annual target over 12 months, priority number, type of right (connection to rules for meeting demands), drought index identifier (connection to *DI* record), and return flow specifications. *WS*, *HP*, *OR*, *SO*, *TO*, and *TS* records attached to a *WR* or *IF* record provide optional additional information regarding the right.

*Instream Flow **IF** Record*.- Instream flow requirements specified on *IF* records are treated as a special form of water right. The *IF* record is similar to the *WR* record, except an instream flow target is entered rather than a diversion target, and several of the *WR* record fields are not applicable. A *WS* record may be attached to an *IF* record similarly as to a *WR* record. *UC*, *UP*, *DI*, *TO*, and *TS* records are used the same with *IF* and *WR* records. The instream flow target restricts the amount of

water available to junior rights. Any number of *IF* records may be assigned to a control point changing the flow target and priority.

*Supplemental Options **SO** Record*.- Information for defining supplemental water right requirements include various limits; alternate control point locations from which streamflow depletions may be made; backup diversion capabilities allowing a water right to supply shortages incurred by another right; and dual simulation options allowing streamflow depletions from an initial simulation to serve as limits in a subsequent simulation. Other limit options include monthly, seasonal, and annual limits on streamflow depletions, diversions, and the amount of water that may be withdrawn from reservoir storage. Intermediate targets to include in the output file may be specified. Certain options may be excluded from particular water rights.

*Dual Simulation and Transient Water Right Options **DT** Record*.- The dual simulation options involve a repeat of the simulation with changes to water rights. The transient water right options involve consideration of rights at dual points in the priority computational loop.

*Target Options **TO** Record*.- Diversion and instream flow targets may be defined as a function of reservoir drawdown and/or naturalized, regulated, and/or unappropriated streamflows at multiple locations using *TO* records.

*Target Series **TS** Record*.- Diversion, instream flow, or hydropower targets or streamflow depletion limits may be entered on *TS* records for each month of the period-of-analysis. The monthly amounts may vary between years as well as within the year.

*Water Right Reservoir Storage **WS** Record*.- Reservoir data on a *WS* record include active and inactive storage capacity and storage-area information, *WS* records are associated with specific water right *WR* records. One primary and multiple secondary reservoirs can be associated with a water right, with a *WS* record for each reservoir following the *WR* record. The water right refills storage in the one primary reservoir as well as using it to supply water. The secondary reservoirs associated with a right meet water use requirements but are not refilled by that particular water right.

*Hydroelectric Power **HP** Record*.- Hydroelectric power parameters include tailwater elevation information, efficiency factor, turbine capacity, and limits constraining energy generation. *HP* record hydropower parameters are associated with the reservoir described by a particular *WS* record.

*Secondary Reservoirs Operating Rules **OR** Record*.- One primary and any number of secondary reservoirs may be associated with a water right. *WS* records are provided for each reservoir. An *OR* record follows the *WR* record for each secondary reservoir to specify multiple-reservoir operating rules. An *OR* record can also be provided for a single secondary reservoir associated with a water right, if needed to either specify the control point location or to activate the pump/pipeline conveyance option. The *OR* record includes the reservoir control point, storage zones used to define release rules, and the gravity-flow versus pipeline switch.

*Monthly-Varying Limits on Streamflow Depletions **ML** Record*.- Streamflow depletions for diversions and refilling storage, associated with a water right *WR* record, are constrained by these maximum allowable limits in each month. A constant limit may be entered on the *SO* record.

*Storage **SV** versus Area **SA** Records*.- A pair of *SV* and *SA* records provides a table of storage volume versus surface area for a reservoir. Each storage volume on the *SV* record corresponds to the surface area in the corresponding field of the *SA* record. The *SV/SA* records represent one of two optional methods for providing a reservoir storage versus area relationship. The alternative option involves use of a regression equation with coefficients entered on a *WS* record. Reservoir storage-area relationships are used within *SIM* for computing net evaporation-precipitation amounts. For a simulated storage volume, the reservoir water surface area is determined by linear interpolation of the *SV/SA* table.

*Storage versus Elevation **PV** and **PE** Records*.- Each reservoir associated with a hydroelectric power right requires a pair of *PV* and *PE* records defining the volume-elevation relationship. Storage volumes are entered on the *PV* record, and the corresponding water surface elevations on the *PE* record. The storage-elevation relationship and is used for computing the head term in the power equation. For a simulated storage volume, the reservoir water surface elevation is determined by linear interpolation of the *PV/PE* table.

*Tailwater Discharge **TQ** versus Elevation **TE** Records*.- Hydropower head is reservoir water surface elevation minus the water surface elevation of the tailwater downstream. Head computations require a tailwater elevation. A constant tailwater elevation may be specified on the *WS* record. Alternatively, a tailwater rating table may be entered as a pair of *TQ* and *TE* records. The tailwater elevation is determined by linear interpolation of this table.

*Monthly Storage Limit **MS** Record*.- A set of 12 monthly reservoir storage capacities may be entered on a *MS* record to define a seasonal rule curve operating plan. Any storage contents above capacity are spilled at the beginning of the month. Seasonally varying storage capacities are normally associated with seasonal reallocations of storage capacity between flood control and conservation pools.

*Drought Index Reservoirs **DI** Record and Storage **IS** and Percentage **IP** Records*.- A drought index mechanism allows diversion, instream flow, and hydroelectric energy generation targets to be expressed as a function of storage in either selected reservoirs or all of the reservoirs. Reservoirs to be included in a drought index are specified on a *DI* record. A drought index is defined as a table of total storage (*IS* record) versus percentage (*IP* record). The storage-percentage relationship is for the total contents of reservoirs specified by a *DI* record. Given the storage computed for each month of the simulation, the index as a percentage is determined from this relationship by linear interpolation. The index percentage is applied to the diversion, instream flow, or hydroelectric power target from a *WR* or *IF* record and *UC* record to determine the target.

*Evaporation Allocation **EA** and Evaporation Allocation Factors **EF** Records*.- The storage capacity of a reservoir may be shared by multiple entities. A set of *WR* and associated records may be used to model the allocation of storage capacity between the multiple owners. An *EA* record defines the manner in which the reservoir evaporation-precipitation is incorporated in the water allocation. An *EF* record provides supplemental information for one of the *EA* record options.

*End-of-Data **ED** Record*.- The *ED* record is placed at the end of the series of records discussed above in the DAT input file. An *ED* record also ends the flow distribution DIS input file.

Records in the Hydrology Files (filenames root.FLO and root.EVA)

*Inflow **IN** and Evaporation **EV** Records*.- Naturalized streamflow data for each control point are either (1) entered on series of inflow *IN* records or (2) computed from naturalized flows entered on *IN* records at one or more other control points. Reservoir net evaporation minus precipitation depths for each control point with a reservoir are entered on *EV* records in the same format as *IN* records. *IN* and *EV* records are stored in various optional alternative record and file formats. *IN* and *EV* records are normally stored in INF and EVA files, respectively, but optionally may be stored in a DAT or HYD file. Unit conversions and other information affecting *IN* and *EV* records are entered on *CP* and *XL* records. *IN/EV* records are normally input for each year of the hydrologic period-of-analysis, but the same record can be repeated for multiple years by specifying the first and last years in fields 3 and 4, respectively.

Records in the Flow Distribution File (Filename root.DIS)

*Flow Distribution **FD** Record*.- *FD*, *FC*, and *WP* records provide information for transferring naturalized streamflows from gaged (known flow) to ungaged (unknown flow) sites. An *FD* record is required for each ungaged control point for which flows are to be synthesized. The identifiers for all pertinent control points are entered on the *FD* record.

*Flow Coefficient **FC** Record*.- Coefficients for the optional coefficient equation flow distribution method are entered on a *FC* record.

*Watershed Parameter **WP** Record*.- The drainage area, curve number, and mean precipitation are provided on a *WP* record for each gaged and ungaged control point for which this information is needed.

*End-of-Data **ED** Record*.- The *ED* record is placed at the end of the DIS input file.

Records in the Flow Adjustment File (Filename root.FAD)

*Streamflow Adjustment **FA** Record*.- Time sequences of adjustments on *FA* records are added to the naturalized flows at a control point and all downstream control points. *FA* record flow adjustments are similar to *CI* record adjustments. Whereas *CI* records contain a set of 12 monthly adjustments that are repeated each year, *FA* records provide multiple-year time series.

Sequential Order of Input Records

The *JD* and *ED* records and at least one *CP*, one *WR* or *IF*, and one *IN* record are required. All other records are optional. The records are organized in the DAT, FLO, EVA, DIS, and FAD input files in the sequential order outlined in Table 3.3. The records for each input file are listed in the sequential order in which they occur in the file.

Table 3.3
Sequential Order of Input Records

Basic Input File (filename root.DAT)

T1,T2,T3	Titles or Headings	T1 is first record. Optional T2 and T3 follow.
**	Comments	Comments may be inserted throughout.
FO	File Options	Optional FO record is located just after or just before T1/T2/T3 records.
JD	Job Control Data	Required JD record follows T1/T2/T3 records.
JO	Job Options	Optional JO and CR records are grouped with required JD record.
CR	Conditional Reliability	Optional JO and CR records are grouped with required JD record.
XL	Multiplication Factors	Optional XL record is located any place between JD and UC records.
FY	Firm Yield	Optional FY record is located any place between JD and UC records.
CO	Control Point Output	CO, RO, WO, GO records are optional and are inserted in any order following the JD record and preceding the UC records.
RO	Reservoir Output	
WO	Water Rights Output	
GO	Groups of Water Rights to Output	
UC	Use Distribution	Set of all UC records follow JD and precede CP and RF records.
UP	Use Priority	Set of all UP records follows set of all UC records.
RF	Return Flow Factors	Set of all RF records follows UC and precedes CP records.
CP	Control Point	All CP records grouped together in any order; at least one.
CI	Constant Inflows	Set of all CI records in any order follows set of all CP records.
IF	Instream Flow	IF and WR records are grouped together in any order, with the set of WS/HP/OR, SO, DT, ML, TO, and TS, and records following their corresponding WR or IF record. HP and OR records must follow WS. WS, SO, DT, ML, TO, TS, and SD records may be in any order, but the set must immediately follow the pertinent WR or IF record.
WR	Water Right	
SO	Supplemental Options	
DT	Dual and Transient	
TO	Target Options	
TS	Target Series	
ML	Monthly Limits	
WS	Reservoir Storage	
HP	Hydroelectric Power	
OR	Operating Rules for a Multiple-Reservoir System	
SV	Storage Volume	Set of all SV-SA tables grouped together in any order, with each SA immediately following corresponding SV.
SA	Surface Area	
PV	Storage Volume	Set of all PV-PE tables grouped together in any order, with each PE immediately following corresponding PV.
PE	Surface Elevation	
TQ	Tailwater Discharge	Set of all TQ-TE tables grouped together in any order, with each TE immediately following corresponding TQ.
TE	Tailwater Elevation	
MS	Monthly Varying Storage Capacity	Set of all MS records grouped together.

Table 3.3 (Continued)
Sequential Order of Input Records

Basic Input File (filename root.DAT) (continued)

DI IS/IP	Drought Index Reservoirs Index Storage/Percentage	Set of all DI/IS/IP records grouped together. Each DI record must be followed by an IS record followed by an IP record.
EA/EF	Evaporation Allocation/Factors	Set of all EA/EF records grouped together.
ED	End of Data	Last record in DAT file except optionally for IN/EV records.

Streamflow (root.INF) and Evaporation-Precipitation (root.EVA) Files
Standard Default Format Subject to Change by INEV in JO Record Field 2
(Optionally, IN and EV records may follow ED record in DAT file.)

IN	Inflows	IN records are grouped together by year. The set of IN records for all control points for a particular year is followed by the set for the next year.
EV	Evaporation	EV records are organized the same as IN records.

Flow Distribution File (filename root.DIS)

FD	Flow Distribution	
FC	Flow Distribution Coefficients	Each FC record follows the corresponding FD record.
WP	Watershed Parameters	The set of all WP records follows the set of all FD/FC records.
ED	End of Data	The DIS file ends with a ED record.

Flow Adjustment File (filename root.ADJ)

FA	Flow Adjustment	Set of all FA records.

Format and Content of Each Type of Input Record

The sets of required and optional records in the *SIM* input files contain information organizing the simulation and representing the river/reservoir/use system being modeled. Input files are prepared using any editor, spreadsheet, and/or other software. Only those records and those fields of a particular record are used as needed for the particular modeling application. Fields not needed are simply left blank. For fields with numeric entries, leaving the field blank is equivalent to entering a zero. The 2-character record identifiers are required. Records with the first two characters blank are not allowed in a data set; this includes totally blank records.

The remainder of this chapter consists of a series of tables and accompanying explanations providing detailed instructions regarding the format and content of each type of input record. Table 3.4 is a quick reference chart for the most commonly used records.

Table 3.4
Quick Reference Chart for SIM

Fields											
1	2	3	4	5	6	7	8	9	10	11	
						Columns					
2	8	16	24	32	40	48	56	64	72	80	page
Basic Input Data File (filename root.DAT)											
T1											46
T2											46
T3											46
**											46
JD	NYRS	YRST	ICHECK	CPOUT	OUTWR	IDSET	ADJINC	NEGINC			49
JO	INEV	FAD	SYSOUT	BES	BRS	STOFLG	NPOPT	PASS2			50
CR	CR1	CR2	CR3	CR4							53
XL	STX	INX	EVX	CIX	SAX	POWFCT	DEPTHX	CNLN	CNUB	MPLB	54
FY	FYIN1	FYIN2	FYIN3	FYIN4	FYIN5	FYWRID	FYGROUP				56
CO	NCPOUT	CPOUID	CPOUID	CPOUID	CPOUID	CPOUID					57
RO	NREOUT	REOUID	REOUID	REOUID	REOUID	REOUID					57
WO	NWOUT		WROUT		WROUT		WROUT		WROUT		58
GO	NGOUT	GROUP	GROUP	GROUP	GROUP	GROUP					58
UC	USEID	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	59
UP	USEID	USEP	USEM	USEFAC							60
RF	RFID	Jan	Feb	Mar	Apr	May	Jun				61
RF		Jul	Aug	Sep	Oct	Nov	Dec				61
CP	CPID1	CPID2	CPDT1	CPDT2	INMETHOD	CPIN	CPEV	EWA	CL	INWS	62
CI	CIID	Jan	Feb	Mar	Apr	May	Jun				64
CI		Jul	Aug	Sep	Oct	Nov	Dec				64
WR	CP	AMT	USE	priority	Type RFM	RFAC	RCP	DINDEX		WRID	65
IF	CP	AMT	USE	priority	IFFLAG	DINDEX		WRID			67
SO	WSHED	MONDEP	ANNDEP	ACPID	BACKUP	MRW	ARW	ISHT			71
DT	DUAL	XP	XPR	XPRIOR	XPOUT	WRID1	WRID2	WRID3			75
ML	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	80
TS	TSL	TSYR2	QTS	QTS	QTS	QTS	QTS	QTS	QTS	QTS	81
WS	RES	capacity	A	B	C	INACT	BEGIN	IEAR	SA	LAKESD	83
HP	WRSYS	WRSYS	TELEV	TQCAP	TPCAP						85
OR	CP	WRSYS(2)	WRSYS(5)	WRSYS(4)	SN2	WRSYS(6)	WRSYS(7)	WRSYS(8)			87
MS	RES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	89
SV	RES	TARA	TARA	TARA	TARA	TARA	TARA	TARA	TARA	TARA	89
SA		TARB	TARB	TARB	TARB	TARB	TARB	TARB	TARB	TARB	89
PV	RES	TARA	TARA	TARA	TARA	TARA	TARA	TARA	TARA	TARA	90
PE		TARB	TARB	TARB	TARB	TARB	TARB	TARB	TARB	TARB	90
DI	DI	DINUM	DIRES	DIRES	DIRES	DIRES	DIRES	DIRES	DIRES	DIRES	91
IS	NS	DISTO	DISTO	DISTO	DISTO	DISTO	DISTO	DISTO	DISTO	DISTO	91
IP		DIPER	DISPER	DISPER	DISPER	DISPER	DISPER	DISPER	DISPER	DISPER	91
ED											46
Flow File (filename root.FLO)											
IN	ID	NYR PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	96
Net Evaporation-Precipitation File (filename root.EVA)											
EV	ID	NYR PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	96
Flow Distribution File (filename root.DIS)											
FD	ID	IDDS	NGAGE	UGID(1)	UGID(2)	UGID(3)	UGID(4)	UGID(5)	UGID(6)	UGID(7)	98
FC	COEF1	COEF2	COEF3								98
WP	ID	DA	CN	MP	DAF						98
ED											46
Flow Adjustment File (filename root.FAD)											
FA	ID	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	99

T1, T2, and **T3** Records – Titles or Headings

field	columns	variable	format	value	description
1	1-2	CD	A2	T1,T2,T3	Record identifier
2	3-78	TITLE	A78	AN	Title or heading

The *SIM* DAT file begins with a *T1* record that optionally may be followed by *T2* and *T3* records. The headings provided by these title records are printed at the beginning of the *SIM* output file and on the *TABLES* cover page.

****** Record – Comments

field	columns	variable	format	value	description
1	1-2	CD	A2	**	Record identifier
2	3-no limit			AN	Comments which are not read by the program

A record beginning with ** is not read by the program, except for the ** identifier. ** records are used to insert notes in the input dataset or to temporarily deactivate selected records. Any number of comment records may be placed at the following locations.

- Almost any logical place in the DAT file. For several record types, ** records may be inserted between groups of records but not within the group.
- Before the first *IN* and *EV* records for each year in the FLO and EVA files.
- Before the *FD* records and between the *FD* and *WP* records in the DIS file.

ED Record – End of Data

field	columns	variable	format	value	description
1	1-2	CD	A2	ED	Record identifier

The *ED* record ends both the DAT and DIS files. The *ED* record is the last record in the DAT file if the *IN* and *EV* records are stored in INF and EVA files or a HYD file. If *IN* and *EV* records are included in the DAT file, they follow after the *ED* record. The *ED* record is the last record in a DIS file signaling the end of the *FD/FC/WP* records.

FO Record – File Options

field	columns	variable	format	value	description
1	1-2	CD	A2	FO	Record identifier
2	7-8	F1	I6	blank,0,+ –1	root.FLO (or INF) file used for IN records (default) root.FLO file is not used (any negative integer)
3	15-16	F2	I8	blank,0,+ –1	root.EVA file is used for EV records (default) root.EVA file is not used (any negative integer)
4	23-24	F3	I8	blank,0,+ –1	root.DIS file is used for FD/WP records (default) root.DIS file is not used (any negative integer)
5	31-32	F4	I8	blank,0,- +	root.HYD file is not used (default) root.HYD file is used for IN and EV records
6	39-40	F5	I8	blank,0,- +	root.FAD file is not used (default) root.FAD file is used for FA records
7	47-48	F6	I8	blank,0,+ –1	root.MSS message file is created (default) root.MSS file is not created
8	55-56	F7	I8	blank,0, – +	HRR file is not created (default) root.HRR hydropower & reservoir release file created
9	63-64	F8	I8	blank,0, – +	YRO file is not created (default) root.YRO yield-reliability output file is created
10	71-72	F9	I8	blank,0, – +	root.BES file is not used (default) root.BES file is used for beginning-ending storages

The optional *FO* record is located just after or just before the T1/T2/T3 records.

The *FO* record is obsolete and no longer needed. In the April 2005 and later versions of *SIM*, files are opened automatically by the program based on parameters read from the *JO* record and other records. However, older datasets with a *FO* record still run correctly in the current version of *SIM*.

JD Record – Simulation Job Control Data

field	columns	variable	format	value	description
1	1-2	CD	A2	JD	Record identifier
2	3-8	NYRS	I6	+	Number of years in the simulation period-of-analysis.
3	9-16	YRST	I8	+	First year of simulation. All *IN* and *EV* records before year YRST will be skipped.
					Level of Error Checks
4	24	ICHECK	I8	–1	Minimal trace messages and reduced error checks
				blank,0	Normal trace and reduced error checks
				1	Normal error checks and input trace
				2	*UC* and *RF* records are copied to MSS file.
				3	*CP* records are copied to MSS file.
				4	*WR/IF* records are copied to MSS file.
				5	*SV/SA* records are copied to MSS file.
				6	*IN/EV* records are copied to MSS file.
				7	*FD/FC/WP* records are copied to MSS file.
				8	Write DUAL simulation information.
				9	Warning messages are deactivated.
					Data Written to OUT Output File
5	31-32	CPOUT	I8	–1	Control point data is output for all control points.
				–2	Control point data is output only for cp's with *IN* records plus those cp's listed on *CO* records.
				+	Control point output is limited to first CPOUT control points plus those cp's listed on *CO* records.
				blank,0	Control point output is specified only by CO records, with no CP output without a *CO* record.
6	39-40	OUTWR	I8	–1	Water rights data is output for all *WR* and *IF* record rights except hydropower rights.
				–2	All *WR* and *IF* record rights including hydropower.
				–3	Non-hydropower *WR* record rights.
				–4	Instream flow (*IF* record) rights.
				+	Water right output is limited to first OUTWR rights in input file plus those listed on *WO* and *GO* records.
				blank,0	Water rights output is specified by *WO* and/or *GO* records, with no wr output without these records.
7	48	IDSET	I8	blank,0,1	First set of identifiers on *WR* input records are used.
				2	Second set of identifiers on *WR* records are used.
					Negative Incremental Naturalized Flow Options
8	56	ADJINC	I8	blank,0,1	Option 1 - No adjustments are performed.
				2	Option 2 – Downstream flow adjustments.
				3	Option 3 - Upstream adjustments applied at all cp's.
				–3	Option 3 with secondary control points excluded.
				4	Option 4 - Adjustment only at cp of the water right.
				–4	Option 4 with secondary control points excluded.
				5	Option 5 – Alternative simulation approach.

JD Record – Simulation Job Control Data (Continued)

field	columns	variable	format	value	description
					Negative Incremental Flow Adjustments to MSS File
9	64	NEGINC	I8	blank,0,1	No adjustments written.
				2	Downstream adjustments written to MSS file.
				3	Upstream adjustments written to MSS file.
					Set Default for Evap-Precip Adjustment
10	72	EPADJ	I8	blank,0	No adjustment unless specified on *CP* record
				–1	Adjustments based on ungaged CP (*FD* field 2)
				–2	Adjustments based on gaged CP (*FD* record field 3)

The *JD* record follows the *T1*, *T2*, *T3* records. Fields 1, 2, and 3 (*CD*, *NYRS*, *YRST*) are the only required entries. All other fields are left blank unless the options activated by each field are needed. Earlier versions of *SIM* had no *JO* record and several parameters now on the *JO* record were included on the *JD* record.

The optional *JO* record normally follows immediately behind the *JD* record. The required *JD* and optional *JO* and *CR* records must be grouped together, but the three records may be placed in any order.

Explanation of JD Record Fields

Field 4: The various levels of checks and messages are defined in Table 2.8 in the preceding Chapter 2.

Fields 5, 6, and 7: These fields in combination with the *CO*, *RO*, *WO*, and *GO* records control which simulation results are written to the output file as explained in the preceding Chapter 2.

Fields 8 and 9: The negative incremental flow options are explained in Chapter 3 of the *Reference Manual*. Field 8 controls the choice of optional computation method. Field 9 allows the negative incremental adjustments used in the computations to be printed to the message file for information.

Field 10: *EPADJ* in field 10 sets the default used to correct the evaporation-precipitation depths from the *EV* records for runoff from the land area covered by a reservoir. The option specified in the *JD* record field 10 is used for all control points for which the *CP* record field 9 is blank [*EWA(cp)*=0]. *EWA(cp)* entered in field 9 of a *CP* record supercedes the default set in field 10 of the *JD* record.

EPADJ of -1 or -2 results in the runoff depth adjustment being computed by dividing the naturalized streamflow by watershed area as defined by *FD* records. For *EPADJ* = –1, the ungaged control point of *FD* record field 2 is used. For *EPADJ* = –2, the gaged control point in *FD* record field 3 record is used. For either option, the control point in field 2 of the *CP* record connects to the control point in field 2 of the *FD* record. However, for ungaged control points, the runoff depth computations may be based on flow/area at either the ungaged or gaged site.

JO Record – Simulation Job Options

field	columns	variable	format	value	description
1	1-2	CD	A2	JO	Record identifier
					Organization of IN and EV Records
2	8	INEV	I6	blank,0,1	Grouped by years in FLO and EVA files.
				–1	Grouped by years in FLO file. No EVA file.
				2	Grouped by control points in FLO and EVA files.
				–2	Grouped by control points in FLO file. No EVA file.
				3	Grouped by years in DAT file.
				4	Grouped by control points in DAT file.
				5	Grouped by years in HYD file in HYD file format.
					Flow Adjustment (FAD) Input File
3	16	FAD	I8	blank, 0	Flow adjustments feature (FAD file) is not activated.
				1	FAD file is read and flow adjustments performed.
					Hydropower and Reservoir Release (HRR) File
4	24	SYSOUT	I8	blank,0	HRR output file is not created.
				1	Water right identifier written to HRR file.
				2	First group identifier written to HRR file.
				3	Second group identifier written to *HRR* file.
					Beginning-Ending Storage (BES) Options
5	32	BES	I8	blank, 0	Feature is not used and BES file is not created.
				1	Ending storages written to BES file.
				2	Beginning storages read from BES file.
				3	Both beginning read and ending written to BES file.
				4	Cycling with BES file automatically created/read.
				5	Cycling without use of a BES file.
				6	Information-only table with water rights data added.
					Beginning Reservoir Storage (BRS) File
6	40	BRS	I8	blank, 0	BRS file is not created.
				1	BRS file is created.
					Multiple-Reservoir System Release Options
7	48	STOFLG	I8	blank,0	End-of-period storage used for system release rules.
				1	Beginning-of-period storage is used for system rules.
					Natural Priority Option Switch
8	56	NPOPT	I8	blank,0	Natural priority option is not used.
				+	Natural priority option is activated.
					Option to Require Second Pass in All Months
9	64	PASS2	I8	blank,0,1	*IFFLAG* in *IF* field 7 controls 2nd pass option.
				2	Second pass is activated for all months regardless.

The required *JD* and optional *JO* and *CR* records must be grouped together, but the three records may be placed in any order. The *JO* record normally follows immediately behind the *JD* record.

Explanation of JO Record Fields

Field 2: The options for organizing the inflows *IN* and evaporation *EV* records are outlined later in this chapter immediately preceding the description of the *IN* and *EV* records.

Field 3: This field activates the flow adjustment input file (filename root.FAD) which consists of *FA* records with flow volume amounts to be added to naturalized streamflows.

Field 4: *SYSOUT* activates the hydropower and multiple reservoir system release output file (filename root.HRR) and specifies the type of water right identifiers to be written to the file.

Field 5: The beginning-ending storage *BES* switch in *JO* record field 5 activates the options outlined on the next page.

Field 6: The beginning reservoir storage file (filename root.BRS) provides beginning-of-simulation storage contents for use by Program *SALT* and by a conditional reliability modeling routine in Program *TABLES*.

Field 7: The *STOFLG* switch is relevant only for reservoirs operated as a multiple-reservoir system that also have multiple water rights associated with one or more of the system reservoirs. Multiple-reservoir system release decisions are based on parameters from the operating rules *OR* records as explained in Chapter 4 of the *Reference Manual*. *STOFLG* allows the multiple-reservoir operating rules to be applied alternatively based on either beginning-of-period storage or latest computed end-of-period storage. The latest computed end-of-period storage reflects end-of-period storage computed for the current period for other more senior rights at the same reservoir. If no other senior rights are associated with the reservoir, the end-of-period storage for the previous month (current month beginning storage) is the last storage computed.

Field 8: Any integer entered in field 8 will activate the natural priority option with water rights being considered in upstream to downstream order instead of in water right priority order. With the natural priority option activated, each right is senior to all other rights located at downstream control points. For streams in parallel, priorities are set by the order that control point records are entered in the DAT file. With the natural priority option activated, the priorities entered in field 5 of the *WR* and *IF* records are ignored.

Field 9: *PASS2* over-rides the *IFMETH* option entered in *IF* record field 6 and forces a second pass through the water rights computation loop in every month regardless of conditions.

Beginning-Ending Storage Options Activated by JO record Field 5

The beginning-ending storage *BES* switch in *JO* record field 5 activates six options:

1. *BES* of 1 specifies that the storage content of each reservoir at the end of the simulation be written to a file named root.BES.

2. *BES* of 2 specifies that initial storages at the beginning of the simulation be read from the BES file.

3. For *BES* = 3, the storages at the beginning of the simulation are read from the BES file, and the storages at the end of the simulation are written to the BES file. Thus, option 3 combines options 1 and 2.

4. With *BES* = 4, the simulation is performed twice; the storages at the end of the first simulation are written to the BES file; and the storages at the beginning of the second simulation are read from the BES file. Thus, the storages at the beginning of the second simulation are set equal to the storages at the end of the first simulation. The root.BES file contains the storages at the end of the first simulation and beginning of the second simulation. The final root.OUT file contains the results of the second simulation.

5. *BES* = 5 performs a dual simulation identical to option 5 except the BES file is not created. The storages at the end of the first simulation become the storages at the beginning of the first simulation without being written to a file.

6. *BES* = 6 creates a listing with reservoir-related water rights information added that cannot be read by *WRAP-SIM*, but rather is designed just for information for the model-user.

BES options 4 and 5 also address return flows and hydropower releases. With the next-month return flow and next-month hydropower options in effect, BES options 4 and 5 return the return flows at the end of the simulation back to the beginning.

Options 1, 2, 3, and 4 involve writing ending storages to a file and/or reading beginning storages from the file. Using options 1, 2, and 3, two or more simulations may be performed by repeated runs of *WRAP-SIM*. Options 4 and 5 involve an automatic second simulation with second simulation beginning storages set equal to the storages at the end of the first simulation. Options 4 and 5 also return next-month option hydropower releases and return flows from the end of the simulation back to the beginning.

A BES file written by *SIM* includes all reservoirs listed in the conventional order established when the DAT file was read. A BES file read by *SIM* may include any number of the reservoirs but they must be listed in the order of the numeric identifiers. The BES file may be manually edited to change storage amounts or delete/add reservoirs. A reservoir may be removed either by entering a -1 for its storage amount or by deleting its entry from the file. If a BES file is read, for any reservoirs not included in the file, beginning storages are set by *WS* record fields 3 and 8 in the conventional manner.

All options except option 5 require activation of a BES file, which is opened automatically.

CR Record – Conditional Reliability Modeling

field	columns	variable	Format	value	description
1	1-2	CD	A2	CR	Record identifier
2	3-8	CR1	I6	+ blank,0	Length of simulation period in months Default = 12
3	9-16	CR2	I8	+ blank,0,–	Starting month for annual cycle option Monthly cycle option is activated
4	17-24	CR3	I8	+ blank,0	Months excluded from output file are still simulated Only the months written to output file are simulated
5	25-32	CR4	F8.0	+ blank,0,–	Factor by which all starting storages are multiplied Default = 1.0

The required *JD* and optional *JO* and *CR* records must be grouped together, but the three records may be placed in any order. No other records may be placed between the *JD*, *JO*, and *CR* records, except ** records.

The *CR* record activates the conditional reliability modeling (CRM) simulation mode. The *CR* record is the only *SIM* input record associated specifically with CRM. Conditional reliability modeling is described in Chapter 2 of the *Supplemental Manual*. Without the *CR* record, a conventional long-term simulation is performed by default and an OUT file is created. With the *CR* record, the period-of-analysis hydrology is divided into multiple hydrologic simulation sequences. The simulation is performed for each hydrologic sequence starting with the same initial storage conditions. The results are stored in a CRM output file (filename root.CRM) which replaces the OUT file.

Program *TABLES* reads the CRM file and performs CRM reliability and frequency analyses. A *5CRM* record directs *TABLES* to read a *WRAP-SIM* CRM file rather than an OUT file and to develop tables in a CRM format which reflects minor changes relative to the conventional format. The *5CRM* record serving as a switch to CRM format is the only CRM-related *TABLES* input record required if the CRM analyses are based on the premise of the multiple hydrologic sequences all being equally-likely to occur. The *Supplemental Manual* documents methodologies and *TABLES* input records required to assign varying probabilities to the hydrologic sequences instead of assuming them all to be equally-likely.

XL Record – Multiplication Factors and Parameter Limits

field	columns	variable	format	value	description
1	1-2	CD	A2	XL	Record identifier
					Multiplication Factors Applied to Input Data
2	3-8	STX	F6.0	+	Multiplier of reservoir storage volumes on *WS*, *OR*, *SV*, *PV*, *MS*, *IS*, and *SD* records.
				Blank, 0	Default = 1.0
3	9-16	INX	F8.0	+	Multiplier of flows on *IN* records, subject to being superceded by non-blank *CP* record field 4.
				Blank, 0	Default = 1.0
4	17-24	EVX	F8.0	+	Multiplier of E-P rates on *EV* records, subject to being superceded by non-blank *CP* record field 5.
				Blank, 0	Default = 1.0
5	25-32	CIX	F8.0	+	Multiplier of flows on *CI* records.
				Blank, 0	Default = 1.0
6	33-40	SAX	F8.0	+	Multiplier of reservoir surface areas on *SA* records.
				Blank, 0	Default = 1.0
					Multiplication Factors Used in Computations
7	41-48	POWFCT	F8.0	+	Multiplier factor for hydropower computations.
				Blank, 0	Default = 0.0010237 (Reference Manual Chapter 4)
8	49-56	DEPTHX	F8.0	+	Multiplier factor for runoff depth in NRCS CN method flow distribution computations.
				Blank, 0	Default = 0.01875 (Reference Manual Chapter 3)
					Limits on CN and Mean Precipitation
9	57-64	CNLB	F8.0	+	Lower limit on CN (Reference Manual Chapter 3)
				Blank, 0	Default = 0.0
10	65-72	CNUB	F8.0	+	Upper limit on CN
				Blank, 0	Default = 100.0
11	73-80	MPLB	F8.0	+	Lower limit on MP
				Blank, 0	Default = 0.0
12	81-88	MPUB	F8.0	+	Upper limit on MP
				Blank, 0	Default = 100 inches or other rainfall unit in effect
					Warning Limit on Runoff EP-Adjustment
13	89-96	EPWL	F8.0	+	Limit for warning message (Reference Manual Ch 3)
				Blank, 0	Default = 2.0 feet or other depth unit in effect

The optional *XL* record is inserted any place between the *JD/JO/CR* records and *UC* records.

Explanation of XL Record Fields

Fields 2-8: The multiplication factors in fields 2 through 8 of the *XL* record are intended primarily for unit conversions as discussed below.

Fields 9-12: The curve number (CN) and mean-precipitation (MP) are watershed parameters entered on *WP* records for use in distributing flows from gaged to ungaged control points. The CN and MP for incremental sub-watersheds are computed from the input values for total watersheds. The CN and MP input and computations may result in unreasonable values. Upper and lower limits may be specified in *XL* record fields 9-12 as discussed in Chapter 3 of the *Reference Manual*.

Field 13: An option activated by *EPADJ* in *JO* record field 4 and *EWA* in *CP* record field 9 adjusts net evaporation-precipitation depths from *EV* records for the precipitation runoff from a reservoir site that is already reflected in the naturalized streamflows. An optional warning message is printed if the adjustment in the runoff depth exceeds a limit specified in field 13. The default is 2.0 units, which would be 2.0 feet if the net evaporation computations are in feet.

Unit Conversions

The multiplication factors in fields 2 through 8 of the *XL* record are intended primarily for unit conversions. The factor *STX* (field 2) with default of 1.0 is multiplied by the storage volume data entered on several other records. The model user must adopt a consistent unit (acre-feet, million cubic meters, etc.) for all the variables representing reservoir storage volumes. However, *STX* allows input data entered in any other units to be converted to the adopted unit.

The variables *INX*, *EVX*, *CIX*, and *SAX* in fields 2, 3, 4, 5 are factors, with defaults of 1.0, by which the data entered on *IN*, *EV*, *CI*, and *SA* records are multiplied. The multipliers *CPDT(cp,1)* and *CPDT(cp,2)* entered on *CP* records replace *INX* and *EVX* for individual control points. *INX* and *EVX* from the *XL* record are applied to *IN* record flows and *EV* record evaporation depths for all control points for which the *CPDT(cp,1)* and *CPDT(cp,2)* fields in the *CP* record are blank. The constant inflows entered on *CI* records are multiplied by *CIX* from the *XL* record. The reservoir water surface areas entered on *SA* records are multiplied by the *SAX* from the *XL* record.

The input variable *DAF* on the *WP* record may be used as a conversion factor to convert *WP* record drainage areas from any units to any other units. The *WP* record mean precipitation may be in any units since this data is used in the form of precipitation ratios. However, the mean precipitation values for all watersheds should be in the same units.

The optional watershed area *EWA(cp)* entered in *CP* record field 9 must be in the same units as the reservoir surface areas.

The variable *POWFCT* entered in *XL* record field 7 is a multiplier factor used in the hydroelectric power computations, which reflects unit conversions and the specific weight of water. This factor is discussed in the hydropower section of Chapter 4 of the *Reference Manual*.

The factor *DEPTHX* entered in *XL* record field 8 is used in the NRCS curve number (CN) method for distributing flows from gaged to ungaged sites as discussed in Chapter 3 of the *Reference Manual*.

FY Record – Firm Yield and Yield-Reliability Table

field	columns	variable	format	value	description
1	1-2	CD	A2	FY	Record identifier
2	3-8	FYIN(1)	F6.0	+	Fraction (0.0-1.0) of monthly target that must be met in order to not count the month a failure in meeting the target in the period reliability computations.
				Blank,0	Default = 1.0
3	9-16	FYIN(2)	F8.0	+	Initial value for the annual target amount. (Must be greater than zero.)
4	10-24	FYIN(3)	F8.0	+	Incremental decrease for first level of decreases for iterative simulations. (Must be greater than zero.)
5	25-32	FYIN(4)	F8.0	+	Incremental decrease for second level of decreases.
				blank,0	Optional second level is not used.
6	33-40	FYIN(5)	F8.0	+	Incremental decrease for third level of decreases.
				blank,0	Optional third and fourth levels are not used.
7	41-56	FYWRID	A16	AN	Water right identifier for *FY* record rights.
8	57-64	FYGROUP	A8	AN	Water right group identifier for *FY* record rights.
9	65-72	MFY	I8	blank,0,1	Proportional to amounts in *WR* record field 3.
				2	Based on priorities in *WR* record field 5.
10	73-80	SIM3	I8	blank,0	Simulation results are not written to root.OUT file.
				+,–	Results for final iteration are written to OUT file.

The *FY* record activates the yield-reliability analysis described in Chapter 2 of the *Reference Manual*. The optional *FY* record is placed between the *JD/JO/CR* records and *UC* records.

Fields 7, 8, 9: The *FY* record yield analysis may be applied to a water right identified in *FY* record field 7 (*WR* record field 11) or to a set of any number of up to 100 rights identified by field 8 of the *FY* record which connects to the group identifiers in fields 12 and 13 of the *WR* records. *MFY* entered in *FY* record field 9 switches between two alternative options for allocating the total annual yield between the specified water rights.

1. The default of leaving *FY* record field 9 blank or entering a zero or 1 activates the option in which the yield is allocated between rights in proportion to the annual diversion amounts in *WR* record field 3. Thus, the allocation is based on fixed fractions.

2. The second option (MFY=2) is based on the priorities from field 7 of the *WR* records. The yield is assigned to the most senior priority right up to the *WR* record field 3 diversion amount. Any yield remaining is assigned to the right with the next most senior priority up to its *WR* record field 3 diversion amount, and so forth. Upon reaching the most junior right, all of the remaining yield, if any remains, is assigned to the most junior right regardless of its *WR* record field 3 diversion amount.

CO Record – Control Point Output Records to be Included in Output File

field	columns	variable	format	value	description
1	1-2	CD	A2	CO	Record identifier
2	7-8	NCPOUT	I6	+	Number of control point identifiers listed on *CO* records. NCPOUT is entered only on first *CO* record. Field 2 should always be blank on the second and subsequent *CO* records.
				blank,0	*CO* records are ignored if NCPOUT is zero.
3-7	9-48	CPOUID(J) J=1,5	5(2x,A6)	AN	Control point identifiers. Output records for cp's with these identifiers will be included in output file.

RO Record – Reservoir Output Records to be Included in Output File

field	columns	variable	format	value	description
1	1-2	CD	A2	RO	record identifier
2	7-8	NREOUT	I6	+	Number of reservoir identifiers listed on *RO* records. NREOUT is entered only on first *RO* record. Field 2 should always be blank on the second and subsequent *RO* records.
				–1	All reservoirs are included in output.
				blank,0	*RO* records are ignored if NREOUT is zero.
3-7	9-48	REOUID(J) J=1,5	5(2x,A6)	AN	Reservoir identifiers. Output records for reservoirs with these identifiers will be included in output file.

The optional *CO*, *RO*, *WO*, and *GO* records are placed as a group between the *JD/JO* records and *UC* records. All *CO* records are grouped together. All *RO* records are grouped as a set. Likewise, all *WO* are grouped together, and all *GO* records are grouped together. It does not matter which of the four sets of records precede or follow the others. All are optional. The *CO*, *RO*, *WO*, and *GO* records are all organized in the same way.

The *CO*, *RO*, *WO*, and *GO* records are used along with *JD* record fields 5-7 to select data to include in the simulation results written to the OUT file. For each, any number of identifiers may be provided on any number of records, with five identifiers per record. However, no more than one CO, one RO, one WO, and one GO record can be used to specify in field 2 the number of control points, reservoirs, water rights or water right groups, respectively, to include. For example, 53 control point identifiers would be listed on 11 *CO* records with five identifiers on each of ten records and three on the 11^{th} record. The integer 53 would be entered in field 2 of the first *CO* record.

WO Record – Water Rights Output Records to be Included in Output File

field	columns	variable	format	value	description
1	1-2	CD	A2	WO	Record identifier
2	7-8	NWOUT	I6	+	Number of water rights identifiers listed on *WO* records. NWOUT is entered only on first WO record. Field 2 should always be blank on the second and subsequent *WO* records.
				blank,0	*WO* records are ignored if NWOUT is zero.
3-7	9-88	WROUT(J) J=1,5	5A16	AN	Water right identifiers. Water right output records for rights with these identifiers will be included in output.

GO Record – Groups of Water Rights Output Records to be Included in Output File

field	columns	variable	format	value	description
1	1-2	CD	A2	GO	Record identifier
2	7-8	NGOUT	I6	+	Number of water rights identifiers listed on *GO* records. NGOUT is entered only on first GO record. Field 2 should always be blank on the second and subsequent *GO* records.
				blank,0	*GO* records are ignored if NGOUT is zero.
3-7	9-48	GROUP(J) J=1,5	5A8	AN	Water right identifiers. Water right output records for rights with these identifiers will be included in output.

Two sets of three optional water rights identifiers are provided in fields 11-16 of the *WR* record. Only one of the two sets of three identifiers are read by *WRAP-SIM*. The selection of which of the two sets to use is specified by *IDSET* in field 8 of the *JD* record. Water rights output records are selected by matching the identifiers on the *WO* record with the first identifier on the *WR* records and matching the *GO* record group identifiers with the second and third identifiers on the *WR* records.

UC Record – Water Use Coefficients (12 monthly use distribution coefficients per record)

field	columns	variable	format	value	description
1	1-2	CD	A2	UC	Record identifier
2	3-8	USEID	A6	AN	Identifier relates sets of use factors to the use type in field 4 of *WR* and *IF* records.
3-14	9-104	PDUSCF	12F8.0	+	Monthly water use coefficients for the 12 months.

UC Records – Water Use Coefficients (two records with six monthly coefficients each)

*First **UC** Record* – Water Use Identifier and Monthly Distribution Coefficients for Months 1-6

field	columns	variable	format	value	description
1	1-2	CD	A2	UC	Record identifier
2	3-8	USEID	A6	AN	Identifier relates sets of use factors to the use type in field 4 of *WR* and *IF* records.
3-8	9-56	PDUSCF (months 1-6)	6F8.0	+	Monthly water use coefficients for months 1-6. Six coefficients are entered on each of 2 UC records.

*Second **UC** Record* – Monthly Distribution Coefficients for Months 7 through 12

field	columns	variable	format	value	description
1	1-2	CD	A2	UC	Record identifier
2	3-8		6x		Field 2 of second record is not used.
3-8	9-56	PDUSCF (months 7-12)	6F8.0	+	Monthly water use coefficients for months 7-12. Six coefficients are entered on each of 2 UC records.

A *UC* record with 12 coefficients or a pair of *UC* records with six coefficients each is provided for each water use type. The two alternative forms of *UC* records are the same except for the number of coefficients included on each record.

The use identifier in field 2 of the single or first *UC* record corresponds to the use identifier in field 4 of the *WR* and *IF* records. The set of 12 monthly factors is used to distribute an annual diversion, instream flow, or hydroelectric energy requirement over the 12 months of the year. *SIM* divides each monthly coefficient by the sum of the 12 coefficients to obtain a set of 12 monthly multipliers.

UP Record – Water Use Priority Adjustment Factors

field	columns	variable	format	value	description
1	1-2	CD	A2	UC	Record identifier
2	3-8	USEID	A6	AN	Identifier relates sets of priority factors to the water use type in field 4 of *WR* and *IF* records.
3	9-16	USEP(I)	I8	+	Priority number which overrides *WR/IF* field 5.
4	17-24	USEM(I)	F8.0	+	Factor by which to multiply priority numbers.
5	25-32	USEFAC(I) I=1,NUSES	F8.0	+	Factor by which to multiply permitted amounts.

The set of all *UP* records follows immediately behind the set of all *UC* records. *UP* records allow modifications to priorities to be applied to selected types of water rights.

Explanation of UP Record Fields

Field 2: Priorities specified on *WR* and *IF* records can be overridden for groups of water rights with a particular water use identifier by the parameters entered on a *UP* record. Water use type identifiers are specified in field 4 of *WR* and *IF* records and field 2 of the *UP* record.

Field 3: For all water rights with the water use identifier entered in *UP* record field 2, the water use priority entered in *UP* record field 3 of replaces the priority number in field 5 of the *WR* or *IF* record. *UP* record priorities supercede *WR* record priorities.

Field 4: Priorities set by *WR* or *IF* records are revised by multiplying by a factor entered in *UP* record field 4.

Field 5: Diversion, instream flow, or hydropower targets from *WR* and *IF* records are multiplied by *USEFAC* from *UP* record field 5 if this field is not blank. The default multiplier factor is 1.0.

RF Record – Monthly Multipliers for Return Flows (12 factors per record)

field	column	variable	format	value	description
1	1-2	CD	A2	RF	Record identifier
2	3-8	RFID(wr)	A6	AN	Identifier relates sets of return flow multipliers to field 8 of *WR* record. [wr = 1,NWRTS]
3-14	9-104	RF (wr,M=1,12)	12F8.0	+	Monthly return flow factors for 12 months.

RF Record – Monthly Multipliers for Return Flows (two records with six factors each)

First RF Record – Return Flow Coefficients for Months 1 through 6

field	column	variable	format	value	description
1	1-2	CD	A2	RF	Record identifier
2	3-8	RFID(wr)	A6	AN	Identifier relates sets of return flow multipliers to field 8 of *WR* record. [wr = 1,NWRTS]
3-8	9-56	RF (wr,M=1,6)	6F8.0	+	Monthly return flow factors for months 1-6 Six factors entered on first RF record, six on second.

Second RF Record – Return Flow Coefficients for Month 7 through 12

field	column	variable	format	value	description
1	1-2	CD	A2	RF	Record identifier
2	3-8		6x		Field 2 of second record is not used.
3-8	9-56	RF (wr,M=7,12)	6F8.0	+	Monthly return flow factors for months 7-12 Six factors entered on first RF record, six on second.

RF records are required for each *RFIDWR* entered in field 8 of *WR* records for return flow options 3 and 4. The diversion amount for a month is multiplied by the appropriate factor from the *RF* record to obtain the return flow. The set of all *RF* records follows the of all *UP* records or the set of all *UC* records if there are no *UP* records.

CP Record – Control Point Information

field	columns	variable	format	value	description
1	1-2	CD	A2	CP	Record identifier
2	3-8	CPID(cp,1)	A6	AN	Control point identifier [cp = 1,NCPTS]
3	11-16	CPID(cp,2)	2x,A6	AN	Identifier of next downstream control point.
				blank,OUT	Basin outlet. There is no control point downstream.
					Multiplier Factors
4	17-24	CPDT(cp,1)	F8.0	+	Factor by which inflows on IN records are multiplied
				blank,0	Default factor = 1.0
5	25-32	CPDT(cp,2)	F8.0	+	Factor by which evaporation rates are multiplied
				blank,0	Default factor = 1.0
					Method for Obtaining Naturalized Flows
6	40	INMETHOD (cp)	I8	0,1	IN records are input for this control point.
				2	Specifications are provided by *CPIN(cp)* in field 7.
				3	Flow distribution equation is used.
				4	NRCS CN method with synthesized flows limited to not exceed source control point flows
				5	NRCS CN method without above noted flow limit
				6	Channel loss coefficient with DAR method
				7	Drainage area ratio method (areas from *WP* records)
				8	NRCS CN method with channel losses
7	43-48	CPIN(cp)	2x,A6	AN	Control point from which *IN* records are repeated
				NONE ZERO	The words *none, zero, NONE, or ZERO* entered in this field indicate zero streamflows at this control point.
					Method for Obtaining Net Evaporation-Precipitation
8	51-56	CPEV(cp)	2x,A6	blank	*EV* records are read as input.
				AN	Control point from which *EV* records are repeated
				NONE ZERO	The words *none, zero, NONE, or ZERO* in this field indicate zero net evaporation at this control point.
					Evaporation-Precipitation Adjustment
9	57-64	EWA(cp)	F8.0	blank,0	Default set by *JD* record field 10 is used.
				–1.0	Ungaged CP from *FD* record field 2 is used.
				–2.0	Gaged CP from *FD* record field 3 is used.
				–3.0, <–3.0	No adjustment. (Overrides non-blank *JD* field 10)
				+	Watershed area in acres for E-P adjustment.
					Channel Loss Factor
10	65-72	CL(cp)	F8.0	+	Channel loss factor for stream reach below CP.
				blank	The default channel loss factor value is 0.0.
					Watershed Areas on WP Records
11	73-80	INWS(cp)	I8	blank,0	Parameters on WP record are for the total watershed.
				+	Parameters on WP record are for incremental watersheds. (any positive integer)

Explanation of CP Record Fields

A *CP* record is required for each and every control point. The control points may be entered in any order, but all *CP* records must be grouped together separated by nothing except ** records.

Field 2.- The six alphanumeric character identifier of the control point is entered on various other types of records to designate location.

Field 3.- The control point located immediately downstream of each control point is designated in order for the model to delineate the spatial configuration of the river system.

Field 4, 5.- The naturalized flows from the *IN* records and net evaporation depths from *EV* records are multiplied by factors in fields 4 and 5 that could be unit conversions, drainage area ratios, or other factors.

Field 6.- Naturalized flows at a control point may be provided as input on *IN* records or synthesized within the model by optional methods selected by field 6.

Field 7.- The naturalized streamflows at a control point may repeated from those provided at another control point or set at zero.

Field 8.- The net evaporation-precipitation depths at a control point may repeated from those provided at another control point or set at zero.

Field 9.- A methodology described in Chapter 3 of the Reference Manual adjusts the evaporation-precipitation depths from the *EV* records for runoff from the land area covered by a reservoir that is reflected in the naturalized streamflows to prevent double-counting. *EWA(cp)* of -1 or -2 results in the runoff depth adjustment being computed by dividing the naturalized streamflow by watershed area as defined by *FD* records. For *EPADJ* = -1, the ungaged control point of *FD* record field 2 is used. For *EPADJ* = -2, the gaged control point in *FD* record field 3 record is used. For either option, the control point in field 2 of the *CP* record connects to the control point in field 2 of the *FD* record. However, for ungaged control points, the runoff depth computations may be based on flow/area at either the ungaged or gaged site.

EPADJ in *JD* record field 10 sets the default used to correct the evaporation-precipitation depths. The option specified in the *JD* record field 10 is used for all control points for which the *CP* record field 9 is blank [*EWA(cp)*=0]. *EWA(cp)* entered in field 9 of a *CP* record supersedes the default set in field 10 of the *JD* record.

Field 10.- The channel loss in a river reach is defined as the flow at the upstream control point multiplied by the channel loss factor entered in *CP* record field 10 for the upstream control point.

Field 11.- The drainage area, curve number, and mean precipitation provided on watershed parameter WP records in a DIS file are used to distribute flows from gaged to ungaged control points. *CP* record field 11 is used to indicate whether these watershed parameters are for the total watershed above the control point or incremental subwatersheds between control points. The default is total watersheds.

CI Record – Constant Inflows and/or Outflows (12 monthly flows per record)

field	columns	variable	format	value	description
1	1-2	CD	A2	CI	Record identifier
2	3-8	CIID	A6	AN	Control point identifier
3-14	9-104	CI(M=1,12)	12F8.0	+,–	Flow added to naturalized flow at control point CIID for month M.

CI Records – Constant Inflows and/or Outflows (two records with six monthly flows each)

*First **CI** Record* – Constant Inflows and/or Outflows for Months 1-6

field	columns	variable	format	value	description
1	1-2	CD	A2	UC	Record identifier
2	3-8	CIID	A6	AN	Control point identifier
3-8	9-56	CI(M=1,6)	6F8.0	+	Monthly flows for months 1-6. Six flows are entered on each of two CI records.

*Second **CI** Record* – Constant Inflows and/or Outflows for Months 7 through 12

field	columns	variable	format	value	description
1	1-2	CD	A2	UC	Record identifier
2	3-8		6x		Field 2 of second record is not used.
3-8	9-56	CI(M=7,12)	6F8.0	+	Monthly flows for months 7-12. Six flows are entered on each of two CI records.

The set of all *CI* records follows the set of all *CP* records. Any number of optional *CI* records may be entered for any control point in any order. Two alternative CI record formats include 12 monthly flows on either one record or two records.

SIM adds flows on the *CI* records to the inflows to the naturalized streamflows at the specified control point and, with adjustments for channel losses, at all downstream control points.

WR Record – Water Right

field	columns	variable	format	value	description
1	1-2	CD	A2	WR	Record identifier
2	3-8	CP	A6	AN	Control point identifier
3	9-16	AMT	F8.0	0,+	Annual diversion or hydropower target
4	19-24	USE	2x,A6	AN	Use type identifier to connect to *UC* records
				blank	Default constant uniform distribution over the year
5	25-32	WRNUM(wr,7)	I8	–,0,+	Priority number
					Water Right Type
6	36	WRNUM	I4	blank,0,1	Type 1 water right
		(wr,5)		2	Type 2 water right (no refilling storage)
				3	Type 3 water right (no streamflow depletions)
				4	Type 4 water right (inflow to stream)
				5, –1	Type 5 water right (hydroelectric power)
				6, –3	Type 6 water right (hydroelectric power)
					Return Flow Specifications
7	40	RFMETH	I4		Return flow method
		(wr)		blank,0,1	Constant factor, flows returned same month
				2	Constant factor, flows returned next month
				3	Monthly factors, flows returned same month
				4	Monthly factors, flows returned next month
8	41-48	RFAC	F8.0	+	Constant return flow factor
		RFIDWR	2x,A6	AN	Identifier on RF record for monthly factors
9	51-56	RCP	2x,A6	blank	Flow returned to next downstream control point
				AN	Identifier of control point to return flow
					Drought Index
10	63-64	DINDEX(wr)	6x,I2	blank,0	Drought index is not used for this water right.
				+,–	Integer identifier (1,2,3,...,15) of drought index. If positive, the drought index is applied as step 3 outlined on page 69. A negative sign switches to applying the drought index as step 6 on page 69.
					First Set of Identifiers
11	65-80	WRID(wr)	A16	AN	Water right identifier
				blank	Option not used
12	81-88	WRIDS	A8	AN	Second water right identifier (group identifier)
		(wr,1)		blank	Option not used
13	89-96	WRIDS	A8	AN	Third water right identifier (group identifier)
		(wr,2)		blank	Option not used
					Alternate Set of Identifiers
14	97-112	WRID(wr)	A16	AN	Alternate water right identifier
				blank	Option not used
15	113-120	WRIDS	A8	AN	Alternate second water right identifier (group)
		(wr,1)		blank	Option not used
16	121-128	WRIDS	A8	AN	Alternate third water right identifier (group)
		(wr,2)		blank	Option not used

Explanation of WR Record Fields

Field 2: The water right has access to available streamflow at this control point. Diversions and streamflow depletions associated with the right occur at this control point.

Field 3: The annual volume/year water supply diversion target or annual hydropower energy generation target is used by *SIM* in setting the monthly target for each month at the beginning of the period computation loop. The annual target amount is multiplied by monthly distribution factors determined from *UC* records to determine monthly targets. These monthly targets may be further adjusted by options controlled by entries on the *DI*, *SO*, and *TO* records. The monthly targets represent a demand or water use requirement that is met subject to water availability.

Field 4: The water use identifier serves the sole purpose of connecting *WR* and *IF* records to *UC* and *UP* records. Any alphanumeric identifier of 6 characters or less may be used along with the two following special cases.

If *WR* or *IF* record field 4 is blank, the 12 monthly water use factors default to a uniform 1/12.

If the terms *NDAYS* is entered in *WR* or *IF* record field 4, the 12 factors otherwise read on the *UC* records are set at the number of days in each month starting with January (31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31). SIM divides these factors by their sum of 365 to obtain the monthly multiplier factors.

Field 5: The priority number is an integer reflecting relative priorities that governs the order in which water rights are considered in the simulation. A blank field 4 assigns a priority of zero, which is treated like any other integer number. The priority in field 4 may be over-ridden or adjusted by factors entered on the *UP* record. Priorities may also be replaced by the upstream-to-downstream natural priority option activated by *JO* record field 8.

Field 6: The water right type specifies rules for meeting water right requirements as described in Chapter 4 of the *Reference Manual*.

The default type 1 right allows a diversion target to be supplied from streamflow depletions and/or storage in one or more reservoirs. The diversion is met from streamflow to the extent that streamflow is available and then from storage. One primary reservoir can be refilled from streamflow depletions and releases from other system reservoirs. The diversion and primary reservoir must be at the control point indicated in field 2.

A type 2 right is identical to a type 1 right except reservoir storage is not refilled.
A type 5 right is identical to a type 1 right except hydroelectric power generation replaces the diversion target.

Field 7, 8, 9: All or a portion of the diversion may be returned to the river system at the same control point as the diversion or at any other control point. The optional methods are outlined in Chapter 3 of the *Reference Manual*.

Field 10: The drought index in field 10 assigns a set of *DI/IS/IP* records to the water right. The drought index in *WR* or *IF* record field 10 is the same as the *NDI* entered in *DI* record field 2.

Field 11-16: Water right identifiers are described in Chapter 2 of this *Users Manual.*

IF Record – Instream Flow Requirement

field	columns	variable	format	value	description
1	1-2	CD	A2	IF	Record identifier
2	3-8	CP	A6	AN	Control point identifier
3	9-16	AMT	F8.0	+	Annual instream flow requirement
4	19-24	USE	2x,A6	AN blank	Use type identifier to connect to *UC* records Default constant uniform distribution over the year
5	25-32	WRNUM(,7)	I8	–,0,+	Priority number
					Type of Instream Flow Computations
6	39-40	IFMETH (wr)	I8	blank,0,1 2 –2 3 4 –4	Constraints on water availability during first pass Constraints on water availability during second pass Constraints during both first and second passes Constraints during first pass, reservoir storage used Constraints during second pass, reservoir storage Constraints during both first and second passes
7	44	IFFLAG2 (wr)	I4	blank,0 1,non-zero	Instream flow limit is based on total regulated flow. Reservoir releases for downstream use are excluded.
					Drought Index
8	47-48	DINDEX(wr)	I4	blank,0 +,–	Drought index is not used for this water right. Integer identifier (1,2,3, ...) of drought index. If positive, the drought index is applied as step 3 outlined on page 69. A negative sign switches to applying the drought index as step 6 on page 69.
					Water Right Identifier
9	49-64	WRID(wr)	A16	AN	Water right identifier (optional)

The data entered in fields 1, 2, 3, 4, 5, 8, and 9 of the *IF* record are similar for both *IF* and *WR* record water rights. *IF* record fields 6 and 7 dealing specifically with instream flow right computations are discussed below.

Field 6 *IFMETH* options 1 and 2 constrain streamflow depletions by all junior rights to protect instream flow targets but do not require releases from storage. Options 3 and 4 result in releases from storage in reservoirs identified by *WS* records associated with the *IF* record to mitigate instream flow shortages.

IFMETH options other than options 1 and 3 exist for the sole purpose of partially mitigating the problem of (1) senior *WR*-record rights not having access to water made available by junior *WR*-record rights through either same-month option diversion return flows or same-month option hydropower releases and (2) the contribution of reservoir releases not being credited in meeting instream flow targets at intermediate control points between the dam and diversion site assuming

IFFLAG2 is zero (blank field 7). *IFMETH* options 1 and 3 should be used if this problem is not a concern and perhaps even if this problem is a concern. All of the other options involve a possible repeat of the simulation, which is called a second pass through the water rights computation loop. With *IFMETH* options 2 and 4, instream flow requirements are not activated during the first pass, and a second pass with instream flow requirements activated is performed if and only if at least one instream flow shortage occurs during the first pass. Options –2 and –4 mean that the instream flow requirements are activated for the first pass as well as second pass. *PASS2* in *JO* record field 7 forces a second pass in all months regardless of the *IF* record *IFMETH* option. With options 2 and 4, instream flow requirements are not reflected in unappropriated flows for months without a second pass.

Location of *WR* and *IF* and Associated *SO*, *DT*, *TO*, *TS*, *ML*, and *WS/HP/OR* Records

WR and *IF* records may be in any order. The set of all *WR* and *IF* records, along with their supporting records, follow the set of all *CP* records. The set of records for each individual water right consists of a *WR* or *IF* record followed in any order by its optional *SO*, *DT*, *TO*, *ML*, *TS*, and/or *WS/HP/OR* records. The set of all of these types of supporting records associated with a particular water right must follow directly behind their *WR* or *IF* record. However, the relative order of the *SO*, *TO*, *TS*, *WS*, *HP*, *OR*, *SO*, and *ML* records within the set is arbitrary other than:

- All *TS* records must be grouped together in chronological order by year.
- If multiple reservoirs are associated with a right, a separate *WS* record is required for each secondary reservoir. The optional *HP* record follows its associated *WS* record. Each optional *OR* record follows immediately behind its *WS* record or *WS/HP* records.

Building Diversion, Instream Flow, and Hydropower Targets

Various options may be applied individually or in combination to define target amounts for a water supply diversion, minimum instream flow requirement, or hydroelectric energy demand. Targets for most rights are set simply by applying only the first step outlined below. More complex requirements may be modeled by exercising ingenuity in combining multiple options within the framework outlined below. In comparing targets determined in different ways, either the smallest or largest may be adopted or targets may be combined through arithmetic operations. A monthly diversion, instream flow, or hydropower target is set in *WRAP-SIM* in a procedure consisting of the following sequential steps.

1. The model combines the annual amount *AMT* entered in field 3 of the *WR* or *IF* record with monthly distribution coefficients from *UC* records to obtain a target for each of the 12 months of the year. UC records are not required if the target is constant over the year.

2. The term *BFIRST* entered in *SO* record field 6 activates the backup option at the first of the target building routine. The diversion shortage from the preceding right is added to the diversion target determined in step 1 above. Alternatively, *BACKUP* activates the backup option as step 8 below.

3. The optional drought index defined by a set of *DI/IS/IP* records modifies the target determined in required step 1 and optional step 2 above as a function of reservoir storage. Alternatively, a negative *DINDEX* entered on the *WR/IF* record switches application of the drought index until step 6 below.

4. One or multiple *TO* records may be used to continue to build a diversion or instream flow target. As specified by *TOTARGET* in field 2 of the *TO* record, the target is defined as a function of naturalized, regulated, or unappropriated streamflow, reservoir storage or drawdown, or water taken by another water right. The *TO* record based diversion or instream flow target is combined with the target determined in the preceding steps by either taking the maximum or minimum of the two targets or by adding them together as specified by *TOCOMB*. Lower and upper limits are placed on the streamflow/storage-based targets by fields 5 and 6, if these fields have positive (non-blank) entries. The three optional applications of these limits are described on the next page.

   The continuation option (*TOCONT*=CONT in *TO* field 10) allows the target building to continue using the next *TO* record. The target developed based on the next record is added to or subtracted from the previously computed target or alternatively the maximum or minimum value is adopted. The *TO* record target building may be repeated any number of times. Each new intermediate target is combined with the preceding cumulative intermediate target.

5. A time series of monthly targets for each month of the hydrologic period-of-analysis may be entered on *TS* records. The manner in which a *TS* record target is combined with the preceding intermediate (steps 1-4 above) target is specified by *TSL* entered in the field 2 of the *TS* record for the first year.

   - The phrase *MAX* entered for variable *TSL* in *TS* record field 2 specifies adoption of the greater of the steps 1-4 intermediate target or the step 5 target from the *TS* record.
   - Entering *MIN* for *TSL* specifies adoption of the lesser of the steps 1-4 versus step 5 values.
   - Entering *ADD*, *MUL*, or *SUB* for *TSL* specifies adding or multiplying the steps 1-4 and step 5 targets or subtracting the step 5 values from the steps 1-4 values.

6. A drought index defined by a set of DI/IS/IP records modifies the target determined above as a function of the storage content of specified reservoirs. The drought index may be applied at this step of the sequence or as step 3 above.

7. *TOTARGET*=10 in *TO* record field 2 or *TOCOMB=LIM* in field 4 results in *TO* record fields 5 & 6 limits being applied at this point as discussed below.

8. The backup option activated by entering *BACKUP* in *SO* record field 6 allows the diversion shortage from the preceding right to be added to the diversion target determined as outlined above.

TO Record Lower and Upper Limits on Targets

The lower and upper limits on diversion, instream flow, or hydropower targets specified in fields 5 and 6 of the target options *TO* record are used in three alternative ways.

- With option 10 in *TO* record field 2, the lower and upper limits are imposed upon the final computed target amount. If the final target would otherwise fall below the lower limit, it is set at the lower limit. If the final target would otherwise be greater than the upper limit, it is set at the upper limit.

- With option *LIM* entered in *TO* record field 4, the computed target is adopted if it falls between the lower and upper limits; otherwise the target is set at zero.

- The third option is in effect if the other two are not activated by *TO* record fields 2 or 4. The limits are imposed upon completion of the other adjustments specified by a particular *TO* record. Different limits may be specified for each individual *TO* record in a series of multiple *TO* records. At each step, if the target would otherwise fall below the lower limit, it is set at the lower limit. If the target would otherwise be greater than the upper limit, it is set at the upper limit.

SO Record Limits on Diversions, Streamflow Depletions, and Regulated Streamflows

MONDEP and *ANNDEP* in *SO* record fields 7 and 8 place monthly and annual or seasonal limits on streamflow depletions taken by a particular water right. Constraints are placed on diversions by the annual/seasonal diversion limit *ADL(wr)* from *SO* record field 10 and the monthly and annual/seasonal reservoir withdrawal limits *MRW(wr)* and *ARW(wr)* from the *SO* record fields 7 and 8. For an instream flow *IF* record right, *ADL(wr)* is a regulated flow limit. Seasons are defined by *LM(wr,1)* and *LM(wr,2)* from *SO* fields 11 and 12. For a *WR* record right, starting with the first month of each year or season, the total cumulative amount diverted by a right that year/season is recorded. Further diversions are curtailed upon reaching the limit *ADL(wr)*. Likewise, the cumulative annual amount diverted from reservoir storage each year or season is limited to *ARW(wr).* For an *IF* record right, the total regulated streamflow is accumulated, and the instream flow requirement is deactivated upon reaching the limit *ADL(wr).* The dual simulation options of *SO* field 14 allow streamflow depletions determined during an initial simulation to serve as limits on depletions during a subsequent simulation.

SO Record – Supplemental Water Right Options

field	columns	variable	format	value	description
1	1-2	CD	A2	SO	Record identifier
					Option for Limiting Water Availability
2	3-8	WSHED (wr)	F6.0	+	Drainage area ratio or other naturalized flow multiplier.
				blank	Watershed flow limit option not used.
					Streamflow Depletion Limits
3	9-16	MONDEP (wr)	F8.0	+	Monthly maximum limit on streamflow depletions.
				blank,0	Either there is no monthly limit on streamflow depletions or limits are entered on a *ML* record.
4	17-24	ANNDEP (wr)	F8.0	+	Annual or seasonal limit on streamflow depletions.
				blank,0	No annual/seasonal limit on streamflow depletions.
					Alternate Control Point for Streamflow Depletions
5	27-32	ACPID	2x,A6	AN	Identifier of alternative control point for streamflow.
				blank,0	Control point specified in field 2 of *WR/IF* record.
					Backup Water Right
6	35-40	BACKUP	2x,A6	BACKUP	Diversion shortages for preceding right added to diversion target at end of target building process.
				BFIRST	Diversion shortages for preceding right added to target at beginning of target building process.
				RETURN	Diversion shortages for preceding right multiplied by RFAC (default=1.0) to be subtracted from target for type 7 right. Used only for type 7 right.
				blank	Backup option is not used.
					Reservoir Withdrawal Limits
7	41-48	MRW(wr)	F8.0	+	Monthly limit on withdrawals from reservoir storage.
8	49-56	ARW(wr)	F8.0	+	Annual/seasonal limit on withdrawals from storage.
					Targets and Shortages Written to Output File
9	64	ISHT(wr)	I8	blank,0	Last target and shortage computed is in output file.
				1	Target and shortage written to output file based on *AMT* from *WR* record field 3 after step 1 described in the accompanying explanation.
				2	After applying *BFIRST* backup option (after step 2).
				3	After applying drought index (after step 3).
				4	After applying options on *TO* record (after step 4).
				5	After *TS* records (after step 5).
				6	After applying drought index (after step 6).
				7	After applying options on *TO* record (after step 7).

Continued on next page.

SO Record – Supplemental Water Right Options (Continued)

field	columns	variable	format	value	description
					Diversion or Instream Flow Limits
10	65-72	ADL(wr)	F8.0	blank,0	Limit option is not used.
				+	Annual or seasonal diversion limit for *WR* record.
				+	Annual or seasonal regulated flow limit for *IF* record.
					ANNDEP(wr), ARW(wr), ADL(wr) Seasons
11	79-80	LM(wr,1)	I8	blank,0,1	Season begins in the first month of the year.
				1-12	Month of year defining beginning of single season.
				–1 to –9	Cyclic season with length defined by *LM(wr,2)*.
12	87-88	LM(wr,2)	I8	blank,0,12	Season ends in the last (12th) month of the year.
				1-12	Month of year defining ending of single season. Length of season if *LM(wr,1)* is negative.
					Options to Not Apply Features for this Right
13	89-96	NOTFLAG	A6	blank	Option is not activated.
				NOCLWR	Channel losses are not applied to streamflow depletions and return flows for this water right
				NORFCL	Channel losses are not applied to just return flows.
				IFNOTA	Instream flow *IF* rights do not restrict this *WR* right.
					Dual Simulation Options
14	97-104	DUAL (wr)	I8	Same as *DT* record field 2. The dual simulation options may be specified by either *DT* record field 2 or *SO* record field 14.	

Explanation of SO Record Fields

Field 2: A drainage area or other parameter ratio *WSHED* entered in field 2 activates the watershed flow option in which the streamflow available to the right is limited to the lesser of: (1) the naturalized streamflow at the control point of the right multiplied by the factor in field 2 and (2) available flow at this control point (*WR* or *IF* record field 2) and all downstream control points as normally computed.

Fields 3 and 4: *MONDEP* and *ANNDEP* are used to specify monthly and annual or seasonal limits on the amount of streamflow that may be taken by the right. Application of this option will typically involve filling storage in an off-channel reservoir, but may be applicable to other situations as well.

Field 5: The alternate control point identifier (*ACPID*) allows streamflow depletions to be made at a control point other than the location indicated in field 2 of the *WR* record. This option is applicable for a reservoir with stream inflows at the control point specified in field 2 of the *WR* record that also receives water through pipelines or canals from one or more other river/reservoir system locations.

Field 6: With *BACKUP* or *BFIRST* is entered in field 6, this water right provides a supplemental backup for the *WR* record immediately preceding the *WR* record of this right in the input. Diversion shortages incurred by the preceding right will be added to the diversion target of this right. *RETURN* is used only in conjunction with a type 7 right (*WR* record field 7) to adjust the return flows for diversion shortages.

Fields 7 and 8: *MRW* and *ARW* are used to specify monthly and annual or seasonal limits on the maximum amount of water that may be withdrawn from reservoir storage by the right.

Field 9: Diversion and hydropower targets are established through a series of optional steps activated by *SO*, *DI*, *TO*, and *TS* records. Intermediate targets may be computed in the process of setting the actual target to be used in the simulation. Only one of these targets and associated shortage are written to the *SIM* output file, which is read by *TABLES*. *ISHT(wr)* in *SO* field 9 specifies which target and corresponding shortage to write to the output file. The default (blank field 9) is to write the final target and shortage at the end of the computations to the output file. A 1 in field 9 results in recording the monthly target initially derived from combining *AMT* from *WR* record field 3 with the distribution factors from *UC* records, which is described as step 1 on the preceding pages. A 2 in *SO* record field 9 specifies use of the target after applying a drought index (steps 2) and so forth. *ISHT(wr)* in field 9 governs only the choice of which monthly targets and shortages are written to the *SIM* output file. The simulation computations are not affected in any way. If the steps 2 through 7 options are not applied, the same step 1 target and shortage are written to the output file regardless of the *ISHT(wr)* entry in field 9.

Field 10: When used with a *WR* record right, starting with the first month of each year or season, the total cumulative amount diverted by that right during that year or season is recorded. Further diversions are curtailed upon reaching the limit specified by *ADL(wr)*.

When used with a *IF* record right, starting with the first month of each year or season, the total cumulative amount of regulated streamflow at that control point during that year or season is recorded. The instream flow requirement is switched-off upon reaching the limit specified by *ADL(wr)*. The instream flow target specified by an *IF* record and supporting records is valid as long as the *ADL(wr)* limit has not been reached. The instream flow target is deactivated if the cumulative regulated flow at the *IF* record control point reaches *ADL(wr)* in the previous month. Thus, for an *IF* record right, the *ADL(wr)* is a cumulative regulated flow limit with the *IF* requirements no longer being enforced after the month in which the accumulated regulated flows reach or exceed the limit.

Fields 11 and 12: Seasons defined by *LM(wr,1)* and *LM(wr,2)* are applicable to the limits on streamflow depletions *ANNDEP(wr)*, withdrawals from reservoir storage *ARW(wr)*, and diversions/regulated flows *ADL(wr)* in fields 4, 8, and 10. Seasons range from 1 to 12 months. If both *LM(wr,1)* and *LM(wr,2)* are blank or zero (default), the limits are annual based on amounts accumulated starting in month 1. This is identical to *LM(wr,1)* and *LM(wr,2)* being set at 1 and 12, respectively. Seasons of less than 12 months may be defined with *LM(wr,1)* and *LM(wr,2)* in two alternative ways as follows.

1. Positive integers from 1 to 12 define a single season extending from *LM(wr,1)* to *LM(wr,2)*. For example, *LM(wr,1)* = 6 and *LM(wr,2)* = 8 define a season extending from June (month 6)

through August (month 8). *LM(wr,1)* = 10 and *LM(wr,2)* = 2 defines a season extending from November (month 10) through February (month 2). The limits *ANNDEP(wr)*, *ARW(wr)*, and *ADL(wr)* are applied during the season extending from month *LM(wr,1)* to month *LM(wr,2)* by comparing to cumulative amounts that have been accumulated beginning in month *LM(wr,1)*.

2. Another alternative method for defining seasons is activated by entering a negative integer for *LM(wr,1)* and a positive integer from 2 to 12 for *LM(wr,2)*. The negative *LM(wr,1)* flags the choice of this alternative option. The *LM(wr,2)* defines the length of a season in months. Seasons begin in month 1 and repeat through the 12-month year. For example, *LM(wr,1)* = -1 (or any negative integer) and *LM(wr,2)* = 3 divides the year into the following four seasons: months 1-3, months 4-6, months 7-9, and months 10-12. *LM(wr,1)* = -1 and *LM(wr,2)* = 6 divides the year into the following two seasons: months 1-6 and months 7-12. If *LM(wr,2)* is greater than 6, only a single season is defined. For example, *LM(wr,1)* = -1 and *LM(wr,2)* = 8 defines a season extending from month 1 through month 8. Thus, *LM(wr,1)* = -1 and *LM(wr,2)* = 8 has the same effect as *LM(wr,1)* = 8 and *LM(wr,2)* = 12. The limits *ANNDEP(wr)*, *ARW(wr)*, and *ADL(wr)* are applied during each season by comparing to amounts that have been accumulated beginning in the first month of that season.

Field 13: Entering *NOCLWR* results in channel losses not being applied to the streamflow depletions and return flows associated with this water right. *NORFCL* results in channel losses being omitted for just the return flows. These options affect only subroutine *AVALB* where downstream flows are adjusted for the effects of flows leaving or entering the stream at an upstream control point.

IFNOTA results in the right not being constrained by instream flow requirements. This option facilitates convenient assessment of the impacts of instream flow requirements on particular *WR* record water rights.

DT Record – Dual Simulation Options and Transient Water Right Options

field	columns	variable	format	value	description
1	1-2	CD	A2	DT	Record identifier
					Dual Simulation Options
2	6-8	DUAL (wr)	I6	1	Right is activated only during the initial simulation.
				2	Right is activated only during the second simulation and is not subject to streamflow depletion constraint.
				3	Right is activated during both simulations. Streamflow depletions during the initial simulation serve as limits during the second simulation.
				4	Right is activated only during the initial simulation. Streamflow depletion array is recorded.
				5	Right is activated only during the second simulation. Streamflow depletions from the preceding option 4 right serve as limits.
					Transient-Priority (XP) Water Right Options
3	9-16	XP	I8	blank,0	Transient priority XP features are not used.
				1	Return flow occurs later in the water right priority loop computations.
				2	Streamflow depletion, return flow, and storage are reversed later in the priority loop computations.
4	17-24	XPR	I8	blank,0,1	End-of-month reservoir storage is restored to beginning-of-month storage for XP option 2 right.
				2	End-of-month reservoir storage is not restored to beginning-of-month storage for XP option 2 right.
5	25-32	XPRIORITY	I8	+	Priority number of 2nd component of water right duo.
6	33-40	XPOUT	I8	blank,0,1	Water right output is treated same as regular rights.
				–1	Water right records are not included in output file.
7	41-56	WRID1	A16	AN	Water right identifier for second component right.
8	57-64	WRID2	A8	AN	Water right group identifier for 2nd component right.
9	65-72	WRID3	A8	AN	Water right group identifier for 2nd component right.

Dual Simulation Options

Dual simulation options may be activated by either *SO* record field 14 or *DT* record field 2. The dual simulation options allow streamflow depletions determined during an initial simulation to serve as upper limits on depletions during a second simulation. A second simulation is automatically performed if and only if DUAL(wr) option 3 or 5 is selected for one or more rights. Alternatively, the simulation may be performed once to develop a set of streamflow depletions, which are then incorporated into an input file as *TS* records for use in further simulations. Option 3 and 4 depletions may be written to the message file with *ICHECK=8* in *JD* field 4.

Although other types of applications are possible, the dual simulation options are designed primarily for situations where multiple water rights with different priorities are associated with the same reservoir or system of multiple reservoirs. Preventing senior right refilling of storage depleted by junior diversion rights is complicated by refilling occurring during future months after reservoir draw-downs. The dual simulation approach deals with this complexity based on repeating the simulation a second time. The initial simulation serves the sole purpose of developing an array of streamflow depletions for a specified senior right that refills reservoir storage. These initial streamflow depletions become constraints that limit the amount of water available to a specified right during the second simulation. The limits are applied in the same manner as the constant monthly and annual depletion limits activated by fields 3 and 4 of the *SO* record and monthly-varying limits activated by *ML* records. The only difference is that the limits are determined by computing streamflow depletions in an initial simulation.

The following five options may be activated by the variable *DUAL* in *SO* record field 14 or *DT* record field 2.

Option 1: The water right is activated only during the initial simulation.

Option 2: The water right is activated only during the second simulation and is not subject to an initial simulation streamflow depletion constraint.

Option 3: A dual simulation is automatically performed. Streamflow depletions computed during the first simulation serve as upper limits on water availability during the second simulation. The streamflow depletions computed during the initial simulation are written to the *MSS* file if *ICHECK*=8 on the *JD* record.

Option 4: The water right is activated only during the initial simulation. A streamflow depletion array is developed. If an option 5 right follows this right, the streamflow depletions serve as upper limits on water availability for the option 5 right during the second simulation. The streamflow depletions are written to the *MSS* file if *ICHECK*=8 on the JD record.

Option 5: A dual simulation is performed with this water right being activated only during the second simulation. The streamflow depletion array from the preceding option 4 right serves as an upper limit on streamflow depletions for this option 5 right.

Option 3 rights use their own streamflow depletion arrays during the second simulation that is repeated automatically. If option 5 is activated for a particular water right, there must be another right with option 4 activated on its *SO* or *DT* record in the input file before the option 5 right. The streamflow depletion array assigned to an option 5 right is from the last right preceding the option 5 right for which a depletion array is generated, based on the sequence order in which the *WR* records are entered in the input file. Option 4 rights may also be used to write streamflow depletions to the *MSS* file even though the automated second simulation is not of interest. The streamflow depletion array written to the MSS file may be manually inserted into an input file as a set of *TS* records for use in subsequent simulations.

DT Record Transient XP Water Right Options

The transient water right options governed by *DT* record fields 3-9 involve changes with respect to location in the priority loop computations. A *WR/DT* record combination creates a pair of computational water rights. The first and second components of the water right duo are assigned priorities from *WR* field 5 and *DT* field 5, respectively. The *DT* record activates two types of XP (dual switching priority) water rights.

1. With XP option 1 in *DT* field 3, return flows may occur later in the priority loop than the corresponding diversion. This option may be used to control which other rights have first access to return flows based on the priority placement of the return flows. The second internal component right does nothing but the return flow. If the return flow priority entered in *DT* field 5 is junior to the priority in *WR* field 5, the return flow occurs in the same month as its diversion. Otherwise, the return flow occurs in the next month which is the next time its priority is reached in the priority based simulation computations.

2. *DT* field 3 XP option 2 is designed for modeling of the effects of subordination agreements. A computational right is activated and deactivated at different points in the computations based on assigned priorities. The objective is to constrain water availability for other rights bracketed by the two priorities. A right is activated based on the senior priority in *WR* field 5. Its streamflow depletion, return flow, and storage change are later reversed automatically within the model as a second component right at the priority in *DT* field 5. Streamflow depletions are returned as to the stream as return flows. Return flows are reversed as streamflow depletions. In typical subordination applications, the actual water right will be modeled with another *WR* record with its actual junior priority.

Field 3: XP is a switch for activating either options 1 or 2 described above. Option 1 simply delays the return flow in the water rights priority-based simulation. Option 2 reverses the streamflow depletion, return flow, and depending on XPR (field 4) the change in storage.

Field 4: The default is for the second automatically created component right to restore the end-of-month reservoir storage to the initial beginning-of-month storage. This implies that actual storage refilling is controlled by another more junior set of *WR/WS* records associated with the same reservoir. Optionally, the effects on reservoir storage of the *WR/WS/DT* record water right may be treated just like a regular *WR/WS* record right.

Field 5: *XPRIORITY* is the priority number of the second component right of the *WR/DT* right duo. The priority number for the first component right is provided in *WR* record field 5. For XP (field 3) option 2, the *DT* record priority should be junior to the *WR* record priority. For XP (field 3) option 1, either priority may be greater but the return flow will occur the next time that the DT record priority is reached in the water right priority loop computations.

Field 6: The default is for the XP right to be treated as any other right in specifying which rights are included in the output file. A -1 omits the XP right from the water right output. XP option 2 flow depletions and return flows are never included in the cumulative control point output data.

Field 7, 8, 9: Identifiers for the first component right are provided in *WR* record fields 14-16. Identifiers for the second component of the water right duo are provided in *DT* record fields 7-9.

TO Record – Target Options

field	columns	variable	format	value	description
1	1-2	CD	A2	TO	Record identifier
					Streamflow at Control Point from Field 7
2	7-8	TOTARGET (n)	I6	1	Target based on same-month naturalized streamflow.
				–1	Target based on prior-month naturalized streamflow.
				2	Target based on same-month regulated streamflows.
				–2	Target based on prior-month regulated streamflows.
				3	Unappropriated streamflows same month.
				–3	Unappropriated streamflows previous month.
					Reservoir Specified in Field 8
				4	Target based on reservoir storage in same month.
				–4	Reservoir storage in previous month.
				5	Target based on reservoir drawdown in same month.
				–5	Reservoir drawdown in previous month.
					Water Right Specified in Field 9
				6	Target based on streamflow depletion that month.
				7	Target based on annual streamflow depletion.
				8	Based on withdrawal from storage that month.
				9	Based on annual withdrawal from storage.
				11	Target based on diversion that month.
				12	Target based on cumulative annual diversion.
					Maximum/Minimum Limits Only
				10	Limits in fields 5 & 6 applied to *WR/IF/DI/TS* target.
					Multiplier Factor
3	9-16	FACT(n)	F8.0	+ or –	Factor multiplied by field 2 amount (default=1.0)
					Apply Limit or Combine with Intermediate Target
4	17-24	TOCOMB (n)	A8	Blank, SET	This is the target, no preceding intermediate target.
				ADD, SUB	Target is added to or subtracted from previous target.
				MUL, DIV	Previous target is multiplied or divided by this target.
				MAX	Maximum of this versus preceding target is adopted.
				MIN	Minimum of this versus preceding target is adopted.
				LIM	*AMT* from *WR/IF* field 3 and *UC/DI* records applied if target falls within limits of *TO* fields 5 and 6
					Lower and Upper Limits
5	25-32	TOLIM(n,1)	F8.0	blank	No lower limit.
				+	Lower limit on either target or quantity setting target.
6	33-40	TOLIM(n,2)	F8.0	blank	No upper limit.
				+	Upper limit on either target or quantity setting target.
					Control Point, Reservoir, or Water Right Identifier
7	43-48	TOFLOW	2x,A6	blank	Control point from *WR* record field 2 used for target.
				AN	Control point of streamflow used to set target.
8	51-56	TORES(n)	2x,A6	AN	Identifier of reservoir used to set target (*TO* field 2).
9	57-72	TOWR(n)	A16	AN	Identifier of water right used to set target (*TO* field 2).

TO Record – Target Options (Continued)

field	columns	variable	format	value	description
					Continue with Another TO Record
10	73-80	TOCONT	A8	blank	Continuation option is not used.
				CONT	Following *TO* record continues building target.

Explanation of TO Record Fields

Field 2: *TOTARGET* specifies whether the target is based on naturalized, regulated, or unappropriated streamflow at the control point specified in field 7, or storage or drawdown in the reservoir specified in field 8, or streamflow depletion, diversion, or withdrawal from storage incurred by the water right specified in field 9. A positive 1, 2, 3, 4, or 5 for *TOTARGET* flags use of amounts in the current month at that stage in the water rights priority-based computation loop. The regulated or unappropriated (available) streamflow or reservoir storage or drawdown values reflect the effects of only senior rights. A negative integer flags the use of values from the preceding month. A *TOTARGET* of 6, 7, 8, 9, 11, or 12 results in basing the target on another water right's total streamflow depletion (6,7), withdrawal from reservoir storage (8,9), or from diversion (11,12), which may be either monthly amounts (6,8,11) or cumulative amounts since the beginning of the year (7,9,12). These are the latest amounts computed in the water rights computation loop, which are same-month for senior rights and preceding-month for junior rights. Any of these variables may be multiplied by *FACT(n)* from field 3.

Field 3: The variable specified in field 2 is multiplied by the factor *FACT* in field 3 to set a diversion or instream flow target. The default (blank field 3) is a multiplier *FACT* of 1.0.

Field 4: *TOCOMB* specifies the manner in which the target resulting from this *TO* record is used. The default (blank field 4) is to simply set the target to the value computed (*TOCOMB* = SET). Alternatively, the target resulting from a *TO* record may be combined with a preceding cumulative intermediate target specified by the preceding *TO* record. The values may be added, the second subtracted from the first, or the first multiplied or divided by the first (*TOCOMB* = ADD, SUB, MUL, DIV). Optionally, either the minimum or maximum adopted (*TOCOMB* = MAX, MIN). With the final option (*TOCOM* = LIM), the *AMT* from the *WR* or *IF* record field 3 adjusted by use coefficient *UC* and drought index *DI* records is adopted if the *TOTARGET*-specified target falls between the limits entered in *TO* record fields 5 and 6, and otherwise the preceding *TO* record target (or zero if no prior *TO* record) is adopted.

Fields 5 and 6: The target is not allowed to drop below the lower limit in field 7 or exceed the upper limit in field 8. For *TOTARGET* ≤ 9, the lower and upper limits are applied to the (*FACT* x *TOTARGET* variable)-based targets. For *TOTARGET*= 10, the fields 5 and 6 lower/upper bounds are applied to the final targets specified on *WR/IF* records or after *TS* records and/or a final drought index.

Field 7: For *TOTARGET* (field 2) of 1, –1, 2, –2, 3, –3, the control point location of the streamflow is entered in field 7. If field 7 is blank, the control point of the water right target in field 2 of the *WR* or *IF* record is the streamflow location. The continuation option (field 10) allows multiple *TO* records to be used to combine flows at multiple locations.

Field 8: For *TOTARGET* (field 2) of 4, –4, 5, –5, the reservoir in which the storage content or storage drawdown is adopted for setting the diversion or instream flow target is entered in field 7. A primary application for the drawdown option is to allow a diversion and return flow to refill a reservoir.

Field 9: For *TOTARGET* (field 2) of 6, 7, 8, 9, the other water right considered in setting the diversion or instream flow target is entered in field 9.

Field 10: The phrase *CONT* entered in field 10 indicates that the next record is another *TO* record that continues to build the diversion or instream flow target. Any number of *TO* records may be attached to an *IF* or *WR* record. For the second and subsequent *TO* records, *CONT* must be entered in field 10 of the preceding record.

ML Record – Monthly-Varying Limits on Streamflow Depletions

field	columns	variable	format	value	description
1	1-2	CD	A2	ML	Record identifier
2	3-8	MSD(L,1)	F6.0	+	Streamflow depletion limit for Month 1
3	9-16	MSD(L,2)	F8.0	+	Streamflow depletion limit for Month 2
4	17-24	MSD(L,3)	F8.0	+	Streamflow depletion limit for Month 3
5	25-32	MSD(L,4)	F8.0	+	Streamflow depletion limit for Month 4
6	33-40	MSD(L,5)	F8.0	+	Streamflow depletion limit for Month 5
7	41-48	MSD(L,6)	F8.0	+	Streamflow depletion limit for Month 6
8	49-56	MSD(L,7)	F8.0	+	Streamflow depletion limit for Month 7
9	57-64	MSD(L,8)	F8.0	+	Streamflow depletion limit for Month 8
10	65-72	MSD(L,9)	F8.0	+	Streamflow depletion limit for Month 9
11	73-80	MSD(L,10)	F8.0	+	Streamflow depletion limit for Month 10
12	81-88	MSD(L,11)	F8.0	+	Streamflow depletion limit for Month 11
13	89-96	MSD(L,12)	F8.0	+	Streamflow depletion limit for Month 12 (L = 1,20 rights with monthly limits)

Streamflow depletions for refilling reservoir storage and diversions, associated with a water right (*WR* record) are constrained by these maximum allowable limits in each month. If the limit is the same in all months, it may entered as variable *MONDEP* in field 3 of the *SO* record.

TS Record – Target Series

field	columns	variable	format	value	description
1	1-2	CD	A2	TS	Identifier required for first year, optional thereafter.
					Manner of Applying TS Amounts
2	3-8	TSL (first record)	3X,A3	blank	*TS* record amounts are the only targets used.
				MAX, max	Maximum of two alternative targets is adopted.
				MIN, min	Minimum of two alternative targets is adopted.
				ADD, add	*TS* record amount is added to preceding target.
				SUB, sub	*TS* record amount is subtracted from preceding target.
				MUL, mul	*TS* record amount is multiplied by preceding target.
				SDL, sdl	Upper limit on allowable streamflow depletions.
					TSL is read with just the first year. This field is not read after first record.
					Years Covered
3	9-12	TSYR1	I4	–	Beginning year (optional)
4	13-16	TSYR2	I4	+	Ending year (required)
					Amounts of Targets or Limits
5-16	17-112	QTS (yr,wr,mt)	12F8.0	+	Amounts for each of the 12 months of the year

Monthly targets entered on *TS* records are for either diversion, instream flow, or hydroelectric energy requirements depending upon the *WR* and *IF* record preceding the *TS* records. The *TS* records may be the only option selected to enter target amounts for a particular *IF* or *WR* record water right. Alternatively, *TS* records may be integrated with other options for setting targets. The mechanism incorporated in *WRAP-SIM* for combining *TS* record targets with other alternative targets are outlined on the pages between the *IF* and *SO* record descriptions.

With SDL (streamflow depletion limit) entered in field 2 for variable *TSL*, the *QTS* values in fields 5-16 are defined as upper limits on streamflow depletions used to constrain water availability in the same manner as the other streamflow depletion limits activated by *SO* record fields 3 and 4 or *ML* records. The *TS* record SDL option may be used in conjunction with the DUAL option activated by *DT* field 2.

TS records provide monthly targets or limits for each month of each year of the hydrologic period-of-analysis. The entire period-of-analysis must be covered, but the number of *TS* records range from one to the number of years in the period-of-analysis. The 12 amounts on each record may be applicable in each year of any sequence of years ranging in length from one year to the entire period-of-analysis. The beginning and ending year of the sub-period covered by an individual *TS* record are specified in fields 3 and 4. However, field 4 controls the program. Field 3 is not used by the program except in an error check and may be left blank. The 12 targets on a record are repeated each year from the year following the ending year on the previous record until the ending year entered in field 4 of the record.

The *TS* records covering all years are grouped together for a particular water right. The set of all *TS* records for a water right may be inserted any place within the set of *TS*, *TO*, *WS/OR*, *HP*, *SO*, *DT*, *ML*, and *SD* records that follow directly behind the *WR* or *IF* record for that right.

TSR Record – Repeat of Another Target Series

field	columns	variable	format	value	description
1	1-3	CD,TSC	A2,A1	TSR	Record identifier
2	6-8	TSL	2x,A3	blank,0 +	Repeat the last time series read. Number of the time series to be repeated.
3	9-16	TSA	F8.0	blank,0 +	Default multiplier = 1.0 Multiplier factor in the equation below.
4	17-24	TSB	F8.0	blank,0 +	Default multiplier = 0.0 Addition factor in the equation below. QTS(yr,TSCOUNT,mt) = TSA [QTS(yr,TSL,mt)] + TSB

A target series QTS(yr,TSCOUNT,mt) associated with a particular *WR* or *IF* record may be repeated or computed from the target series QTS(yr,TSL,mt) previously entered as *TS* records for another *WR* or *IF* record based on the following equation:

$$QTS(yr,TSCOUNT,mt) = TSA\ [QTS(yr,TSL,mt)] + TSB$$

The factors TSA and TSB are entered in *TSR* record fields 3 and 4. QTS(yr,TSL,mt) are entered on a previous set of *TS* records or developed with a previous *TSR* record.

Target series are automatically numbered consecutively (1, 2, 3, ...) by *WRAP-SIM* in the order read from the DAT file. TSL in *TSR* record field 2 is the integer identifier of the series to be repeated. For example, a 3 entered for TSL in *TSR* record field 2 would repeat the third set of *TR* record quantities found in the dataset. The default is to repeat the last series read.

WS Record – Reservoir Storage Associated with a Water Right

field	columns	variable	format	value	description
1	1-2	CD	A2	WS	Record identifier
2	3-8	RES	A6	AN	Reservoir identifier
3	9-16	WRSYS(sr,3)	F8.0	+	Total storage capacity at top of the conservation pool.
					Storage-Area Relationship
4	17-24	EVCFA	F8.0	+	Multiplier *A* for storage-area equation shown below.
5	25-32	EVCFB	F8.0	+	Exponent *B* for storage-area equation shown below.
6	33-40	EVCFC	F8.0	+	Constant *C* for storage-area equation shown below. surface area = $A\,(\text{storage})^{B} + C$
					If fields 4, 5 & 6 are all blank, a table on *SV* & *SA* records is required to define the storage-area relation.
					Optional Storage Specifications
7	41-48	INACT	F8.0	+	Storage capacity at top of the inactive pool.
8	49-56	BEGIN	F8.0	Blank,0	Reservoir is full to capacity (field 3) at the beginning.
				+	Storage volume at the beginning of the simulation.
					Evaporation Allocation Reservoirs
9	57-64	IEAR	I8	Blank,0	Option not used.
				+	*EA* record identifier (1, 2, 3, ...). 1 for first *EA* record.
10	71-72	SA	I8	Blank,0	A separate storage-area relationship is provided.
				–1	Use *SV/SA* records for first reservoir on *EA* record.
					Downstream Versus Lakeside Diversions
11	79-80 = WRNUM(wr,11) or SN3(swr,sr)	LAKESD	I8	Blank,0	Water supply diversions are accessible to hydropower.
				-1	Lakeside diversions do not generate hydropower.

Multiple reservoirs may be associated with a single water right. A *WS* record is required for each reservoir associated with a right. The optional hydropower *HP* and operating rules *OR* records are connected to a particular *WS* record and follow directly after the *WS* record. A *HP* record follows directly behind its *WS* record. The *OR* record follows directly behind the *HP* record. If there is no *HP* record, the *OR* record follows directly behind the *WS* record. A set of *WS/HP/OR* may be placed anyplace in the group of supporting records that follow a *WR* or *IF* record.

Multiple rights may be associated with a particular reservoir. The total storage capacity in *WS* field 3, inactive storage capacity in field 7, and turbine/lakeside diversion switch in field 11 are connected to a water right and may vary with different rights at the same reservoir. Likewise, the parameters entered on *OR* records to define operating rules are associated with a particular water right and may vary between multiple rights at the same reservoir. Other data entered on *WS* and *HP* records are connected to a particular reservoir and are constant for that reservoir with no variation between multiple rights. After being entered with one right, these data do not have to be repeated for other rights at the same reservoir. Fixed reservoir data include *WS* fields 4, 5, 6 and *HP* fields 4, 5, 6. *SV/SA*, *PV/PE*, and *TQ/TE* record tables are also fixed for a reservoir.

Explanation of WS Record Fields

Field 3: A water right refills a reservoir to the storage capacity entered in field 3 subject to water availability. Multiple rights at the same reservoir may refill storage to various levels at different priorities. The conservation storage capacity for a junior right must equal or exceed the storage capacity associated with more senior rights at the same reservoir.

Fields 4, 5, 6: *WRAP-SIM* provides two options for inputting the storage volume versus surface area relationship for a reservoir: (1) a table provided on *SV* and *SA* records and (2) coefficients for the following equation provided in fields 4, 5, and 6 of the *WS* record:

$$\text{surface area} = A\,(\text{storage})^{B} + C$$

If *WS* record field 4 is blank, a pair of *SV/SA* records must be provided for the reservoir. For multiple rights associated with a particular reservoir, the storage-area input only has to be provided once, with the first right (*WR/IF* record) read. There is only one storage-area relationship for a reservoir even if the reservoir is associated with multiple water rights. Fields 4, 5, and 6 of the *WS* record is left blank if the storage-area information is specified elsewhere.

Field 7: Releases or withdrawals are curtailed whenever storage contents fall below the top of the inactive pool.

Field 8: The reservoir is assumed full to capacity (field 3) at the beginning of the first month of the first year of the simulation unless an initial storage is entered in *WS* record field 8 or the beginning-ending-storage feature is activated by *JO* record field 5.

Field 9: The integer identifier connects this reservoir to an *EA* record, used to define options for allocating net evaporation between component reservoirs used to model a multiple-owner reservoir. An *EA* record is needed only if the multiple owners have access to different amounts of storage capacity with different priorities in the same reservoir. An *EA* record is not needed for multiple owners with access to the same storage pool. The integer 1 in *WS* record field 9 links this reservoir to the first *EA* record in the input file, a 2 links to the second *EA* record, a 3 links to the third *EA* record, and so forth. There is no limit on the number of EA records that may be included in a dataset.

Field 10: The reservoirs listed on an *EA* record may share the storage-area table provided by the *SV/SA* records for the first reservoir listed, or each reservoir may have its own storage-area relationship. A negative integer for *SA* in field 15 indicates that since this reservoir is adopting the same *SV/SA* records as the first reservoir on its *EA* record, a separate storage-area relationship is not entered in either *WS* record fields 4, 5, 6 or as *SV/SA* records.

Field 11: Field 11 is used for a diversion right to flag whether the diversion is available later in the priority loop for junior hydropower rights. *LAKESD* specifies whether a water supply diversion is released through the turbines, incidentally generating hydroelectric energy, or withdrawn lakeside without being accessible for hydropower production. *WS* record field 11 is relevant only for a senior water supply diversion met by releases from a reservoir at which a hydroelectric power plant for a more junior hydropower right is also located.

HP Record – Hydroelectric Power

field	columns	variable	format	value	description
1	1-2	CD	A2	HP	Record identifier
2	3-8	WRSYS(sr,4)	F6.0	Blank,0 +	Default efficiency = 0.85 Energy efficiency for hydroelectric power plant.
3	9-16	WRSYS(sr,1)	F8.0	Blank,0 +	Tailwater discharge-elevation from TQ/TE records. Constant tailwater elevation.
4	17-24	TELEV(res)	F8.0	Blank,0 +	Bottom power pool defined by INACT in WS field 7. Turbine inlet invert elevation.
5	25-32	TQCAP(res)	F8.0	Blank,0 +	No limit on turbine discharge. Turbine discharge capacity.
6	33-40	TPCAP(res)	F8.0	Blank,0 +	No limit on amount of secondary energy generated. Maximum limit on energy production.

A hydroelectric power right is activated by a water right type of 5 or 6 in *WR* record field 6. A *HP* record is placed immediately behind the corresponding *WS* record to provide hydropower parameters. A *HP* record is not required for a hydropower right if the default values are adopted for all of the hydropower parameters.

Explanation of HP Record Fields

Field 2: The efficiency is a fraction less than 1.0 representing the ratio of electrical energy to hydraulic energy used in the power equation. The default efficiency is 0.85.

Field 3: A constant tailwater elevation may be entered in *HP* record field 3 for computing the head used in the power equation. If a *HP* record is not used or field 3 is blank, a tailwater rating table is entered on *TE/TQ* records.

Field 4: Hydroelectric power is not generated if the average water surface elevation during the month falls below the limiting elevation specified in field 4. The hydropower computational routine first determines whether the energy target can be met with flows already available without releases from storage specifically for hydropower generation. Hydropower generation from these flows already available to the turbines is constrained by the turbine inlet invert elevation but not the inactive storage capacity of the hydropower reservoir. If additional releases from storage are required, these releases are constrained by the inactive storage capacity as well as hydropower generation being constrained by the turbine inlet invert elevation.

Reservoir releases for any purpose are curtailed whenever storage falls below the inactive storage capacity entered in *WS* record field 7. Subject to the LAKESD switch in *WS* record field 11, water supply diversions at the reservoir associated with rights that are senior to the hydropower right are allowed to flow through turbines contributing flow for the more junior hydropower right. Pass-through flows and water supply releases from upstream reservoirs for other senior rights also flow through the turbines. These flows associated with other rights senior to the hydropower right are constrained by their own inactive pool storage (*WS* record field 7). Reservoir releases for a hydropower right are likewise possible only if the storage contents exceed the inactive pool storage specified in *WS* record field 7. The turbine inlet invert elevation of *HP* record field 4 also constrains hydropower generation even if incidental flows are available from other senior water rights even without releases for the hydropower right.

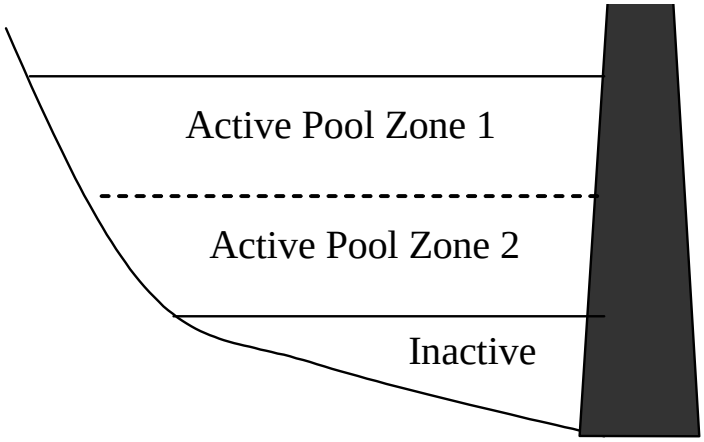
Field 5: A maximum limit may be imposed on the flow volume/month that may be used to generate electric power. If field 5 is left blank, unlimited turbine discharge capacity is assumed.

Field 6: A maximum limit may be imposed on the electric energy/month that may be generated. If an energy production limit is specified, it must be greater than the monthly energy target developed based on adjusting the annual target entered in *WR* record field 3. Thus, the *HP* record field 6 limit affects only secondary energy generated in excess of the *WR* record field 3 firm energy target.

OR Record – Operating Rules for Secondary Reservoirs

field	columns	variable	format	value	description
1	1-2	CD	A2	OR	Record identifier
2	3-8	CP	A6	AN	Control point identifier of reservoir location.
				Blank,0	Control point for reservoir is assigned by prior right.
3	9-16	WRSYS(sr,2)	F8.0	+	Storage capacity at top of zone 2 (bottom of zone 1).
				Blank,0	Default = inactive storage from *WS* record field 7
4	17-24	WRSYS(sr,5)	F8.0	+	Zone 1 multiplier factor (M).
				–1.0	Multiplier factor set at zero.
				blank,0	Default = 1.0
5	25-32	WRSYS(sr,4)	F8.0	+	Zone 2 multiplier factor (M).
				–1.0	Multiplier factor set at zero.
				blank,0	Default = 1.0
6	33-40	SN2(swr,sr)	I8	–1	Withdrawals through pump and pipeline conveyance as well as releases as river flow.
				blank,0	Releases only as gravity flow in river channels.
7	41-48	WRSYS(sr,6)	F8.0	+	Zone 1 addition factor (A).
				blank,0	Default = 0.0
8	49-56	WRSYS(sr,7)	F8.0	+	Zone 2 addition factor (A).
				blank,0	Default = 0.0
9	57-64	WRSYS(sr,8)	F8.0	+	Monthly release limit.
				blank,0	Optional release limit feature is not used.

$$\text{rank index} = M \left[\frac{\text{content}}{\text{capacity}} \right] + A$$



An *OR* record follows the *WS* record or *WS/HP* records. *OR* records are used to specify multiple-reservoir system operating rules based on the storage zones defined by the figure above and the rank index computed with the equation above with M from *OR* record fields 4 and 5 and A from fields 7 and 8. Defaults are adopted if there is no *OR* record or if the fields are blank.

Diversion, instream flow and hydropower requirements may be supplied by releases from multiple reservoirs. System operating rules are explained in Chapter 4 of the *Reference Manual*. For a diversion supplied by releases from two or more reservoirs, release decisions are governed by a *WR* record with type 2 or 3 specified in field 6 and pairs of *WS/OR* records for each reservoir in the system. Storage in each individual reservoir is refilled by a separate type 1 (*WR* field 6) right with its own *WR* and *WS* records. An *OR* record is not provided for the primary reservoir with storage refilled by the water right (type 1 right in *WR* record field 6) or at which the hydroelectric power plant is located for a hydropower right (type 5 or 6).

An *OR* record may also be used for a water right with a single secondary (no storage refilling) reservoir with the diversion occurring at a location other than the control point of the reservoir. *OR* record field 6 activates the gravity flow or pump/pipeline options.

The *OR* record is not required if the control point has been defined by previously read *WR/WS* records and defaults are adopted for all of the variables on the *OR* record. If a multiple-reservoir system right is modeled with a set of *WS* records without accompanying *OR* records, storage zone 2 is eliminated by the *OR* record field 2 default of setting the capacity at the top of zone 2 equal to the inactive pool capacity. The multiplier factors (M) are 1.0 and addition factors (A) are 0.0 in the rank index equation. The CP location must have been previously assigned.

Explanation of OR Record Fields

Field 2: Field 2 may be left blank if the control point identifier of the reservoir location has been assigned to the reservoir by a water right read earlier in the DAT file.

Field 3: Each reservoir of a multiple-reservoir system may optionally be divided into the two zones shown in the figure in conjunction with defining release rules. Releases are not made from zone 2 of any reservoir until zone 1 has been emptied in all reservoirs.

Fields 4, 5, 7, 8: The multiplier factors entered in fields 4 and 5 and the addition factors entered in fields 7 and 8 are used in the rank index equation shown on the previous page. If one or more reservoirs have water stored in their designated zone 1, the ranking index is computed for zone 1. If all reservoirs are drawn-down to zone 2, the ranking index is computed for zone 2. The rank index is computed each month to determine from which reservoir to release. The release is made from the reservoir with the greatest value for the rank index. The release is limited to the amount that empties the zone, switching to the next highest ranked reservoir as necessary. The release is also constrained to not exceed the maximum release limit entered in Field 9.

Field 6: Diversion, instream flow, or hydropower requirements at locations other than the reservoir's control point may be supplied from releases or withdrawals from the reservoir. For the default SN2 of zero (blank field 9), a reservoir can release only for water use requirements at downstream locations accessible by gravity flow in the river below the reservoir. A -1 entered for SN2 in field 6 removes this location constraint, thus simulating pump and pipeline or canal conveyance to any location.

Field 9: An optional constant volume/month limit on the release each month from this reservoir for this particular system water right may be entered in field 9.

MS Record – Monthly Storage Limit

field	columns	variable	format	value	description
1	1-2	CD	A2	MS	Record identifier
2	3-8	RES	A6	AN	Reservoir identifier
3-14	9-104	STMON(M) M=1,12	12F8.0	+	Storage limits for months 1 through 12

The set of *MS* records for any number of reservoirs follows the set of optional *SV/SA-PV/PE-TQ/TE* records. An optional *MS* record is entered for a reservoir to model a seasonal rule curve operating policy. The storage capacities on the *MS* record serve as upper limits constraining storage.

SV Record – Storage Volumes for Reservoir Storage versus Area Table

field	columns	variable	format	value	description
1	1-2	CD	A2	SV	Record identifier
2	3-8	RES	A6	AN	Reservoir identifier
3-14	9-104	TARA(I) I=1,12	12F8.0	+	Reservoir storage volumes corresponding to surface areas in same fields of the following *SA* record

SA Record – Surface Areas for Reservoir Storage versus Area Table

field	columns	variable	format	value	description
1	1-2	CD	A2	SA	Record identifier
2	3-8	RES	6x		Field not used
3-14	9-104	TARB(I) I=1,12	12F8.0	+	Reservoir surface areas corresponding to storage volumes in same fields of the preceding *SV* record

The *SV, SA, PV, PE, TQ, and TE* records have the same format. Storage volume (*SV* record) versus surface area (*SA* record) tables are used in the reservoir net evaporation-precipitation computations. A storage-area relationship may be defined optionally with a pair of *SV-SA* records or by equation coefficients provided on the *WS* record. Storage volume versus water surface elevation (*PV-PE* records) and tailwater rating tables (*TQ-TE* records) are used only for computing head in hydroelectric power computations. The *SV-SA*, *PV-PE*, and *TQ-TE* tables are allowed a maximum of 12 pairs of values. A *SV (or PV or TQ)* record must be followed by the corresponding *SA (or PE or TE)* record. A complete set of all *PV-PE* records grouped together follows the complete set of all *SV-SA* records. Likewise, an entire set of *TQ-TE* records follows the complete set of all *PV-PE* records.

PV Record – Storage Volumes for Storage versus Elevation Table for Hydropower Right

field	columns	variable	format	value	description
1	1-2	CD	A2	PV	Record identifier
2	3-8	RES	A6	AN	Reservoir identifier
3-14	9-104	TARA(I) I=1,12	12F8.0	+	Reservoir storage volumes corresponding to surface elevations in same fields of the following *PE* record

PE Record – Surface Elevations for Storage versus Elevation Table for Hydropower Right

field	columns	variable	format	value	description
1	1-2	CD	A2	PE	Record identifier
2	3-8	RES	6x		Field not used
3-14	9-104	TARB(I) I=1,12	12F8.0	+	Reservoir surface elevations corresponding to storage volumes in same fields of the preceding *PV* record

TQ Record – Tailwater Discharges for Flow versus Elevation Table for Hydropower Right

field	columns	variable	format	value	description
1	1-2	CD	A2	TQ	Record identifier
2	3-8	RES	A6	AN	Reservoir identifier
3-14	9-104	TARA(I) I=1,12	12F8.0	+	Tailwater streamflows corresponding to tailwater elevations in same fields of the following *TE* record

TE Record – Tailwater Elevations for Discharge versus Elevation Table for Hydropower Right

field	columns	variable	format	value	description
1	1-2	CD	A2	TE	Record identifier
2	3-8	RES	6x		Field not used
3-14	9-104	TARB(I) I=1,12	12F8.0	+	Tailwater elevations corresponding to streamflows in same fields of the preceding *TQ* record

DI Record – Drought Index Reservoirs

field	columns	variable	format	value	description
1	1-2	CD	A2	DI	Record identifier
2	7-8	NDI	I6	+	Drought index integer identifier
3	11-12	EMPTY (NDI)	I4	blank,0	Reservoir emptying option is not used.
				–1	Reservoir(s) is emptied at beginning of every month.
				1,2,3, ... 12	The month in which emptying occurs each year.
4	15-16	NR	I4	+	Number of reservoirs (Not to exceed 12)
				–1	All reservoirs
5-16	17-112	DIRES (NDI,I)	12(2x,A6)	AN	Reservoir identifiers (NDI = number of *DI* records, I=1,12)

IS Record – Drought Index Storage

field	columns	variable	format	value	description
1	1-2	CD	A2	IS	Record identifier
2	7-8	NS	I6	+	Number of storage-percentage pairs (not to exceed 12)
3-12	9-104	DISTO(I)	12F8.0	+	Reservoir storage corresponding to *IP* record DIPER

IP Record – Drought Index Percentages

field	columns	variable	format	value	description
1	1-2	CD	A2	IS	Record identifier
2	7-8		6x		Field 2 is not used.
3-12	9-104	DIPER(I)	12F8.0	+	Percentages corresponding to *IS* record DISTO

The sets of all *DI/IS/IP* records are grouped together just before the *ED* record and following the *MS* records. For each drought index, an *IS* record must follow its *DI* record. The *IP* record follows the *IS* record. Each drought index is based on either the total storage in one to 12 specified reservoirs or all the reservoirs in the model. The storage versus index relationship is defined by the IS/IP records with a set of no more than 12 pairs of storage and index percentage values.

EA Record – Net Evaporation-Precipitation Allocation

field	columns	variable	format	value	description
1	1-2	CD	A2	EA	Record identifier
2	7-8	NEA	I6	+	*EA* record integer identifier which may be blank since *SIM* automatically numbers. NEA = 1, 2 , 3, ...
					Allocation Method
3	16	NEAF (NEA)	I8	blank,0,1	Incremental based on water right priorities
				2	Based on beginning-of-month storage content
				3	Based on factors from following *EF* record
					Reservoirs
4-23	17-176	EARES (NEA,I)	20(2x,A6)	AN	Reservoir identifiers for from 2 to 20 reservoirs. I = 1, 20

EA records are used in situations where multiple water supply entities hold rights, with different priorities, to storage capacity in the same reservoir. The storage capacity owned by each entity may be modeled as a separate reservoir, with its own *WR* and *WS* records. The *EA* record allows the component separate *computational* reservoirs to share the same storage-area relationship, in the form of total storage in all component reservoirs versus total water surface area, for use in the computation of net evaporation-precipitation volumes. The following alternative methods for allocating net evaporation between the component reservoirs are selected in *EA* record field 3.

Option 1 assigns the most senior right the net evaporation computed prior to considering any other junior rights. Each subsequent right is allocated its incremental additional net evaporation as the rights are considered in the simulation in priority order.

Option 2 allocates net evaporation between reservoirs in proportion to their beginning-of-month storage. If the beginning-of-month storage is zero in all reservoirs, net evaporation is divided equally between the reservoirs.

Option 3 is based on factors provided on an EF record.

Each *EA* record represents a multiple-owner reservoir modeled as from two to 20 component reservoirs. *WS* record field 2 identifiers of component computational reservoirs that compose the actual multi-owner reservoir are listed in fields 4-23 of the *EA* record. Each component reservoir has its own *WR* and *WS* records and must be associated with a type 1 right (*WR* field 6). *WS* record field 14 connects to the *WR/WS* records to a *EA* record.

SIM numbers the *EA* record data sets in sequential order (1, 2, 3, ...), with no limit on the maximum allowable number of *EA* records. The optional *NEA* in field 2 must conform to this numbering system; otherwise, an error message is activated. The *EA* record *NEA* integer identifiers connect to and must match the *IEAR* in field 14 of the *WS* record of the component reservoirs.

The storage volume versus surface area relationship provided on *SV/SA* records must be input for the first component reservoir listed on the *EA* record but do not have to be repeated for the other reservoirs. *WS* record field 15 flags the reuse of the SV/SA records entered for the first reservoir listed on the *EA* record. The component reservoirs will normally share the same storage-area relationship, but separate and different relationships may be entered for each reservoir. If storage-area relationships are provided by coefficients entered in *WS* record fields 4-6, the coefficients must be entered for each reservoir.

EF Record – Net Evaporation-Precipitation Allocation Factors

field	columns	variable	format	value	description
1	1-2	CD	A2	EF	Record identifier
2	3-8	EAO(NEA)	I6	blank,0,1 2	Limit applies to storage of any individual reservoir. Limit applies to sum of storage in all reservoirs.
3	9-16	EAL(NEA)	F8.0	blank,0.0 +	Default = 0.010 Fractional (0.0 to 1.0) limit on storage.
4-23	17-176	EAF(NEA,I)	20F8.0	+	Factors for NEAF (*EA* field 3) option 3. I = 1, 20

An *EF* record must follow directly behind a *EA* record if and only if allocation method option 3 is selected in field 3 of the *EA* record. Each factor on the *EF* record corresponds to a reservoir on the *EA* record. The monthly net evaporation-precipitation volume allocated to a component reservoir is computed by multiplying the total monthly net evaporation-precipitation volume by a fraction determined based on the factors. The *EAF(NEA,I)* factors entered on the *EF* record may be any set of numbers. Program *SIM* converts the factors to fractions summing to 1.00 by dividing each factor by the sum of all the factors.

The *EAL(NEA)* limit of *EF* record field 3 defines a beginning-of-period storage limit below which the *EAF(NEA,I)* factors are no longer applied. The storage limit is computed as the storage capacity (*WS* record field 3) multiplied by *EAF(NEA,I)* defined by *EF* record field 3. The *EAO(NEA)* option of field 2 specifies whether the limit is associated with the beginning-of-period storage of each individual reservoir or the total sum of the beginning-of-period storage of all the component reservoirs. With *EAO(NEA)* = 1, application of the factors is curtailed any time the beginning-of-month storage of any reservoir falls below the *EAL(NEA)* limit. With *EAO(NEA)* = 2, the factors are no longer used if the total sum of the beginning-of-month storage in all reservoirs falls below the *EAL* limit. With either *EAO* option, whenever storage falls below the limit, the algorithm switches to allocating net evaporation based on beginning-of-month storage content, which is equivalent to *NEAF(NEA)* option 2.

The evaporation allocation algorithms include provisions for the situation in which the beginning-of-month storage is zero in all reservoirs. *With NEAF(NEA)* option 2 specified in *EA* record field 3, with zero beginning-of-month storage, net evaporation is allocated equally between all reservoirs. With option 3, with zero beginning-of-month storage, net evaporation is allocated between all reservoirs in proportion to the *EF* record *EAF* factors. With either options 2 or 3, evaporation volumes may be underestimated if an individual reservoir has insufficient refilling during the month to cover its allocated share of the total evaporation. *NEAF(NEA)* option 1 needs no special provision for dealing with zero beginning-of-month storage.

Alternative Formats for IN and EV Records

Sequences of monthly naturalized streamflow volumes are entered on inflow *IN* records. Sequences of monthly net evaporation-precipitation depths are entered on evaporation *EV* records. The *IN* and *EV* records are organized by year and control point. The ordering of control points must be consistent for all of the years of *IN* records and *EV* records but is otherwise arbitrary. The years must be in chronological order starting with the earliest year and ending with the last.

Field 3 of the *IN* and *EV* records contains the variable *NYR* (first year) which signals the program to repeat the 12 monthly values on the record from the year *NYR* (field 3) through the year *PYR* (field 4). If field 3 is blank or zero, the *IN* or *EV* record represents only one year. If records are not repeated for multiple years, field 4 (*PYR*) may also be left blank after the first year since the records must be in chronological sequence. An error check confirms that any years entered are in the correct chronological sequence, but zeros (blanks) are ignored.

The standard default set of input files include a FLO (or INF) file for storing *IN* records and a EVA file for storing *IN* records. The *IN and EV* records may also be stored at the end of the DAT file following the *ED* record. Optionally, *SIM* will also read *EV* and *IN* records in an old format adopted in *WRAP2* and *WRAP3* (*SIM* predecessors) stored in a HYD file. The default record format and file organization are described first followed by a description of the old approach still maintained as an option. There are two record grouping options for storing the *IN* and *EV* records in FLO and EVA files or the DAT file. The alternative groupings are by year and by control point.

The variable *INEV* in *JO* record field 2 specifies the manner in which the *IN* and *EV* records are organized. Options 2 and 4 require much more active computer memory than Options 1, 3, and 5 but may be more convenient. A *SIM* simulation is performed chronological by year. The input files are read sequentially. With Options 1, 3, and 5, SIM reads the *IN* and *EV* records for only one year in an iterative annual loop. With Options 2 and 4, all of the *IN* and *EV* records are read at the beginning of the simulation, requiring much more memory.

WRAP-HYD Option for Changing IN/EV Record Grouping

WRAP-SIM JO record field 2 *INEV* options 1, 3, and 5 require that records be grouped by year. A group of records for all control points for the year 1941 will follow a similar set of records for all control points for the year 1940. Typically, developing a complete time series of *IN* and/or *EV* records covering the entire period-of-analysis for each individual control point is more convenient. Options 2 and 4 allow this more convenient format but require much more computer memory. The program *WRAP-HYD* includes an option for converting a file with records grouped by control points into a file of records grouped by year which may be input to *WRAP-SIM* in the format of Options 1 or 3.

At least one *IN* record is required to execute *WRAP-SIM*. However, *EV* records are not required. An entry of −1 or −2 for the *JO* record field 2 INEV switch activates a FLO file without a corresponding EVA file.

Alternative Formats for IN and EV Records (Continued)

The options are as follows.

Option 1: INEV = 0 or 1 in JO record Field 2

With the default format, the *IN* and *EV* records are stored in separate files, with filenames root.FLO and root.EVA, respectively. The records are in the format shown on the next page. In the FLO and EVA files, the records for all control points are grouped together by year. All the records for a year are followed by a complete set of records for the next year. A *JO* record field 2 entry of −1 is used to activate a *FLO* file without an EVA file if there are no *EV* records.

Option 2: INEV = 2 in JO record Field 2

Option 2 is identical to option 1 except the *IN* and *EV* records are grouped by control point. All records for all years for the first control are grouped together before the records for the second control point. A *JO* record field 2 entry of −2 is used to activate a *FLO* file without an EVA file if there are no *EV* records.

Option 3: INEV = 3 in JO record Field 2

Option 3 is identical to Option 1 except the records are stored at the end of the DAT file following the *ED* record. The set of all *IN* records for a particular year is followed by the set of all *EV* records for that year.

Option 4: INEV = 4 in JO record Field 2

Option 4 is identical to Option 2 except the records are stored at the end of the DAT following the *ED* record. The set of all *IN* records is entered first followed by the set of all *EV* records.

Option 5: INEV = 5 in JO record Field 2

The *IN* and *EV* records are stored in a single hydrology file, with the filenames root.HYD. Pairs of records with six months on each are in the format shown on the page after the next page. In the HYD file, the records for all control points are grouped together by year. All the records for a year are followed by a complete set of records for the next year.

IN and EV Records in the Standard Default Format

IN Record – Inflows, Naturalized Streamflows at a Control Point

field	columns	variable	format	value	description
1	1-2	CD	A2	IN	Record identifier
2	3-8	ID	A6	AN	Control point identifier
3	9-12	NYR	I4	+	First year for an *IN* record repeated for multiple years
				blank,0	*IN* record is for one year only; it is not repeated
4	13-16	PYR	I4	+	Year (last year to repeat if field 3 is not zero or blank)
5	17-24	INFLOW(cp,1)	F8.0	+	Naturalized streamflow for Month 1
6	25-32	INFLOW(cp,2)	F8.0	+	Naturalized streamflow for Month 2
7	33-40	INFLOW(cp,3)	F8.0	+	Naturalized streamflow for Month 3
8	41-48	INFLOW(cp,1)	F8.0	+	Naturalized streamflow for Month 4
9	49-56	INFLOW(cp,5)	F8.0	+	Naturalized streamflow for Month 5
10	57-64	INFLOW(cp,6)	F8.0	+	Naturalized streamflow for Month 6
11	65-72	INFLOW(cp,7)	F8.0	+	Naturalized streamflow for Month 7
12	73-80	INFLOW(cp,8)	F8.0	+	Naturalized streamflow for Month 8
13	81-88	INFLOW(cp,9)	F8.0	+	Naturalized streamflow for Month 9
14	89-96	INFLOW(10)	F8.0	+	Naturalized streamflow for Month 10
15	97-104	INFLOW(11)	F8.0	+	Naturalized streamflow for Month 11
16	105-112	INFLOW(12)	F8.0	+	Naturalized streamflow for Month 12

EV Record – Net Reservoir Evaporation-Precipitation Rates for a Control Point

field	columns	variable	format	value	description
1	1-2	CD	A2	IN	Record identifier
2	3-8	ID	A6	AN	Control point identifier
3	9-12	NYR	I4	+	First year for an *EV* repeated for multiple years
				blank,0	*EV* record is for one year only; it is not repeated
4	13-16	PYR	I4	+	Year (last year to repeat if field 3 is not zero or blank)
5	17-24	EVAPR(cp,1)	F8.0	+	Net evaporation-precipitation for Month 1
6	25-32	EVAPR(cp,2)	F8.0	+	Net evaporation-precipitation for Month 2
7	33-40	EVAPR(cp,3)	F8.0	+	Net evaporation-precipitation for Month 3
8	41-48	EVAPR(cp,1)	F8.0	+	Net evaporation-precipitation for Month 4
9	49-56	EVAPR(cp,5)	F8.0	+	Net evaporation-precipitation for Month 5
10	57-64	EVAPR(cp,6)	F8.0	+	Net evaporation-precipitation for Month 6
11	65-72	EVAPR(cp,7)	F8.0	+	Net evaporation-precipitation for Month 7
12	73-80	EVAPR(cp,8)	F8.0	+	Net evaporation-precipitation for Month 8
13	81-88	EVAPR(cp,9)	F8.0	+	Net evaporation-precipitation for Month 9
14	89-96	EVAPR(10)	F8.0	+	Net evaporation-precipitation for Month 10
15	97-104	EVAPR(11)	F8.0	+	Net evaporation-precipitation for Month 11
16	105-112	EVAPR(12)	F8.0	+	Net evaporation-precipitation for Month 12

IN and EV Records in HYD File Format

In the old *WRAP2/WRAP3* format, now specified as Option 5 in *JO* record field 5, the records are stored in a HYD file (filename root.HYD). *IN* records for all control points for a year are followed by a corresponding set of *EV* records for all control points for the year. *IN/EV* records for all control points are grouped together by year. All the records for a year are followed by a complete set of records for the next year.

First IN Record for Each Year – Inflows

field	columns	variable	format	value	description
1	1-2	CD	A2	IN	Record identifier
2	3-8	ID	A6	AN	Control point identifier
3	9-16	PYR	I8	+	Year
4	17-24	Q(1)	F8.0	+	Naturalized streamflow for Month 1
5	25-32	Q(2)	F8.0	+	Naturalized streamflow for Month 2
6	33-40	Q(3)	F8.0	+	Naturalized streamflow for Month 3
7	41-48	Q(4)	F8.0	+	Naturalized streamflow for Month 4
8	49-56	Q(5)	F8.0	+	Naturalized streamflow for Month 5
9	57-64	Q(6)	F8.0	+	Naturalized streamflow for Month 6

Second IN Record for Each Year – Inflows

field	columns	variable	format	value	description
1	1-2	CD	A2	IN	Record identifier
2	3-8		6X		not used
3	9-16		8X		not used
4	17-24	Q(7)	F8.0	+	Naturalized streamflow for Month 7
5	25-32	Q(8)	F8.0	+	Naturalized streamflow for Month 8
6	33-40	Q(9)	F8.0	+	Naturalized streamflow for Month 9
7	41-48	Q(10)	F8.0	+	Naturalized streamflow for Month 10
8	49-56	Q(11)	F8.0	+	Naturalized streamflow for Month 11
9	57-64	Q(12)	F8.0	+	Naturalized streamflow for Month 12

First EV Record for Each Year – Reservoir Evaporation Rates

field	columns	variable	format	value	description
1	1-2	CD	A2	EV	Record identifier
2	3-8	ID	A6	AN	Control point identifier
3	9-16	PYR	I8	+	Year
4	17-24	EV(1)	F8.0	+	Reservoir evaporation rate for Month 1
5	25-32	EV(2)	F8.0	+	Reservoir evaporation rate for Month 2
6	33-40	EV(3)	F8.0	+	Reservoir evaporation rate for Month 3
7	41-48	EV(4)	F8.0	+	Reservoir evaporation rate for Month 4
8	49-56	EV(5)	F8.0	+	Reservoir evaporation rate for Month 5
9	57-64	EV(6)	F8.0	+	Reservoir evaporation rate for Month 6

Second EV Record for Each Year – Same format as indicated above.

FD Record – Flow Distribution

field	columns	variable	format	value	description
1	1-2	CD	A2	FD	Record identifier
2	3-8	ID	A6	AN	Control point identifier for ungaged CP
3	11-16	DSG	2x,A6	AN	Source gaged control point
4	17-24	NG	I8	+	Number of gaged cp's above ungaged site (blank = 0)
				–1	Ungaged CP is downstream of source CP
5-19	25-144	UGID(I)	30(2x,A6)	AN	Identifiers of upstream gaged control points [I=1,MAXGAG; *DL* record default = 15)]

FC Record – Coefficients for Flow Distribution Equation

field	columns	Variable	format	value	description
1	1-2	CD	A2	FC	Record identifier
2	3-8	COEF1	F6.0	+	Coefficient *a* (may be drainage area ratio)
3	9-16	COEF2	F8.0	+ or –	Coefficient *b* (default = 1.0)
4	17-24	COEF3	F8.0	+ or –	Coefficient *c* (default = 0.0)
					$Q_{ungaged} = a\, Q_{gaged}^{\ b} + c$

WP Record – Watershed Parameters

field	column	Variable	format	value	description
1	1-2	CD	A2	WP	Record identifier
2	3-8	ID	A6	AN	Control point identifier
3	9-16	DA	F8.0	+	Drainage area
4	17-24	CN	F8.0	+	Curve number
5	25-32	MP	F8.0	+	Mean precipitation
6	33-40	DAF	F8.0	+	Multiplier to convert drainage area to square miles

A *FD* record is required for each ungaged control point for which flows are synthesized. *FD* records are also required if pertinent options are specified (*JD* field 10 and *CP* field 9) for computing adjustments to evaporation-precipitation depths. Flows are transferred from the source control point (*FD* field 3) to the ungaged location (*FD* field 2). Either field 2 or 3 control points may be used for adjusting evap-precip depths. Upstream control points (*FD* fields 5-19) define incremental watersheds for either application.

A *FC* record follows the *FD* record if the flow distribution method option 3 (field 6 of *CP* record) is applied for this control point requiring coefficients for the equation:

$$Q_{ungaged} = a\, Q_{gaged}^{\ b} + c$$

A *WP* record is provided for each gaged and ungaged control point involved in applying flow distribution methods 4-8 specified in *CP* record field 6. The unit conversion multiplier *DAF* in field 6 applies to this and all subsequent *WP* records until a new *DAF* is entered on another *WP* record. The default *DAF* is 1.0.

A *FC* record must follow directly behind its *FD* record. Otherwise, the *FD/FC* and *WP* records may be in any order in the DIS file. The records are stored in a DIS file that ends with an *ED* record. The end-of-file *ED* record is required.

FA Record – Flow Adjustments

field	columns	variable	format	value	description
1	1-2	CD	A2	FA	Record identifier (optional)
2	3-8	ID	A6	AN	Control point identifier (optional)
	9-12	-	4x	-	not read
3	13-16	PYR	I4	+	Year (optional)
4	17-24	FA(1)	F8.0	+	Streamflow adjustment for month 1
5	25-32	FA(2)	F8.0	+	Streamflow adjustment for month 2
6	33-40	FA(3)	F8.0	+	Streamflow adjustment for month 3
7	41-48	FA(4)	F8.0	+	Streamflow adjustment for month 4
8	49-56	FA(5)	F8.0	+	Streamflow adjustment for month 5
9	57-64	FA(6)	F8.0	+	Streamflow adjustment for month 6
10	65-72	FA(7)	F8.0	+	Streamflow adjustment for month 7
11	73-80	FA(8)	F8.0	+	Streamflow adjustment for month 8
12	81-88	FA(9)	F8.0	+	Streamflow adjustment for month 9
13	89-96	FA(10)	F8.0	+	Streamflow adjustment for month 10
14	97-104	FA(11)	F8.0	+	Streamflow adjustment for month 11
15	105-112	FA(12)	F8.0	+	Streamflow adjustment for month 12

Adjustments to the naturalized flows are entered on *FA* records stored in a flow adjustment file (filename root.FAD).

CHAPTER 4
PROGRAM TABLES

The program *TABLES* reads *SIM*, *SIMD*, and *SALT* input and output files, performs various computations, and develops an assortment of tables, which are written to an output file. The simulation model output files are designed for storing large quantities of data in a concise format. *TABLES* provides flexible capabilities for computing reliability and frequency relationships and organizing, summarizing, and displaying simulation results as a set of user specified tables. These tables may be viewed directly in the text file created by *TABLES* or transported to a spreadsheet or word processor program for graphics or report preparation. *TABLES* also converts simulation results to HEC-DSS files to be read by *HEC-DSSVue* for plotting or other purposes.

Input and Output Files

An execution of *TABLES* begins with an interactive routine in which filename roots are assigned, typically through the *WinWRAP* interface. Filenames are in the format *root.ext* with a user-specified *root* and a standard extension *ext* denoting the type of file. All of the files may have the same filename root. Optionally, the TIN and TAB files may have roots that are different than the root for the other files. File types are listed in Table 4.1.

Table 4.1
TABLES Input and Output File Types

	TABLES Input Files Pertinent to this Manual
root3.TIN	required ***T****ABLES* ***in***put file with specifications regarding tables to be developed
root1.DAT	*SIM/SIMD* input DAT file
root1.OUT	*SIM/SIMD* output OUT file
root1.HRR	*SIM/SIMD* output HRR file
root2.DIS	*SIM/SIMD* input DIS file
	TABLES Output Files Pertinent to this Manual
root4.TAB	***TAB****LES* output file with the tables developed by the various routines
root4.TMS	***T****ABLES* ***m******es***sage file
root1.DSS	HEC-***DSS*** file created by *TABLES*
root1.DSC	***c***atalog listing the pathnames of the records stored in a DSS file
	Additional *TABLES* Input Files Addressed in the Supplemental Manual
root1.SAL	salinity simulation results file produced by program *SALT*
root1.FFA	*SIMD* ***f***lood ***f***requency ***a***nalysis output file with annual series of peak flow and storage
root1.CRM	*SIM/SIMD* ***c***onditional ***r***eliability ***m***odeling output file
root1.SFF	***s***torage-***f***low-***f***requency file created by *TABLES 2CR1* record and read by *2CR2* record in conjunction with the SFF conditional reliability option

The *TABLES* input TIN file specifies the tables and/or other types of information to be developed and stored in the *TABLES* output TAB file. The data from which the tables and data listings are compiled are read from *SIM* input and/or output files. Most applications involve *TABLES* reading simulation results from a *SIM* OUT file. However, various *TABLES* options activated by the records in the TIN file may involve reading data from other *SIM* files as well.

Program Organization

The Fortran program *TABLES* consists of a main program and a number of subroutines. The main program opens files, checks the identifier on each record of the TIN file, and calls the appropriate subroutines. The *SIM* input and output files are read and the specified tables and data listings are developed and written to the *TABLES* output file by the subroutines. Each subroutine is associated with specific types of tables or data listings and is activated by one or more types of input records read from the TIN file. The types of *TABLES* input records included in a TIN file are listed in Table 4.2 with the four-character identifiers that are placed at the beginning of each record. Headings for the tables created by several of these records are shown as Tables 4.3 through 4.8. Examples in the *Reference Manual* and *Fundamentals Manual* illustrate the format and content of various types of tables.

Some of the *TABLES* input records activate subroutines that simply rearrange and tabulate, with appropriate table headings, selected data read from *SIM* input or output files. The subroutines also include various computational algorithms. In some cases, summing or other simple arithmetic combining of data are involved. Other subroutines include more complex arithmetic operations. For example, a 1SRT record calls a subroutine containing a water rights sorting algorithm. A 2REL record activates the computation of period and volume reliabilities. A 2FRE record develops frequency statistics for naturalized, unregulated, or unappropriated streamflow, reservoir storage, or instream flow shortages. A 2REL record activates a subroutine that converts reservoir storage from volume units to percentages of storage capacity and also develop drawdown-frequency and storage-reliability tables.

Table 4.2
Input Records and Associated Tables

Miscellaneous Records

TITL – titles or headings	UNIT – units for table headings
COMM or **** – comments	TEST – checks of *SIM* output file
PAGE – title page	ENDF – end of input data file

Type 1 Records - Develop Tables from *SIM* Input File

1REC – listing of specified input records
1SUM – water rights summary by control point or type of use
1SRT – listing of water rights sorted by priority, type of use, control point, or water right type
1CPT – listing of control point information in upstream-to-downstream order

Table 4.2 (Continued)
Input Records and Associated Tables

Type 2 Records - Develop Tables from *SIM* Output File

Time Series Tables in Optional Formats or HEC-DSS File

2NAT – naturalized stream flow
2REG – regulated stream flow
2UNA – unappropriated stream flow
2CLO – channel loss
2CLC – channel loss credits
2RFR – return flow entering at this control point
2URR – regulated flow this control point from upstream reservoir releases
2STO – reservoir storage
2EVA – reservoir evaporation-precipitation volume
2EPD – reservoir evaporation-precipitation depth
2DEP – stream flow depletion
2TAR – diversion target
2SHT – diversion shortage
2DIV – diversion
2RFL – return flow
2ASF – available stream flow
2ROR – releases from other reservoirs
2IFT – instream flow target
2IFS – instream flow shortage
2HPS – hydropower shortage or secondary energy
2HPE – energy generated
2RID – inflows to reservoir from stream flow depletions
2RIR – inflows to reservoir from releases from other reservoirs
2RAH – releases accessible to hydropower
2RNA – releases not accessible to hydropower

Reliability and Frequency Tables

2REL – reliability summary by control point, water right, water right group, or reservoir
2RET – composite volume reliability supplement to 2REL summary table
2FRE – frequency table for stream flow, storage, or instream flow shortage
2FRQ – frequencies for specified stream flow, storage, or instream flow shortage
2RES – reservoir percentage of storage capacity, draw-down duration, and storage reliability

Summary Tables

2SCP – monthly or annual summary table for a control point
2SWR – monthly or annual summary table for a water right
2SRE – monthly or annual summary table for a reservoir
2SGP – monthly or annual summary table for a water right group
2SBA – monthly or annual summary table for the entire river basin

Table 4.2 (Continued)
Input Records and Associated Tables

Type 3 Records - Develop Streamflow Records from *SIM* Output File

3REG – records of regulated streamflows
3NAT – records of naturalized streamflows
3UNA – records of unappropriated streamflows
3DEP – records of stream flow depletions
3U+D – records of unappropriated flows plus stream flow depletions
3EPD – records of reservoir evaporation-precipitation depth

Type 4 Records - Develop Tables from *SIM* System Release/Hydropower File

4SWR – system reservoir releases for selected water rights
4SGP – system reservoir releases for selected water right groups

Table 4.3
Headings for Water Rights Summary Specified by 1SUM Record
(Heading for first column may be either use, control point, water right type, or group.)

USE	NUMBER OF RIGHTS	PERMITTED DIVERSIONS (AC-FT/YR)	NUMBER OF RESERVOIRS	RESERVOIR STORAGE (AC-FT)	PRIORITIES RANGE FROM	TO

Table 4.4
Annual Rows with Monthly Columns Format Headings for Tables Specified by Time Series Records such as the 2NAT, 2REG, 2UNA, 2DEP, 2DIV, 2SHT, 2IFS, 2CLO, 2CLC, 2STO, and Other Similar Records

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

Table 4.5
Headings for Reliability Summary Specified by 2REL Record

NAME	PERMITTED DIVERSION (AC-FT/YR)	MEAN SHORTAGE (AC-FT/YR)	RELIABLITY PERIOD (%)	RELIABLITY VOLUME (%)	PERCENTAGE OF MONTHS WITH DIVERSIONS EXCEEDING PERCENTAGE OF PERMITTED DIVERSION 0%	5%	10%	25%	50%	75%	100%	PERCENTAGE OF YEARS 0%	2%	5%	10%	25%	50%	100%

Table 4.6
Headings for Frequency Tables Specified by 2FRE Record

CONTROL POINT	MEAN	STANDARD DEVIATION	PERCENTAGE OF MONTHS WITH FLOWS EQUALING OR EXCEEDING VALUES SHOWN 100%	99%	98%	95%	90%	75%	60%	50%	40%	25%	10%	MAXIMUM

Table 4.7
Headings for Annual Summary Specified by 2SCP and 2SBA Records
(Headings are similar for 2SWR, 2SRE, and 2SGP records.)

YEAR	NATURALIZED STREAMFLOW (AC-FT)	RETURN FLOW (AC-FT)	FLOW DEPLETION (AC-FT)	UNAPPROPRIATED FLOW (AC-FT)	EOP STORAGE (AC-FT)	EVAP (AC-FT)	REGULATED STREAMFLOW (AC-FT)	ACTUAL DIVERSION (AC-FT)	DIVERSION SHORTAGE (AC-FT)

Table 4.8
Headings for Monthly Summary Specified by 2SWR Record
(Headings are similar for 2SCP, 2SBA, 2SRE, and 2SGP records.)

YEAR	MONTH	AVAILABLE STREAMFLOW (AC-FT)	STREAMFLOW DEPLETION (AC-FT)	EOP STORAGE (AC-FT)	EVAP (AC-FT)	SYSTEM RELEASES (AC-FT)	TARGET DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)

Input Records and Associated Tables

The tables or data sets to be developed are specified by records in an input file with the filename extension TIN. Each type of table is associated with an input record that begins with a four-character record identifier, followed by parameters providing instructions associated with that particular type of table or data listing. All records are optional; there are no required records. No limits are placed on the number or order of the records, with the exception of title TITL records that are limited to a maximum of five records and must be located at the beginning of the input file. Any number of each type of record, except the TITL records, can be placed in any order in the TIN file.

TABLES reads one record of the input file (filename root.TIN); develops the table or multiple tables specified; stores the tables in the output file (filename root.TAB); and then goes on to the next record of the input file. The input records are handled in sequential order. Thus, erroneous *TABLES* TIN file records are easy to locate. If the program terminates prematurely due to input data problems, the erroneous record in the TIN file is located simply by observing the last record read. *TABLES* also writes various error and warning messages to the monitor and/or message file (filename root.TMS) to help in detecting and correcting blunders in the table-specification input file.

Miscellaneous Records

TITL records provide titles or headings to be reproduced on the cover page and at the top of each type 2 or type 3 table. Zero to five TITL records may be used.

COMM records provide a means to insert comments or notes at any location in the input file. COMM records are not read or used in any way by the program.

UNIT records specify unit labels to include in table headings other than the default *AC-FT* for volume and *MW-HR* for hydroelectric energy. The unit headings entered on a UNIT record are adopted for all records following the UNIT record. Without a *UNIT* record, the defaults of *AC-FT*

and *MW-HR* are adopted. In program *TABLES*, the units pertain only to tables headings, not actual computations. *TABLES* computations are manipulations of the *SIM* simulation results performed without reference to units.

The TEST record activates of series of tests of the *SIM* output file that are described in the last section of Chapter 2. The TEST record is designed to be used only in rare instances in which *TABLES* fails to run for unknown reasons that may be attributable to problems in the SIM OUT file.

The ENDF record denotes the end of the input file. Any records following the ENDF record will not be read. Although an ENDF record is not required, a message is printed on the monitor screen, as a reminder, if the input file has no ENDF record. Routinely used records may be conveniently stored behind the ENDF record when not used in particular executions of *TABLES*.

Type 1 Records – Tables are developed from data from a SIM input file.

1REC, 1SUM, 1SRT, and 1CPT records specify listings and tabulations of data which are read from *SIM* input files. The four-character identifiers for type 1 records begin with the numeral one (1REC, 1SUM, 1SRT, 1CPT) signifying that the source of data is a *SIM* input file. All four records create tables from data read from the main *SIM* DAT file. The 1CPT record also includes an option that reads watershed areas from a flow distribution DIS file.

Inclusion of a 1REC record in a *TABLES* input file results in a listing of specified *SIM* input records. The 2-character identifiers of the *SIM* input records to be included, or alternatively to be omitted, in the listing are entered on the 1REC record.

A 1SUM record results in a summary table of water rights data by control point, type of use, water right type, or water right group. This table includes number of rights, diversion amounts, number of reservoirs, storage capacity, and range of priorities. The heading for a 1SUM record by type of use is shown as Table 4.3. The types of water use listed in the first column may be replaced with control points, water right types, or water right groups.

A 1SRT record creates a listing of water rights sorted in priority order or a listing sorted by type of use, control point, water right type, or water right group in priority order.

The *1CPT* record activates a set of routines that reorder control points in upstream-to-downstream order and list information read from the *CP* records. Two alternative definitions of *upstream-to-downstream order* may be selected. With one option, the sequencing is based on each control point being listed earlier than any other control point located downstream of it. With the other option, a first sequence goes from a most-upstream control point to the basin outlet, and each subsequent sequence extending from a most-upstream control point to a previously ordered stream. With either option, most-upstream control points are selected in the order they are found in the original *CP* records in the *SIM* input file.

The *1CPT* record provides several options for writing information to the *TABLES* output file. One option is to reproduce the *CP* records in upstream-to-downstream order. The *CP* records created by *TABLES* are identical to those read from the *SIM* input file except their order

is changed to upstream-to-downstream. Various sets of information from the CP records may be listed. Watershed area read from *WP* records in the DIS file may also be included. The sets of information listed in upstream-to-downstream order may include the following:

- control point identifier (*CP* record field 2)
- identifier of next downstream control point (*CP* record field 3)
- number of control points located immediately upstream
- identifiers of upstream control points (L=1,NUP(cp))
- method for obtaining naturalized flows (*CP* record field 6)
- drainage area (*WP* record field 3)
- channel loss factor (*CP* record field 9)

Type 2 Records – Tables are developed from data from a SIM output file.

Type 2 records result in tables being developed from the SIM simulation results contained in the water right, control point, and reservoir/hydropower records of a *SIM* OUT file as listed in Tables 2.3, 2.4, and 2.5. A *SIM* water right output record contains data for an individual water right. A control point record contains data summed for all the water rights located at the control point or data, such as regulated or unappropriated flows, not associated with a particular water right. A reservoir/hydropower record contains data for a reservoir including hydroelectric energy generation data if a power plant is located at the reservoir. Reservoir data are also included on the control point and water right output records.

The *SIM* simulation results listed in Tables 2.3, 2.4, and 2.5 are tabulated as a standard set of time series tables by 2NAT, 2REG, 2UNA, 2CLO, 2CLC, 2RFR, 2URR, 2STO, 2EVA, 2DEP, 2DIV, 2TAR, 2SHT, 2RFL, 2ASF, 2ROR, 2IFT, 2IFS, 2HPS, 2HPE, 2RID, 2RAH, 2RNA, and 2EPD records. These *TABLES* input records all have the same format. The time series tables created by these records also all have the same format regardless of variable. The time series are converted by *TABLES* to three optional formats: (1) tables with annual rows and monthly columns with headings shown in Table 4.4, (2) a tabulation in a columnar format designed for transporting the data to spreadsheet programs such as Microsoft Excel, and (3) records in a HEC-DSS file.

A 2REL record creates a table of volume and period reliabilities including the percentage of time that certain percentages of demand are met. A 2REL summary may be developed for either selected water rights, water right groups, control points, or hydroelectric power reservoirs. Three separate 2REL records would be used to obtain three separate reliability summary tables for selected water rights, control points, and hydroelectric power reservoirs, respectively. Volume reliability is the total volume of shortages (or total energy shortage) divided by the corresponding total target diversion volume (or target firm energy production). Period reliability is the number of months for which shortages occurred divided by the total number of months in the simulation. The table expresses period reliabilities in terms of the percentage of the months and the percentage of the years during the simulation for which the water right diversion or hydroelectric energy generated equaled or exceeded specified percentages of the diversion or hydroelectric energy target. The format of this table is illustrated by Table 4.5. Fixed percentages of target amounts are tabulated in the heading, and the computed exceedance frequencies are shown on each row of the table. Reliability indices are defined in Chapter 2 of the *Reference Manual*.

The 2FRE record determines the mean, standard deviation, and frequency relationship for naturalized flows, regulated flows, unappropriated flows, or reservoir storage associated with a specified control point or the reservoir storage or instream flow shortage associated with a specified water right. The flow or storage amount is computed and tabulated for each of the exceedance frequencies shown in Table 4.6. The frequencies are defined as the percentage of the months in the simulation for which the flow or storage equaled or exceeded the amount shown in the table. For a specified frequency (90% for example), if a particular flow value in the simulation results is equaled or exceeded exactly that percentage of the time, that value is selected. Otherwise, linear interpolation is applied to the two flow values bracketing the specified frequency.

The 2FRQ record also develops a frequency relationship for naturalized flows, regulated flows, unappropriated flows, or reservoir storage associated with a specified control point or the reservoir storage or instream flow shortage associated with a specified water right. The frequencies associated with up to seven user-specified flow or storage values are computed.

The 2FRQ and 2FRE records both provide frequency relationships for the same variables but differ as follows. The 2FRE record determines flows for the set frequencies shown in Table 4.6. Conversely, the 2FRQ record determines frequencies for flows specified by the user as input on the 2FRQ record. Whereas, a single 2FRE table may include rows of information for multiple control points or water rights, each 2FRQ table is limited to a single specified control point or water right. Of course, any number of 2FRQ records may be included in the input file. Examples of tables created with 2FREQ and 2FRQ records may be found in the *Reference Manual* and *Fundamentals Manual*. Frequency analysis methods are discussed in Chapter 2 of the *Reference Manual*.

The 2RES record builds three tables for specified reservoirs: (1) tabulations of end-of-period reservoir storage as a percentage of a user-specified storage capacity, (2) draw-down duration summary, and (3) storage reliability summary. Sets of 2PER records are used to specify the reservoirs to be included in the tabulation and, for each reservoir, the storage capacities C_1 and C_2 at the top and bottom, respectively, of the conservation pool or zone. The end-of-period storages S are read from the reservoir/hydropower record of the *SIM* output file. Percentage storage content tabulations are particularly useful for reviewing simulation results for multiple-reservoir system operations. The storage content as a percentage of capacity is computed as follows:

$$\text{storage as percentage of capacity} = \left(\frac{S - C_2}{C_1 - C_2} \right) 100\%$$

The 2RES draw-down duration table is developed in terms of the number of months for which the storage draw-down equaled or exceeded specified percentages of storage capacity of the defined zone. The storage reliability table expresses the percentage of months in which end-of-month storage contents equaled or exceed tabulated percentages of storage capacity of the defined zone.

2SCP, 2SWR, 2SGP, and 2SRE records result in water budget summary tables for specified control points, water rights, water right groups, or reservoirs, respectively. These tables consist of either a monthly or annual tabulation of the data items contained on the *SIM* control point, water right, or reservoir/hydropower output records. The heading for an annual summary table created by a 2SCP record is shown as Table 4.7. Each row of data in the table corresponds to a year in the hydrologic period-of-analysis. A monthly table has an additional column for the month and 12

times as many rows as an annual table. Each row of data is for a particular month. The headings for a monthly water right summary table associated with a 2SWR record are shown in Table 4.7.

A 2SGP record results in a summation of certain data on the *SIM* water right output records of multiple rights with the same group identifier in fields 12 or 13 of the *WR* input records. This water right group summary table has the summation of the streamflow depletions, diversions, and diversion shortages associated with all water rights with the specified group identifier.

A 2SBA record results in a basin summary table, with the same headings and data as the 2SCP record shown in Table 4.7. The naturalized, regulated, and unappropriated streamflows in the 2SBA table are the maximum of the values found at any of the control points. The other tabulated data are the summation of values for all of the control points.

Type 3 Records − Streamflow records are developed from data from a SIM output file.

Type 3 records instruct *TABLES* to read naturalized flows, regulated flows, unappropriated flows, and/or streamflow depletions from a *SIM* output file and convert these data to records in the format of *SIM IN* or *TS* records. The resulting streamflows written to the *TABLES* output file are in the same format as *IN* or *TS* records except the model user selects any two-character identifier for the first two characters of each record, which could be *IN*, *TS*, blanks, or any other two characters. Records are developed for all control points included in the *SIM* output file. The records created by *TABLES* may contain either of the following:

- naturalized streamflows (3NAT record)
- regulated streamflows (3REG record)
- unappropriated streamflows (3UNA record)
- streamflow depletions (3DEP record)
- summation of streamflow depletions plus unappropriated flows (3U+D record)
- evaporation-precipitation depths from reservoir output records (3EPD record)

Each record created by *TABLES* contains a user-specified two-character record identifier (such as *TS* or *IN*), control point identifier, year, and 12 monthly streamflow values for the specified year and location. Options allow the records, for multiple years and locations, to be grouped either by control point or by year. With the first option, all the *IN* records for all years are grouped together for a given control point followed by a set of *IN* records for all years for the next control point, and so forth. With the other optional format, the *IN* records for all control points are grouped together for a given year are followed by a group of all control points for the next year. Inputted multiplier factors can be used for converting units or otherwise scaling the streamflows.

A 3NAT record creates streamflow records in the format of *SIM* input *IN* or *TS* records containing the naturalized streamflows read from the *SIM* output file for all control points. 2REG, 3UNA and 3DEP records are identical to the 3NAT record except regulated flows (3REG record), unappropriated flows (3UNA record), or the total streamflow depletions at each control point (3DEP record) are written on the records instead of naturalized streamflows (3NAT). A 3U+D record is the same as the others except the summation of unappropriated flows and streamflow depletions is computed and written to the output records. A 3U+D record must be used with caution because it combines unappropriated flows which are relevant to a particular control point with

streamflow depletions which affect flows at all downstream control points as well as the control point at which the depletions occur. The 2EPD record requires *SIM* reservoir output records.

Type 3 records facilitate use of adjusted streamflows from *SIM* simulation results as input to either *SIM* or another model. For example, regulated streamflows computed by *SIM* for a particular water management strategy may be treated as *TS* record instream flow requirements for other executions of *SIM*. Streamflows from *SIM* may be transported to a water quality model or to another yield analysis model. In studies during the mid-1980's, *WRAP* was combined with the *HEC-5 Simulation of Flood Control and Conservation Systems* model from the USACE Hydrologic Engineering Center. A river basin with several hundred water rights was simulated with *SIM* with the streamflow available to a select few rights being reflected in the resulting streamflow depletions plus unappropriated flows. The streamflow depletions plus unappropriated flows were read as streamflow inflow *IN* records by *HEC-5* to perform further analyses of the select few water rights.

Type 4 Records – Data from SIM Hydropower and Reservoir Release File.

Type 4 records result in tables being developed from the data contained in a *SIM* hydropower and multi-reservoir system release file (filename root.HRR). 4SWR or 4SGP records provide monthly or annual tabulations of system releases from all reservoirs associated with a water right (4SWR record) or group of water rights (4SGP record). Releases tabulated for a primary reservoir include streamflow depletions made to meet the permitted diversion as well as water released or withdrawn from storage.

In the *SIM* HRR output file, reservoir releases each month of the simulation for a given water right is listed as a row, which may contain releases from multiple reservoirs associated with that water right. The 4SWR and 4SGP records create tables with releases from each reservoir listed as columns. The 4SWR record results in a table for a specified water right in which monthly releases from each reservoir for that right are listed in a column. The 4SGP record results in a table for a specified group of water rights in which the total monthly releases for all rights in the group from each reservoir for that group are listed in a column.

JO record field 4 of the *SIM* DAT file specifies whether or not a HRR file is created. Water right identifiers are written to the HRR file by default unless group identifiers are specified in *JO* record field 4 . The same water rights are included in both the OUT and HRR output files. Thus, whichever water rights are selected by SIM options to output to the basic OUT file (filename root.OUT) are also included in the HRR file (filename root.HRR). Unlike the OUT file which is a direct access file, the HRR file is read sequentially. Thus, 4SWR/4SGP tables may require significant computer time searching for water right identifiers in the HRR file.

Format and Content of Input Records

Program *TABLES* reads *SIM* input and output files and builds a set of user-specified tables and data listings which are written to the *TAB* output file. Another *TABLES* input file with the filename root.TIN is required containing the records described by this chapter which specify the tables to be built. The following instructions outline the format and content of each type of record used to define the tables and other information to be developed by program *TABLES*. The

WinWRAP interface program provides a built-in editor for creating and editing *TABLES* input TIN files. The TIN file also may be created with Microsoft WordPad or any other editor.

The first four characters of each record consists of the record identifier. TITL records are placed at the beginning of the file. No more than five TITL records can be used. The ENDF record is the last record read. Any records placed after an ENDF record will not be read. With the exceptions of the TITL and ENDF records, the records can be placed in any order, and any type of record can be used any number of times. All records are optional. There are no required records.

Format of Input Variables Serving as Alphanumeric Identifiers

Several of the records include the optional identifier variable *(IDEN(ID,I),I=1,NUM)*, where only eight values of *IDEN* can be entered on one record. Therefore, if *NUM* is greater than eight, the remaining values of *IDEN* are entered in fields 4-11 of subsequent records immediately following the first record. For *NUM* greater than 8, fields 2 and 3 of the second and subsequent records are not read. Control point and reservoir identifiers may contain a maximum of six characters and are entered in 8-character fields in the format 8(2x,A6). Water right group identifiers may contain a maximum of eight characters and are entered in 8-character fields in the format 8A8. Water right identifiers may contain a maximum of 16 characters and are entered in 16-character fields in the format 8A16. A read feature automatically deletes the trailing blanks for water right identifiers and most other alphanumeric identifiers. Thus, right or left justification is not required, though the identifiers must be contained within their appropriate fields.

Alternative Fixed Field Width and Comma Delimited Formats

This *Users Manual* presents input format in terms of fixed-width fields. The *WinWRAP* built-in TIN file editor creates records in the standard fixed-width field format. For example, an integer with an I4 format is right justified in a 4-character wide field. However, an alternative option applicable to numeric data allows use of a comma to shorten a field. A comma may be used to shorten the width of a field, but the number of characters in a field can not exceed the width specified in this manual. The 2STO record in Table 2.7 of Example 2 from Chapter 2 of the *Reference Manual* is reproduced below in the standard fixed-field-width format.

(A4,I4,I4,I4,I4,I4,A8)

```
2STO   1   1   1   0   1     CP1
```

Alternatively, this record could be written in comma-delineated format as follows.

```
2STO1,1,1,0,1,     CP1
```

Both fixed-width and comma-delineated data may be combined in the same record as illustrated below.

```
2STO   1   1 1,   0 1,     CP1
```

A comma ends the field being truncated. Commas are used only to shorten the field widths of numeric data in integer (I) or real number (F) formats. Alphanumeric data for character (A format) variables and spacers (X format) must abide by the fixed field width format.

Table 4.9
Quick Reference Chart for Selected TABLES Records

					columns						
4	8	12	16	20	24	28	32	36	40	44	page
TITL											105
COMM											105
PAGE											105
UNIT											106
ENDF											105

Job Type 1 Records – Tables from SIM Input File Data

1REC	KK	NUM	REC	REC	REC	REC	REC	REC	REC	REC	107
1SUM	KK										107
1SRT	KK										107

Job Type 2 Records – Tables from SIM Output File Data

2REL	TFLAG	RFLAG	ID	MONTH	NUM		IDEN		IDEN		115
2RET	TAR										115
2FRE	ID	MONTH	NUM		IDEN		IDEN		IDEN		117
2FRQ	ID	MONTH	NM		IDEN		QF(1)		QF(2)		117
2RES	TABLE	MONTH	NUM		IDEN		IDEN		IDEN		118
2SCP	MNAN	NUM		IDEN		IDEN		IDEN		IDEN	120
2SWR	MNAN	NUM				IDEN				IDEN	120
2SGP	MNAN	NUM		IDEN		IDEN		IDEN		IDEN	121
2SRE	MNAN	NUM		IDEN		IDEN		IDEN		IDEN	121
2SBA	MNAN										121
2NAT	TA	PT	NEW	ID	NUM		IDEN		IDEN		121
2REG	TA	PT	NEW	ID	NUM		IDEN		IDEN		121
2UNA	TA	PT	NEW	ID	NUM		IDEN		IDEN		121
2DEP	TA	PT	NEW	ID	NUM				IDEN		121
2TAR	TA	PT	NEW	ID	NUM				IDEN		121
2DIV	TA	PT	NEW	ID	NUM				IDEN		121
2SHT	TA	PT	NEW	ID	NUM				IDEN		121
2RFL	TA	PT	NEW	ID	NUM				IDEN		121
2IFT	TA	PT	NEW	ID	NUM				IDEN		121
2IFS	TA	PT	NEW	ID	NUM				IDEN		121
2CLO	TA	PT	NEW	ID	NUM		IDEN		IDEN		121
2CLC	TA	PT	NEW	ID	NUM		IDEN		IDEN		121
2STO	TA	PT	NEW	ID	NUM		IDEN		IDEN		121

3NAT	CDOUT	HEC	INFAC								122
3REG	CDOUT	HEC	INFAC								122
3UNA	CDOUT	HEC	INFAC								122
3DEP	CDOUT	HEC	INFAC								122
3U+D	CDOUT	HEC	INFAC								122

4SWR	MNAN	NUM		IDEN		IDEN		IDEN		IDEN	123
4SGP	MNAN	NUM	IDEN	IDEN	IDEN	IDEN	IDEN				123
4	8	12	16	20	24	28	32	36	40	44	page

Legend for Format Column of Tables

A4	alphanumeric (AN) label right justified in a field that is 4 characters wide
8A8	up to 8 alphanumeric labels right justified in fields that are 8 characters wide
2x	two blank spaces
F8.0	real number in field of 8 characters (either include decimal or right justify)
I8	integer number right justified in field of 8 characters

TITL Record – Titles or Headings

field	columns	variable	format	value	description
1	1-4	CD	A4	TITL	Record identifier
2	5-78	TITLE	A76	AN	Title or heading

From zero to five TITL records are entered as the first records of the input file. The alphanumeric information provided on the records is printed on the cover page and at the top of each table.

COMM or **** Record – Comments

field	columns	variable	format	value	description
1	1-4	CD	A4	***** or ** or COMM	Record identifier
2	5-no limit			AN	Comments or notes

Any number of comment records can be inserted anyplace in the input file to provide notes or comments. The comment records are not read or used in any way by the program.

PAGE Record – Title Page

field	columns	variable	format	value	description
1	1-4	CD	A4	PAGE	Record identifier - Prints title page

ENDF Record – End of Input File

field	columns	variable	format	value	description
1	1-4	CD	A4	ENDF	Record identifier

Records placed after the ENDF record are not read.

TEST Record – Test of SIM Output File for Problems

field	columns	variable	format	value	description
1	1-4	CD	A4	TEST	Record identifier

The TEST record activates a series of error checks of the *SIM* output file which are described in the last section of Chapter 2. TEST is normally used only if *TABLES* terminates for unknown reasons.

UNIT Record – Information for Table Headings

field	columns	variable	format	value	description
1	1-4	CD	A4	UNIT	Record identifier
2	5-9	UNIT	A5	AN blank	Volume units printed in table headings. Without a *UNIT* record, the default is AC-FT.
3	10-14	UNHP	A5	AN blank	Hydropower units printed in table headings. Without a *UNIT* record, the default is MW-HR.
4	15-19	MONTH1	A5	blank AN	Default is to begin headings with the month JAN. First month in the table headings may be entered as either JAN (default), FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, or DEC.
5	20-24	NEWPAGE	I5	blank,0,+ -1,-	Each table starts a new page. No page breaks.

Several table headings include volume and/or energy units. If a *UNIT* record is not used, the defaults are:

UNIT = AC-FT
UNHP = MW-HR

If a *UNIT* record is included in the data set with blank entries for *UNIT* and/or *UNHP*, their values are blanks. The units entered on the *UNIT* record are printed in the table headings but do not affect the data in the tables. Program *TABLES* organizes and manipulates data from *SIM* input and output files without considering units in its computations.

The listing of months in the table headings is controlled by field 4. If field 4 is left blank, the 12 monthly columns begin with January. The 12-month year may start in any other month as specified by an entry in field 4.

The variable *NEWPAGE* in field 5 is a switch specifying whether or not page breaks are inserted after each table. If *NEWPAGE* is zero (blank field 5) or positive, a page break is placed after each table causing the next table to begin a new page. A negative integer entered in field 5 results in omission of the page breaks.

A *UNIT* record is applicable to all subsequent records in the *TABLES* input data set.

1REC Record – Listing of Specified WRAP Input Records

field	columns	variable	format	value	description
1	1-4	CD	A4	1REC	Record identifier
2	5-8	KK	I4	blank, 0	List specified records
				non-zero	List all records except specified records
3	9-12	NUM	I4	+	Number of record identifiers to follow
4-20	13-80	REC	17A4	AN	Identifiers of specified WRAP input records (REC(I),I=1,NUM)

1SUM Record – Water Rights Summary

field	columns	variable	format	value	description
1	1-4	CD	A4	1SUM	Record identifier
2	8	KK	I4	blank, 0	Summary by control point with only totals printed
				1	Summary by control point
				2	Summary by type of use
				3	Summary by water right type
				4	Summary by groups as defined by GO record

1SRT Record – Listing of Sorted Water Rights

field	columns	variable	format	value	description
1	1-4	CD	A4	1SRT	Record identifier
2	8	KK	I4	blank, 0	Listing of rights in priority order
				1	Listing of rights by control point in priority order
				2	Listing of rights by type-of-use in priority order
				3	Listing of rights by water right type in priority order

1LEN Record – Limiting Record Length to 128 Characters

field	columns	variable	format	value	description
1	1-4	CD	A4	1LEN	Record identifier

Comments are often added to the right of data fields, particularly for *WR* records. The 1LEN routine copies a DAT file to a TAB file with all records limited to 128 characters, removing comments written to the right.

1CPT Record – Upstream-to-Downstream Sequencing of Control Points

field	columns	variable	format	value	description
1	1-4	CD	A4	1CPT	Record identifier
2	8	KK	I4	blank,0	Reproduction of CP records in rearranged order
				1	Listing of only control point identifiers, CPID(cp,1)
				2	Listing of cp and next downstream cp identifiers
				3	Listing of cp and next upstream cp identifiers
				4	Listing of INMETHOD and CL from CP records
				5	Option 4 listing with DA from WP records added
				6	data from options 2-5 combined: CPID(cp,1), INMETHOD, CL, DA, CPID(cp,2), NUP, upstream cps
3	16	OO	I8	blank,0,1	Order based on listing cp before all downstream cp's
				2	Order based on full-length stream tributaries
4	17-24	LIM	I8	-1, -	List only control points with INMETHOD = 0 or 1
				blank,0,+	Include all control points in the output listing
5	25-32	CPLIM	2x,A6	AN	Include only cps located downstream of this cp
				blank	Include all control points

The control points are rearranged in upstream-to-downstream order. For order option (OO) of 1 (blank field 3), the sequencing is based on each control point being listed earlier than any other control point located downstream of it. This is the order required by *WRAP-SALT*. With OO = 2, the first sequence goes from a most-upstream control point to the basin outlet, and each subsequent sequence goes from a most-upstream control point to a previously ordered stream. With either option, most-upstream control points are selected in the order they are found in the original *CP* records in the *WRAP-SIM* input file.

The *LIM* option activated by field 4 allows the listing to be limited to only primary control points defined by *INMETHOD* of 0 or 1 in *CP* record field 6 indicating that naturalized flows are input on *IN* records. Entering a control point identifier in field 5 activates the option of limiting the control points considered to only those located downstream of the *CPLIM* control point.

KK in field 2 specifies the information to be included in the output. For KK=0, the *CP* records are reproduced, with only their order being changed. KK option 6 results in a listing of control points with each line having the following variables listed in the order shown below:

CPID(cp,1)	control point identifier (*CP* record field 2)
INMETHOD	method for obtaining naturalized flows (*CP* record field 6)
CL(cp)	channel loss factor (*CP* record field 9)
DA(cp)	drainage area (*WP* record field 3)
CPID(cp,2)	identifier of next downstream control point (*CP* record field 3)
NUP(cp)	number of control points located immediately upstream
UPID(cp,L)	listing of identifiers of upstream control points (L=1,NUP(cp))

Options 1-5 provide some but not all of the option 6 data listed above. The drainage area is read from *WP* records in the DIS file. The other data are read from *CP* records in the DAT file.

Variables in WRAP-SIM Output File Read by TABLES

Program *TABLES* reads the *SIM* output file that contains the monthly time series variables listed in Tables 2.3, 2.4, and 2.5 of Chapter 2 and reiterated below. The *SIM* output records are for control points (ID=0), water rights (ID=1), or reservoir/hydropower projects (ID=2). Water right groups (ID=3) refer to the summation within *TABLES* of data read for the water rights included in a specified group, as defined by the group identifiers on the *WR* input records that are reproduced in fields 11 and 12 of the output records.

Table 4.10 SIM Output Record Fields Read by TABLES

TABLES Input Record Pages 112-113	Control Point ID = 0 Table 2.3	Water Right ID = 1 Table 2.4	Reservoir/Hydropower ID = 2 Table 2.5	WR Group ID = 3
2NAT	CP field 9			
2REG	CP field 10			
2UNA	CP field 7			
2CLO	CP field 12			
2CLC	CP field 11			
2RFR	CP field 8			
2URR	CP field 13			
2STO	CP field 5	WR/IF field 6	R/H field 5	Applicable
2EVA	CP field 4	WR/IF field 5	R/H field 4	Applicable
2DEP	CP field 6	WR/IF field 7		Applicable
2TAR	CP field 3	WR/IF field 4		Applicable
2SHT	CP field 2	WR/IF field 3		Applicable
2DIV	field 3 – field 2	field 4 – field 3		Applicable
2RFL		WR field 13		Applicable
2ASF		WR/IF field 8		
2ROR		WR/IF field 9		
2IFT		IF field 11		
2IFS		IF field 12		
2HPS			R/H field 2	
2HPE			R/H field 3	
2RID			R/H field 6	
2RIR			R/H field 7	
2RAH			R/H field 8	
2RNA			R/H field 9	
2EPD			R/H field 10	

Time Series of SIM Simulation Results

The following list consists of the *TABLES* input record identifiers tabulated in the first column of Table 4.10 above and definitions of the corresponding variables from the *SIM* simulation results OUT file. The fields of the output records in the SIM OUT file from which

TABLES obtains the data are listed in Table 4.10. All of the variables are time series of monthly amounts. All are monthly volumes except for monthly depths associated with the 2EPD record. The *TABLES* time series input record for each variable has the format outlined on pages 112-113.

2NAT Naturalized streamflows at a control points are either read from *IN* records or computed with flow distribution methods.

2REG Regulated streamflow computed by *SIM* is defined in the *Reference Manual*.

2UNA Unappropriated streamflow is defined in the *Reference Manual*.

2CLO Channel loss for a river reach below a control point as defined in the *Reference Manual*.

2CLC Channel loss credits for the river reach below a control point.

2RFR Return flows returning here are the summation of return flows from all diversions that reenter the stream system at this control point.

2URR This portion of the regulated flow consists of the summation of releases from reservoirs located at this control point and upstream control points that were made to meet water right requirements at other control points located downstream.

2STO End-of-period reservoir storage may be for an individual water right or reservoir. For a control point, it is the summation of storage for all reservoirs assigned to that same control point.

2EVA Reservoir net evaporation-precipitation volume may be for an individual water right or reservoir. For a control point, it is the summation for all reservoirs assigned to that same control point.

2DEP A streamflow depletion is the amount of water appropriated by a water right to meet diversion requirements and maintain reservoir storage. The amount reported for a control point is the summation of streamflow depletions for all water rights assigned to the control point.

2TAR A diversion target is set in accordance with *WR*, *UC*, *SO*, *TO*, *DI*, and other *SIM* input records. The amount reported for a control point is the summation for all water rights assigned to the control point. For an *IF* record right, the target is an *IFMETH* 3 or 4 reservoir release target.

2SHT The diversion shortage is associated with individual water rights. The amount reported for a control point is the summation of shortages for all water rights assigned to the control point. For an *IF* record right, the shortage is a failure to meet an *IFMETH* 3 or 4 reservoir release target.

2DIV The actual diversion is not included in the *SIM* output file but is computed by *TABLES* as the target minus the shortage. For an *IF* record right, the amount reported is release from an *IFMETH* 3 or 4 reservoir.

2RFL The diversion return flow for this particular water right is the volume returned to the stream system.

2ASF The amount of streamflow that is available to a water right is computed as each right is considered in turn in the water rights priority loop.

2ROR For a multiple-reservoir water right, releases from secondary reservoirs are made following rules specified on *OR* records to meet the target requirements of the right.

2IFT Instream flow targets are specified by *IF* records and supporting records.

2IFS An instream flow shortage is the amount by which the regulated flow falls below the instream flow target.

2HPS The hydroelectric energy shortage is reported as a positive energy amount. Secondary energy is reported as a negative amount. Shortages represent shortfalls in meeting an energy target. Secondary energy is the amount greater than the target resulting from releases through the turbines to meet other senior water right requirements.

2HPE The energy generated represents the portion of the energy target that was met.

2RID Streamflow depletions associated with a reservoir include all the water taken from streamflow to meet water right requirements at the reservoir.

2RIR Reservoir inflows from other reservoirs consist of releases from secondary reservoirs to meet water right requirements at that reservoir.

2RAH Releases from the reservoir that can be used to generate hydropower.

2RNA Releases from the reservoir that are not accessible to the turbines for use in generating hydropower.

2EPD Evaporation-precipitation depths used to compute volumes are based on *EV* records but are subject to adjustments as specified by *JD* record field 10 and *CP* record fields 8 and 9.

Alternative Formats for TABLES Time Series Output

The *TABLES* input record types described on the following pages 112 and 113 convert the time series variables listed above to the following three alternative formats.

- A text file with the filename root.TAB has each time series organized into a table with annual rows and monthly columns with headings illustrated by Table 4.4. Each variable considered is presented in a separate table in the TAB file. This format is designed for report preparation and convenient viewing of simulation results.

- A text file with the filename root.TAB has each time series variable of interest tabulated as one column of a table. This format is designed for convenient conversion to a Microsoft Excel spreadsheet for plotting or further computations.

- A binary file with the filename root.DSS has each time series variable of interest stored as a HEC-DSS record. This format is designed to allow the data to be read by HEC-DSSVue for plotting or further computations.

Time Series Records

The following types of input records build tables in the same optional formats, with the only difference being the selection of variable to be tabulated. The items in parenthesis indicate whether the variable is associated with a control point, water right, and/or reservoir.

2NAT Record – Naturalized Streamflow (control points)
2REG Record – Regulated Streamflow (control points)
2UNA Record – Unappropriated Streamflow (control points)
2CLO Record – Channel Loss (control points)
2CLC Record – Channel Loss Credits (control points)
2RFR Record – Return Flow Entering at this Control Point (control points)
2URR Record – Regulated Flow at this Control Point from Upstream Reservoir Releases (control points)
2STO Record – Reservoir Storage (control points, water rights, reservoirs)
2EVA Record – Reservoir Evaporation-Precipitation Volume (control points, water rights, reservoirs)
2DEP Record – Streamflow Depletion (control points, water rights)
2TAR Record – Diversion Target (control points, water rights)
2SHT Record – Diversion Shortage (control points, water rights)
2DIV Record – Diversion (control points, water rights)
2RFL Record – Return Flow (water rights)
2ASF Record – Available Streamflow (water rights)
2ROR Record – Releases from Other Reservoirs (water rights)
2IFT Record – Instream Flow Target (instream flow rights)
2IFS Record – Instream Flow Shortage (instream flow rights)
2HPS Record – Hydropower Shortage (+) or Secondary Energy (-) (reservoir/hydropower)
2HPE Record – Energy Generated (reservoir/hydropower)
2RID Record – Inflows to Reservoir from Streamflow Depletions (reservoir/hydropower)
2RIR Record – Inflows to Reservoir from Releases from Other Reservoirs (reservoir/hydropower)
2RAH Record – Releases Accessible to Hydropower (reservoir/hydropower)
2RNA Record – Releases Not Accessible to Hydropower (reservoir/hydropower)
2EPD Record – Evaporation-Precipitation Depths (reservoir/hydropower)

Continued on next page.

Time Series Records – All Record Types Listed on Preceding Page

field	columns	variable	format	value	description
1	1-4	CD	A4	page 112	Record identifier from the list on preceding page.
2	8	TA	I4	Blank,0	Do not develop annual row/monthly column table.
				1	Develop table with annual rows and monthly columns.
3	12	PT	I4	Blank,0	Do not activate either HEC-DSS or text file option.
				1	Develop columns of monthly data in text file.
				2	Develop columns of annual totals or means in text file.
				3	Develop columns of 12 monthly means in text file.
				4	Develop HEC-DSS monthly time series records.
				5	Develop HEC-DSS annual time series records.
4	16	NEW	I4	0	Write columns; next record starts a new table.
				1	Add more columns to existing table or start first table.
5	20	ID	I4	0	Develop tables for default ID or for control points.
				1	Develop tables for water rights.
				2	Develop tables for reservoirs.
				3	Develop tables for water right groups.
6	24	NUM	I4	0	Tables for all control points (ID=0), rights (ID=1), or reservoirs (ID=2). NUM cannot be zero if ID=3.
				–	Develop tables for the NUM control points, water rights, or reservoirs listed on the previous record.
				+	Number of control points, water rights, reservoirs, or water right groups to follow (up to 80, eight per record)
7-14	25-88	IDEN	8(2x,A6)	AN	Identifiers of control points (ID=0), water rights (ID=1), reservoirs (ID=2), water right groups (ID=3) to include in the table. IDEN(ID,I), I=1,NUM
	25-88	IDEN8	8A8		
	25-152	IDEN16	8A16		
				blank	If NUM is zero or negative.

Explanation of Time Series Input Record Fields

Field 1: One of the 25 alternative record identifiers listed on the preceding page is entered in field 1. Variables are selected by this record identifier.

Field 2: A set of one or more tables with rows for years and columns for months is created by entering the integer 1 in field 2. The tables are written to the TAB file. Annual totals or means are included in the table along with the monthly amounts.

Field 3: Either columns of data may be written to the TAB text file or HEC-DSS records may be written to the binary DSS file. The data may include either monthly amounts or annual means/totals but not both.

A table activated by entering a 1, 2, or 3 in field 3 consists of a single column for each variable with multiple variables being included as separate columns in the same table. This format is designed to be read by Microsoft Excel or other spreadsheet programs for plotting or additional computational manipulations. The column may contain either the entire time series of monthly data (PT=1 in field 3), annual totals or means for each year of the simulation (PT=2), or a set of 12 means for each of the 12 months of the year (PT=3). The parameter *NEW* in field 4 controls whether a column is included in the same table with previous columns.

Options 4 and 5 in field 3 consist of storing the monthly or annual time series as binary records in a HEC-DSS file. These options allow use of the graphing and computational capabilities provided by HEC-DSSVue.

Field 4: Field 4 is relevant only if a columnar tabulation is activated by entering a 1, 2, or 3 in field 3. Each variable is tabulated as a single column in a table. The parameter *NEW* in field 4 specifies whether to place another column in the current table or to create another new table. Each table can include any number of columns up to a limit of 100 columns. At least one record must have a *NEW* of zero in order to write the table.

Field 5: The time series variables are associated with either control points (ID=0), water rights (ID=1), reservoirs (ID=2), and/or water right groups as indicated in Table 4.10. For those variables associated with only one ID, field 5 may be left blank. For variables that may be associated with more than one ID, an ID selection is entered in field 5. Summation of the data for all water rights in a group (ID=3) may be tabulated by 2STO, 2EVA, 2DEP, 2TAR, 2SHT, or 2DIV records.

Field 6: The default is to include all of the control points (ID=0), water rights (ID=1), or reservoirs (ID=2) found in the *SIM* OUT file. Optionally, lists of control points, water rights, reservoir/hydropower projects, or water right groups may be entered in fields 7 through 14 to specify inclusion in the *TABLES* tables. Water right groups may be selected only by listing them in fields 7-14.

The number of identifiers to be read in fields 7-14 do not necessarily have to be repeated for multiple records. A negative value for NUM may be entered in field 6 to indicate that the list read from the previous record is to be repeated. For example, a −32 tells TABLES to use the first 32 identifiers that remain in memory from a previous record. The 2REL, 2FREQ, 2SCP, 2SWR, and 2SRE records also enter identifiers into memory in this same repeatable format.

Fields 7-14: Up to 8 identifiers may be entered on a single record. Additional records with blank fields 1-6 may be used to extend the number of identifiers associated with a single set of tables or columns. Up to 80 identifiers on 10 records may be entered as a group. Any number of record groups may be entered.

2REL Record – Water Supply Diversion or Hydroelectric Energy Reliability Summary

field	columns	variable	format	value	description
1	1-4	CD	A4	2REL	Record identifier
2	8	TFLAG	I4	0, blank	Optional feature is not used.
				1,+	Diversion summary table is added at the end of the reliability table. A 2RET record must follow.
3	12	RFLAG	I4	0,blank	N = number of months with non-zero targets
				1,+	N = NYRS*MONTHS for $R_P = (n/N)*100\%$
4	16	ID	I4	0	Table includes selected control points.
				1	Table includes selected water rights.
				2	Table includes selected hydropower reservoirs.
				3	Table includes selected water right groups.
5	20	MONTH	I4	0,blank	All months are included in the computations.
				+	The month for which the analysis is performed.
6	24	NUM	I4	0	Include all control points (ID=0), water rights (ID=1), or reservoirs (ID=2) in table.
				+	Number of water rights, reservoirs, water right groups, or control points to follow (1 to 80; 8 per record)
				–	NUM identifiers from previous record are repeated.
7-14	25-88	IDEN	8(2x,A6)	AN	Identifiers of control points (ID=0), water rights (ID=1), reservoirs (ID=2), or water right groups (ID=3) to include in table (IDEN(ID,I),I=1,NUM)
	25-88	IDEN8	8A8		
	25-152	IDEN16	8A16		
				blank	If NUM is zero or negative.

2RET Record – Supplemental 2REL Summary Table

field	columns	variable	format	value	description
1	1-4	CD	A4	2RET	record identifier
2	5-12	TAR	F8.0	+	Annual diversion or hydropower target
				−1, −	adopt target from *WRAP-SIM* output file

Explanation of 2REL/2RET Record Fields

Field 2: *TFLAG* in field 2 adds a table showing the diversion target, diversion, shortage, and volume reliability for the total of all the control points, water rights, reservoirs, or groups included in the reliability table, based on a total diversion target specified by the user. This option requires that a *2RET* record follow the *2REL* record. The only entry on the *2RET* record

is the diversion target to be adopted for the add-on summary, which if left blank defaults to the summation of the pertinent targets from the *SIM* output file.

The supplemental *2RET* table allows a target to be input for use in computing volume reliability for the aggregate of all of the rights in the *2REL* table. Several water right *WR* records with associated *SO*, *TO*, *DI*, *WS*, and other supporting records may be combined to represent a particular water use requirement. A *2REL* record will create a table containing a line for each component *WR* record. However, model users may be interested in the combined reliability of the total water use requirement rather than the individual reliabilities associated with its component *WR* records. The complexity of interpreting the overall reliability from the component rights in the reliability table depends upon the options applied in building the targets in *SIM*. The totals line at the bottom of the *2REL* table is applicable if the table contains a number of separate rights, but may not meaningfully reflect certain combinations of intermediate targets built with combinations of *WR*/*SO/TO/DI* records.

Field 3: Reliability computations may be based either on using the simulation results from only the months with non-zero targets or using all 12 months of all years regardless of the target amounts.

Field 4: For control points (ID=0), water rights (ID=1), and water right groups (ID=3), reliabilities are computed for water supply diversions. For hydropower reservoirs (ID=2), reliabilities are computed for electric energy generation. *TABLES* reads the data for control points (ID=0) from the control point records (Table 2.4) in the *SIM* OUT file. The data for water rights (ID=1) and water right groups (ID=3) are from the water right records (Table 2.3) in the *SIM* OUT file. The data for the hydropower reservoirs (ID=2) are from the reservoir/hydropower records (Table 2.5).

For water right groups, the computed reliabilities are for the aggregation or summation of the diversions for all the water rights included in the group. For control points, reliabilities are for the summation of the diversions for all the water rights located at the control point.

Field 5: If a 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 is entered for *MONTH* in field 4, reliabilities are computed for the specified month. For example, reliabilities for meeting a diversion target in August (*MONTH* = 8) may be computed. The default is to include is all months in the simulation, subject to the optional *RFLAG* constraint of field 3.

Field 6: A blank or zero field 6 results in all of either the control points (ID=0 in field 5), water rights (ID=1), or reservoir/hydropower projects (ID=2) included in the *SIM* output file being included in the reliability table. Optionally, lists of control points, water rights, reservoir/hydropower projects, or water right groups may be entered in fields 7 through 14 for inclusion in the table. Water right groups may be selected only by listing them in fields 7-14. A negative value for NUM in field 6 indicates that the list read from the previous record is to be repeated. The time series, 2REL, 2FREQ, 2SCP, 2SWR, and 2SRE records enter identifiers into memory in the same format that may be repeated with a negative NUM.

Fields 7-14: Up to 80 identifiers (*NUM* = 80 in field 6) on ten records (8 identifiers per record) may be included in a single table. Any number of tables may be created using multiple 2REL records. Water rights *IDEN16* are unique identifiers for individual rights; so diversions and shortages are not aggregated. If multiple rights in the *SIM* OUT file have the same identifier, only the first right with *IDEN16* is used.

2FRE Record – Flow-Frequency or Storage-Frequency Relationships

field	columns	variable	format	value	description
1	1-4	CD	A4	2FRE	Record identifier
2	5-8	ID	I4	1	Naturalized flows
				2	Regulated flows
				3	Unappropriated flows
				4	Reservoir storage associated with a control point
				–4	Reservoir storage with only totals included in table
				5	Reservoir storage associated with a water right
				–5	Reservoir storage with only totals included in table
				6	Instream flow shortage for an *IF* record right
3	9-12	MONTH	I4	0,blank	All months are included in the computations.
				+	The month for which the analysis is performed.
4	16	NUM	I4	0	Include all control points or water rights in table
				+	Number of control points or rights to follow (80 maximum, eight per record)
				–	NUM identifiers from previous record are repeated.
5-12	17-80	IDCP IDEN16	8(2x,A6) 8A16	AN	Identifiers of control points (ID=1-4) or rights (ID=5,6) to include in table. IDEN(ID,I), I = 1,NUM
				blank	If NUM is zero or negative

2FRQ Record – Frequency for Specified Flow or Storage

field	columns	variable	format	value	description
1	1-4	CD	A4	2FRQ	Record identifier
2	5-8	ID	I4	1	Naturalized flows
				2	Regulated flows
				3	Unappropriated flows
				4	Reservoir storage associated with a control point
				5	Reservoir storage associated with a water right
				6	Instream flow shortage for an *IF* record right
3	12	MONTH	I4	0,blank	All months are included in the computations.
				+	The month for which the analysis is performed.
4	16	NM	I4	+	Number of flows or storages entered for *TABLES* to determine frequencies (NM may range from 1 to 7)
5	17-24 17-32	IDEN IDEN16	2x,A6 A16	AN	Identifier of control point (ID=1-4) or water right (ID=5,6)
6-12	25-80 33-88	QF(I) I=1,NM	7F8.0	+	Streamflows (ID=1,2,3), storage (ID=4,5), or instream flow shortage (ID=6) for which to compute frequency

2RES Records – Reservoir Storage Tables

First 2RES Record

field	Columns	variable	format	value	description
1	1-4	CD	A4	2RES	Record identifier
2	8	TABLE	I4	0	All three tables are created.
				1	Storage contents as a percentage of capacity table.
				2	Storage draw-down duration table is created.
				3	Storage reliability table is created.
				4	Both draw-down and reliability tables are created.
3	11-12	MONTH	I4	0,blank	All months are included in the computations.
				+	The month for which the analysis is performed.
4	15-16	NUM	I4	+	Number of reservoir identifiers in following fields.
5-24	17-176	IDEN(res) res=1,20	20(2x,A6)	AN	Reservoir identifiers

Second 2RES Record – Total Storage Capacity (required)

field	columns	variable	format	value	description
1	1-4	CD	A4	2RES	Record identifier
2-4	5-16		12X		Blank or comments (not read by *TABLES*)
5-24	17-176	C1(res) res=1,20	20F8.0	+	Total storage capacity in each reservoir (C_1).

Third 2RES Record – Inactive Storage Capacity (optional)

field	columns	variable	format	value	description
1	1-4	CD	A4	2RES	Record identifier
2-3	5-16		12X		Blank or comments (not read by *TABLES*)
5-24	17-176	C2(res) res=1,20	20F8.0	+	Inactive storage capacity in each reservoir or bottom of the storage zone being considered (C_2).

The third 2RES record is generally optional, with all C_2 defaulting to zero. However, the third record is required even if the C_2 are zero if followed by another set of 2RES records.

Explanation of 2RES Records

A set of 2RES records results in storage contents being read from reservoir records in the *SIM* output file. A maximum of 20 reservoirs can be included. The reservoir identifiers are provided on the first 2RES record. The C_1 storage capacities are provided on the required second 2RES record. The C_2 storage capacities are provided on the optional third record. C_2 is assumed zero for all reservoirs if the third 2RES record is not provided. The third 2RES record is required if followed by another set of 2RES records. C_1 and C_2 are the storage capacities at the top and bottom of the storage zone being considered. Typically, C_1 will be the total conservation storage capacity and C_2 will be either zero or the inactive storage capacity. However, the pool zone may be defined to fit the application.

The set of 2RES records develop three different tables selected by the entry for *TABLE* in field 2 of the first record.

The first type of table is a tabulation of end-of-period reservoir storage contents expressed as a percentage of a user-specified storage capacity, with one column per reservoir.

$$\text{storage as percentage of capacity} = \left(\frac{S - C_2}{C_1 - C_2} \right) 100\%$$

where S is the end-of-month storage content and C_1 and C_2 are the capacities at the top and bottom of the storage zone being considered. The percentage storage tabulation is useful is comparing the relative storage of reservoirs in a system of multiple reservoirs.

The second table is a storage draw-down duration relationship expressed in terms of the number of months for which the draw-down equaled or exceeded specified percentages of storage capacity of the zone defined by the equation above.

The third table is a storage reliability relationship expressed in terms of the percentage of months for which the contents equaled or exceeded specified percentages of storage capacity of the zone defined by the equation above.

If a 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 is entered for *MONTH* in field 3 of the first *2RES* record, tables are constructed for the specified month. The default is to consider all months in the analysis of simulation results.

2SCP Record – Summary Tables for Control Points

field	columns	variable	format	value	description
1	1-4	CD	A4	2SCP	Record identifier
2	8	MNAN	I4	0	Annual table
				1	Monthly table
				2	Both annual and monthly tables
3	9-12	NUM	I4	blank ,0	Develop tables for all control points.
				+	Number of control points to follow.
				–	NUM identifiers from previous record are repeated.
4-11	13-76	IDCP	8(2x,A6)	AN	Identifiers of control points for which to develop tables. IDCP(ID,I), I = 1,NUM

2SWR Record – Summary Tables for Water Rights

field	columns	variable	format	value	description
1	1-4	CD	A4	2SWR	Record identifier
2	5-8	MNAN	I4	0	Annual table
				1	Monthly table
				2	Both annual and monthly tables
3	9-12	NUM	I4	blank,0	Develop tables for all water rights.
				+	Number of water rights to follow.
				–	NUM identifiers from previous record are repeated.
4-11	13-140	IDEN16	8A16	AN	Identifiers of water rights for which to develop tables. IDEN16(ID,I), I = 1,NUM
				blank	If NUM is zero or negative

2SCP, 2SWR, 2SGP, and 2SRE records are essentially the same except *IDCP and IDRES* denote control point and reservoir identifiers which may have a maximum of six characters, *IDEN8* denotes water right group identifiers which may consist of up to eight characters, and *IDEN16* is for water right identifiers which may be up to 16 characters long.

Water right groups must be listed explicitly on the 2SGP record. *NUM* cannot be zero for a water right group operation.

TABLES reads the data for 2SCP and 2SBA tables from the control point records (Table 2.4) in the *WRAP-SIM* output file. The data for the 2SWR and 2SGP tables are from the water right records (Table 2.3) in the *SIM* output file. The data for the 2SRE table are from the reservoir/hydropower records (Table 2.5) in the *SIM* output file.

2SGP Record – Summary Tables for Water Right Groups

field	columns	Variable	format	value	description
1	1-4	CD	A4	2SGP	Record identifier
2	5-8	MNAN	I4	0	Annual table
				1	Monthly table
				2	Both annual and monthly tables
3	9-12	NUM	I4	+	Number of water right groups to follow.
				–	NUM identifiers from previous record are repeated.
4-11	13-140	IDEN8	8A8	AN	Identifiers of water right groups for which to develop tables. IDEN8(ID,I), I = 1,NUM
				blank	If NUM is negative

2SRE Record – Summary Tables for Reservoirs

field	columns	variable	format	value	description
1	1-4	CD	A4	2SRE	Record identifier
2	5-8	MNAN	I4	0	Annual table
				1	Monthly table
				2	Both annual and monthly tables
3	9-12	NUM	I4	0	Develop tables for all reservoirs.
				+	Number of reservoirs to follow.
				–	NUM identifiers from previous record are repeated.
4	13-76	IDRES	8(2x,A6)	AN	Identifiers of reservoirs for which to develop tables. IDRES(ID,I), I = 1,NUM
				blank	If NUM is zero or negative.

2SBA Record – Aggregate Summary Table for the Entire River Basin

field	column	variable	format	value	description
1	1-4	CD	A4	2SBA	Record identifier
2	8	MNAN	I4	0	Annual table
				1	Monthly table
				2	Both annual and monthly tables

3NAT Record – Naturalized Streamflows
3REG Record – Regulated Streamflows
3UNA Record – Unappropriated Streamflows
3DEP Record – Streamflow Depletions
3U+D Record – Unappropriated Flows plus Streamflow Depletions
3EPD Record – Net Evaporation-Precipitation Depths

field	columns	variable	format	value	description
1	1-4	CD	A4	3NAT	Record identifier for naturalized streamflows
				3REG	Record identifier for regulated streamflows
				3UNA	Record identifier for unappropriated streamflows
				3DEP	Record identifier for streamflow depletions
				3U+D	Record identifier for summation of streamflow depletions plus unappropriated streamflows
				3EPD	Record identifier for net evaporation depths
2	5-8	CDOUT	2x,A2	AN	Two-character identifier at beginning of each record
3	9-12	HEC	I4	blank, zero	Streamflow records grouped by control point
				1	Streamflow records grouped by year
4	13-20	INFAC	F8.0	blank,0	Default INFAC=1.0
				+	Factor by which streamflows are multiplied

The 3NAT, 3REG, 3UNA, 3DEP, 3U+D, and 3EPD records have the same format. The specified data are read from control point output records in the *SIM* output file except for the 3EPD record that reads reservoir output records. *TABLES* converts the data to the format of *SIM IN* or *TS* input records. Any two-character identifier, including but not limited to *IN* or *TS* or blank, may be written at the beginning of each record created as specified by field 2 of the input record.

Each record written to the *TABLES* output file contains 12 flows for the 12 months of the year. Records are created for all years and all control points or reservoirs in the *SIM* output file. The records may be ordered with all years grouped together for a control point followed by all years for the next control point (default of *HEC* = 0 in field 3). Alternatively, records for all control points may be grouped together for each year (*HEC* = 1 in field 3).

HEC = 0	
CP1	1990
CP1	1991
CP1	1992
CP2	1990
CP2	1991
CP2	1992
CP3	1990
CP3	1991
CP3	1992

HEC = 1	
CP1	1990
CP2	1990
CP3	1990
CP1	1991
CP2	1991
CP3	1991
CP1	1992
CP2	1992
CP3	1992

The multiplier in field 4 may be a unit conversion factor or otherwise used to scale the flows.

4SWR Record – Hydropower and Reservoir Release Table for a System Water Right

field	column	variable	format	value	description
1	1-4	CD	A4	4SWR	Record identifier
2	8	MNAN	I4	0 1 2	Annual table Monthly table Both annual and monthly tables
3	12	NUM	I4	+	Number of water rights to follow (1 to 30)
4-8	13-92	IDEN(I) I=1,5	A16	AN	Water right identifiers for which to develop reservoir release tables (maximum of 5/record and six records)

4SGP Record – Hydropower and Reservoir Release Table for a Water Right Group

field	column	variable	format	value	description
1	1-4	CD	A4	4SGP	Record identifier
2	5-8	MNAN	I4	0 1 2	Annual table Monthly table Both annual and monthly tables
3	9-12	NUM	I4	+	Number of water right groups to follow (1 to 30)
4-8	13-52	IDEN(I) I=1,5	8X,A8	AN	Identifiers of water rights groups for which to develop reservoir release tables (maximum of 5/record)

The 4SWR and 4SGP records are the only *TABLES* records that result in data being read from a *SIM* hydropower and reservoir release HRR output file. System water rights in included in a HRR file are hydropower (type 5 and 6) and type 2, 3, and 4 rights and/or rights with multiple reservoirs. In the HRR output file, reservoir releases each month of the simulation for a given water right is listed as a row. The releases from each reservoir are listed as a column in the tables. Each reservoir associated with the water right (4SWR record) or group of rights (4SGP record) has a column of monthly releases. The reservoir identifiers head each column. The format of the 4SWR and 4SGP records and resulting tables are the same.

The 4SWR record results in a table for a specified water right in which monthly releases from each reservoir for that right are listed in a column. The 4SGP record results in a table for a specified group of water rights in which the total monthly releases for all rights in the group from each reservoir for that group are listed in a column. For either the 4SWR or 4SGP record, each reservoir associated with the right or group is represented by a column.

A 4SWR record may develop tables for each of up to 30 water rights. Up to 5 rights are listed in fields 4-8, and up to six records may be used. Fields 2 and 3 are not read on the second and subsequent records. Likewise, up to 30 groups of water rights may be listed on up to six 4SGP records with 5 groups per record.

Field 8 of the *FO* record in a *WRAP-SIM* input field specifies whether or not a *HRR* file is created. Water right identifiers are written to the *HRR* file by default unless group identifiers are specified in field 13 of the *JD* record.

4SWR/4SGP tables may use significant computer time searching for identifiers in the *HRR* output file. *TABLES* run times may be reduced by minimizing the number of water rights output by *SIM*.

CHAPTER 5
WRAP-HYD

The purpose of the *WRAP* program *HYD* is to facilitate developing hydrology-related input data for *SIM*. The *HYD*rology data program provides a set of optional routines to read, modify, and create files of naturalized streamflows (*IN* records) and net evaporation-precipitation depths (*EV* records). *HYD* output files are read by *SIM* as input files. *HYD* provides certain computational routines that are also available in *SIM* and others that are not. For the routines incorporated in both programs, the format of the computed output is different. The primary *HYD* output is files of *IN* and *EV* records that are read by *SIM* as input. *HYD* also includes options for reading and writing streamflow and evaporation-precipitation data as columns in a table, which facilitates transferring data from and to spreadsheet programs such as Microsoft Excel.

WRAP-HYD is a set of computational options designed to provide assistance in developing sequences of naturalized streamflows and net evaporation-precipitation rates (*IN* and *EV* records). Capabilities are provided for performing the tasks outlined in Table 5.1 and discussed in the following paragraphs. The tasks are listed in Table 5.1 generally in the order in which they are performed within *HYD*. All tasks are optional. The model-user specifies any number of tasks to be performed in a particular run of *HYD* through entries on the *CP*, *FO*, *EP*, *JC*, *AS*, *RS* and *EQ* input records. Table 5.2 notes the records that are used to choose each of the *HYD* capabilities outlined in Table 5.1. These data manipulation options involve reading *IN* and/or *EV* records and creating revised *IN* and/or *EV* records stored in new files. *HYD* options include developing several related tables as well as sets of *IN* and *EV* records. A single execution of *HYD* may include any number of data adjustments. Alternatively, in order to sequence the adjustments certain ways, multiple runs may be made with the output file from one run being read as the input file for the next. Files may also be transported back and forth between *HYD* and spreadsheet programs.

Initial Manipulations of IN and/or EV Records

The following optional tasks are performed as the *IN* and *EV* records are initially read. These options are activated by input entered on *XL*, *CP*, and *MF* records.

- The flows and/or evaporation-precipitation rates from *IN* or *EV* records are multiplied by factors specified on *XL*, *CP*, and *MF* records. The monthly factors on *MF* records may also be added.

- Streamflows and/or evaporation-precipitation rates may be assigned to a control point by either verbatim repeating data from another control point or by multiplying the repeated flows by the factors from the *CP* records.

The *XL* and *CP* record factors in *HYD* are similar to the previously discussed factors in *SIM*. The factors may be used for unit conversions, such as converting streamflows from second-feet-day ($ft^3/s \times day$) to acre-feet or net evaporation-precipitation depths from inches to feet. Also, the same streamflow or evaporation-precipitation rates may be conveniently assigned to multiple control points as appropriate. Drainage area ratios may be applied to transfer flows from gaged to ungaged sites. These data adjustments occurring immediately after the original data are read are then followed by the other optional tasks listed in Table 5.1.

Table 5.1
Capabilities Provided by HYD

- *Initial Manipulations of IN and/or EV Records*

  1. Multiplying the streamflows or evaporation-precipitation depths from *IN* or *EV* records by constants specified on *XL* or *CP* records or multiplying or adding monthly-varying factors from *MF* records
  2. Assigning flows or net evaporation-precipitation rates to a control point by either verbatim repeating data from another control point or by multiplying the repeated flows by the factors from the *CP* records

- *Developing Sets of Net Evaporation-Precipitation Depths (EV Records)*

  3. Subtracting precipitation depths from evaporation depths to obtain net evaporation-precipitation depths
  4. Developing rates for a particular control point as a weighted average of values from two, three, or four other data sets
  5. Adjusting evaporation-precipitation depths (E) using the equation: $E_{adjusted} = a\,E^{b} + c$

- *Developing Sets of Naturalized Streamflows (IN Records)*

  6. Adding or subtracting sets of adjustments to streamflows associated with historical water supply diversions and return flows, reservoir storage and evaporation, and other factors that may be pertinent to the flow naturalization computations
  7. Developing adjustments for the historical effects of reservoir storage and net evaporation-precipitation
  8. Applying the equations: $Q_{adjusted} = a\,Q^{b} + c$ or $\Delta Q_{adjustment} = (a\,Q^{b} + c) - Q$
  9. Distributing flows from gaged (known flow) to ungaged (unknown flow) locations
  10. Adjusting streamflows to prevent incremental flows from being negative

- *Changing the Organization and Format of IN and EV Record Files*

  11. Converting the format of the files from records grouped by control point to the standard INF and EVA file format with records grouped by year
  12. Converting an HYD file to INF and EVA files in the standard format or vice versa

- *Converting between IN/EV Record and Columnar Spreadsheet Table Formats*

  13. Converting flows and evaporation-precipitation depths to a columnar format, and vice versa, to facilitate manipulating and plotting data with *Microsoft Excel* or other programs

Table 5.2
Activating HYD Capabilities

Optional Capability	Activation Switch
• *Initial Manipulations of IN and/or EV Records*	
1. Multiplying by factors on *XL, CP,* or *MF* records or adding factors from *MF* records	*CP* record fields 4 and 5 *MF* and *XL* records
2. Repeating data at multiple control points	*CP* record fields 7 and 8
• *Developing Sets of Net Evaporation-Precipitation Rates (EV Records)*	
3. Subtracting precipitation rates from evaporation rates	*EP* record
4. Averaging data sets	*EP* record
5. Applying the equation: $E_{adjusted} = a\ E^{b} + c$	*EQ* record
• *Developing Sets of Naturalized Streamflows (IN Records)*	
6. Adding adjustments	*AS* record
7. Reservoir adjustments	*AS* followed by RS record
8. Applying the equation: $Q_{adjusted} = a\ Q^{b} + c$	*EQ* record
9. Flow distribution	*FO* field 4 and *CP* field 6
10. Negative incremental flow adjustments	*JC* record fields 11 & 12
• *Changing the Organization and Format of IN and EV Record Files*	
11. Converting from control point group format	*JC* record fields 1, 2, 4
12. Converting *WRAP2/WRAP3* HYD file	*JC* record fields 1, 2, 4
• *Converting between IN/EV Record and Columnar Formats*	
13. Converting between a table in columnar format	*JC* record fields 1, 2, 5

Developing Sets of Net Evaporation-Precipitation Depths

HYD includes an option to perform the following arithmetic operations on two, three, or four arrays of numbers.

1. Each array is altered by multiplying each element by a user-specified constant, which may be positive or negative depending on the application. The default multiplier is 1.0.

2. The arrays are combined by adding corresponding elements.

This option is designed to combine sets of reservoir evaporation, precipitation, and/or net evaporation minus precipitation rates (depth/month) to develop sets of *EV* records for input to *SIM*. Typical applications of this feature include:

- subtracting precipitation rates from evaporation rates to obtain net evaporation-precipitation rates
- developing rates for a particular control point as a weighted average of values from multiple data sets

The first application consists of simply subtracting a set of precipitation depths from concurrent evaporation depths to obtain net evaporation-precipitation depths. The second application involves determining evaporation-precipitation rates for a control point as a weighted average of values from two to four other data sets. *HYD* multiplies the different sets of data by user-specified weighting-factors and sums the products. The Texas Water Development Board maintains precipitation and evaporation databases based on a grid of quadrangles covering the state. This *HYD* option is designed to determine values for a control point as a weighed-average of data from two, three, or four adjoining quadrangles.

Developing Sets of Naturalized Streamflows

A *WRAP-SIM* simulation begins with sequences of monthly naturalized streamflows covering the hydrologic period-of-analysis at all control points. The following *HYD* capabilities are provided to facilitate developing the naturalized flows which are input to *SIM* as *IN* records.

1. adding or subtracting sets of adjustments to streamflows
2. developing streamflow adjustments for the historical effects of reservoirs
3. applying the equations: $Q_{adjusted} = a\,Q^{b} + c$ or $\Delta Q_{adjustment} = (a\,Q^{b} + c) - Q$
4. distributing flows from gaged (known flow) to ungaged (unknown flow) locations
5. adjusting streamflows to prevent incremental flows from being negative

Streamflow Naturalization Adjustments

Naturalized streamflows are gaged flows adjusted to remove the effects of human water management and use. *HYD* has options for modifying streamflows by adding or subtracting any number of data sets of flow adjustments. Typically, the original unadjusted streamflows will be historical gaged flows. Typical adjustments include historical water supply diversions, return flows from surface and/or groundwater diversions, reservoir storage changes, and reservoir surface evaporation/precipitation. Other types of adjustments may be added or subtracted as well.

The adjustment data sets are simply time series of numbers to be added to the streamflows. The streamflow adjustments may be positive, negative, or zero. An option allows an adjustment data set to be multiplied by a user-specified factor prior to being added to the streamflows. Any number of sets of adjustments may be applied at a particular control point. The data sets are added at a specified control point and optionally at all downstream control points. If the channel loss factor field of the *CP* record is non-zero, channel losses are reflected in cascading the adjustments downstream. Options are provided for setting the final adjusted flows to zero if the computations result in negative values. Particular adjustments may cover all or any portion of the hydrologic period-of-analysis.

The adjustments to be combined with the streamflows may consist of either constant annual sequences of 12 monthly values or longer multiple-year time series. Adjustments for the effects of reservoirs are computed within *HYD* and then handled the same as the other adjustments read from input files. The following types of sets of adjustments may be added to the streamflows.

1. A constant may be entered in field 9 of the *AS* record to add to the flows.
2. A set of 12 adjustments for each of the 12 months of the year to be repeated annually during a specified span of years are input on constant inflow *CI* records.
3. Time series of adjustments spanning any number of years are entered on flow adjustment *FA* records.
4. Adjustments for the effects of reservoirs are computed within *HYD* as discussed in the next section.

All four types of adjustments are handled the same. An adjustment specification *AS* record provides the following information for each set of adjustments.

- control point identifier
- beginning and ending year of adjustments
- whether adjustments are to be applied to all downstream control points
- factor by which adjustments are multiplied
- selection of negative streamflow option

Adjustments may result in negative streamflows. Options are available to either maintain the negative streamflows as the adjustments accumulate or set them equal to zero. For multiple sets of adjustments, the negative values in the cumulatively adjusted streamflows may be set to zero after any specified adjustment. If negative flows are changed to zero, an option allows flow in the next month to be decreased by the amount of the negative flow. Another option limits the adjustment to the amount of streamflow. For example, if an adjustment of 25 acre-feet/month is to be subtracted from a streamflow of 15 ac-ft/month, the adjustment is changed to 15 ac-ft/month. The 15 ac-ft (not 25 ac-ft) adjustment is applied at each control point as the adjustment cascades downstream.

Streamflow Adjustments for the Effects of Reservoirs

Input data required to compute adjustments for the effects of reservoirs on streamflow include historical end-of-month storage content (*SC* records) and storage-area relationships (*SV/SA* or *RS* records), and net evaporation-precipitation rates (*EV* records). The adjustments include the following user-specified component parts.

- increases in reservoir storage content
  (*RS* record field 3; default: adjustment to be added to streamflows)
- decreases in conservation storage content
  (*RS* record field 4; default: adjustment to be subtracted from streamflows)
- decreases in storage above a specified storage capacity which represent spills or flood releases (*RS* field 5; default: adjustment to be subtracted from streamflows)

- net evaporation minus precipitation volumes
  (*RS* record field 6; default: adjustment to be added to streamflows)
- portion of naturalized streamflow representing runoff from land area covered by reservoir that would have occurred without the reservoir
  (*RS* record field 7; default: adjustment to be added to streamflows)

The model-user specifies on the *RS* record which component parts to include in the total adjustment. *HYD* combines the component parts to obtain a total adjustment which is applied just like other *FA/CI* record adjustments to adjust the streamflows at the control point of the reservoir and optionally at each downstream control point. Each component part of the adjustment may be either added to or subtracted from the streamflow, with defaults shown in parentheses in the preceding list. The defaults represent the typical conventional process of naturalizing gaged streamflows. *RS* record field 8 specifies creation of a table showing the component parts of the monthly reservoir adjustments.

HYD computes net evaporation-precipitation volumes by applying rates (depth/month) to the average water surface area during the month determined by combining storage contents with the storage-area relationship for the reservoir. Net evaporation-precipitation depths are either read from *EV* records or computed as specified by *EP* records based on data read from *EV* records. The format for entering reservoir storage volume versus water surface area relationships is the same in both *HYD* and *SIM*. A storage-area relationships may be provided as either a table on *SV* and *SA* records or as equation coefficients entered on a *RS* record (rather than *SIM WS* record).

HYD also has an option for increasing the naturalized streamflows to account for runoff derived from precipitation falling on dry land, that historically was actually covered by the reservoir. The precipitation falling on the reservoir is removed in the flow naturalization process with the net evaporation less precipitation adjustments. As explained in Chapter 3 of the *Reference Manual*, the adjustment for the portion of the streamflow representing runoff from the land area covered by a reservoir that would have occurred without the reservoir is incorporated in both *SIM* and *HYD* and is conceptually the same as the drainage area method for transferring flows. The adjustment is computed by multiplying the naturalized streamflow by the ratio of reservoir water surface area to watershed drainage area. Since the current value for naturalized flow at the control point is used, this adjustment should be made after other relevant adjustments.

JC record field 13 (*EPADJ*), *CP* record field 9 (*EWA*), and *RS* record field 7 (*RS(5)*) activate this option. *RS(5)* specifies whether the site runoff is included in a particular reservoir adjustment. The *JC* record field 13 sets the default option applied to all control points for which the *CP* record field 9 is left blank. An entry for *EWA* on a *CP* record overrides the default option set by *EPADJ* on the *JC* record. The precipitation-runoff adjustment requires a drainage area. An effective total watershed area may be input as a positive number in *CP* record field 9 for use with the total naturalized flows at that control point. Alternatively, the incremental or total watershed area and corresponding incremental or total naturalized flows for either the ungaged (*FD* record field 2) or gaged (*FD* record field 3) control points may be used by entering a –1 or –2 in *CP* record field 9 (applicable to that control point) or *JC* record field 13 (default for all control points). Incremental flows and watershed areas determined based on information from

the *FD* and *WP* records are identically the same for the rainfall-runoff adjustments as for distributing streamflows from gaged to ungaged sites.

The increase or decrease in reservoir storage content during each month is computed from the end-of-month storage contents provided on *SC* records. Storage increases, decreases, or both may be included in the adjustment. Storage decreases occurring above and below a specified storage capacity are determined separately. The user-specified storage capacity is typically the full conservation storage. Storage above this capacity represents flood storage, and corresponding storage reductions represent spills or flood releases. Flood control pool spills are shown as a separate column in the table created by *RS* record field 8. With the *RS* record default options, flood spills are handled the same as decreases in conservation pool storage in the final adjustments. However, if water supply diversion data is lacking, conservation pool storage decreases may be omitted to compensate for omissions of diversions in the adjustments.

Regression Equation to Adjust Flows and/or Evaporation-Precipitation Depths

The monthly streamflows (Q) and evaporation-precipitation depths (E) at a control point may be further adjusted by applying the equations:

$$Q_{adjusted} = a\,Q^{b} + c \qquad \text{and/or} \qquad E_{adjusted} = a\,E^{b} + c$$

The *Q* coefficients *a*, *b*, and *c* and *E* coefficients *a*, *b*, and *c* for particular control points or groups of control points are entered on *EQ* records.

The second equation converts the evaporation-precipitation depth *E* at a specified control point to an adjusted value $E_{adjusted}$, without considering other control points. The *Q* equation may also be applied directly to a specified control point without considering flows at downstream locations. However, alternatively, an incremental Q adjustment may be cascaded downstream. The incremental Q adjustment is computed as:

$$\Delta Q_{adjustment} = (a\,Q^{b} + c) - Q$$

$\Delta Q_{adjustment}$ is treated like any other adjustment to be added to the streamflows. It may be cascaded downstream with channel losses and with additions to the flows at downstream control points.

The regression equation feature may be used in various ways. One alternative strategy for quantifying the effects of either climate change or watershed land use changes involves modeling a watershed with a precipitation-runoff simulation model such as the *Soil and Water Assessment Tool (SWAT)* developed at the USDA Agricultural Research Service and TAMUS Texas Agricultural Experiment Station Research Center in Temple, Texas. *SWAT* computes streamflow given precipitation and other climatic data and watershed characteristics. Changes in climate are reflected in precipitation, temperature, and other climatic variables. Changes in land use are modeled by changing watershed parameter values. *SWAT* is applied to compute streamflows for scenarios with and without climate or watershed changes. Regression analyses are then applied to flows computed with different scenarios to obtain a set of *a*, *b*, *c* coefficients for input to *HYD*. The regression equation for evaporation-precipitation depths may likewise be used to reflect climate change.

Distributing Flows from Gaged to Ungaged Locations

Naturalized streamflows are typically developed for locations of gaging stations by adjusting the recorded observed flows. Naturalized flows at numerous ungaged sites of water rights are then estimated based on combining the concurrent naturalized flows at gaging stations with parameters characterizing the watersheds above the gaged and ungaged sites. Alternative methods for transferring naturalized flows from gaged (known flow) to ungaged (unknown flow) locations are outlined in detail in the *Reference Manual*. These techniques include the drainage area ratio method, a modified version of the NRCS curve number methodology, and other related approaches. Watershed parameters are entered on *FD*, *FC*, and *WP* records in a DIS file. *HYD* includes an option for developing tables displaying the watershed parameters including both values inputted on WP records and values for incremental watersheds computed within *HYD*.

The same flow distribution techniques are incorporated in both *HYD* and *SIM*, but the computed flows are stored in different formats. *HYD* stores the flows computed for the ungaged control points as *IN* records along with the original *IN* records for the known-flow (gaged) control points. *SIM* writes synthesized naturalized flows to its output file just like all the other simulation results. In a typical major river basin application, recorded streamflows may be used from perhaps 10 to 25 pertinent gaging stations. Naturalized flows developed at the gage sites may then be distributed to several other key control points (perhaps another 10-25 sites) within *HYD* with the results permanently stored as *IN* records in the *HYD* output (*SIM* input) file. Within *SIM*, naturalized streamflows may be distributed to several hundred other water rights sites internally without further enlarging the file of *IN* records.

Negative Incremental Streamflow Adjustments

Total, rather than incremental, naturalized streamflows are provided as *SIM* input. All computational and data handling procedures in *SIM* and *HYD* are based on total flows. Negative incremental streamflows are an indication of complexities that perhaps could cause inaccuracies in the simulation. The incremental local flow at a control point is defined as the total flow at the control point minus the corresponding flow at control point(s) located immediately upstream. Since flows normally increase going downstream, incremental flows are usually positive. However, flows may be greater upstream than downstream for various reasons. As discussed in Chapter 3 of the *Reference Manual*, *HYD* and *SIM* include options to (1) identify negative incremental flows and (2) adjust the naturalized streamflows to alleviate negative incrementals. The negative incremental flow adjustments may be written to a file for information.

Negative incremental inflow options 1, 2, and 3 specified on the *HYD JC* record or *SIM JD* record are the same in either program. Option 4 involves computations performed within the *SIM* water rights loop and thus is not pertinent to *HYD*. *HYD* adjusts the actual *IN* records. *SIM* adjusts flows used in the internal computations but never actual changes the *IN* records in the data file.

Changing the Organization and Format of IN and EV Record Files

In the default set of input files, *IN* and *EV* records are stored in separate files with filenames root.INF and root.EVA. In the standard format, each *IN* and *EV* record has 12 values for the 12

months of the year. Each record corresponds to both a year and a control point location. In the standard format, the records are grouped by year. The group for each year consists of records for all control points. Records for all of the control points grouped together for a year are followed by records for all control points for the next year.

HYD reads input files near the beginning of the data handling and computational tasks and writes to output files near the end. The format for the output files may be different than that of the input files. Options allow reading input files in alternative formats and converting to the standard default format noted in the preceding paragraph. These options facilitate:

- changing the format of the files from records grouped by control point to the standard WRAP format with records grouped by year
- changing a *WRAP2/WRAP3* hydrology file (filename root.HYD) to the standard WRAP format and vice versa

The first capability listed above consists of reading a file with record groups consisting of all years for a control point and creating a corresponding file in the standard format of records for all control points grouped together for a year. Developing files with the records grouped by control point may be more convenient than the standard format. In this alternate format, IN and EV records for a control point are grouped together with each group beginning with the record for the first year and continuing in chronological order. *HYD* can read a root1.INF and/or root1.EVA file in this alternative format and convert to root2.INF and EVA files in the standard format or to a HYD file.

HYD can also read a HYD file of *IN* and *EV* records in the old WRAP2/WRAP3 format and create INF and EVA files or a HYD file in the standard format. Standard format WRAP files can also be converted to a HYD file in *WRAP2/WRAP3* format.

Converting between IN/EV Record and Columnar Formats

Spreadsheet programs such as Microsoft Excel are useful for plotting, regression analyses, and other manipulations of streamflow and evaporation/precipitation data. For example, naturalized streamflows at multiple control points may be developed by adjusting gaged streamflows at gaging stations with different record lengths and with gaps of missing data. Naturalized flows covering different time periods may be transported from *HYD* to Microsoft Excel to apply regression analyses to fill in missing months and extend coverage to a common simulation period for all control points and then back to *HYD* to convert to standard *IN* record format.

HYD will write and read monthly streamflow or evaporation/precipitation data in a text file, with the data sequence for each selected control point being in a single column. Working with monthly time series data in columns, of length 12 months x number of years in hydrologic simulation period, is often more convenient than two dimensional arrays with 12 columns for January-December and a row for each year. With the columnar text file format, each column contains all streamflows (or evaporation/precipitation depths) for a particular control point. For example, 1940-1999 monthly naturalized flows at 125 selected control points may be represented by 125 columns with each containing 600 monthly flows. The columns may have different lengths and gaps with missing data.

HYD writes the tables in the following format. The year and month columns are each four-characters wide, and the flow (or evaporation-precipitation) columns are 8-characters wide with the data right-justified.

Year	Mon	CP-1	CP-2	CP-3	CP-4	CP-5	CP-6
1991	1	778.1	239.8	827.5	452.6	49.2	1723.0
1991	2	3215.4	319.5	4513.2	299.2	64.6	6293.8
1991	3	2185.4	399.4	3149.5	354.1	53.8	5298.1

In reading the table, the first eight characters (year and month columns) are not read by *HYD* and thus may be blank or contain notes or other information. Lines starting with ** or 40 blank characters are skipped over. Thus, ** may be used to insert notes. The table is written with the control points (columns) in the same order as the *CP* records. However, the columns may be in any order in reading a table. Any number of control points ranging from one to the total number of *CP* records may be included in a table. The control point identifiers in the first row must correspond to the identifiers in field 2 of the *CP* records. Every year of the period-of-analysis (with 12 monthly rows per year) must be included in chronological sequence. Example 8 in Appendix F of the *Reference Manual* further illustrates the table format.

Input and Output Files

WRAP-HYD input filenames (*root.extension*) all have the same root, denoted here as *root1*, and extensions indicating the type of data in each file. The input files are as follows.

basic data *DAT* file	root1.DAT	file with all input not included in following files
inflow *FLO* file	root1.FLO	inflow *IN* records with streamflows
evaporation *EVA* file	root1.EVA	*EV* records with evap-precip depths
distribution *DIS* file	root1.DIS	flow distribution *FD, FC, WP* records
hydrology *HYD* file	root1.HYD	*IN* and *EV* records combined in a single file

The basic input file with filename root1.DAT file is always required. The other files are provided as needed depending upon the tasks being performed with *HYD*.

The *HYD* and *SIM* DAT files are similar. The format of the *HYD* FLO file is the same as the *SIM* FLO file except streamflow adjustments may be included in the *HYD* FLO file. EVA, DIS, and HYD files have the same format in either program.

HYD output filenames have a common root, denoted here as *root2*, and extensions indicating the type of data in each file. The root (*root2*) of the filenames for the output files will typically be different than the root (*root1*) of the input files to prevent existing files from being overwritten. The output files are as follows:

output *OUT* file	root2.OUT	file with all output not included in the following files
message *MSS* file	root2.MSS	messages used to find errors in the input
inflow *FLO* file	root2.FLO	inflow *IN* records with naturalized streamflows
evap *EVA* file	root2.EVA	evaporation *EV* records with net evap-precip
hydrology *HYD*	root2.HYD	*IN* and *EV* records combined in a single file

The FLO and EVA output files are created by *HYD* to serve as input files for *SIM*. The HYD file is an alternative to the FLO and EVA files with the IN and EV records being combined in a single file. The message file (root2.MSS) is similar to the message file created by *SIM*. Other optional miscellaneous information that may be stored in a file with filename root2.OUT include tables of (1) flows and evaporation depths, (2) component parts of reservoir adjustments, (3) watershed parameters, and (4) negative incremental flow adjustments. The output files are all optional, depending on the tasks being performed.

Types of Input Records

WRAP-HYD input files contain a set of records controlling various options and supplying the data to be used in the computations. The various types of records and the files in which they are stored are listed in Table 5.3. The record types are labeled by a two-character identifier placed at the beginning of each record. These record identifiers provide a mechanism for organizing and referencing the input by data type.

Some of the same input record types are used in both *HYD* and *SIM*. Several *HYD* records are not used by *SIM*. Likewise, several record types associated with the main *SIM* input file are not pertinent to *HYD*. However, these records may be included in a *HYD* root1.DAT file and will be simply ignored by *HYD*.

The following record types are used by *HYD* as well as *SIM*. The format and content of these records, described in Chapter 3, are essentially the same with either program.

***, CP, CI, SV, SA, ED, IN, EV, FD, FC, WP*

A file options *FO* record serves the same purpose in both *HYD* and *SIM*. However, the *FO* record is different in the two programs to accommodate differences in file organization. The *JC*, *EP*, *AD*, *FA*, *RS*, *SC*, and *EQ* records are unique to *HYD*. Descriptions follow for the *WRAP-HYD* records that are different than the common *SIM* and *HYD* records already described in the *SIM* Section.

*File Options **FO** and **JC** Records*.- The files to be opened are specified on the *FO* record. The *JC* record is used to specify the period-of- analysis and select various options.

*Evaporation-Precipitation **EP** Manipulation Record*.- The *EP* record controls the combining of reservoir evaporation-precipitation data sets.

*Adjustment Specifications **AS** Record*.- The *AS* record activates streamflow adjustment computations and controls the selection of adjustment options.

*Flow Adjustments **FA** Record*.- Streamflow adjustment amounts may be input on *FA* records.

*Reservoir Specifications **RS** Record*.- A *RS* record activates routines for computing streamflow adjustments modeling the effects of a reservoir. Information needed for the computations are provided, and the selection of adjustment options is controlled.

*Storage Contents **SC** Record*.- Historical storage contents for a reservoir are input on *SC* records for use in developing the streamflow adjustments specified on a *RS* record.

*Regression Equation **EQ** Record*.- Coefficients for the regression equation are provided on EQ records.

Table 5.3
Types of HYD Input Records

	Basic Input File (filename root1.DAT)
	Records for organizing the data management and computational tasks
**	comments or notes not read by the computer that may be inserted throughout
FO	*F*ile *O*ptions specifying which types of input and output files are to be used
JC	*J*ob *C*ontrol data with basic data and option switches
XL	multiplier factors designed primarily for use as unit conversions
MF	monthly factors for arithmetic manipulation of flows and net evaporation rates
EP	specification of *E*vaporation-*P*recipitation rate manipulations
ED	*E*nd of *D*ata
EQ	Coefficients for regression *EQ*uations
	Records for defining control point connectivity and providing information for each control point
CP	*C*ontrol *P*oint connectivity and naturalized flow, evaporation, and channel loss data
CI	*C*onstant *I*nflows or outflows entering or leaving system at a control point
	Records for describing storage-volume relationship for a reservoir
SV	*S*torage *V*olumes corresponding to areas on *SA* record
SA	*S*urface *A*rea corresponding to volumes on *SV* record
RS	coefficients for storage-area equation may be entered on *R*eservoir *S*pecification record
	Hydrology Input Files (root1.FLO, root1.EVA, root1.HYD)
IN	*IN*flows to the system (naturalized streamflows)
EV	*EV*aporation (reservoir net evaporation-precipitation depths)
	Flow Distribution File (filename root1.DIS)
FD	*F*low *D*istribution specifications for transferring flows from gaged to ungaged sites
FC	*F*low distribution *C*oefficients for certain flow distribution options
WP	*W*atershed *P*arameters used in the flow distribution computations
	Either Basic Data File or Flow File (root1.DAT or root1.FLO)
	Records for Adjusting Streamflows
AS	*A*djustment *S*pecifications for adjusting streamflows
FA	*F*low *A*djustments
RS	*R*eservoir *S*pecifications for developing streamflow adjustments
SC	*S*torage *C*ontents of a reservoir

Locating Errors in the Input Data

WRAP-HYD contains features similar to those of *WRAP-SIM* to help detect missing records or inconsistencies and locate erroneous records that cause program execution to terminate due to illegal computer operations. These features do not pertain to those situations in which reasonable but incorrect data are input in the right format.

Tracking Program Progress

Tracing the progress of reading input records and performing computations up to program termination may be useful in locating the input record causing the problem. The following *HYD* features trace the progress of the simulation.

HYD execution begins with an interactive session in which the user supplies the root of the input (*root1*) and output (*root2*) filenames, and the files are opened. The program checks whether the specified files exist, writes a message to the monitor if an input file is missing, and allows the user to confirm overwriting of existing output files. The following messages then appear on the monitor as various tasks are performed.

```
Reading the input data from file_____.DAT
************************************************
Number of CP, SV/SA, and EV records read from DAT file.
   ___ control points
   ___ control points with IN records
   ___ storage-area table SV/SA records
   ___ evap-precip rate adjustment EP records
************************************************
Reading the IN/EV records
Developing EV records as specified by EP records
Adjusting flows as specified by AS records
Distributing flows from gaged to ungaged control points (FD records)
Writing IN and/or EV records to output file(s)

*****  Normal Completion of Program WRAP-HYD  *****
```

Progress is tracked in more detail by notes the program writes to the message file, which has a filename in the format *root2.MSS*. If program execution is terminated prior to completion the specified tasks, the trace messages help locate the input record causing the problem. Optional levels of input data traces are specified by input variable *ICHECK* in field 4 of the *JC* record. The basic trace (*ICHECK* ≥ 0) consists of printing the messages shown in Table 5.4 to the MSS file. Only those messages associated with options included in the *HYD* application will be written to the message file. If model execution is prematurely terminated, the last message provides the approximate location in the input files at which a problem occurred.

Additional information noted in Table 5.5 may also be written to the message file as specified by *ICHECK* in field 4 of the *JC* record. The *ICHECK* = 1 trace shown in Table 5.4 is used to find the general location of the problem record based on where the trace stops. The program is then rerun with a different *ICHECK* value to check which records in the groups noted

in Table 5.5 are read and copied correctly. For *ICHECK* options 3 through 7, the records noted in Table 5.5 are written to the MSS file immediately after each record is read. The records are copied to the MSS file almost verbatim as read, except most real numbers are written in a F8.0 Fortran format with zero digits to the right of the decimal point. Blank fields read as zeros are output as zeros. If the program reads some but not all records of a particular record type, the problem will typically be associated with either the last record read and copied to the MSS file or more likely the next record in the input file.

Error and Warning Messages

HYD contains a variety of error checks. Most are performed as the input files are read. If data are missing or in the wrong format, program execution is stopped and an error message is written. Warning messages identify potential problems, but program execution is not terminated. Error and warning messages are written to the MSS file. *HYD* and *SIM* both generate two types of error messages:

1. The Fortran input/output status specifier *IOSTAT* is included in most of the read statements.
2. Many other specific error check algorithms are coded into the various routines. Many of the *SIM* error messages listed in Table 2.10 and other similar messages are incorporated in *HYD*.

If violation of a Fortran rule is indicated by the *IOSTAT* variable in a read statement, the following complete message is written to the message file, the first two lines of the message are displayed on the monitor, and execution is terminated.

ERROR: Fortran IOSTAT error occurred reading an input record with identifier CD of ___
IOSTAT status variable = ____
The first 80 characters of each of the last two records read are as follows:

The last two records read from the input file prior to termination of the program are written following this message. The message indicates the value for the *IOSTAT* variable as defined within the Fortran language compiler. A negative one (-1) means the end of file was reached without finding the data record. A -2 indicates the end of the record was reached without finding the data. A positive integer refers to Fortran error condition messages provided by the compiler. The most common value for the *IOSTAT* variable is 64, which means input data is in the wrong format, such as a letter in a real or integer numeric field or a decimal in an integer field. A 39 indicates a problem with a read statement, but no information regarding the problem is available.

A value of 2 for *ICHECK* activates an additional *IN/EV* record check along with the other error checks in effect for *ICHECK* of 1 and 3-7. The *HYD ICHECK=2* check is not included in *SIM*. The *ICHECK=2* routine is applicable to INF and EVA files but not a HYD file. The routine reads the control point identifiers entered in field 2 of the *IN* and *EV* records and matches them against those on the *CP* records. The following warning message is written to the MSS file for each *IN* or *EV* record that does not match a CP record.

WARNING: Control point ___ on (IN or EV) record matches no identifier on CP records.

Table 5.4
HYD Trace Messages Written to MSS File

*** Starting to read file ____.DAT.
*** JC record was read.
*** Starting to read CP records.
*** Finished reading CP records.
*** Starting to read CI records.
*** Finished reading CI records.
*** Starting to read SV/SA records.
*** Finished reading SV/SA records.
*** Counting EP records. (They will be reread later.)
*** Finished reading file ____.DAT.
****

Number of CP, SV/SA, and EP records read from DAT file.
___ control point CP records
___ control points with IN records
___ storage-area table SV/SA records
___ evap-precip rate adjustment EP records

****

*** Starting ICHECK=2 check of IN records.
*** Finished ICHECK=2 check of ____ IN records.
*** Starting ICHECK=2 check of EV records.
*** Finished ICHECK=2 check of ____ EV records.
*** Starting to read IN/EV records.
*** Rearranging first year inflows and multiplying by factors on CP records.
*** Reading first year evap-precip rates.
*** Rearranging first year evap and multiplying by factors on CP records.
*** Finished reading IN/EV records.
*** Starting to read IN records from INF file in optional format [JC(1)=2].
*** Reordering IN records and multiplying by factors on CP records.
*** Starting to read EV records from EVA file in optional format [JC(1)=2].
*** Reordering EV records and multiplying by factors on CP records.
*** Finished reading IN/EV records.
*** Starting to read EP records.
*** Finished developing EV records as specified by EP records.
*** Starting to adjust flows as specified by AS and/or EQ records.
*** Finished adjusting flows as specified by AS and/or EQ records.
*** Starting negative incremental flow routine (ADJINC/NEGINC on JC record).
*** Finished negative incremental flow routine.
*** Starting to read flow distribution DIS file.
*** Finished reading flow distribution DIS file.
*** Starting flow distribution computations.
*** Finished flow distribution computations.
*** Starting to write IN and/or EV records to INF/EVA files.

***** Normal Completion of Program WRAP-HYD *****

Table 5.5
Trace Information Copied to Message File for Various Values of ICHECK

ICHECK = -1	Minimal trace messages; most error detection routines in effect
ICHECK = 0	Messages shown in Table 5.4; most error detection routines in effect
ICHECK = 1	Messages shown in Table 5.4; all error detection routines in effect
ICHECK = 2	Messages shown in Table 5.4; IN and EV record check
ICHECK = 3	Messages shown in Table 5.4 plus all *CP* records as read
ICHECK = 4	Messages shown in Table 5.4 plus all *AS* records as read
ICHECK = 5	Messages shown in Table 5.4 plus all *SV* and *SA* records as read
ICHECK = 6	Messages shown in Table 5.4 plus all *IN* and *EV* records as read
ICHECK = 7	Messages shown in Table 5.4 plus all *FD*, *FC*, and *WP* records as read

Table 5.6
HYD Error and Warning Messages

Written to Monitor from Subroutine FILINI before Opening MSS File
ERROR: No FO record found when opening files.
WARNING: No input file is specified in FO record.

Written to MSS File from main program
WARNING: ICHECK=2 option specified on JC record is invalid without INF and EVA files.
WARNING: No output is written since INEV(1)=5 in field 12 of first CP record.

Written to MSS File from Subroutine WRAPIN
ERROR: Missing JC record.
ERROR: Number of years on JC record must be at least one.
ERROR: JC(1,2,3,4,5,6) of __ on JC record is not valid.
ERROR: (Input,Output) file required by JC(1,2,3,4,5,6) of __ on JC record is missing on FO record.
ERROR: ADJINC of ___ and NEGINC of ___ on JC record are not compatible.
ERROR: ADJINC of ___ on JC record is not valid.
ERROR: EPDADJ of ___ in JC field 13 is not valid.
ERROR: Control point ____ has an invalid INEV of ___ (CP record field 12)
ERROR: Missing CP record. Read CD of _____
ERROR: Control point _____ has an invalid INMETHOD of ___
ERROR: Downstream control point identifier [CPID(cp,2)] _____ on CP record for _____ matches no CPID(cp,1).
ERROR: Identifier _____ is assigned to both control points ___ and ___
ERROR: Control point identifier _____ from CI record ___ matches no control point identifier on CP records.
ERROR: Missing SV/SA record. Read CD of _____
ERROR: Missing or duplicate reservoir ID found while reading SV/SA records.
ERROR: Read CD of __ when expecting ED record.

Written to MSS File From Subroutine INFEVA
ERROR: In reading first IN record for first year _____ read NYR of ____ and PYR of _____
ERROR: In reading first IN record for first year, read CD of _____ instead of IN.
ERROR: In reading (IN, EV) records for control point _____ for year _____ read PYR of _____
ERROR: In reading (IN,EV) records for year ___ a CD of ___ was read.
ERROR: (IN,EV) record was not found for year ___ for control point identifier _____
ERROR: (CPIN, CPEV) in field (7, 8) of CP record for _____ was not found.

Table 5.6 (Continued)
HYD Error and Warning Messages

Written to MSS File from Subroutine IACNP
ERROR: Found CD of __ in the DIS file, when expecting FD, FC, or WP record.
ERROR: _____ from field 2 of FD record ___ matches no control point identifier on CP records.
ERROR: Upstream gage identifier _____ from FD record ___ matches no control point identifier on CP records.
ERROR: _____ on the __ WP record matches no control point identifier on CP records.
ERROR: On FD record for _____ the upstream gage _____ is not upstream of the downstream gage _____
ERROR: NG is -1 on FD record for _____ but the source gage _____ is not upstream of the ungaged control point.
ERROR: Upstream control point UGID(I) of _____ is repeated twice on FD record for CP _____
ERROR: The downstream gaged source control point associated with ungaged CP _____ is missing or not specified on a FD record.
ERROR: The drainage area for CP _____ is missing, zero, or negative: _____
ERROR: The incremental drainage area for CP _____ is zero or negative: _____

Written to MSS File from Subroutine FLDIST
ERROR: NRCS CN method can not be applied for zero or negative drainage area for CP _____
ERROR: Gaged CP _____ is not downstream of ungaged CP _____ as required by INMETHOD (6,8)
WARNING: The incremental CN and/or mean precipitation MP is negative for gaged ___ or ungaged ___
gaged CN, ungaged CN, gaged MP, ungaged MP = ____ ____ ____ ____
WARNING: Convergence criterion of 0.5% was not met for flow distribution option 8 after 100 iterations
at ungaged CP _____ for year ___ , month ____. Last flow computed of _____ was adopted.
WARNING: Evap-precip adjustment at control point ____ for EWA(cp) of ___ for year ___, month ____
Runoff Adjustment (feet) = _____

Written to MSS File from Subroutine BISECT
WARNING: Subroutine BISECT stopped at 100 iterations in solving the NRCS CN equation for P.

Written to MSS File from Subroutine EPADD
ERROR: ID of ___ from EP record matches no identifier on the CP records.
ERROR: Read CD of __ when expecting an EP record.

Written to MSS File from Subroutine FLOWADJ
ERROR: JC(3) of __ on JC record is not valid.
ERROR: AS(3,4,5) of __ on AS record is not valid.
ERROR: ID of ___ on AS record matches no identifier on the CP records.
ERROR: CD of __ found when expecting (FA,SC) record.
ERROR: In reading (FA,SC) record for CP _____, read year of ____ when expecting _____
ERROR: RS(1,2,3,4,5,6) of __ on RS record is not valid.
ERROR: The identifier ____ on RS record matches no reservoir identifier on SV records.
ERROR: Interpolation of SV/SA records is out of range for reservoir _____
ERROR: In performing flow adjustments, reached end of input file (unit=__) without reading ED record.
WARNING: Read a FA record when AS(3) is greater than 1.
WARNING: Read a RS record when AS(3) is not 2.

If *IN* records are provided, the variable *INMETHOD* in field 6 of the *CP* record should be zero or one. If this is not the case, the following message is written.

WARNING: INMETHOD is ___ on CP record for control point _____ on IN record.

If *EV* records are provided, field 8 of the CP record (*CPEV*) should be blank. If this is not the case, the following message is written.

WARNING: CPEV is _____ on CP record for control point _____ on EV record.

The *ICHECK=2* routine also counts the total number of *IN* and *EV* records and includes these counts in the trace messages shown in Table 5.4. The total number of control points with *IN* records (also shown in the trace of Table 5.4) multiplied by the number of years in the simulation period should equal the total number of *IN* records.

Other error and warning messages are listed in Table 5.5. Subroutines *INFEVA*, *IACNP*, and *FLDIST* are similar in *HYD* and *SIM* and have the same error messages. *HYD* includes a number of other error and warning messages associated with those features not included in *SIM*.

Dimension Limits

The arrays in the Fortran code are dimensioned to reserve memory space. The number of control points is determined automatically by *HYD* by counting the CP records. Other dimension limits are set by the optional *DL* record, with the defaults shown in Table 5.7 being in effect unless overridden by entries on the *DL* record. There are no limits on the number of streamflow adjustments specified on *AS*, *FA*, *RS*, *RC*, *CI*, and *EQ* records.

Table 5.7
HYD Dimension Limits

control points	set internally by program by counting *CP* records
reservoir storage-area tables	set by *DL* record, default = 50
number of upstream gages on *FD* records	set by *DL* record, default = 15
number of years in period-of-analysis	set by *DL* record, default = 100

Sequential Organization of HYD Operations

WRAP-HYD is designed for flexibility for use is a myriad of ways. A single execution of the program may include any number of data adjustments. Alternatively, in order to sequence the adjustments certain ways, multiple runs may be made with the output file from one run being read as the input file for the next. Files may also be transported back and forth between *HYD* and spreadsheet or other programs.

HYD operations are organized around creating, adjusting, and writing streamflow *FLOW(cp,year,month)* and evaporation-precipitation *EP(cp,year,month)* arrays with values for all control points on the *CP* records covering the hydrologic period of analysis specified in *JC* record fields 2 and 3. As currently dimensioned, the maximum size of the two 3-dimensional arrays is as follows: *FLOW(250,100,12)* and *EP(250,100,12).* All elements are set equal to zero at the beginning of a *HYD* execution. The following sequence of operations on the *FLOW* and *EP* arrays are performed in the order listed. All operations are optional.

1. Files are opened, the DAT file is read, and initial error checks are performed.

2. The original flow and evaporation-precipitation data are read from either *IN/EV* records or as columns in a table as specified by *JC(1)* and *JC(2)* on the *JC* record. These are assigned to the *FLOW(cp,year,month)* and *EP(cp,year,month)* arrays. Any elements not read in are still zeros.

3. Combining of sets of evaporation-precipitation depths are performed as specified by *EP* records to obtain new sets of values stored in the *EP(cp,year,month)* array.

4. Streamflow adjustments are performed as specified by adjustment specification *AS* and/or regression equation *EQ* records. Each *AS* or *EQ* record results in revised values in the *FLOW(cp,year,month)* array for the specified control point and optionally downstream control points. The *AS* and/or *EQ* record adjustments are performed in sequential order as each *AS* or *EQ* record is read from the input file. Thus, the order of the *AS* and *EQ* records set the order of the adjustment computations. Any number of *AS* and *EQ* records and resulting adjustments, in any order, may be included in a *HYD* run.

   Information required to perform *AS* record adjustments is provided by associated *FA*, *CI*, *RS*, and *SC* records. A reservoir specification *RS* record defines the component parts computed within *WRAP-HYD* of an adjustment for the effects of a reservoir. The computed component parts may be written to the OUT file as a table for information. The total reservoir adjustment is treated just like any other adjustment of the *FLOW(cp,year,month)* array. Any number of reservoirs (*RS* records) may be included in a *WRAP-HYD* run. All adjustments are performed sequentially in the order that the *AS* records are entered in the input file.

   The regression equations:

$$Q_{adjusted} = a\,Q^{b} + c$$

$$\Delta Q_{adjustment} = (a\,Q^{b} + c) - Q$$

$$E_{adjusted} = a\,E^{b} + c$$

   are applied to the *FLOW(cp,year,month)* and *EP(cp,year,month)* arrays as specified by *EQ* records with the coefficients *a*, *b*, and *c* read from the *EQ* records. Again, any number of *EQ* records may be included in the data set, with the adjustments being performed in the order that the EQ records are read. If both *EQ* and *AS* records are included, they may be intermixed in any order.

5. Streamflows are distributed from gaged (known flow) to ungaged (unknown flow) control points as specified by *FD*, *FC*, and *WP* records from the DIS file. Watershed parameter tables may be written to the OUT file for information. The synthesized flows are stored in the *FLOW(cp,year,month)* array.

6. Negative incremental flow adjustments are performed as specified by *ADJINC* on the *JC* record. The *FLOW(cp,year,month)* array is modified. The adjustments may also be written to the OUT file as specified by *NEGINC* on the *JC* record.

7. The *FLOW(cp,year,month)* and *EP(cp,year,month)* arrays are written to output files as *IN* and *EV* records and/or as tables, as specified by *JC(4)*, *JC(5)*, and *JC(6)* on the *JC* record.

Alternative Formats for IN and EV Records

HYD will read inflow *IN* and evaporation-precipitation *EV* records in the file and record formats described in Table 5.8. *HYD* options allow writing *IN* and *EV* records to output files in these same alternative formats, except option 2 is limited to input only. Input and output options are controlled by the files specified on the files options *FO* record and the job control variables on the *JC* record. The options for reading the streamflow and evaporation-precipitation data are selected by entries for JC(1) and JC(2) on the *JC* record. For options 1, 2, 3, and 4, the monthly naturalized streamflows and evaporation, precipitation, or net evaporation-precipitation depths are read as sets of *IN* and *EV* records. For option 5, these data are read as a table with each column containing the data for a particular control point.

Table 5.8
Options for Organizing Streamflow and Evaporation-Precipitation Input Data

Option	Filename Extension	JC Record JC(1)-JC(2)	Format Description
1	FLO & EVA	1	Records are grouped by year. Records for all control points for a year are followed by a complete set of records for the next year. Each record contains 12 values for the 12 months of the year.
2	FLO & EVA	2	Records are grouped by control point. Records for all years for a control point are followed by a complete set of records for the next control point. Otherwise, option 2 is the same as option 1.
3	HYD	3	IN records for all control points for a year are followed by EV records for all control points for the year in WRAP2/WRAP3 format with pairs of records with each covering six months.
4	HYD	4	Same record sequencing as option 3 but each record covers 12 months
5	FLO&EVA	5	The data are in columns of a table rather than IN/EV records.

In the standard format (option 1), records for all control points are grouped together for each year as required by *SIM*. The set of all records for a year is followed by the set of all records for the next year. However, compiling data by control point is usually more convenient. The second option noted above allows the records for all years for a particular control point to be grouped together. *HYD* converts the records to the required *SIM* sequencing.

The *IN* and *EV* record format and file organization have been restructured in the current *WRAP* compared to its 1996 predecessor *WRAP2/WRAP3* versions. However, *HYD* and *SIM* include options for reading *IN* and *EV* records in either the old or new record and file formats. With the current standard approach, the *IN* and *EV* records are in a 12-months-per-record format and are separated into two files, with filenames root.INF and root.EVA. In the old *WRAP2/WRAP3* method (option 3 in the table above), each record covers six-months (two

records per year), and the *IN* and *EV* records are combined and stored as a hydrology root.HYD file. *HYD* has an option that reads an old-format root1.HYD file and converts to the new format root2.INF and root2.EVA files and vice versa.

SIM will also read *IN/EV* records from a DAT file. The fourth option allows flows to be read and written to a HYD file in the format required for a *SIM* DAT file. The *IN/EV* records can be transferred between a *SIM* DAT file and *HYD* HYD file.

The fifth option facilitates transporting data between a spreadsheet program such as Microsoft Excel and *WRAP-HYD*. With the fifth option, the data are read as columns from a spreadsheet table rather than as rows of *IN/EV* records. *HYD* writes streamflow and evaporation-precipitation data in this same format if specified by JC(5) on the *JC* record.

Format of Input Records

The record identifier is entered as the first two characters of each record. Comment records are not read by the program, except for the ** identifier. The other records begin with a two-character identifier, followed by a 6-character wide field and several eight-character fields. This manual describes input format in terms of fixed-width fields. However, optionally, fields with integer *I* and real *F* numerical data formats may be delimited with commas.

The Fortran format specifications found in the fourth column of the following tables describing each record type are defined as follows.

A6	alphanumeric (AN) label right justified in a field that is 6 characters wide
2X	two blank spaces (Fields with the spacing descriptor X are skipped over and not read.)
F8.0	real number in field of 8 characters with any number of digits to the right of the decimal (Either include decimal or right justify the number.)
12F8.0	twelve real numbers with each in a field with a width of 8 characters
I8	integer number right justified in field of 8 characters (Decimal is not allowed.)
3I8	three integer numbers with each right justified in field of 8 characters

In the fixed-width-fields format, variables with integer *I* format and character *A* specifications are right-justified in the appropriate field with no decimal. Real variables (F format) should either be right justified or include the decimal.

Examples 8 and 9 in the *Reference Manual* Appendix F illustrate the differences between the fixed-width field and comma-delimited formats. These two examples are the same, except the input files for Example 8 are totally in fixed-width-fields format, while much of the input in Example 9 comma-delimited. Commas may be used to truncate numeric (integer *I* and real *F* format) data. However, comma-delimited data entry is not applicable to character variables and spacing (*A* and *X* formats). A comma may be used to shorten the width of a field, but the number of characters in a field can not exceed that specified in this manual.

Sequential Order of Input Records

The input records are organized in the files in the sequential order outlined in Table 5.9. Other records from a *SIM* DAT file may be included in their normal sequence even though they are not used by *HYD*. The unused records will simply be passed over.

Table 5.9
Sequential Order of Input Records

	Basic Input File (filename root1.DAT)	
**	Comments	Comments may be inserted throughout.
FO	File Options	FO record is preceded only by optional comment ** records.
JC	Job Control Data	The JC record follows the FO record.
DL	Dimension Limits	Optional DL record follows JC record.
CP	Control Point	All CP records are grouped together following the JC record.
CI	Constant Inflows	Set of optional CI records follows set of all CP records.
SV	Storage Volumes	Set of all SV-SA tables grouped together in any order, with
SA	Surface Area	each SA immediately following corresponding SV.
EP	Evaporation-Precipitation Specifications	All EP records are grouped together.
AS, FA, RS, SC,EQ		Set of streamflow adjustment records listed below.
	Streamflow adjustment records (EQ,AS,FA,RS,SC) are placed at the end of either the: Basic Input File (filename root1.DAT) or Streamflow File (filename root1.INF)	
AS	Adjustment Specifications	An AS record precedes each set of FA records and each
FA	Flow Adjustments	set of RS/SC records. FA records for CP are grouped.
RS	Reservoir Specifications	A RS record precedes each group of SC records.
SC	Storage Content	SC records for a control point are grouped together.
EQ	Regression Equation	EQ records may be before, after, or between AS records.
ED	End of Data	ED is last record in files containing AS/FA/RS/RC records.
	Streamflow File (filename root1.INF)	
**	Comments	Comments may be inserted before each group of records.
IN	Inflows	IN records are grouped together by year and control point. Control points may be in any order. Years should be in sequential chronological order. IN records precede flow adjustment record sets.
	Evaporation-Precipitation Depth File (filename root1.EVA)	
**	Comments	Comments may be inserted before each group of records.
EV	Evaporation	EV records are organized the same as IN records.

Table 5.9 (Continued)
Sequential Order of Input Records

Flow Distribution File (root.DIS)

**	Comments	Comments may be inserted before each group of records.
FD	Flow Distribution	Each FC record follows the corresponding FD record. The set of all WP records follows the set of all FD/FC records.
FC	Flow Distribution Coefficients	
WP	Watershed Parameters	
ED	End of Data	

Hydrology File (filename root2.HYD) [alternative to standard INF and EVA files]

IN	Inflows	IN/EV records are grouped by year. Set of EV records for all control points for year follow set of all IN records for the preceding year.
EV	Evaporation	

Format and Content of Each Type of Input Record

The remainder of this chapter consists of a set of tables outlining the information to be entered in each field of each type of *WRAP-HYD* input record.

Table 5.10
Quick Reference Chart for WRAP-HYD

						field					
1	2	3	4	5	6	7	8	9	10	11	
						column					
2	8	16	24	32	40	48	56	64	72	80	page

Basic Input Data File (filename root.DAT)

**											
FO	INF	EVA	DIS	HYD	MSS	OUT	INF	EVA	HYD		158
JC	NYRS	YRST	ICHECK	JC(1)	JC(2)	JC(3)	JC(4)	ADJINC	NEGINC		159
CP	CPID1	CPID2	CPDT1	CPDT2	INMETH	CPIN	CPEV	EWA	CL	INWS	161
CI	CIID	Jan	Feb	Mar	Apr	May	Jun				162
CI		Jul	Aug	Sep	Oct	Nov	Dec				162
SV	RES	TARA	TARA								163
SA		TARB	TARB								163
EP	ID	EPID(1)	EPM(1)	EPID(2)	EPM(2)	EPID(3)	EPM(3)	EPID(4)	EPM(4)		163
ED											157

Inflow File (filename root.INF)

IN	ID	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	164

Net Evaporation-Precipitation File (filename root.EVA)

EV	ID	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	164

Flow Distribution File (filename root.DIS)

FD	ID	IDDS	NGAGE	UGID(1)	UGID(2)	UGID(3)	UGID(4)	UGID(5)	UGID(6)	UGID(7)	166
FC	COEF1	COEF2	COEF3								166
WP	ID	DA	CN	MP	DAF						166
ED											157

Flow Adjustment Records in Basic Input (root.DAT) or Inflow (root.INF) Files

AS	ID	AS(1)	AS(2)	AS(3)	AS(4)	AS(5)	AS(6)				167
FA	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	168
FA	ID	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	168
RS	ID	RS(1)	RS(2)	RS(3)	RS(4)	RS(5)	CAP	EVCFA	EVCFB	EVCFC	169
SC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	170
SC	ID	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	170
EQ	ID	A	B	C	AS(1)	AS(2)	QE	AS(4)	AS(5)		171
ED											157

2	8	16	24	32	40	48	56	64	72	80	page

****** Record – Comments

field	columns	variable	format	value	description
1	1-2	CD	A2	**	Record identifier
2	3-no limit			AN	Comments which are not read by the program

Comment (**) records are not read by the program, except for the ** identifier. They are used to insert notes in the input dataset. ** may also be used to temporarily deactivate records.. Any number of comment records may be placed at the following locations.

- almost any place in the DAT file
- before the first *IN* and *EV* records for each year in the INF and EVA files
- before each set of flow adjustment (*AS* record) in the DAT and INF files
- before each set of reservoir adjustment (*RS* and *SC* records) in the DAT and INF files
- before the *FD* records and between the *FD* and *WP* records in the DIS file

ED Record – End of Data

field	columns	variable	format	value	description
1	1-2	CD	A2	ED	Record identifier

A *ED* record is required at the end of a file containing *AS*, *FA*, *RS*, *SC* and records (DAT or INF) and also at the end of a flow distribution (DIS) file.

DL Record – Dimension Limits

field	columns	variable	format	value	description
1	1-2	CD	A2	DL	record identifier
2	3-8	MAXTAB	I8	+ 0,blank	limit on number of pairs of SV/SA records default = 50
3	9-16	MAXGAG	I8	+ 0,blank	limit on number of upstream gages on FD records default = 15
4	17-24	MAXYRS	I8	+ 0,blank	limit on number of years default = 100

FO Record – File Options (Required)

field	columns	variable	format	value	description
1	1-2	CD	A2	FO	Record identifier
2	8	F(2)	I6	blank,0,- +	root1.INF inflow file is not read root1.INF inflow file is read
3	16	F(3)	I8	blank,0,- +	root1.EVA evaporation file is not read root1.EVA evaporation file is read
4	24	F(4)	I8	blank,0,- +	root1.DIS flow distribution file is not read root1.DIS flow distribution file is read
5	32	F(5)	I8	blank,0,- +	root1.HYD hydrology file is not read root1.HYD hydrology file is read
6	40	F(6)	I8	- blank,0,+	root2.MSS error message file is not created root2.MSS error message file is created
7	48	F(7)	I8	blank,0,- +	root2.OUT output file is not created root2.OUT output file is created
8	56	F(8)	I8	blank,0,- +	root2.INF inflow file is not created root2.INF inflow file is created
9	64	F(9)	I8	blank,0,- +	root2.EVA evaporation file not created root2.EVA evaporation file is created
10	72	F(10)	I8	blank,0,- +	root2.HYD hydrology file not created root2.HYD hydrology file is created

The *FO* record specifies the files to be used. Entering a positive integer indicates that the file will be used. A negative integer results in the file not being used. With the exception of the message (MSS) file which defaults to the file being opened (created), leaving the field corresponding to a file blank or entering a zero results in the file not being opened. The MSS file should essentially always be used. Selection of the other files depends on the operations specified on the JC record. Also, the RS(6) reservoir adjustment table is activated from the *RS* record. The program writes error messages and terminates execution if the files required for the operations specified by the *JC* and *RS* records are not opened by the *FO* record.

JC(1) = 1, 2, or 5	root1.INF file is required, F(2) = 1
JC(1) = 3 or 4	root1.HYD file is required, F(5) = 1
JC(2) = 1, 2, or 5	root1.EVA file is required, F(3) = 1
JC(2) = 3 or 4	root1.HYD file is required, F(5) = 1
JC(3) = 2, 3, or 4	root1.INF file is required, F(2) = 1
JC(3) = 0, 1, or 2	root2.INF and/or EVA files are required, F(8) = 1 and/or F(9) = 1
JC(4) = 3, or 4	root2.HYD file is required, F(10) = 1
JC(5) = non-zero	root2.OUT file is used if F(7) = 1, otherwise INF and/or EVA files used.
JC(6) = non-zero	root2.OUT file is required, F(7) = 1
NEGINC = 2 or 3	root2.OUT file is used if F(7) = 1, otherwise MSS file is used.
RS(6) = 1	root2.OUT file is required, F(7) = 1

JC Record – Job Control (required)

field	columns	variable	format	value	description
1	1-2	CD	A2	JC	Record identifier
2	3-8	NYRS	I6	AN	Number of years in simulation
3	9-16	YRST	I8	+	First year of hydrologic period-of-analysis
					Level of Error Checks
4	24	ICHECK	I8	-1	minimal trace messages and reduced error checks
				blank,0	normal trace and reduced error checks
				1	normal error checks and input trace
				2	*IN/EV* record check
				3	copy *CP* records to MSS file
				4	copy *AS* and *EQ* records to MSS file
				5	copy *SV/SA* records to MSS file
				6	copy *IN/EV* records to MSS file
				7	copy *FD/FC/WP* records to MSS file
					Input Options
5	32	JC(1)	I8	blank,0	Streamflows are not read as input.
				1	*IN* records read from FLO file in standard format
				2	*IN* records read from FLO file in optional format
				3	*IN* records read from HYD file in WRAP3 format
				4	*IN* records read from HYD file with 12 flows/record
				5	Streamflows read from FLO file in columnar format
6	40	JC(2)	I8	blank,0	Evaporation-precipitation depths are not read.
				1	*EV* records from EVA file in standard format
				2	*EV* records read from EVA file in optional format
				3	*EV* records read from HYD file in WRAP3 format
				4	*EV* records read from HYD file with 12 values/record
				5	Evap-precip read from FLO file in columnar format
7	48	JC(3)	I8	blank,0	No flow adjustments
				1	Flow adjustment data read from DAT file
				2	Flow adjustment data read from FLO file
				3	Flow adjustment from DAT(1^{st}) and FLO (2^{nd}) files
				4	Flow adjustment from INF (1^{st}) and DAT (2^{nd}) files
					Output Options
8	56	JC(4)	I8	blank,0,1,2	Standard FLO and/or EVA output files as needed
				3	*WRAP3* format HYD output file is used instead
				4	HYD file with 12 values/record is used instead
9	64	JC(5)	I8	blank,0	Option with output in columns is not used.
				1	Streamflows written as columns in a table
				2	Evap-precip depths written as columns in a table
				3	Both streamflows and evap-precip tables created
10	72	JC(6)	I8	blank,0	Watershed parameter tables are not created.
				1	Incremental watershed parameter table in OUT file
				2	Table of parameters from *WP* records in OUT file
				3	Both watershed parameter tables created

JC Record – Job Control (continued)

field	columns	variable	format	value	description
					Negative Incremental Flow Options
11	80	ADJINC	I8	blank,0,1	Negative incremental flows are not considered
				2	Downstream flow adjustments are performed
				3	Upstream flow adjustments are performed
				-3	Option 3 with secondary control points excluded
12	88	NEGINC	I8	blank,0,1	No incremental flow adjustments written
				2	Downstream flow adjustments written
				3	Upstream flow adjustments written
					Set Default for Evap-Precip Adjustment
13	96	EPADJ	I8	blank,0	No adjustment unless specified on *CP* record
				-1	Adjustments based on ungaged CP (*FD* field 2)
				-2	Adjustments based on gaged CP (*FD* record field 3)

XL Record – Multiplication Factors

field	columns	variable	format	value	description
1	1-2	CD	A2	XL	Record identifier
2	3-8	STX	F6.0	+	Multiplier of reservoir storage volumes on *WS*, *OR*, *SV*, *PV*, *MS*, *IS*, and *SD* records.
				blank, 0	Default = 1.0
3	9-16	INX	F8.0	+	Multiplier of flows on *IN* records, subject to being superceded by non-blank *CP* record field 4.
				blank, 0	Default = 1.0
4	17-24	EVX	F8.0	+	Multiplier of E-P rates on *EV* records, subject to being superceded by non-blank *CP* record field 5.
				blank, 0	Default = 1.0
5	25-32	CIX	F8.0	+	Multiplier of flows on *CI* records.
				blank, 0	Default = 1.0
6	33-40	SAX	F8.0	+	Multiplier of reservoir surface areas on *SA* records.
				blank, 0	Default = 1.0
7	49-56	DEPTHX	F8.0	+	Multiplier factor for runoff depth in NRCS CN method flow distribution computations.
				blank, 0	Default = 0.01875

The *XL* record in *HYD* contains fewer variables than the similar *XL* record in *SIM*. The factors common to *HYD* and *SIM* are used in the same manner in both programs. The factors are previously discussed in conjunction with their use in *SIM*.

CP Record – Control Point Information (A *CP* record is required for each control point.)

field	columns	variable	format	value	description
1	1-2	CD	A2	CP	Record identifier
2	3-8	CPID(cp,1)	A6	AN	Control point identifier [cp = 1,NCPTS]
3	11-16	CPID(cp,2)	2x,A6	AN	Identifier of next downstream control point.
				Blank,OUT	Basin outlet. There is no control point downstream.
					Multiplier Factors
4	17-24	CPDT(cp,1)	F8.0	+	Factor by which inflows on IN records are multiplied
				blank,0	Default factor = 1.0
5	25-32	CPDT(cp,2)	F8.0	+	Factor by which evaporation rates are multiplied
				blank,0	Default factor = 1.0
					Method for Obtaining Naturalized Flows
6	40	INMETHOD (cp)	I8	0,1	IN records are input for this control point.
				2	Specifications are provided by *CPIN(cp)* in field 7.
				3	Flow distribution equation is used.
				4	NRCS CN method with synthesized flows limited to not exceed source control point flows
				5	NRCS CN method without above noted flow limit
				6	channel loss coefficient incorporated in DAR method
				7	drainage area ratio method (areas from WP records)
				8	NRCS method with channel losses
7	43-48	CPIN(cp)	2x,A6	blank	INMETHOD in field 6 is not 2.
				AN	Another CP from which *IN* records are repeated
				NONE ZERO	The words *none, zero, NONE, or ZERO* indicate zero streamflows at this control point.
					Method for Obtaining Net Evaporation-Precipitation
8	51-56	CPEV(cp)	2x,A6	blank	*EV* records are read as input
				AN	Another CP from which *EV* records are repeated
				NONE ZERO	The words *none, zero, NONE, or ZERO* in this field indicate zero net evaporation at this control point.
					Adjustment for Runoff from Reservoir Site
9	57-64	EWA(cp)	F8.0	+	Watershed area in acres for runoff adjustment.
				-1	Negative number flags use of *FD* and *WP* records.
				blank,0	Net evaporation-precipitation option is not used.
					Channel Loss Factor
10	65-72	CL(cp)	F8.0	+	Channel loss factor for stream reach below CP.
				blank	The default channel loss factor value is 0.0.
					Watershed Areas on WP Records
11	73-80	INWS(cp)	I8	blank,0	Parameters on WP record are for the total watershed.
				+	WP record parameters for incremental watersheds.
					Do Not Include IN/EV Records in Output
12	88	INEV(cp)	I8	1	omit the *IN* records for this CP in the output file
				2	omit the *EV* records for this CP in the output file
				3	omit both the *IN* and *EV* records in the output file
				4	omit both for this CP and all previous control points
				5	omit for this CP and all subsequent control points

MF Record – Monthly Factors

field	columns	variable	format	value	description
1	1-2	CD	A2	MF	Record identifier
2	3-8	MF	F6.0		Factors for each of 12 months
3-13	9-96	MF	F8.0		

Control point *CP* record fields 4 and 5 are multiplier factors for all streamflows on the *IN* records and all evaporation-precipitation depths on the *EV* records for that control point. The MF record expands this capability. A negative number for *CPDT(cp,1)* or *CPDT(cp,2)* indicates that the *CP* record will be followed by a *MF* record with a set of 12 numbers. The 12 monthly factors on the *MF* record are applied as specified in *CP* record fields 4 and 5 as follows.

For *CPDT(cp,1)* or *CPDT(cp,2)* of -2.0, flows or evaporation depths from the *IN* or *EV* records are multiplied by the *MF* record factors.

For *CPDT(cp,1)* or *CPDT(cp,2)* of -3.0, *MF* record factors are added to flows or evaporation depths from the *IN* or *EV* records.

For *CPDT(cp,1)* or *CPDT(cp,2)* of -4.0, the operation and factors specified for the preceding control point are repeated for this control point.

CI Record – Constant Inflows and/or Outflows

Field	columns	variable	format	value	description
1	1-2	CD	A2	CI	Record identifier
2	3-8	CIID	A6	AN	Control point identifier
3-8	9-56	CI(M=1,6) CI(M=7,12)	6F8.0	+,-	Flow added to streamflow at control point CIID for month M. Six entered on first CI record, six on second. Field 2 on the second CI record is not read.

The set of *CI* records follows the *CP* records in *HYD* just like in *SIM*. *CI* records are in pairs with each record containing streamflow adjustments for six months of the year. Any number of pairs of *CI* records may be entered for any control point.

SV Record – Storage Volumes for Reservoir Storage versus Area Table

Field	columns	variable	format	value	Description
1	1-2	CD	A2	SV	Record identifier
2	3-8	RES	A6	AN	Reservoir identifier
3-14	9-104	TARA(I) I=1,12	12F8.0	+	Reservoir storage volumes corresponding to surface areas in same fields of the following *SA* record

SA Record – Surface Areas for Reservoir Storage versus Area Table

field	columns	variable	format	value	description
1	1-2	CD	A2	SA	Record identifier
2	3-8	RES	6x		Field not used
3-14	9-104	TARB(I) I=1,12	12F8.0	+	Reservoir surface areas corresponding to storage volumes in same fields of the preceding *SV* record

The *SV* and *SA* records have the same format. Storage volume (*SV* record) versus surface area (*SA* record) tables are used in the reservoir net evaporation-precipitation computations. A storage-area relationship may be defined optionally with a pair of *SV-SA* records or by equation coefficients provided on the *AS* record. The *SV-SA* tables are allowed a maximum of 12 pairs of values. A *SV* record must be followed by the corresponding *SA* record. A complete set of all *SV-SA* records are grouped together.

EP Record – Evaporation-Precipitation Combining Specifications

field	columns	variable	format	value	description
1	1-2	CD	A2	EP	record identifier
2	3-8	ID	A6	AN	control point identifier
3	11-16	EPID(1)	2x,A6	AN	control point identifier
4	17-24	EPM(1)	F8.0	+	multiplier
5	27-32	EPID(2)	2x,A6	AN	control point identifier
6	33-40	EPM(2)	F8.0	+	multiplier
7	43-48	EPID(3)	2x,A6	AN	control point identifier
8	49-56	EPM(3)	F8.0	+	multiplier
9	59-64	EPID(4)	2x,A6	AN	control point identifier
10	75-72	EPM(4)	F8.0	+	multiplier

All *EP* records are grouped together in the DAT file. The monthly evaporation-precipitation depths for the control point identified in field 2 are computed as a weighted average of the values read for the control points identified in fields 3, 5, 7, and 9 using the multipliers from fields 4, 6, 8, and 10.

IN and EV Records in the Standard Default Format

Records for all control points are grouped together by year. All the records for a year are followed by the complete set of records for the next year.

IN Record – Inflows - Naturalized Streamflows at a Control Point

field	columns	variable	format	value	description
1	1-2	CD	A2	IN	record identifier
2	3-8	ID	A6	AN	control point identifier
3	9-12	NYR	I4	+	first year for an *IN* record repeated for multiple years
				blank,0	*IN* record is for one year only; it is not repeated
4	13-16	PYR	I4	+	year
5	17-24	INFLOW(cp,1)	F8.0	+	naturalized streamflow for Month 1
6	25-32	INFLOW(cp,2)	F8.0	+	naturalized streamflow for Month 2
7	33-40	INFLOW(cp,3)	F8.0	+	naturalized streamflow for Month 3
8	41-48	INFLOW(cp,1)	F8.0	+	naturalized streamflow for Month 4
9	49-56	INFLOW(cp,5)	F8.0	+	naturalized streamflow for Month 5
10	57-64	INFLOW(cp,6)	F8.0	+	naturalized streamflow for Month 6
11	65-72	INFLOW(cp,7)	F8.0	+	naturalized streamflow for Month 7
12	73-80	INFLOW(cp,8)	F8.0	+	naturalized streamflow for Month 8
13	81-88	INFLOW(cp,9)	F8.0	+	naturalized streamflow for Month 9
14	89-96	INFLOW(10)	F8.0	+	naturalized streamflow for Month 10
15	97-104	INFLOW(11)	F8.0	+	naturalized streamflow for Month 11
16	105-112	INFLOW(12)	F8.0	+	naturalized streamflow for Month 12

EV Record – Evaporation, Precipitation , or Net Reservoir Evaporation-Precipitation Depths

field	columns	variable	format	value	description
1	1-2	CD	A2	IN	record identifier
2	3-8	ID	A6	AN	control point identifier
3	9-12	NYR	I4	+	first year for an *EV* record repeated for multiple years
				blank,0	*EV* record is for one year only; it is not repeated
4	13-16	PYR	I4	+	year
5	17-24	EVAPR(cp,1)	F8.0	+	evaporation-precipitation for Month 1
6	25-32	EVAPR(cp,2)	F8.0	+	evaporation-precipitation for Month 2
7	33-40	EVAPR(cp,3)	F8.0	+	evaporation-precipitation for Month 3
8	41-48	EVAPR(cp,1)	F8.0	+	evaporation-precipitation for Month 4
9	49-56	EVAPR(cp,5)	F8.0	+	evaporation-precipitation for Month 5
10	57-64	EVAPR(cp,6)	F8.0	+	evaporation-precipitation for Month 6
11	65-72	EVAPR(cp,7)	F8.0	+	evaporation-precipitation for Month 7
12	73-80	EVAPR(cp,8)	F8.0	+	evaporation-precipitation for Month 8
13	81-88	EVAPR(cp,9)	F8.0	+	evaporation-precipitation for Month 9
14	89-96	EVAPR(10)	F8.0	+	evaporation-precipitation for Month 10
15	97-104	EVAPR(11)	F8.0	+	evaporation-precipitation for Month 11
16	105-112	EVAPR(12)	F8.0	+	evaporation-precipitation for Month 12

IN and EV Records in the Old *WRAP2/WRAP3* Format

IN records for all control points for a year are followed by a corresponding set of *EV* records for all control points for the year. *IN/EV* records for all control points are grouped together by year. All the records for a year are followed by a complete set of records for the next year. The records are stored in file root.HYD.

First IN Record for Each Year – Inflows

field	columns	variable	format	value	description
1	1-2	CD	A2	IN	record identifier
2	3-8	ID	A6	AN	control point identifier
3	9-16	PYR	I8	+	year
4	17-24	Q(1)	F8.0	+	naturalized streamflow for Month 1
5	25-32	Q(2)	F8.0	+	naturalized streamflow for Month 2
6	33-40	Q(3)	F8.0	+	naturalized streamflow for Month 3
7	41-48	Q(4)	F8.0	+	naturalized streamflow for Month 4
8	49-56	Q(5)	F8.0	+	naturalized streamflow for Month 5
9	57-64	Q(6)	F8.0	+	naturalized streamflow for Month 6

Second IN Record for Each Year – Inflows

field	columns	variable	format	value	description
1	1-2	CD	A2	IN	record identifier
2	3-8		6X		not used
3	9-16		8X		not used
4	17-24	Q(7)	F8.0	+	naturalized streamflow for Month 7
5	25-32	Q(8)	F8.0	+	naturalized streamflow for Month 8
6	33-40	Q(9)	F8.0	+	naturalized streamflow for Month 9
7	41-48	Q(10)	F8.0	+	naturalized streamflow for Month 10
8	49-56	Q(11)	F8.0	+	naturalized streamflow for Month 11
9	57-64	Q(12)	F8.0	+	naturalized streamflow for Month 12

First EV Record for Each Year – Reservoir Evaporation Rates

field	columns	variable	format	value	description
1	1-2	CD	A2	EV	record identifier
2	3-8	ID	A6	AN	control point identifier
3	9-16	PYR	I8	+	year
4	17-24	EV(1)	F8.0	+	reservoir evaporation rate for Month 1
5	25-32	EV(2)	F8.0	+	reservoir evaporation rate for Month 2
6	33-40	EV(3)	F8.0	+	reservoir evaporation rate for Month 3
7	41-48	EV(4)	F8.0	+	reservoir evaporation rate for Month 4
8	49-56	EV(5)	F8.0	+	reservoir evaporation rate for Month 5
9	57-64	EV(6)	F8.0	+	reservoir evaporation rate for Month 6

Second EV Record for Each Year – Same format as indicated above.

FD Record – Flow Distribution

field	columns	variable	Format	value	description
1	1-2	CD	A2	FD	record identifier
2	3-8	ID	A6	AN	control point identifier for ungaged CP
3	11-16	IDDS	2x,A6	AN	source gaged control point
4	17-24	NGAGE	I8	+	number of gaged cp's above ungaged site (blank = 0)
				-1	ungaged CP is downstream of source CP
5-19	25-144	UGID(I)	15(2x,A6)	AN	identifiers of upstream gaged control points [I=1,MAXGAG=15]

The *FD*, *FC*, and *WP* records are stored in a DIS file, that ends with an *ED* record. A *FD* record is required for each ungaged control point for which flows are to be synthesized. Flows are transferred from the source control point (field 3) to the ungaged control point (field 2). Upstream control points define incremental watersheds. The *FD* and *WP* records also define incremental watersheds for use in the reservoir site runoff adjustments specified by *EPADJ* on the *JC* record, *EWA(cp)* on the *CP* record, and *RS(5)* on the *RS* record.

FC Record – Coefficients for Flow Distribution Equation

field	columns	variable	Format	value	description
1	1-2	CD	A2	FC	record identifier
2	3-8	COEF1	F6.0	+	coefficient *a* (may be drainage area ratio)
3	9-16	COEF2	F8.0	+ or -	coefficient *b* (default = 1.0)
4	17-24	COEF3	F8.0	+ or -	coefficient *c* (default = 0.0)
					$Q_{ungaged} = a\, Q_{gaged}^{\ b} + c$

A *FC* record follows the *FD* record if the flow distribution method option 3 (field 6 of *CP* record) is applied for this control point requiring coefficients for the equation: $Q_{ungaged} = a\, Q_{gaged}^{\ b} + c$

WP Record – Watershed Parameters

field	column	variable	format	value	description
1	1-2	CD	A2	WP	record identifier
2	3-8	ID	A6	AN	control point identifier
3	9-16	DA	F8.0	+	drainage area
4	17-24	CN	F8.0	+	curve number
5	25-32	MP	F8.0	+	mean precipitation
6	33-40	DAF	F8.0	+	multiplier to convert drainage area to square miles

A *WP* record is provided for each gaged and ungaged control point involved in applying flow distribution methods 4, 5, 6, 7, or 8 specified in field 6 of the *CP* records or determining runoff adjustments specified by JC/CP/RS records. The set of all *WP* records follow the set of all *FD/FC* records in the root.DIS file. The unit conversion multiplier *DAF* in field 6 applies to this and all subsequent *WP* records until a new *DAF* is entered on another *WP* record. The default *DAF* is 1.0.

AS Record – Streamflow Adjustment Specifications

field	columns	variable	format	value	description
1	1-2	CD	A2	AS	record identifier
2	3-8	ID	A6	AN	control point identifier
					Beginning and Ending Years of Adjustments
3	13-16	AS(1)	I8	blank,0	first year of adjustments = first year of analysis period
				+	first year of adjustments
4	21-24	AS(2)	I8	blank,0	last year of adjustments = last year of analysis period
				+	last year of adjustments
					Source of Adjustments
5	32	AS(3)	I8	blank,0,1	following *FA* records
				-1	following *FA* records in format that includes the year and control point
				2	following *RS* and *SC* records
				-2	following *RS* and *SC* records with *SC* records in format that includes year and control point
				3	*CI* records previously read from root1.DAT file
				4	constant adjustment from field 9
					Cascade Downstream? Yes or No?
6	40	AS(4)	I8	0	adjustments apply to all downstream control points
				1	adjustments apply to only this control point
					Negative Flow Options
7	48	AS(5)	I8	0	allow negative streamflows
				1	change negative streamflows to zero
				2	change to zero and subtract next month
				3	modify adjustments to prevent negative streamflows
				4	modify adjustments and subtract negative next month
					Multiplier Factor
8	49-56	AS6	F8.0	+	factor to multiply flow adjustments (default=1.0)
					Constant Flow Adjustment
9	57-64	AS7	F8.0	+	constant streamflow adjustment applied in all months

EQ, AS, FA, RS, and *SC* records may be placed as the last records in either the DAT and/or INF files as specified by *JC(3)* entered in field 7 of the *JC* record.

The format of the *FA* and *SC* records vary depending on *AS(3)* in field 5 of *AS* record.

Negative flow options (field 7) may be applied with each individual *AS* record set of adjustments. Alternatively, the negative flow options may be applied to the final streamflows after all cumulative adjustments by inserting a final *AS* record with *AS(3)*=4 and *AS7*=0.0.

FA Record – Streamflow Adjustments

field	columns	variable	format	value	description
1	1-2	CD	A2	FA	record identifier (optional after first record)
2	3-8	FA(1)	F6.0	+	streamflow adjustment for Month 1
3	9-16	FA(2)	F8.0	+	streamflow adjustment for Month 2
4	17-24	FA(3)	F8.0	+	streamflow adjustment for Month 3
5	25-32	FA(4)	F8.0	+	streamflow adjustment for Month 4
6	33-40	FA(5)	F8.0	+	streamflow adjustment for Month 5
7	41-48	FA(6)	F8.0	+	streamflow adjustment for Month 6
8	49-56	FA(7)	F8.0	+	streamflow adjustment for Month 7
9	57-64	FA(8)	F8.0	+	streamflow adjustment for Month 8
10	65-72	FA(9)	F8.0	+	streamflow adjustment for Month 9
11	73-80	FA(10)	F8.0	+	streamflow adjustment for Month 10
12	81-88	FA(11)	F8.0	+	streamflow adjustment for Month 11
13	89-96	FA(12)	F8.0	+	streamflow adjustment for Month 12

FA Record – Streamflow Adjustments (Alternative format with control point ID and year)

field	columns	variable	format	value	description
1	1-2	CD	A2	FA	record identifier (optional)
2	3-8	ID	A6	AN	control point identifier (optional)
3	13-16	PYR	I8	+	year (optional)
4	17-24	FA(1)	F8.0	+	streamflow adjustment for Month 1
5	25-32	FA(2)	F8.0	+	streamflow adjustment for Month 2
6	33-40	FA(3)	F8.0	+	streamflow adjustment for Month 3
7	41-48	FA(4)	F8.0	+	streamflow adjustment for Month 4
8	49-56	FA(5)	F8.0	+	streamflow adjustment for Month 5
9	57-64	FA(6)	F8.0	+	streamflow adjustment for Month 6
10	65-72	FA(7)	F8.0	+	streamflow adjustment for Month 7
11	73-80	FA(8)	F8.0	+	streamflow adjustment for Month 8
12	81-88	FA(9)	F8.0	+	streamflow adjustment for Month 9
13	89-96	FA(10)	F8.0	+	streamflow adjustment for Month 10
14	97-104	FA(11)	F8.0	+	streamflow adjustment for Month 11
15	105-112	FA(12)	F8.0	+	streamflow adjustment for Month 12

The choice of format for the *FA* and *SC* records is specified by *AS(3)* in field 5 of *AS* record. The only difference between the two options is whether to include optional fields for the control point ID and year PYR as fields 2 and 3. These records, like all others, may also be in comma delimited format.

RS RECORD – Reservoir Specifications for Streamflow Adjustments

field	columns	variable	format	value	description
1	1-2	CD	A2	RS	record identifier
2	3-8	ID	A6	AN	reservoir identifier
					Adjustment Components
3	16	RS(1)	I8	blank,0	add storage increase (default)
				1	add storage increase
				-1	subtract storage increase
				-9	do not consider storage increase
4	24	RS(2)	I8	blank,0	subtract conservation storage decrease (default)
				1	add conservation storage decrease
				-1	subtract conservation storage decrease
				-9	do not consider conservation storage decrease
5	32	RS(3)	I8	blank,0	subtract flood storage decrease (spill) (default)
				1	add flood storage decrease (spill)
				-1	subtract flood storage decrease (spill)
				-9	do not consider flood storage decrease (spill)
6	48	RS(4)	I8	blank,0	add net evaporation-precipitation (default)
				1	add net evaporation-precipitation
				-1	subtract net evaporation-precipitation
				-9	do not consider net evaporation-precipitation
7	48	RS(5)	I8	blank,0	add watershed runoff from reservoir site (default)
				1	add watershed runoff from reservoir site
				-1	subtract watershed runoff from reservoir site
				-9	do not consider runoff from reservoir site
					Reservoir Adjustments Table
8	56	RS(6)	I8	blank,0	Option not used
				1	Adjustments table written to OUT file
					Reservoir Information
9	57-64	CAP	F8.0	+	Reservoir storage capacity
10	65-72	EVCFA	F8.0	+	Multiplier *A* for storage-area equation shown below.
11	73-80	EVCFB	F8.0	+	Exponent *B* for storage-area equation shown below.
12	81-88	EVCFC	F8.0	+	Constant *C* for storage-area equation shown below. surface area = A (storage)$^B + C$
13	88-96	RS7	F8.0	+	beginning storage (beginning of first month)
				blank,0	beginning storage content is zero
14	97-104	RS8	F8.0	+	factor to multiply storage contents
				blank, 0	default: RS7 = 1.0

A *RS* record must be preceded by an *AS* record and followed by a *SC* record.

SC Record – Storage Contents

field	columns	variable	format	value	description
1	1-2	CD	A2	SC	record identifier (optional)
2	3-8	SC(1)	F6.0	+	storage contents for Month 1
3	9-16	SC(2)	F8.0	+	storage contents for Month 2
4	17-24	SC(3)	F8.0	+	storage contents for Month 3
5	25-32	SC(4)	F8.0	+	storage contents for Month 4
6	33-40	SC(5)	F8.0	+	storage contents for Month 5
7	41-48	SC(6)	F8.0	+	storage contents for Month 6
8	49-56	SC(7)	F8.0	+	storage contents for Month 7
9	57-64	SC(8)	F8.0	+	storage contents for Month 8
10	65-72	SC(9)	F8.0	+	storage contents for Month 9
11	73-80	SC(10)	F8.0	+	storage contents for Month 10
12	81-88	SC(11)	F8.0	+	storage contents for Month 11
13	89-96	SC(12)	F8.0	+	storage contents for Month 12

SC Record – Storage Contents (Alternative format with control point ID and year PYR)

field	columns	variable	format	value	description
1	1-2	CD	A2	SC	record identifier (optional after first record)
2	3-8	ID	A6	AN	reservoir (optional)
3	13-16	PYR	I8	+	year (optional)
4	17-24	SC(1)	F8.0	+	storage contents for Month 1
5	25-32	SC(2)	F8.0	+	storage contents for Month 2
6	33-40	SC(3)	F8.0	+	storage contents for Month 3
7	41-48	SC(4)	F8.0	+	storage contents for Month 4
8	49-56	SC(5)	F8.0	+	storage contents for Month 5
9	57-64	SC(6)	F8.0	+	storage contents for Month 6
10	65-72	SC(7)	F8.0	+	storage contents for Month 7
11	73-80	SC(8)	F8.0	+	storage contents for Month 8
12	81-88	SC(9)	F8.0	+	storage contents for Month 9
13	89-96	SC(10)	F8.0	+	storage contents for Month 10
14	97-104	SC(11)	F8.0	+	storage contents for Month 11
15	105-112	SC(12)	F8.0	+	storage contents for Month 12

The choice of format for the *FA* and *SC* records is specified by *AS(3)* in field 3 of *AS* record. The only difference between the two options is whether to include optional fields for the control point ID and year PYR as fields 2 and 3. These records, like all others, may also be in comma delimited format.

EQ Record – Regression Equation

field	columns	variable	format	value	description
1	1-2	CD	A2	AS	record identifier
2	3-8	ID	A6	AN	control point identifier
					Regression Equation Coefficients
3	9-16	A			coefficient A
4	17-24	B			coefficient B
5	25-32	C			coefficient C
					Beginning and Ending Years of Adjustments
6	37-40	AS(1)	I8	blank,0	first year of adjustments = first year of analysis period
				+	first year of adjustments
7	45-48	AS(2)	I8	blank,0	last year of adjustments = last year of analysis period
				+	last year of adjustments
					Type of Adjustments
8	56	QE	I8	blank,0,1	Flow $Q_{adjusted} = A\ Q^B + C$
				2	Flow Change $\Delta Q_{adjustment} = (A\ Q^B + C) - Q$
				3	Evap-Precip $E_{adjusted} = A\ E^B + C$
					Cascade Downstream if QE=2 (Yes or No?)
9	64	AS(4)	I8	0	QE=2 adjustments apply to all downstream cp's
				1	*QE=2* adjustments apply to only this control point
					Negative Flow Options
10	72	AS(5)	I8	0	allow negative streamflows
				1	change negative streamflows to zero
				2	change to zero and subtract next month
				3	modify adjustments to prevent negative streamflows
				4	modify adjustments and subtract negative next month

EQ records are grouped with *AS*/*FA*/*RS*/*SC* records and may be placed before, after, or interdispersed with the *AS*/*FA*/*RS*/*SC* records. These records are the last records in either the DAT and/or INF files as specified by *JC(3)* entered in field 7 of the *JC* record.

Fields 6, 7, 9, and 10 of the *EQ* record are identical to fields 3, 4, 6, and 7 of the *AS* record.

Only $\Delta Q_{adjustment}$ may be applied to downstream control points. Therefore, field 9 is blank unless option 2 is selected for *QE* in field 8.

Field 8 specifies the manner in which a regression equation is applied. Streamflows (*QE=1*) or evaporation-precipitation depths (*QE=3*) are adjusted by direct substitution into the equation.

$$Q_{adjusted} = A\ Q^B + C \quad \text{or} \quad E_{adjusted} = A\ E^B + C$$

Alternatively, for streamflows (*QE=2*), a change in flow $\Delta Q_{adjustment}$ may be computed that is then handled identically as adjustments read from *FA* records or computed in accordance with *RS* records.

$$\Delta Q_{adjustment} = (A\ Q^B + C) - Q$$

INDEX OF INPUT RECORDS